October 20, 1961

electronics

A McGraw-Hill Publication 75 Cents

As two fields merge:

OPTICS FOR ELECTRONICS

Aspheric lens (left) reduces system size *see p 47*

For reliable design

THERMAL CONDITIONING

Ten ways to cool electronic equipment *see p 54*

TUNNEL-DIODE MEMORY

5-Mc unit increases digital computer speed, *p 66*

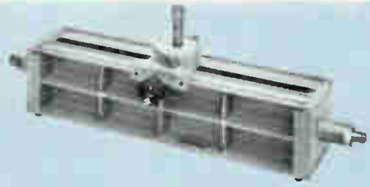
TESTED *waveguide and coaxial equipment*

752 Multi-Hole Coupler

Precision directional couplers provide coupling factors of 3, 10 or 20 db. Coupling accuracy ± 0.4 db or 0.7 db. Directivity better than 40 db full range, SWR less than 1:1 (752A), 1:05 (752C/D). Cover frequencies 2.6 to 40 GC. $100.00 to $375.00.

760D/761D Dual Directional Couplers

Ideal for reflectometer systems, these coaxial couplers are flat to ± 0.5 db over 4-to-1 frequency range. Directivity is 35 db (760D) and 30 db (761D). Feature high power capacity, low insertion loss and SWR. 760D, 250 MC to 1 GC, $200.00; 761D, 1 to 4 GC, $185.00.



870A/872A Slide Screw Tuners

For waveguide, coaxial (872A shown) applications. Probe position, penetration sets up reflection cancelling existing reflection. Lead screw or micrometer varies probe insertion for 870A Tuners, 2.6 to 40 GC, $125.00 to $300.00. Micrometer drive varies insertion on 872A, 500 MC to 4 GC, $525.00.

372 Precision Attenuators

Rugged, broadband fixed attenuators retaining precise calibration regardless of humidity, temperature or time. Invariant attenuation assured by permanent, "multi-hole coupler" joining of two waveguides. 10 and 20 db models, 2.6 to 18.0 GC. $110.00 to $400.00.

375A Variable Flap Attenuators

Simple, convenient for adjusting waveguide power or isolating source and load. Max. SWR less than 1.15 full range; attenuation variable 0 to 20 db, dissipates average powers up to 0.5 or 1 watt. S through R bands, 2.6 to 40.0 GC. $90.00 to $190.00.

362A Low Pass Filter

Compact models increase SWR measurement accuracy by suppressing harmonics; feature low insertion loss, broad stop band. 8.2 to 40.0 GC (includes N-band model). $325.00 to $385.00.

430C Microwave Power Meter
476A/477B/485 Mounts

430C reads rf power direct in dbm or mw, requires no calculations. Covers 2.6 to 40.0 GC, operates with 476A, 477B, 485 bolometer, thermistor or detector mounts; also with 487 Broadband Waveguide Thermistor Mounts (see alongside). 430C, (cabinet), $250.00; 430CR, (rack mount), $255.00. *476A Universal Bolometer Mount,* 10 to 1,000 MC without tuning, $85.00. *477B Coaxial Thermistor Mount,* 10 MC to 10 GC without tuning, $75.00. *485 Detector Mounts* available in three basic series: S485A 2.60 to 3.95 GC, no tuning; 485B, 3.95 to 12.4 GC; 485D, 2.6 to 8.2 GC. 485 models, $75.00 to $185.00.

487 Waveguide Thermistor Mounts

Models covering 2.6 to 40.0 GC. Each covers full range of guide; no tuning, SWR 1.35 to 2.0. 10 mw max power. Uses permanently installed 100 ohm negative coefficient thermistor; 18.0 to 40 GC models use 200 ohm thermistor. $75.00 to $225.00.

810/815B Slotted Sections

810B Slotted Sections. 810B, for 809B carriage, flanged, waveguide section with accurately machined slot. Slot tapered at ends to minimize reflection. 3.95 to 18.0 GC. $90.00 to $125.00.

S810A. Complete slotted section assembly including probe carriage. In 2.6 to 3.95 GC (S-band) size only. $450.00.

815B Slotted Sections. For mounting in 814B carriage. Available in two bands, 18.0 to 40.0 GC. Accurately machined; easy interchange, precise positioning. $265.00.

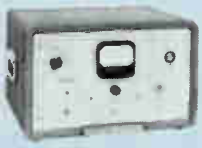
806B Coaxial Slotted Section. 3 - 12 GC, fits 809B, Type N connectors. $200.00.

805C/D Slotted Lines

Utmost mechanical rigidity, less leakage, greater accuracy, SWR 1.02 or 1.04. Range 500 MC to 4 GC, reads in cm and mm to 0.1 mm. 805C, for 50 ohm Type N, 805B, for 46.3 ohm RG 44/U. 805C, $525.00; 805D, $600.00.

415B/C Standing Wave Indicators

415B operates with all waveguide and coaxial slotted sections, gives readings in SWR or db. Low noise level, 0.1 μv full scale sensitivity, 60 db calib. attenuator. $200.00 (cabinet), $205.00 (rack). *New 415C* (pictured) offers similar characteristics but is transistorized, incorporates revolutionary four-times expansion of readings at any point on any scale. Price on request.



416A Ratio Meter

Displays ratio between two signals, irrespective of common amplitude variations. Especially useful for swept frequency measurement of VSWR, reflection coefficient, gain, insertion loss and other microwave parameters. Calibrated in VSWR, % reflection, db. See offer for Application Note 42 elsewhere in this advertisement. $550.00 (cabinet), $535.00 (rack).

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Your hp representative offers two very important advantages

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- **complete assurance that the equipment will perform precisely as specified or better**

hp makes sure you get what you pay for by rigid quality control plus 100% electrical testing using hp developed methods including reflectometer and swept frequency techniques. hp *knows* when a parameter is out of spec; never gambles your money and time that 3 or 4 sample measurements taken across an instrument's range truly indicate its full-range performance.

See your hp rep now for FULL-RANGE TESTED microwave equipment . . . *get what you pay for.*

New Microwave Catalog

A new 32-page Hewlett-Packard Microwave Instrumentation catalog is yours for the asking. Contact your rep or write direct for this catalog which discusses theoretical and how-to-do-it techniques and includes a complete listing of hp microwave instruments and their specifications.

hp NOISE FIGURE MEASURING EQUIPMENT

hp 344A Noise Figure Meter

Quickly, accurately measures noise figure of operating radar sets. Automatic operation; simple front panel calibration. Militarized, transistorized, reliable in extreme environments, minimum size and weight. Continuous noise figure presentation on most radar receivers. Extremely high sensitivity permits decoupling noise source up to 20 db from main transmitter line to minimize system degradation. Provision for automatic alarm, remote noise figure monitoring, modulating. Meter scale/excess noise options; 25 or 30 MC input frequency, 1 MC bandwidth, 75 ohms input impedance. Approx. $1,600.00 (depending on options, modifications).

hp 340B/342A Noise Figure Meters

General - purpose instruments making possible, in minutes, receiver and component alignment jobs that once took hours. Simplifies accurate alignment; encourages better maintenance, performance.

hp 340B automatically measures, continuously displays IF or receiver noise figure at 30 or 60 MC; other frequency on order. $715.00 (cabinet), $700.00 (rack).

hp 342A, similar, operates on 30, 60, 70, 105, 200 MC .30 MC and 4 other frequencies between 38 and 200 MC on order. $815.00 (cabinet), $800.00 (rack). (Note: Models 340B and 342A available only in the U.S.A. and Canada.)

hp 343A VHF Noise Source, temperature limited diode broadband source, 10 to 600 MC, 5.2 db excess noise, $100.00.

hp 345B IF Noise Source, 30 or 60 MC (others to order); 4 impedances, 5.2 db excess noise. $100.00.

hp 347A Waveguide Noise Source, Argon gas discharge tubes in waveguide section; frequencies 2.6 to 18.0 GC, 15.2 db excess noise. $200.00 to $300.00.

hp 349A UHF Noise Source, 400 to 4,000 MC, wider with correction. 15.2 excess noise. $325.00.

Basic test, power and impedance measuring equipment

Complete line of FULL-RANGE

BASIC TEST EQUIPMENT

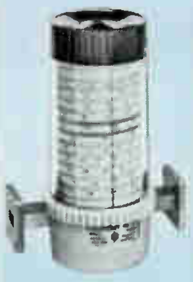
hp 382A/B/C Broadband Precision Waveguide Attenuators

Dielectric loading in new S832, X382 produces long electrical length for high accuracy with short physical dimension, provides hitherto unknown convenience. Calibrated range, 0 to 60 db. Degree-of-rotation scale allows accurate small changes at high attenuation and accurate resetting to high values of attenuation. hp 382B models calibrated to 0.1 degrees; 382C models to 0.01 degrees. hp 382A series rotary-vane attenuators, 3.95 to 40 GC, attenuation 0 to 50 db, $275.00 to $800.00; hp 382B/C models, $295.00 to $650.00.

hp 422A, 421A, 420A/B Crystal Detectors

High sensitivity (0.05 v/mw), flat frequency response (±2 db) and accurate square-law characteristics (± 1 db from —3 to —40 dbm) are available with new hp 422A Crystal Detectors (pictured), K and R bands, 18 to 40 GC. hp 422A, $200.00 each, available in matched pairs for reflectometer systems, $420.00 a pair. hp also offers high sensitivity detectors covering a wide frequency range: 421A, 7 to 18 GC, $75.00 to $130.00; 420A for Type N coax lines, 10 MC to 12.5 GC, $50.00 each; 420B for reflectometer systems, matched pair, $150.00.

hp 532/536A Frequency Meters



Comparable wide band, direct reading convenience are offered by hp 532 series, 3.95 to 40 GC, and hp 536A, 1 to 4 GC coaxial, Frequency Meters. Comprise high Q resonant cavity tuned by choke plunger; no sliding contacts. Transmit virtually full power at resonance. 532 series, $175.00 to $325.00; hp 536A, $500.

hp 914A/B, 906A Moving Loads

Full frequency coverage, 1 to 40 GC is available from hp waveguide or coaxial moving loads. Model 914 series, 2.6 to 40.0 GC, are waveguide sections containing sliding, tapered, low-reflection loads. Plunger controls load position, travels ½ wavelength at lowest frequency to reverse phase of residual load reflection. Model 906A, 1 to 12.4 GC, coaxial, includes adapters for Type N male, female connectors. hp 914A/B series, $50.00 to $250.00; hp 906A, $250.00.

POWER MEASURING EQUIPMENT

hp 434A Calorimetric Power Meter

Connect and read powers 10 mw to 10 watts, dc to 12.4 GC. No barretter, thermistor needed, no external terminations or plumbing. Measures CW or pulsed power. Two simple controls. DC input impedance 50 ohms approx.; input SWR less than 1.7 full range, less than 1.3 to 5 GC. Accuracy within 5% full scale. $1,600.00 (cabinet); $1,585.00 (rack mount).

hp 431A Microwave Power Meters. hp 478A/486A Thermistor Mounts

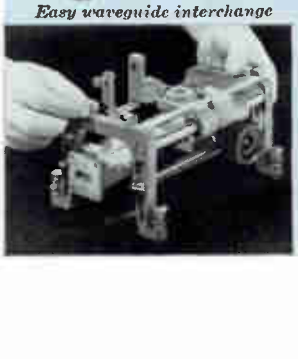
Now end tedious zero setting with new hp 431A Power Meter (pictured). Measures 10 μw to 10 mw full scale in 7 ranges, also reads in dbm. ± 3% accuracy all ranges, drift less than 2 μw/°C! One zero setting for all ranges, good for hours. Provides additional sensitivity of 10 db over previously available instruments. Operates with hp 478A, 486A Thermistor Mounts. hp 431A, $345.00. *New hp 478A* (center, above) covers 10 MC to 10 GC without tuning, is truly temperature compensated, contains two thermistor pairs for use with dual bridge of 431A. SWR less than 1.5, high accuracy, drift-free operation. $145.00. *New hp X486A Waveguide Mount,* also temperature compensated, gives high accuracy, new convenience. 8.2 to 12.4 GC without tuning, SWR less than 1.5. $145.00.

IMPEDANCE MEASURING EQUIPMENT

hp 809B/814B Universal Probe Carriages

hp 809B, 810B

Easy waveguide interchange



hp 814B, 815B, 446B

Models 809B and 814B are precision built mechanical assemblies operating, respectively, with hp 810B and 815B series slotted sections.

Combination of the 809B carriage and 810 slotted sections covers 2.6 to 18.0 GC. Combination of 814B carriage and 815B series sections covers 18.0 to 40.0 GC.

On either carriage, waveguides can be interchanged in seconds. Only one probe (for each carriage) covers full frequency range. Manufacture is of highest quality, assures positive mechanical positioning of interchangeable waveguides and precise installation of mating hp probes. hp 809B has vernier scale reading to 0.1 mm, is equipped for dial gauge mounting. hp 814B has dial read directly to 0.01 mm. hp 809B, $175.00, hp 814B, $225.

hp 444A/446B Untuned Probes

hp 444A (shown) is modified crystal (1N76 or 1N26) plus small antenna in convenient housing. Probe penetration easily variable; locks in position. No tuning; sensitivity superior to elaborate single, double tuned probes. Range 3.0 to 18.0 GC; fits ¾" bore. hp 446B for hp 814 Probe Carriage, similar but covers 18.0 to 40.0 GC. hp 444A, $40.00. hp 446B, $145.00. hp also offers model 440A, for barretter or crystal, Type N coaxial, $85.00.

October 20, 1961

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

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

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

**79% nickel-iron molybdenum alloy*

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

MAGNETIC METALS

Hayes Avenue at 21st Street, Camden 1, New Jersey
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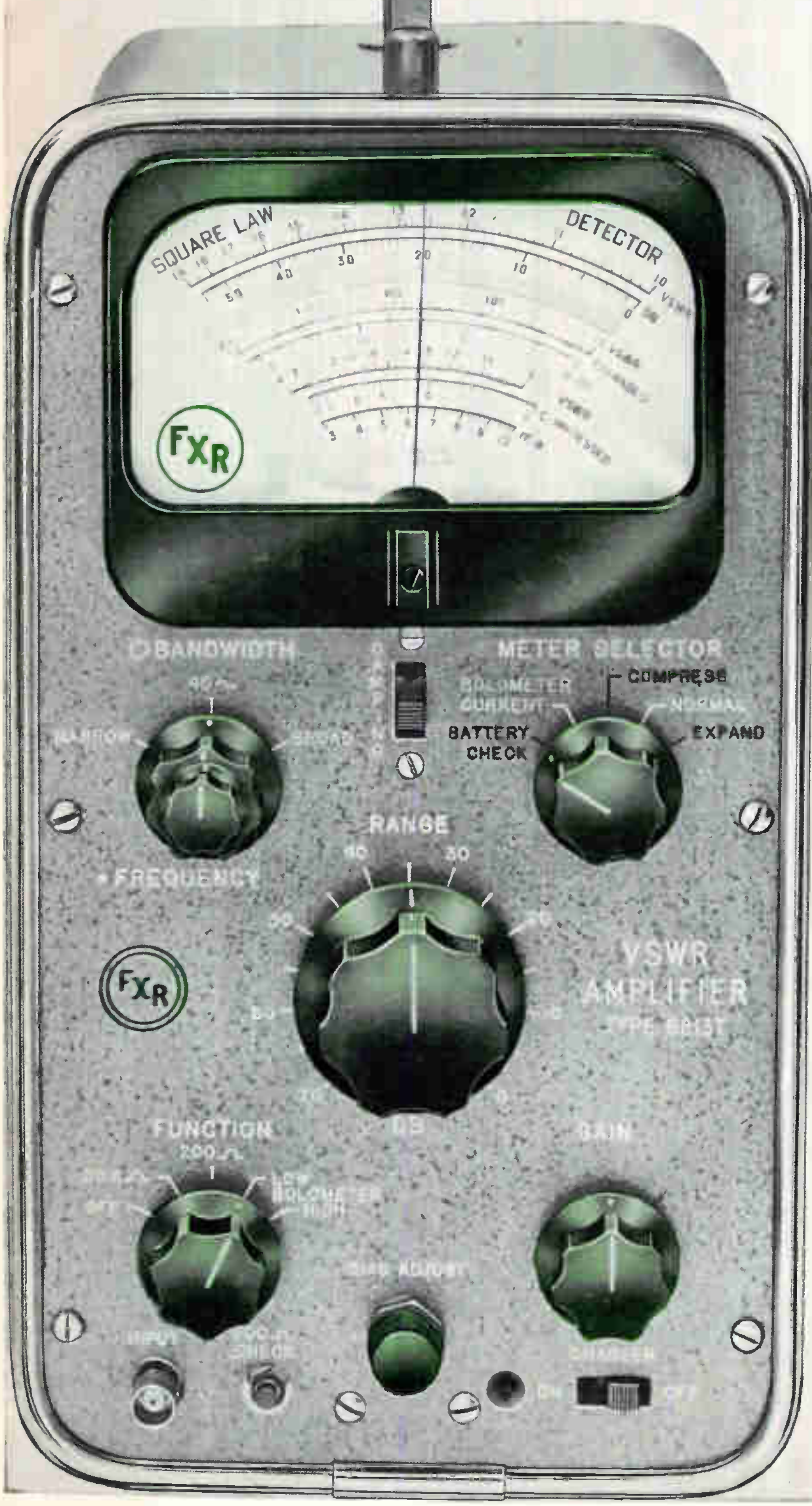
transformer laminations • motor laminations • tape-wound cores
powdered molybdenum permalloy cores • electromagnetic shields

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



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

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

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

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

FXR ®

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- high power electronics
- systems

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Audited Paid Circulation

CROSSTALK

Stock Prices vs. Earnings

RECENT EARNINGS of many companies, and stock prices, prompt the question "What's wrong with electronics?"

There is nothing wrong with electronics. It is a leading growth industry. It is an industry whose potential for increasing world living standards has scarcely been scratched.

Experiences of the past several months do prove, however, that the electronics industry is as vulnerable to the evils of overproduction and price cutting, poor cost control and, particularly, financial manipulation, as any other business.

The day is passing in which manipulators can assume control, let's say of the Joe Doaks Dry Cleaning Company, mortgage the assets, factor the receivables, hire a couple of Ph.D.'s and double or triple the company's stock price-to-earnings ratio simply by calling it the Joe Doaks Astroelectronics Corporation.

Many investors who have seen market favorites lose perhaps half their value in a few short weeks know better today. Nevertheless, some marginal manufacturing operations are being kept alive by intravenous financial feeding from hopeful investment groups. This will not go on forever.

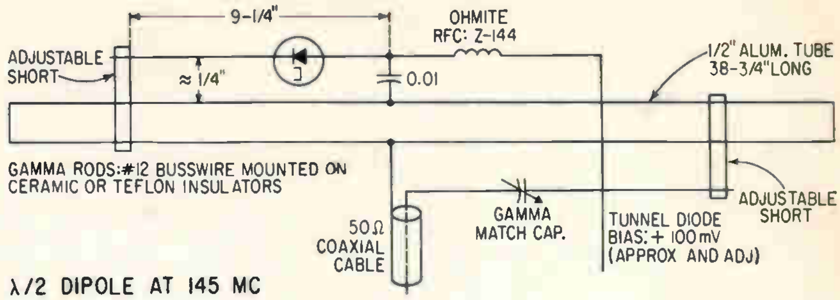
Manufacturers who will participate most fully in the future growth of electronics are those who offer unique products or services in important areas. There are many examples in many branches of the business. To take just one, a manufacturer may achieve a position in, say, the semiconductor business, by making the fastest switching transistors. A manufacturer could also insure a place for himself by making the most reliable transistors. Or a manufacturer might make the best all-around transistor for the least money. It is conceivable that a manufacturer could simultaneously make the most technically advanced unit, of highest reliability, and sell it at the lowest price, but this is not often possible because of necessary trade-offs in designs and manufacturing.

There is plenty of room left in the electronics industry. However, the manufacturer who takes someone else's design and knocks it out on a production line has only a marginal place if, indeed, he has a place at all. In the long run, such a manufacturer is not going to be helped by any high-sounding corporate name or any enthusiastic promotion or "image-building."

One man in a loft with an idea could set the industry on fire a few years ago. It can be done today. But the idea better be a really good one. And every aspect of the operation, as a business, had better be sound.

CIRCLE 5 ON READER SERVICE CARD→

COMMENT



λ/2 DIPOLE AT 145 MC

Antennafier

Several requests have been received for construction details of the dipole antennafier (Oct. 6, p 68).

We have obtained modest success with a 145-Mc dipole made from a piece of ½-inch aluminum tubing about 38¾ inches long. The outer conductor of the coaxial feed line is grounded to the center of the dipole as shown in the figure. The capacitor indicated in the tunnel diode gamma match is a 0.01 disc ceramic bypass for the bias supply.

The 9¼-inch length indicated for the gamma match was determined experimentally for the individual diode used, and could be considerably different for other diodes.

The usual precautions must be observed for the tunnel-diode bias source, in that it must be low impedance, well filtered and, preferably, regulated. This d-c bias may be brought in on the coaxial cable, rather than a separate conductor, if desired.

By adjusting the bias just short of the point where oscillations begin, we have observed as much as 15-db gain from this device, but there is considerable room for improvement in our indicated noise figures, which have been in the range of 10 to 15 db to date.

One vitally important fact must be observed in the use of tunnel-diode antennafiers. The tunnel diode is basically a small-signal element, and is easily overloaded by strong r-f fields from any nearby tv, f-m, or other vhf transmitting stations. Measurements are impossible in close proximity to such stations unless a screened room is available. We have avoided this problem by taking all our measurements late at night after the nearby stations have signed off the air.

We would be very pleased to hear the results of any tests your readers might perform with this or other types of antennafiers or antennaverters.

JOHN R. COPELAND
WILLIAM J. ROBERTSON
The Ohio State University
Columbus, Ohio

Medical Electronics

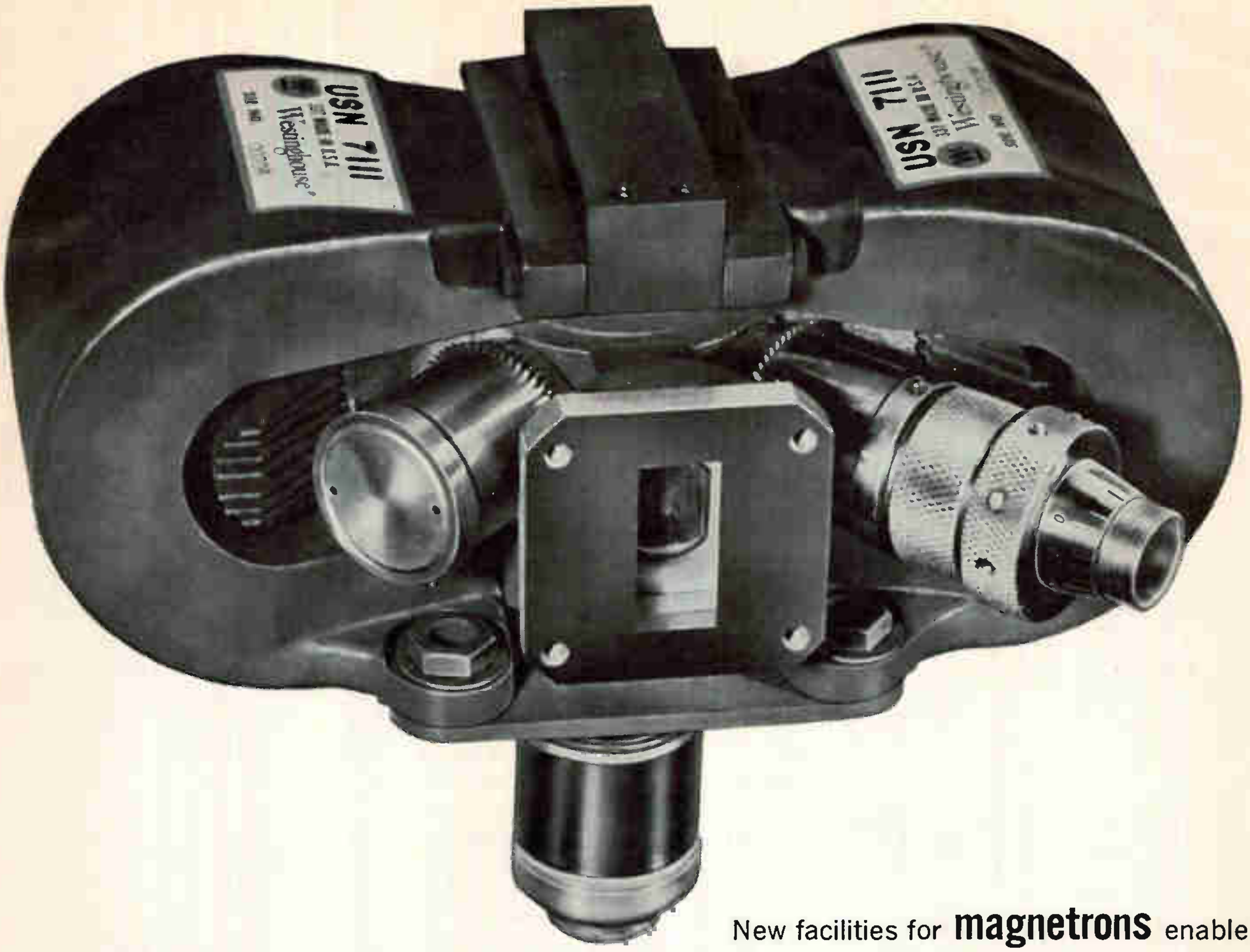
The Medical Electronics Part V article in the July 21 issue (p 63) is excellent, as are the other parts in this series. Thank you very much for the mention of the Atronic Pacer.

However, my blocking oscillator analog should not have been combined with reference to the Medtronic Pacemaker in Fig. 1 of your article.

Regardless, your efforts have been instrumental in the increased interest of electronic engineers in medical applications.

DAVID G. KILPATRICK
General Atronics Corporation
Bala Cynwyd, Pa.

Figure 1 (p 67) shows at left an electrical analog of the heart's natural pacemaker, as visualized by Mr. Kilpatrick. At right are electrocardiagrams showing the effect of the Medtronic Corporation's Cardiac Pacemaker.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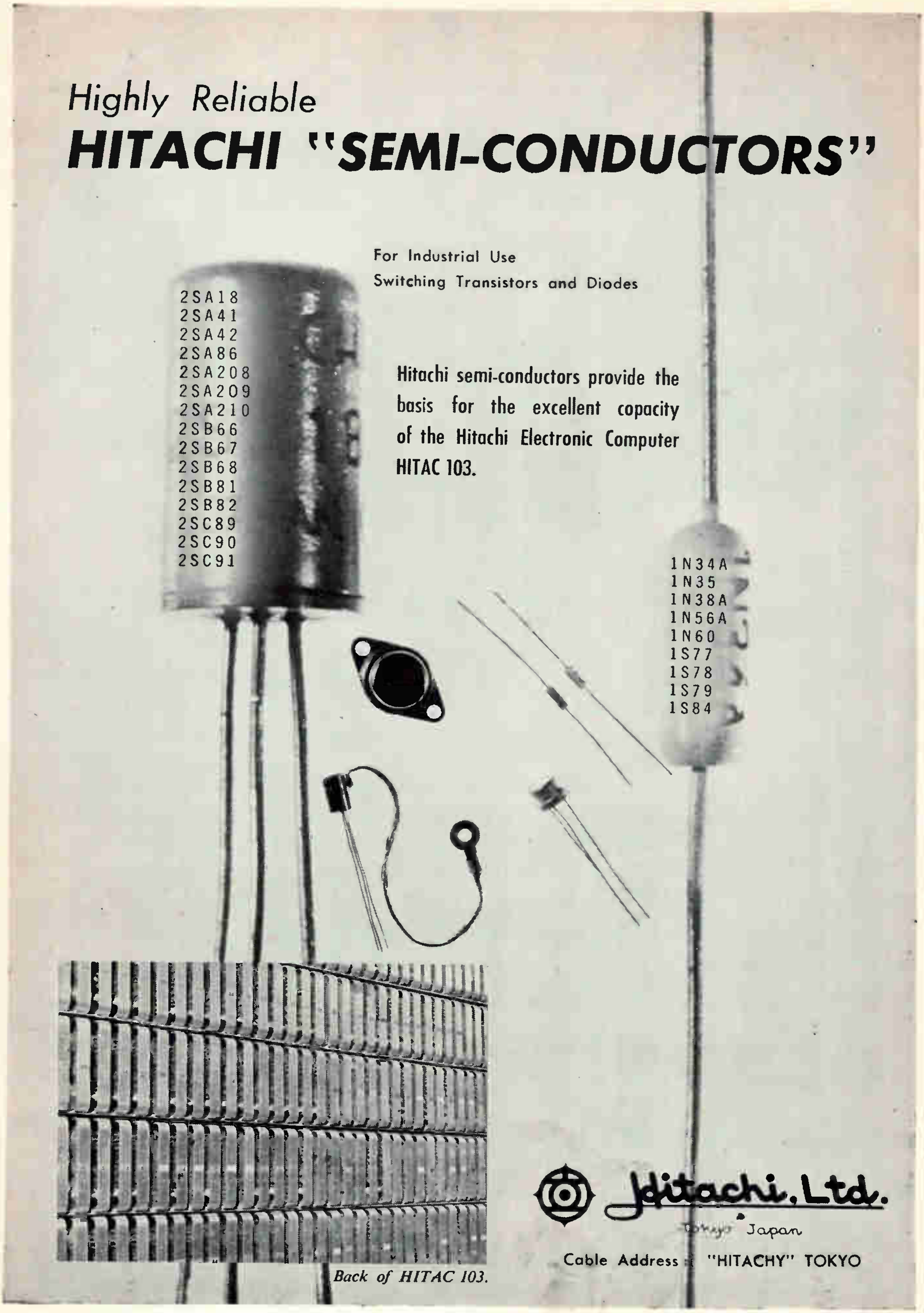
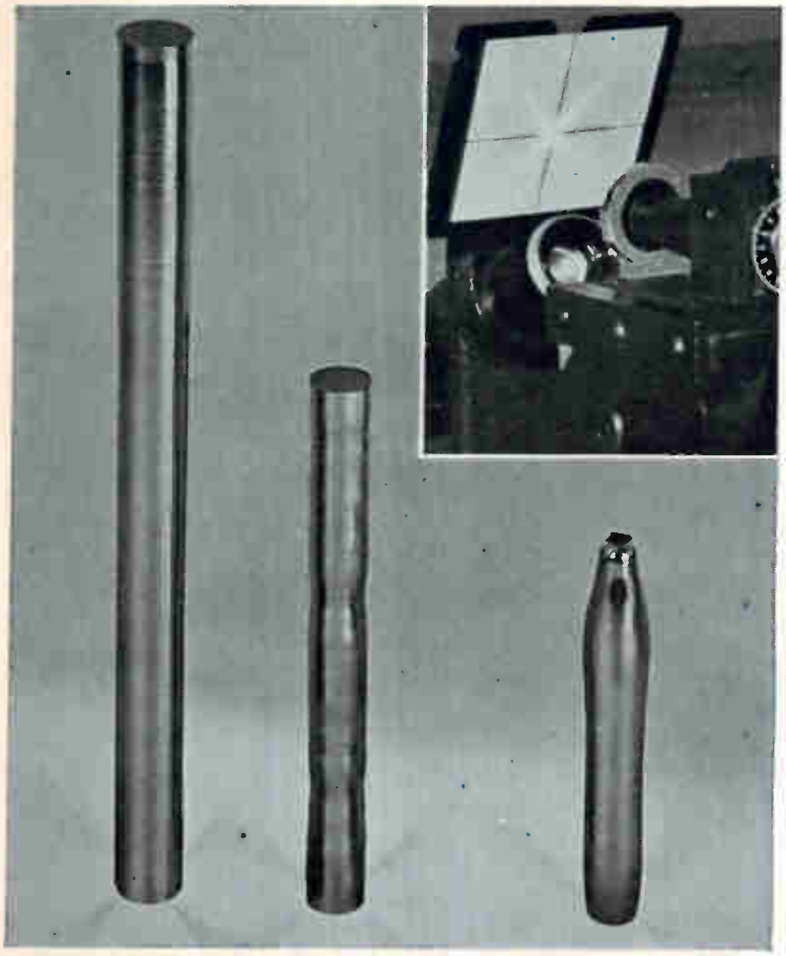


Back of HITAC 103.

SILICON NEWS from Dow Corning

Need 1-0-0 Silicon?

Specify float zoned crystals for these three reasons...



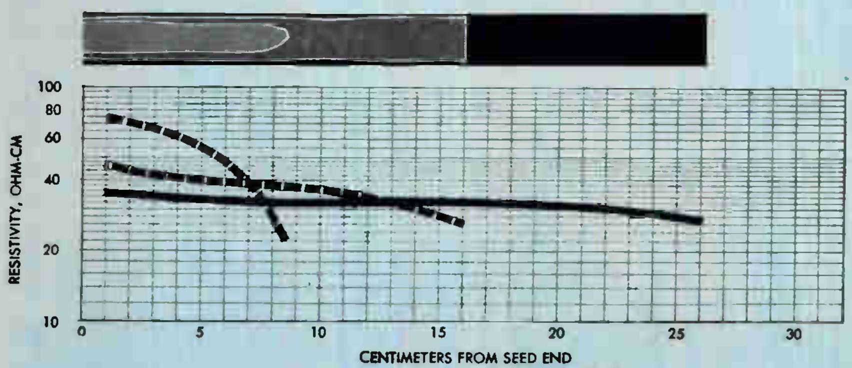
You will find Dow Corning Hyper-Pure (1 0 0) crystals provide a number of definite advantages over Czochralski pulled crystals with (1 0 0) orientation.

More Uniform Dimensions. With Dow Corning vacuum float-zoned (1 0 0) crystals, you get more than twice the useable length of the usual Czochralski crystal . . . better than 50% more than the best premium Czochralski crystal. Physical profile is far more uniform, so wafers have more consistent physical dimensions. Result: crystals that are easier to process . . . less waste.

More Uniform Parameters. Lateral and radial parameters are more uniform throughout the entire length of Dow Corning vacuum float-zoned (1 0 0) crystals. Typical resistivity curves show float-zoned crystals vary less from end to end—and the ends are up to three times further apart. This consistent quality — plus uniformity from rod to rod — means fewer rejects . . . increased device yield.

Ease of Handling. For the clean cleavage and nearly waste-free handling of (1 0 0) oriented silicon crystals, plus the advantages of uniform dimensions and uniform parameters, specify Dow Corning crystals. Greater length means less chance for contamination, less waste and easier handling in scribing and scoring wafers.

Whatever your need — float-zoned crystals of (1 0 0) orientation; crystals of (1 1 1) orientation; doped to specification or high resistivity rod; polycrystalline rod or prepackaged one-piece crucible charges — Dow Corning should lead your list of sources.



Length:	50 mm to 250 mm (approx. 2" to 12")
Diameter:	12 mm to 20 mm (.5" to .79")
Diameter Variation:	less than 1 mm (.040")
Type:	P or N
Resistivity:	1 to greater than 1000

For free brochure — "Hyper-Pure Silicon for Semiconductor Devices" write Dept. 4222.

Dow Corning CORPORATION

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CIRCLE 9 ON READER SERVICE CARD

FOR TRANSMISSION MEASUREMENT

Simple carrier reinsertion in this Frequency Selective Voltmeter

Sierra Model 125B-CR Frequency Selective Voltmeter

Monitoring of single-sideband carrier telephony signals is simple with self-contained crystal oscillators for carrier reinsertion in the Model 125B-CR Frequency Selective Voltmeter. Continuous tuning 3 to 620 kc, the 125B-CR is also a flat ac VTVM, 1 to 620 kc.

Direct-reading frequency, continuously tunable. Virtual elimination of spurious responses. Variable selectivity – 250, 2,500 cps, each 3 db down. Accuracy ±1 db, –80 to +32 dbm (as flat VTVM, ±0.5 dbm, –20 to +32 dbm), ideal for measuring carrier levels. Self-contained crystal oscillator for both frequency and level calibration

- **ACCURATE,**
- **SENSITIVE,**
- **VERSATILE**

SPECIFICATIONS common to selective operation of the
Sierra Model 125A, popular general purpose model
Sierra Model 125B-CR, with internal crystal oscillators for easy carrier reinsertion
Sierra Model 125B-Y, incorporating special 20-pin connector for carrier rack fast patch

Frequency Range	Selectivity		Frequency Accuracy		Measuring Accuracy	Line Impedance for direct reading in dbm
	3 db down	45 db down	Low End	High End		
3-620 kc	±125 cps ±1250 cps	±500 cps ±5 kc	±1 kc	±2 kc	±1 db	Bal. or unbal. 135 & 600 Ω; bridging input impedance, 20 kΩ nominal.

The Sierra Model 158A Frequency Selective Voltmeter operates from 500 kc to 10 mc; selectivity ±2000 cps 3 db down, ±20 kc 45 db down; frequency accuracy ±0.056 mc low end, ±0.08 mc high end; measuring accuracy ±2 db; line impedance for direct reading in dbm, unbalanced 600 ohms.

Three flexible models in the convenient Sierra 125 series of Frequency Selective Voltmeters

Rapid location of faults on cables, transmission lines!

Sierra Model 124A Line Fault Analyzer; Instantly pinpoints shorts, opens, grounds, indicates nature of fault, plus exact location. Easy to use, operates on "radar" principles; operates on most metallic power and communication lines, direct reading ½ to 100 miles, accuracy within ¼ mile.

Write or call Sierra today for complete data on these and other instruments for communications application. *Data subject to change without notice.*

sierra

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ELECTRONICS NEWSLETTER

B-52 and X-15 May Launch Space Probe

CAN AIRCRAFT be substituted for the first stages of space probe boosters? Such a method could sharply reduce costs of space experiments—and money now spent for first stage instrumentation and ground-support gear.

Aeronutronic, a Ford Motor division, and North American Aviation are proposing to the Air Force that the first two stages of the Blue Scout system be replaced by a B-52 and an X-15. The B-52 would launch X-15, which would launch Blue Scout's third and fourth stages.

The companies say this would save two-thirds the cost of each Blue Scout orbital space shot, approximately $500,000. Savings on deep space and shallow space probes would run about 50 percent.

Blue Scouts have carried many scientific experiments into space. Latest mission is to orbit a simulation package to test the worldwide tracking and communications network before our first manned orbital flight.

Protect Patents, NEC Speaker Warns Industry

ACTION AGAINST potential government takeover of electronic patents was proposed at the National Electronics Conference's closing luncheon by Robert W. Galvin, Motorola president. "Government appropriation of patents strikes at the very root strength of this industry," he said.

He charged that pending legislation for government ownership of patents arising from research for the U. S. would stifle industrial initiative.

Owning patents, the government could in extreme cases shift production to depressed areas, reassign workers or order an engineer to move with his patent, Galvin predicted.

At the closing session, Adm. (Ret.) Rauson Bennett, of Sangamo, warned "pay for at least part of your R&D or become extinct". Government support, he said, could cost important patents.

Panelists agreed that Chicago area electronics companies and educational institutions should cooperate to counter the flight of researchers to other areas. Research must be stepped up if the area is to remain competitive within the next five to ten years, they said.

WEMA Worried About Pending Wage Hike

AFL-CIO RECOMMENDATION to raise the industry's minimum wage to $1.72 would be disastrous to many West Coast firms, says William Miller, Western Electronics Manufacturers Association's Los Angeles chairman.

Just back from Washington, he expects the Secretary of Labor to set a figure between $1.50 and $1.70 later this month. "There is little we can do at this time to combat this," he said, "but we can file briefs and request a regional hearing after the decision."

Recent WEMA survey showed minimum wage in the west ranges from $1.31 to $1.80 and averages $1.55. Miller fears many small contractors paying less would go out of business. Prime contractors will buy less if wages and prices go up, he believes. This could lead to higher prices to the government, he said.

Holes in Copper Sheet Code Twistor Memory

MEMORY MODULE developed by Automatic Electric for future telecommunications systems uses the twistor principle for semipermanent storage. Twistor elements are enclosed in a "virtual solenoid" made of a copper sheet and printed-circuit conductor.

When an eddy current is created by pulsing the conductor, flux density disturbs twistor elements. Punching a hole in the copper sheet at a particular bit location makes the flux density too weak to disturb that twistor element. Storage at any given one or zero-bit location is governed by the hole pattern on solenoids plugged into the module.

The array is a 16-plane stack. Each plane has eight words of 60 bits. For noise reduction, each twistor is paired with a plain copper wire to form a transmission pair. Solenoids are placed at right angles to the pairs. Each intersection is a bit and all bits along a solenoid form a word.

Sonar Telemetry to Probe Ocean Depths

SEA TESTS for the first of Bendix-Pacific's deep sea probes, combining telemetry and sonar techniques, are

Military to Change Procurement Rules

PENTAGON IS EXPECTED to overhaul the Armed Services Procurement Regulations shortly to spur contractors into assumption of higher risks for greater profits. New policies will reportedly:

(1) Use more cost-plus-incentive-fee contracts on development and early production projects and less cost-plus-fixed-fee awards.

(2) Use less price redetermination clauses in fixed-price contracts.

(3) Move major projects more rapidly into fixed-price incentive-type contracts.

(4) Provide a wider fee range in cost-reimbursement contracts.

(5) Allow contractors a larger share of savings on incentive contracts.

scheduled for late this month. First probe is designed to operate at 2,000-foot depth. Second, using pressurized components, will go to 10,000 ft.

The probes will continuously convert oceanographic data to f-m/f-m sound waves for acoustical transmission to surface receivers. System operates on IRIG channels from 10.5 Kc to 52.5 Kc.

Bendix says the system can transmit human voice. Ranges go up to five miles with one-percent accuracy. Follow-on models are being designed for undersea biomedical studies, underwater weapons research and oil exploration.

Want Space-Tracking Radar on the Equator

AIR FORCE is proposing to DOD construction of advanced radar and optical systems for equatorial detection and tracking of satellites. Since satellites cross the equator twice every orbit, systems would either be placed at the equator with extensive fan-out, or would back off the equator and look at it constantly. Military will need phased-array techniques for large-volume coverage radar that can scan as well as track without prohibitive power requirements.

Electro-Optical Systems Study Missile Reentry

HYPERVELOCITY range instrumentation, to study simulated missile reentry, is being developed by Perkin-Elmer under Army contract. One goal is techniques for complete infrared scan of a projectile in one microsecond.

One instrument recently delivered will record behavior of projectiles fired into ballistic tunnels. Multiplier-phototube system measures radiation of self-luminous projectiles. Infrared modules and supporting instrumentation will be delivered later this year.

New Materials Extend Laser Frequency Range

LASER OPERATION in the photographable infrared region, 10,600 A, has been obtained with a neodymium in calcium tungstate crystal. At room temperature, input power is as little as five joules, reported F. F. Johnson and K. Nassau at a Bell Telephone Laboratories symposium last week.

In two other experiments, the second reported at NEC, blue fluorescence was obtained by focusing red beams on crystals. W. Kaiser and C. G. B. Garrett used a crystal of calcium fluoride containing divalent europium ($CaF_2:Eu^{2+}$). The mechanism is explained as a two-quantum process in which an atom in a material is made to absorb two quanta, or photons, of energy simultaneously.

R. J. Collins and J. Giordmane used a potassium dihydrogen phosphate crystal. Red beam at 6,934 A gave a coherent blue harmonic at 3,472 A. Efficiency is 10^{-7}.

Semiconductor Device Has Multiple Control

IBM REPORTS development of an experimental semiconductor device that performs at higher voltages than transistors and has characteristics similar to a vacuum tube. Called a Chargistor, it can be assembled with multi-control elements which act like grids to control current flow.

The device has operated at 200 volts with greater than 1-Mc frequency response. Triode working model has a conducting channel of high-resistivity germanium. It has three junctions, a *p*-type charger, *n*-type feeder and *p*-type gate. Adding or taking away positive or negative charges in the channel alters or controls the current.

Measuring Instruments Use Laser Principle

OPTICS and Metrology division of Keuffel & Esser Co. reports it has developed a series of laser measuring instruments designed to promote research and practical use of laser amplification in measurement.

Possible applications include optical interferometry, checking of plano-parallel plates, optical wedge calibration for measurement of laser alignment, measuring indices of refraction and photographing photoelectric phenomena.

In Brief . . .

MATHEMATICAL MODELS of countermeasures will be set up by Sperry Gyroscope in study aimed at helping U. S. ICBM's penetrate enemy radar defenses.

YARDNEY ELECTRIC is in pilot production on hermetically sealed rechargeable silver-cadmium button cells. Modules will have capacities of one to six ampere-hours.

LEAR joins General Precision team developing Navy system to correlate and display antisubmarine warfare data. Lear will do initial research on display.

GENERAL ELECTRIC gets over $31 million in Air Force communications equipment contracts. Included are tactical air weapons warning and control system and work at three Titan missile bases.

TERRAIN AVOIDANCE computers for IBM's B-52 bomb-nav system will be produced by Autonetics under $12.5 million contract.

ARMY awards $8 million contract to Aeronutronic for continued development of Shillelagh missile system.

KOLLSMAN INSTRUMENT has a new $1.9 million contract for automatic astro compasses, currently used on B-52 and B-58 bombers.

GENERAL DYNAMICS is buying $1.5 million in air transportable Army area communications systems from Adler Electronics.

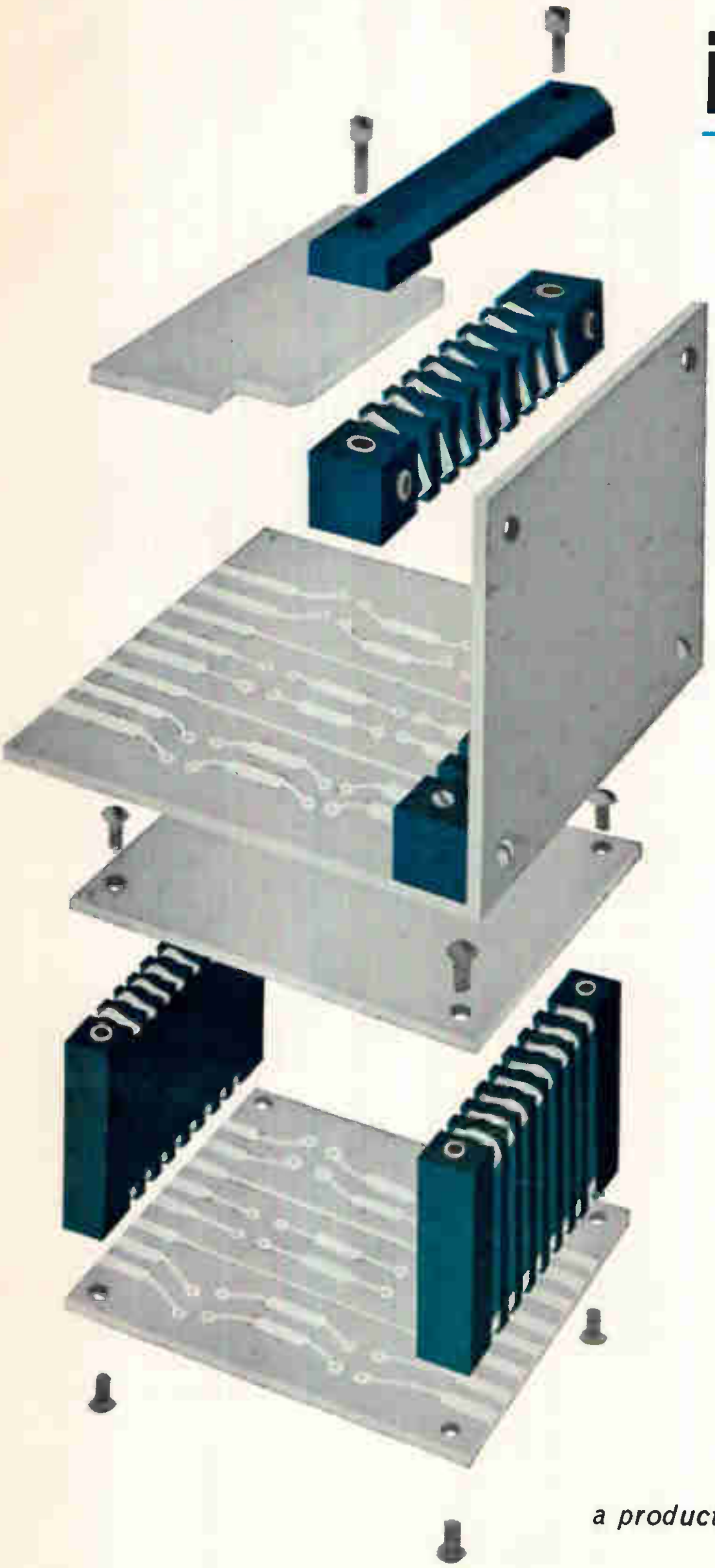
SEISMIC RESEARCH and analysis for Air Force will be performed by United Electrodynamics under five contracts totaling $475,000. Work is part of nuclear explosion detection program.

COLLINS RADIO will modify Army's AN/TRC-80 portable troposcatter communications terminal for $475,000.

MAXSON ELECTRONICS announces Navy contract of $445,000 for Talos missile adapter kits.

FEDERAL AVIATION AGENCY orders 70 VOR systems from Televiso Corp., for $2.1 million.

New Development in Connectors!



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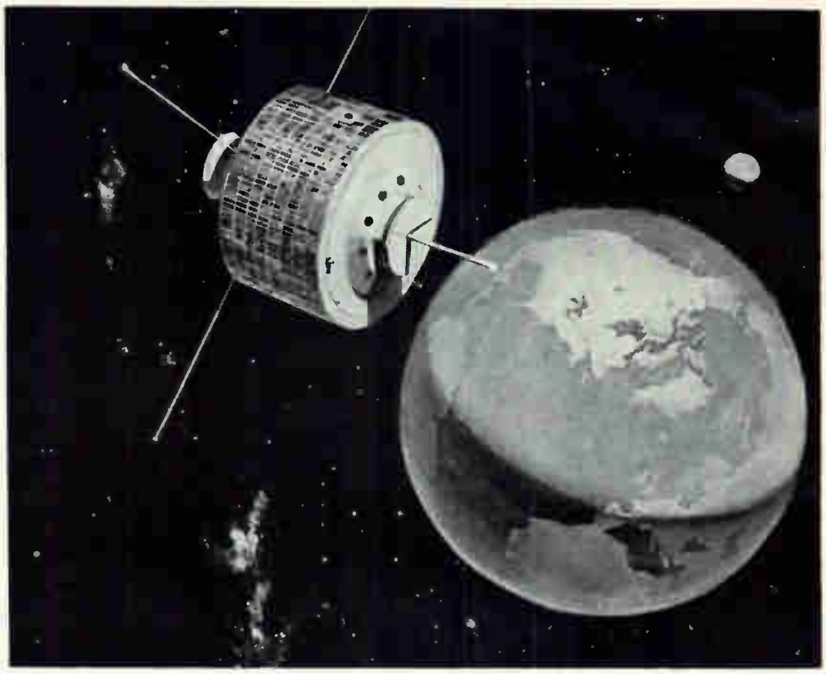
WASHINGTON OUTLOOK



HUGHES AIRCRAFT has unveiled details of its new Syncom (see sketch) communications satellite. Four of the small, 55-lb, two-voice-channel test satellites have already been ordered by the National Aeronautics and Space Administration under a $4-million contract, with the first of the satellites due for orbiting by fall of 1962.

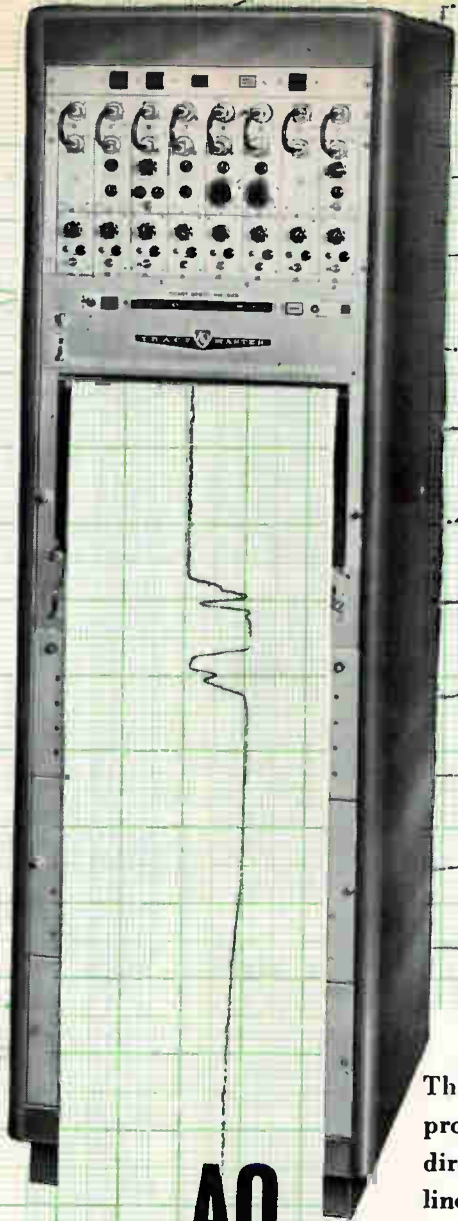
Later models of Syncom will have 300 voice channels or one tv channel. Hughes predicts total cost for a worldwide net of three stationary satellites along the equator would be no more than some $3 million.

FUTURE OF UHF TELECASTING is being shaped as the FCC-sponsored experimental New York station, WUHF, begins trial operations. Most FCC commissioners believe that uhf must be revived if the U. S. is to have a competitive tv system and if future demands for commercial and educational tv channels are to be met.

Uhf's plight is dire. There are 1,319 commercial uhf spots available, but only 79 stations are operating. Half of these are in trouble, and 99 uhf stations have already failed. On the other hand, out of 556 available vhf stations, 456 are operating, with practically all openings snapped up in centers of population.

PRICE OF SILVER, an increasingly important metal for electronics, is bound to go up—it's just a matter of time. Producers have put considerable pressure on Treasury Department to stop selling silver or hike its price from 91 cents per ounce. Even if treasury does not stop selling its dwindling hoard of free silver right away, the silver will run out almost automatically and the price will have to go up well over the $1 mark.

Silver is now being used primarily as an industrial commodity. The electronics industry takes a big chunk of the U. S. 100-million-ounce industrial silver consumption pie.



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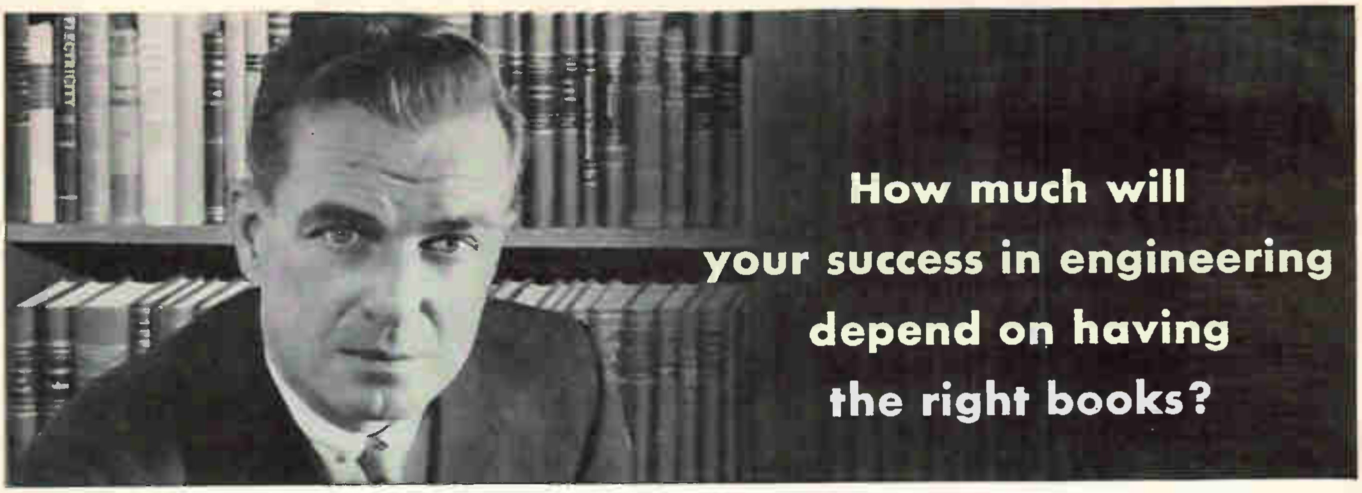

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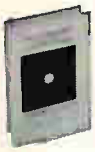

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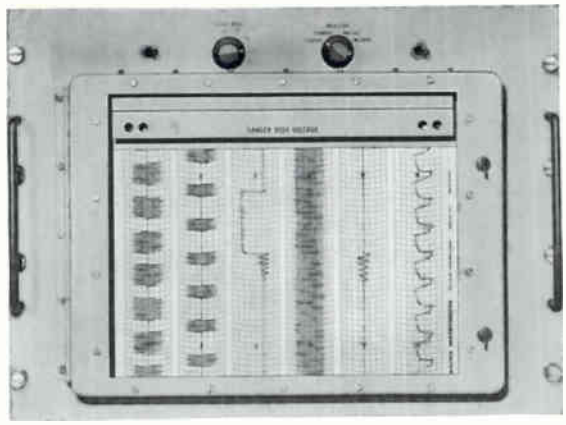

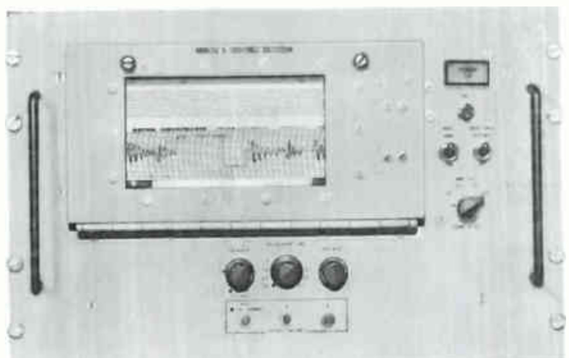

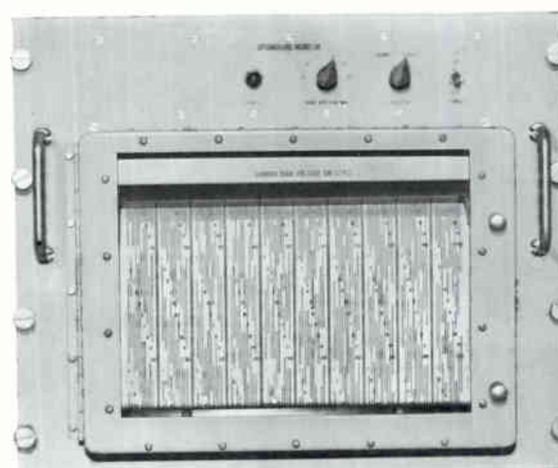

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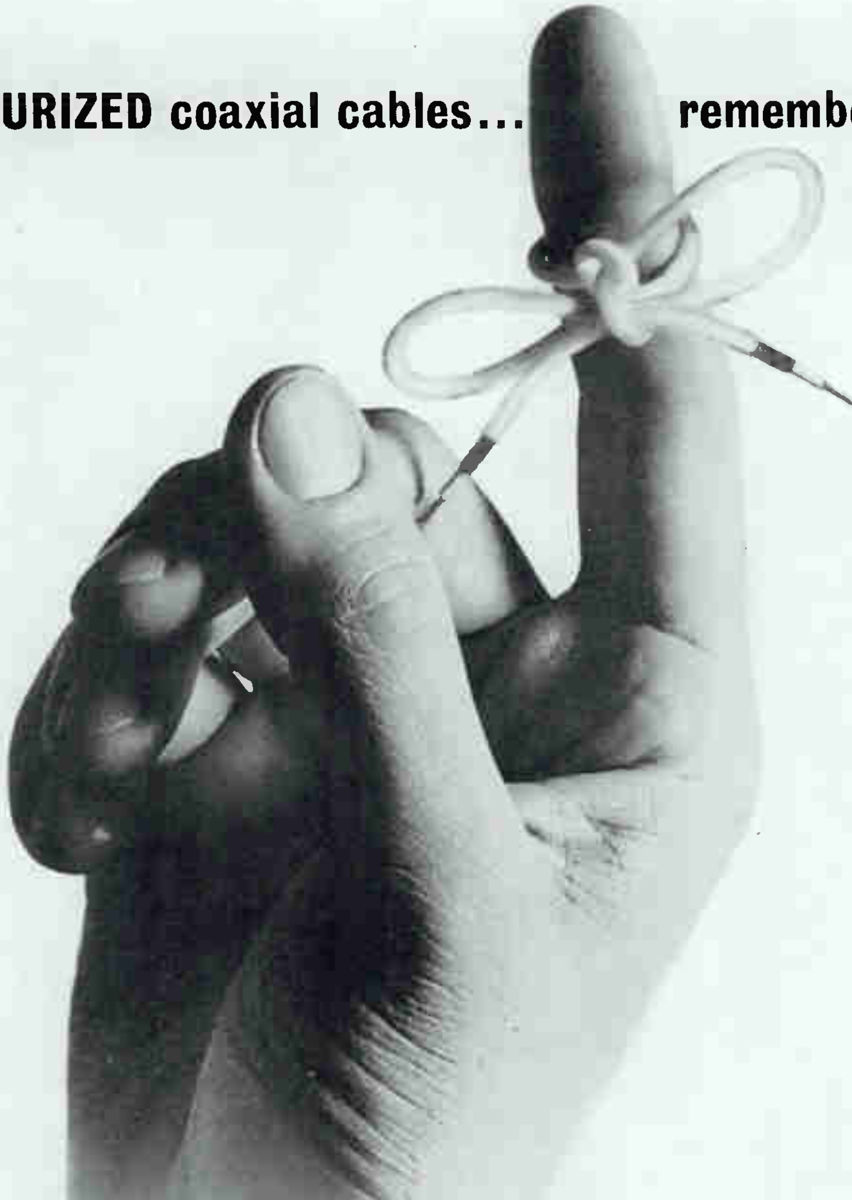

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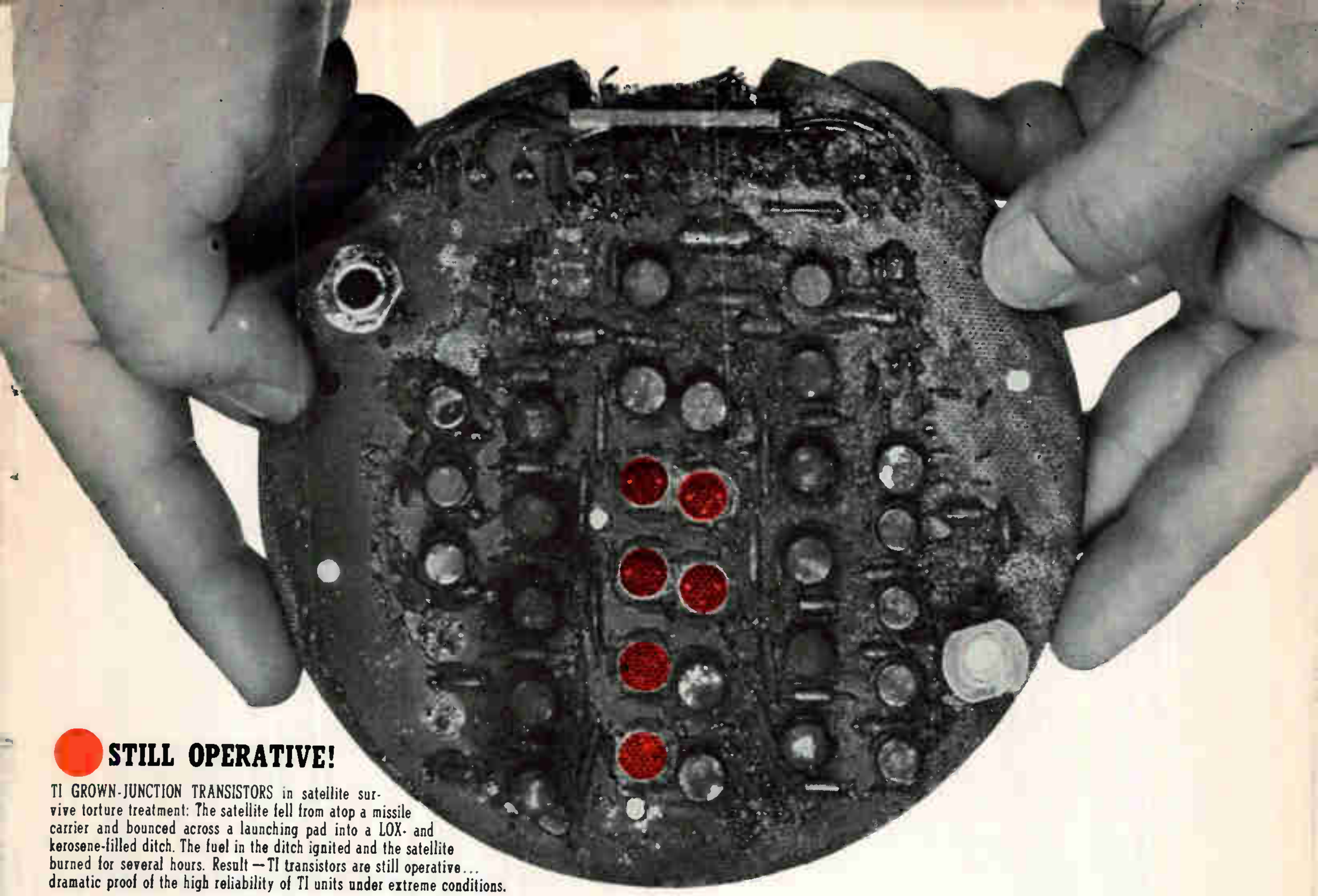

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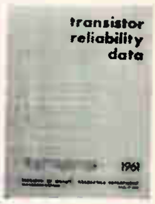

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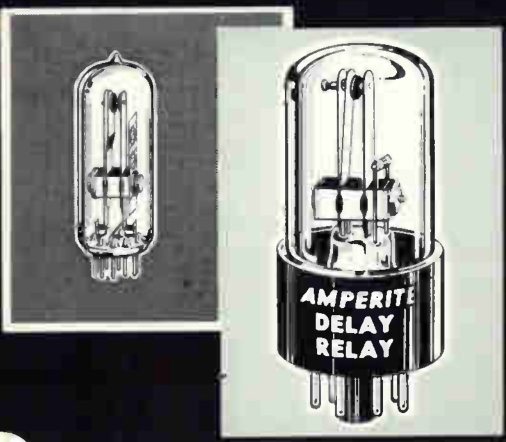

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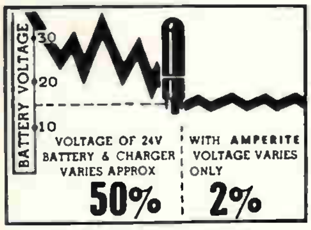

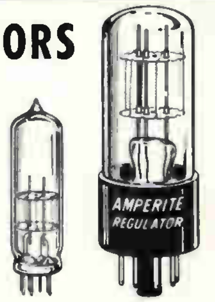

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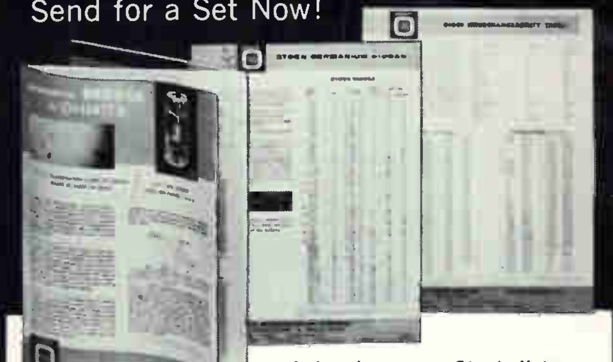

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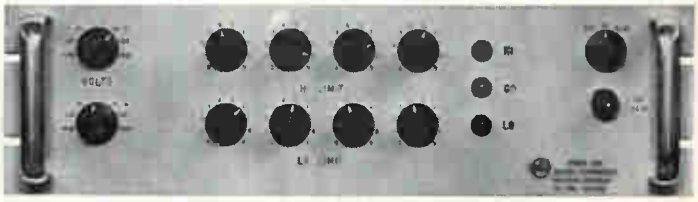
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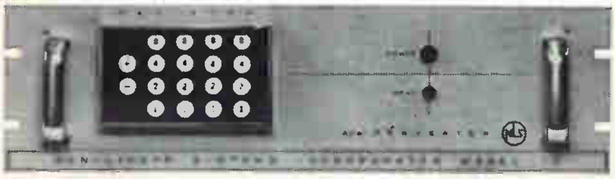
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MODEL 15 A/D CONVERTER — 4-digit instrument bringing high accuracy to high-speed measuring and data logging . . . 15,000 measurements/sec . . . accuracy: ±0.01% ± 1 digit from 0 to full scale from 0 to 40°C . . . any range from ±1 to ±100 v. full scale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

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

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

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

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

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

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

CIRCLE 21 ON READER SERVICE CARD

An 8-Fold Improvement In Stereo Controls

1. High Stability SURETRAK* Elements — the first inherently stable carbon composition elements. Less than 3% resistance change from 20°C to 105°C . . . less than 7% change under 95% RH for 240 hours at 40°C . . . negligible change with age and mechanical wear. Excellent load life at 70°C.

2. Controlled Characteristics assure that whatever resistance changes do occur will be of similar magnitude and direction in both front and rear SURETRAK elements.

3. Automatic Element Matching for maximum uniformity between front and rear elements.

4. Zero Backlash between shaft and both sections.

5. Precise Mechanical Assembly assures uniform electrical and mechanical performance.

6. Velvety Smooth "Feel" available if desired for professional quality stereo equipment.

7. Tailored Attenuation — Linear over all or only a portion of the attenuation curve as needed.

8. Precision to Fit Any Budget — Degree of tracking limited only by price considerations . . . as close as ½ db tracking now possible.

Here's the kind of variable resistor performance that pays off in greater circuit design freedom . . . in continued customer satisfaction. Thanks to their new high stability SURETRAK* elements, these new Stackpole single-shaft dual controls stay within initially close tolerances throughout years of use or disuse — and with minimum derating.

To learn more about this basic advance in variable resistors for stereo, ask your local Stackpole sales engineer about Type LST (bushing mount) or Type LST-T (twist-tab mount), or write: Electronic Components Div., Stackpole Carbon Co., St. Marys, Pa.

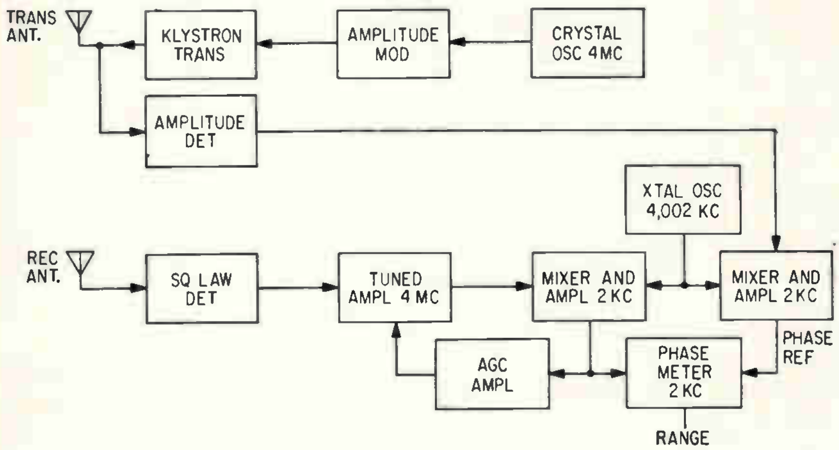
*Trademark

STACKPOLE VARIABLE composition RESISTORS

COLDITE 70+® FIXED COMPOSITION RESISTORS • SLIDE AND SNAP SWITCHES • CERAMAG® FERRITE CORES • FIXED COMPOSITION CAPACITORS • CERAMAGNET® CERAMIC MAGNETS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT ELECTRICAL CONTACTS • GRAPHITE BEARINGS, SEAL RINGS, ANODES • HUNDREDS OF RELATED CARBON AND GRAPHITE PRODUCTS

Short Range A-M Radar Can Guide Vehicles

System convertible to landing altimeter is among new aerospace and navigational equipment to be reported at conference



Radar's phase meter reading indicates range. Experimental a-m set has given six-inch ranging accuracy at distances to 60 feet

NEXT WEEK at the IRE East Coast Conference on Aerospace and Navigational Electronics, in Baltimore, most speakers will report on aircraft and space equipment, or design of components and support equipment.

Four of the twelve sessions will be devoted to classified papers on military electronics topics like antijamming communications, countermeasures, realtime data processing, aerospace command and control.

In this context, one of the most unusual reports describes what the authors call "an extremely simple method of radar". O. K. Nilssen and W. D. Boyer, of Ford Motor Co., have built an experimental a-m radar set with a range of zero to 60 ft. Its maximum ranging error is about six inches.

The radar set was designed as an obstacle sensor for land vehicles. But it can be applied to other cases in which target echo is stronger than direct leakage signal between transmitter and receiver. It could be used as a landing altimeter for aircraft, for example.

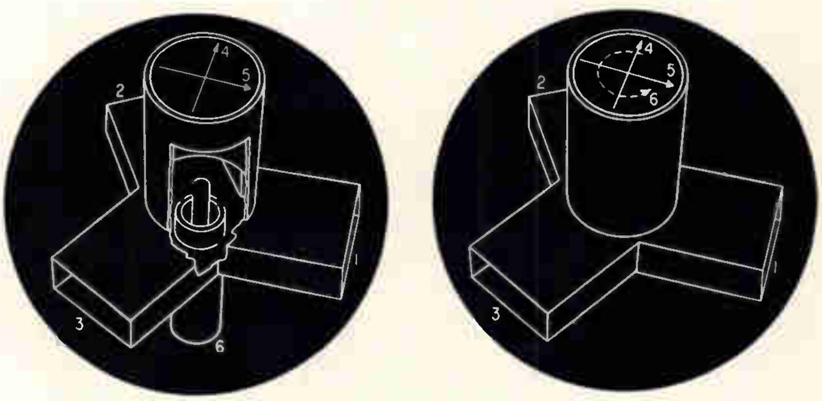
Operation of the set is illustrated by the block diagram. The 2-Kc i-f signal, obtained by heterodyning the 4,000-Kc output with a 4,002-Kc signal, is used as a phase reference. The remainder of the receiver produces a second 2-Kc signal, which is also applied to the phasemeter. Phasemeter reading gives a direct measure of range. At a 4-Mc modulation frequency, each foot of range corresponds to 2.93 degrees. The 2-Kc signal is created because it is easier to process than a 4-Mc signal. The antennas are two 12-in parabolic reflectors spaced two feet apart and three feet above ground.

Radar boresight error effects on high-accuracy tracking radars have been reported extensively. Less attention has been paid the effects of obstacles such as structures near ground or ship-based radar antennas. John Callahan and Leo Topper, of Sperry Gyroscope, who have made a study of malfunctions caused by such obstacles, are to report on procedures for overcoming obstacle effects.

F. W. Ellersick, of IBM, will present several data compactor designs for spaceborne pcm telemetry systems. The designs are based on simple circuits and use state-of-the art equipment.

The reaction of forces used to control aerodynamic surfaces in aerospace vehicles set up parasitic feedback loops in control systems. G. S. Axelby and W. B. Lloyd, of Westinghouse Air Arm, say these loops can be overcome by a modification of the power actuator, known as pressure derivative feedback.

Bendix Radio has developed a squelch system for vhf receivers. The circuit, reported by J. M.



Junction combines all-around impedance match with complete isolation at the three ports. Signal can be split into three components

Tewksbury, allows a narrow pass band in the squelch channel, giving the system a high degree of immunity from noise. A double superheterodyne reflex process converts any carrier in the pass-band to one specific crystal-controlled frequency. Converted to an audio tone, this signal produces a voltage which activates the receiver audio amplifier.

Work on unusual configurations for microwave structures will be described by R. S. Potter, of the Naval Research Laboratory. NRL has previously reported designs of seven-port, trimode turnstile junctions for waveguide.

Next week, Potter will talk about trimode turnstile junctions which have three symmetrically-distributed rectangular ports (see sketch). Either of these junctions are matched in impedance from all possible viewpoints and show complete isolation among the three rectangular ports.

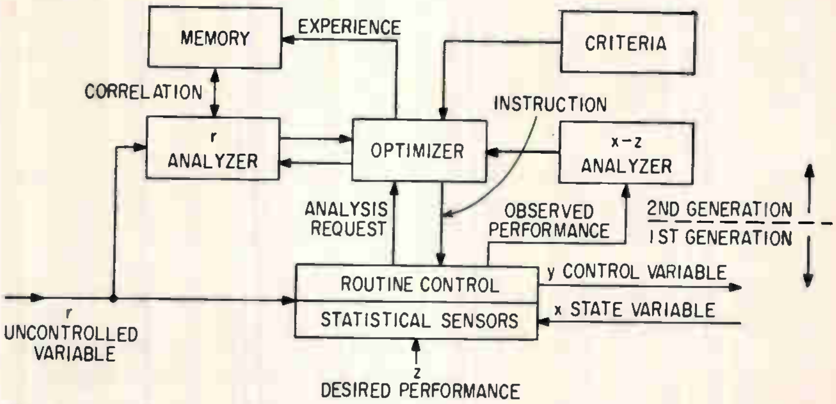
"This unusual type of isolation is completely new to the microwave field," Potter says, "and holds promise of many new applications."

In an experimental model, impedance matches among the rectangular ports were obtained by adjusting insertion depth of the coaxial inner and outer conductors. Mismatch of the circular port was corrected by adding an inductive iris to it.

The junction can be used, Potter reports, to measure definitive features of an arbitrary incident polarization on a three-component basis. Since the coaxial junction may permit local oscillator injection through the coaxial port, polarization features would be available at i-f in the outputs of three linear crystal mixers connected to the rectangular ports, without crosstalk among the mixers.

Computer Control of Communications

By LAURENCE D. SHERGALIS,
Associate Editor



First generation adaptive control system provides routine control of communications network; second generation corrects for more variables

UTICA, N. Y.—Incorporating computers in communications systems, to effect adaptive control, is one way to get the most use out of the system. Adaptive control can provide economical operation despite numerous uncontrolled system variables.

This argument for computer-communications systems was presented by R. F. Filipowsky and F. H. Krantz, of IBM, at the Seventh National Communications Symposium this month. After analyzing variables, they suggested methods to minimize their effects by adaptive control.

Variables include source variables, such as type of information and its flow, and tolerable delay; circuit variables, including transfer function, nonlinear distortions and noise, and network variables like traffic load and distribution, and delay balance.

It has been customary to design for worst-case conditions, resulting in high cost per message. A better way, according to Filipowsky and Krantz, is to use special purpose computers in a network-wide, time-sharing, integrated operation which would make adaptive control economical.

The figure shows a general model for adaptive control. R might be message length; Y, message block length selected; X, total number of binary elements, and Z represents desired system performance.

In the first generation system, only routine control operations and some statistical sensors would be provided. It might minimize effect of varying message lengths. A second generation system would perform a detailed analysis of variables and compute optimum message-handling procedures.

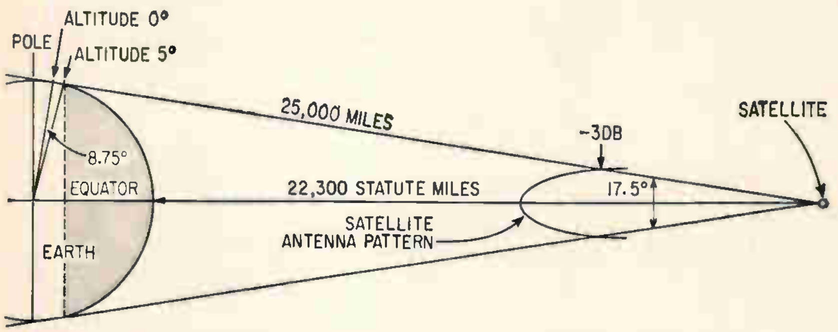
In a general discussion of satellite communications, R. G. Sageman, of AT&T, explained preparations being made for experimental trials next spring. The satellite relay will carry one tv circuit with a 2.5-Mc bandwidth and 60 two-way telephone circuits.

Within three or four years, AT&T foresees a 30-satellite system in 7,000-mile-high polar orbits. Eventually, 50 to 60 relays will link all parts of the world.

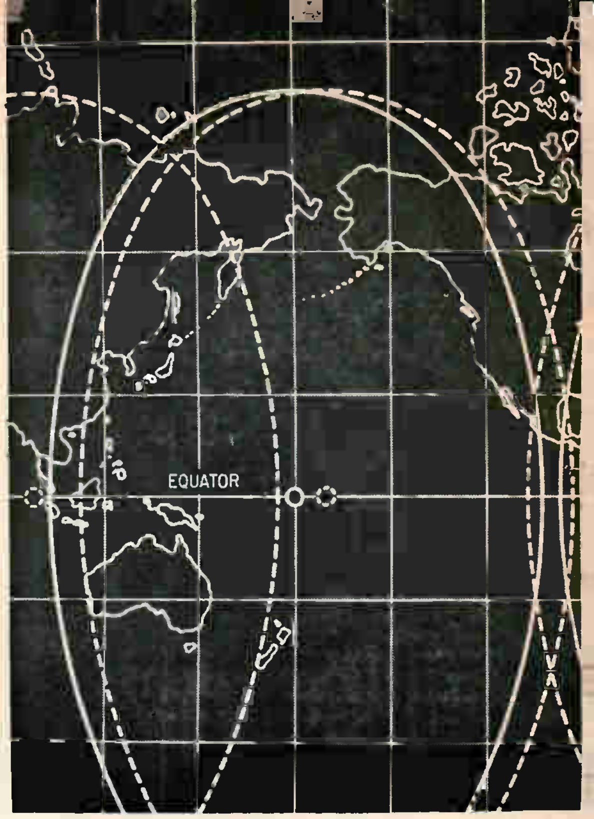
Several papers examined stationary satellite systems (see p 26). S. G. Lutz and D. E. Miller, of Hughes, reviewed interference problems that might arise from various proposed orbits. Satellites might easily interfere with each other. High-altitude equatorial satellites could cause intolerable interference problems if they are not adequately spaced. Even at low altitude, there would be considerable interference at equatorial stations.

Lutz and Miller pointed out that at 22,300 miles, message delay would be about 0.6 seconds. They suggested that such satellites not be used for telephony. At 6,000 miles orbital altitude, delay would be 0.2 second. W. A. Runge, of ITT, investigated this delay problem. He said telephone users would hear an echo of their voice. But a study showed a delay of 0.6 seconds would be acceptable to most users when echo intensity is reduced to 25 db below the input speech level.

Synchronous Satellite System Outlined at Space Conference



At 22,300-mile altitude, satellite goes into synchronous orbit, maintaining a fixed position relative to stations on earth



Two satellites (solid lines) or three communications coverage for most

OPERATIONAL CONCEPT of a high-capacity, intercontinental microwave communications system based on synchronous satellites was the topic of one of the many electronics-oriented papers presented last week at the American Rocket Society Convention in New York. Others discussed developments in space communications, telemetry, information retrieval and plasma.

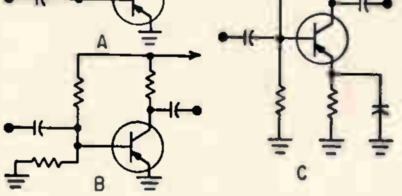
The case for synchronous satellites was presented by E. A. Laport and S. Metzger, of United Aircraft. One or more repeater satellites in fixed position relative to earth would allow users to locate ground stations at sites most convenient to the users. Moving satellite stations, they said, are less convenient because interstation connection patterns constantly change.

Satellites can be orbited in a fixed position relative to the equator by lofting them to an altitude of 22,300 miles. Army has such a project underway, called Advent.

Laport and Metzger said a practical system should have at least 1,000 duplex telephone channels. Geographic coverage would be all points on earth from which the satellite has an unrefracted elevation of five degrees or more. Earth stations would all use a single standard system frequency transmitted from a master control station. Each station's messages would be sorted out by use of single-sideband suppressed carriers. Ssb frequencies would be interleaved to form a substantially continuous band of frequencies.

Such a system, the authors say, would be flexible enough for future intercontinental communications. It could be used for all types of traffic, including television. Privacy and speech interpolation techniques could be employed. Although the height of the satellite would introduce a transmission delay of 0.55 second, it would also minimize doppler shifts.

Feasibility and need for communications satellites was underscored by K. G. McKay, of Bell Telephone Laboratories. He pointed out that transatlantic traffic is increasing 18 percent a year. In 1980, at this rate, 4,000 voice channels will be needed. Present and planned cable facilities will be less than 400 channels in 1965.



Simplest circuit (A) is the most reliable when packaged to prevent wide fluctuations in transistor junction temperature

Discussing economic factors, McKay divided these into launching costs—the biggest expense—manufacturing and replacement. Considering tradeoffs, a component reliability rate lower than 10 per 10^9 hours is needed and can be achieved.

Thomas M. Conrad, of Flight Electronics, examined basic concepts of simplicity for reliability. He used as examples telemetry for a biological satellite. Circuit redundancy tempts a designer to use modules. However convenient this is, Conrad indicated, too many modules can compound size and reliability problems.

A better approach, he suggested, is to concentrate on circuit simplicity. For example, 50 simple audio amplifiers may be required. Of three alternatives, *A* (see sketch) is the simplest, but is thermally unstable. *B* is better, but its higher power dissipation creates temperature problems with tight packaging. *C* has excellent stability, but is significantly larger.

His solution was to use circuit *A*, placing all capacitors in a cord-

satellites (dotted lines) would give points on earth

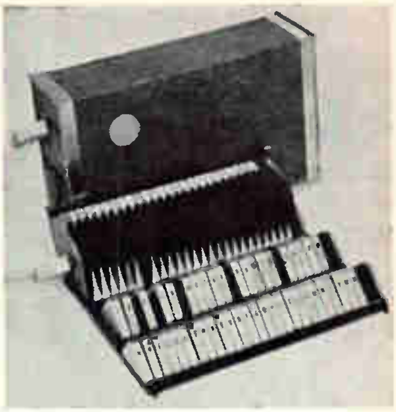
wood structure. Painted resistors and uncased or microsize transistors are placed on thin wafers. The entire structure is potted in aluminum-filled epoxy and placed on a Peltier cold plate to limit transistor junction temperatures to a small range.

H. S. Glick, of Cornell Aeronautical Laboratory, described a hypersonic shock tunnel six feet in diameter. It was built to help solve problems uncovered by research on the interaction of electromagnetic waves with the plasma sheath around high-velocity vehicles. Studies include communications blackouts, location of reentering ICBM warheads, microwave methods of discriminating between warheads and decoys, and antenna design for hypersonic gliders.

D. G. Elliott, of Cal Tech's Jet Propulsion Laboratory, proposed that a liquid metal conductor be used in magnetohydrodynamic generators. He said this would give high plasma temperatures needed for a lightweight electric power system. The metal, heated in a nuclear reactor, is mixed with the vapor of the working fluid. The metal is separated from the vapor—which goes on to the MHD generator—and is recirculated. Estimated weight of a 500-Kw powerplant is 3,500 lb.

Microcomputer Solves Single

Engineer points to folded printed circuit boards



Component-carrying chips wrap around heat exchanger

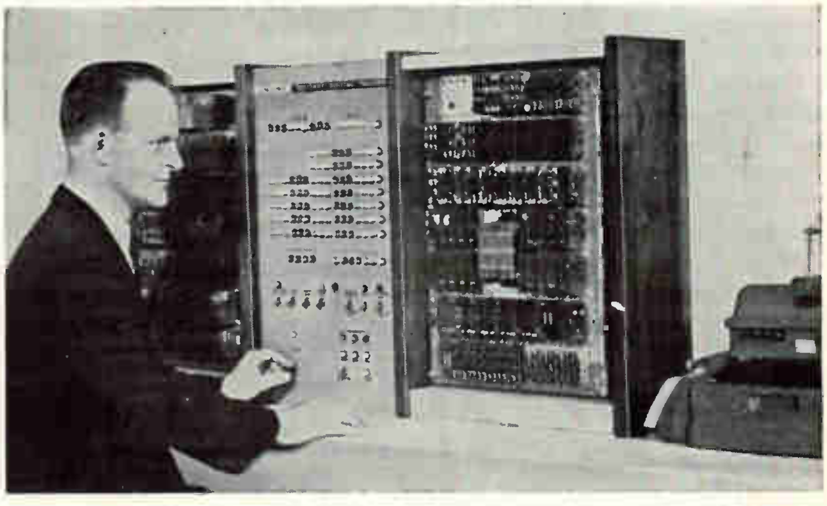
MINIATURIZED COMPUTER has been developed by the Burroughs Corp. No larger than a loaf of bread, the small single purpose computer has some 5,500 components housed in a space measuring 3 × 6 × 11 inches. Component density is 69,000 parts per cubic foot and total weight is 12 pounds. Burroughs hopes to interest the military in the new computer.

Called Maddam (for Macro-module and Digital Differential Analyzer Machine), the baby computer can perform 33,000 mathematical calculations per second. Built by scientists at company laboratories in Paoli, Pa., the computer uses only off-the-shelf electronic components.

Aimed primarily for the military market, Burroughs says its computer is ideal for single-purpose problems requiring high speed solution. One such example would be in solving target chase-and-catch problems from an airplane, spacecraft or missile. The equipment also lends itself readily to navigation and control.

Maddam is described as a 16-integrator serial computer capable of providing solutions to the integral-differential class of equations. A digital equivalent of an analog computer, Maddam solves differential equations. Each of Maddam's 16 integrators is de-

Desk Top Computer Trains Military Personnel



Univac's new small binary computer can be used for problem solving, but is primarily designed for training military personnel in computer maintenance, design, programming and data processing. Console permits operator intervention and all logical circuitry and test points are accessible. Introductory training courses have been given instructors at the Naval Academy and Keesler Air Force Base, Miss.

Problems

signed to represent a set of different differential equations. Maddam solves its equations serially rather than in parallel.

To dissipate heat, modules have a finned heat exchanger as a central element in a row of triangular chips. Measuring only some three-eighths inch thick and roughly the height of a half dollar, the chips plug into a folding printed circuit board.

Additional compactness is obtained by wrapping the circuit board around the heat exchanger. Two such rows of chips, some three inches square and ten inches long, contain the circuitry, logic, memory and other working parts of the computer.

The company says that compactness of the design speeds operation of the computer. A signal will flow in 25 nanoseconds through a logic chain of seven AND/OR gates and two saturated cascaded inverters.

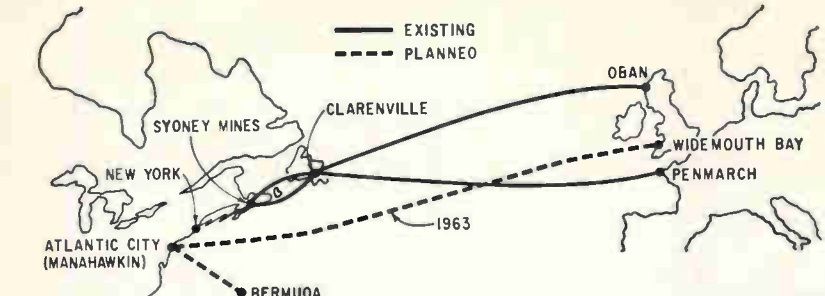
AP Will Use Computers To Transmit Stock Data

THE ASSOCIATED PRESS will install a computer-based system to tabulate and transmit stock market tables to AP members. The data-processing system, developed by IBM, will handle stock data from four major exchanges, the New York, American and Midwest Stock Exchanges and the New York Bond Exchange.

Transmission of stock tables will follow the stock ticker by 15 seconds. Tapes will be read by two paper tape readers. Data will be converted to machine code, stored and processed so that daily changes and highs and lows are transmitted line by line in newspaper format.

Data will be transmitted three times daily for the Midwest Exchange and seven times daily for the other three exchanges. Stock table tapes will be prepared at a rate of 4,500 words a minute. Newspapers can receive the information in code, for automatic line-casting machines, or in regular form for conventional typesetting.

The system is scheduled to go into operation by the end of 1962.



Routes of AT&T cables linking U.S. with Europe and western isles

Beryllium-copper alloy housing for submarine repeater amplifiers

Two-Way Talk on New Atlantic Cables

WORK STARTS next month on the first of three undersea telephone cables that will handle two-way traffic simultaneously. The cables will add 5,600 nautical miles to a system now taxed with some four million calls annually.

The lines will be using a new type of repeater amplifier developed by Bell Telephone Laboratories. Operating over a 1-Mc band, they amplify signals in two directions over a single cable. The repeaters will be spaced at 20-mile intervals.

Protective covering for the repeater amplifiers has been developed jointly by Bell Labs and the Beryllium Corporation. Built of beryllium-copper alloy, the thin-walled enclosures can withstand continuous pressure of 12,000 psi.

Operations will be started in mid-November by American Telephone and Telegraph on an 80-channel system between the U. S. and Bermuda. The cable will be 750 nautical miles long.

Early next year, work will begin on a cable between Florida City, Fla., and Jamaica, B.W.I. This cable will be 850 nautical miles long and will handle 128 voice channels.

The longest cable—running about 4,000 nautical miles between Manahawkin, N. J., and Widemouth Bay, England—will also have 128 voice channels. It will be the first such direct connection between the two continents, AT&T says.

All three cables are to be completed by 1963. In addition, plans are to link the U. S. mainland with Hawaii and Hawaii with Japan by 1964.

The Hawaii-Japan cable will run 5,500 miles, by way of Midway, Wake and Guam Islands. AT&T will operate portions of the cable jointly with Kokusai Denshin Denwa Co. Ltd., of Japan. A Federal Communications Commission announcement of its authorization said the Hawaii-Japan cable later will connect with a submarine telephone cable between Canada, New Zealand and Australia, to be constructed by those countries.

Army Installs Pocket Air Defense Systems

ARMY IS INSTALLING $500,000 air defense coordination systems at 19 locations, most of them cities of about 600,000 population. One of the Birdies (for Battery Integration and Radar Display Equipment) is in use at Turner Air Base, near Albany, Ga. Other locations will not be announced until installations are completed, within seven months. The systems are being built by Martin's Orlando, Fla., plant at a cost of about $500,000 each. Martin so far has some $1,136,000 in Birdie contracts.

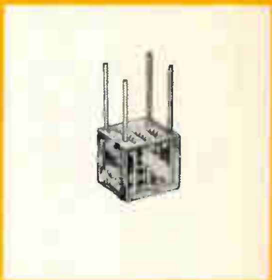
TRANSITRON EXPANDS ITS PACKAGED ASSEMBLY PROGRAM

WELDED CIRCUIT PACKAGES Transitron custom-assembles and encapsulates any variety of three-dimensional circuit configurations of conventional, miniature or micro-miniature components. Utilization of advanced production processes, including precision welding, assures strong, uniform joints and results in high packing density, light weight and high structural reliability. Typical custom-made packages are:

FLIP-FLOP

A general purpose flip-flop module capable of counting at speeds of 3-5Mc and operating as a logic element at bit rates in excess of 2Mc.

(Tentative Data)
Frequency in excess of 3Mc
Supply Voltage 12 Volts DC ±30%
Power Dissipation (typical) 150mW
Clock Rate in excess of 2Mc
Maximum Load 1.5KΩ



LOW LEVEL AMPLIFIER

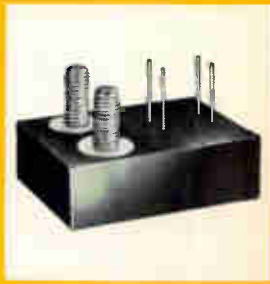
Gives high input impedance and low noise performance with a voltage gain of approximately 20.

(Tentative Data)
Input Impedance 500KΩ
Output Impedance 3KΩ
Voltage Gain 20
Equivalent Input Noise Voltage 5μV
Voltage Supply +18 Volts
Band width DC to 100Kc

3 to 5 WATT AUDIO AMPLIFIER

Contains a stable gain push-pull amplifier circuit capable of up to 5 Watts.

(Tentative Data)
Voltage Supply 18 Volts
Maximum Input Voltage 1 Volt p.p. from 3KΩ source resistance
Maximum Linear Output (Push-Pull) 3 Watts (20 Ω load)
Band width 20-20,000 cps



First to introduce the REF-AMP, Transitron, a 5-year pioneer in the development of packaged semiconductor assemblies, is pleased to announce the broad expansion of its Special Products Service Department. In response to the increasing demand for packaged assemblies, Transitron offers the electronic industry a growing line of standard assemblies as well as a highly versatile and flexible custom design service.

VIDEO AMPLIFIER DOUBLET

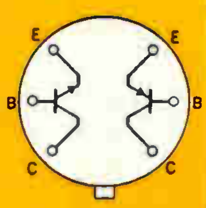
Utilizes a stable gain circuit giving a broad flat band width and relatively low noise operation.

(Tentative Data)
Band width 20 cps to 7Mc
Voltage Supply 22 Volts
Current Gain of approximately 20 per doublet
Equivalent Input Noise Current over entire band width is typically less than 0.02μA RMS

MULTIPLE SEMICONDUCTOR ASSEMBLIES

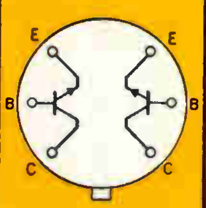
An extension of standard assembly techniques has resulted in the packaging of a number of devices in the same space normally occupied by one standard transistor package. Transitron's compact packaging features electrical isolation, close thermal proximity between junctions, matching of specific electrical specifications, and reduction of external connections. Three typical Transitron Multiple Assemblies are:

DIODE BRIDGE



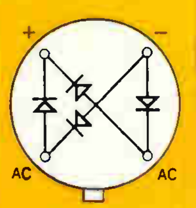
BOTTOM VIEW

COMPLEMENTARY PAIR



BOTTOM VIEW

DIFFERENTIAL INPUT PAIR



BOTTOM VIEW

PACKAGED REFERENCE ASSEMBLIES

A further diversification of Transitron's packaged assembly program has produced two new additions to the firm's broad standard line of quality silicon references . . .
Selecting from among its most reliable and stable units, including devices used in the Minuteman missile, Transitron combines for the first time both temperature-compensation and close tolerances in a double anode packaged reference assembly. Further efforts have also produced a low current reference assembly which offers precision tolerance reference voltages (10 to 100 volts) in a package especially suited for high-density circuitry.
For further information, ask for Transitron's "Packaged Reference Assembly" bulletins.

Transitron electronic corporation
wakefield, melrose, boston, mass.

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MEETINGS AHEAD

AERONAUTICAL & NAVIGATIONAL Elec., East Coast Conference, PGANE of IRE; Lord Baltimore Hotel, Baltimore, Md., Oct. 23-25.

URSI-IRE, Fall Meeting, URSI, PGAP of IRE; Univ. of Texas Student Union Bldg., Austin, Texas, Oct. 23-25.

NUCLEAR PROPULSION, Aero-Space, PGNE of IRE; Hotel Reviera, Las Vegas, Nev., Oct. 23-27.

QUALITY CONTROL, American Society, ASQC; Sheraton Hotel, Philadelphia, Oct. 24-25.

INDUSTRIAL ELECTRONICS Exposition, Electronic Representatives, Inc., Detroit Artillery Armory; Detroit, Oct. 24-26.

COMPUTER APPLICATIONS Symp. Armour Research Foundation; Morrison Hotel, Chicago, Oct. 25-26.

RELIABILITY ASSURANCE Techniques for Semiconductor Specifications, AIA, ASQC, EIA, IRC, JEDEC; Dept. of Interior Auditorium, Wash., D. C., Oct. 25-26.

BIOMEDICAL RESEARCH Symposium Instrumentation Facilities, PGBME of IRE, AIEE, ISA, Univ. of Nebraska; Sheraton Fontenelle Hotel, Omaha, Nebraska, Oct. 26-27.

ELECTRON DEVICES, PGED of IRE Sheraton Park Hotel, Washington, D. C., Oct. 26-28.

AIR TRAFFIC CONTROL Assoc., ATCA; Deauville Hotel, Miami Beach, Florida, Oct. 30-31.

RADIO FALL MEETING, EIA, IRE; Hotel Syracuse, Syracuse, New York, Oct. 30-Nov. 1.

DATA PROCESSING, Automatic Systems, Current Developments, Oct. 30-Nov. 3.

HIGH MAGNETIC FIELDS, International Conf., Air Force Office of Scientific Research; Massachusetts Institute of Technology, Cambridge, Mass., Nov. 1-4.

INSTRUMENTATION Conf., Louisiana Polytechnic Institute, Campus, Ruston, Louisiana, Nov. 2-3.

MAGNETICS, Non-Linear, AIEE, IRE; Statler Hilton Hotel, Los Angeles, Nov. 6-8.

DOCUMENTATION, American Documentation Inst. Annual, Advanced Retrieval Theory; Kresge Auditorium, MIT, and Hotel Somerset, Boston, Nov. 6-8.

NEREM, Northeast Research & Engineering Meeting, Commonwealth Armory and Somerset Hotel, Boston, Nov. 14-16.

AEROSPACE Electrical Society, Pan Pacific Auditorium, Los Angeles, Nov. 15-17.

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

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.1	.590″ x .156″	.625″ x 1.125″
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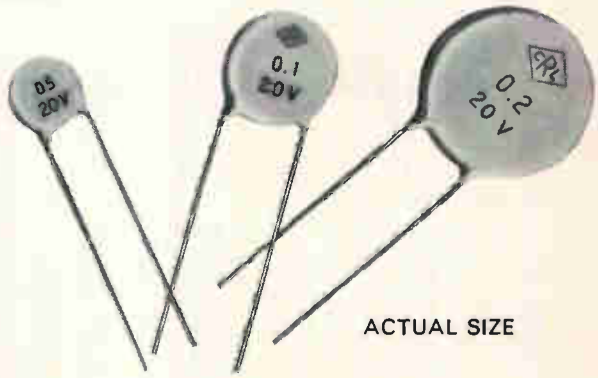

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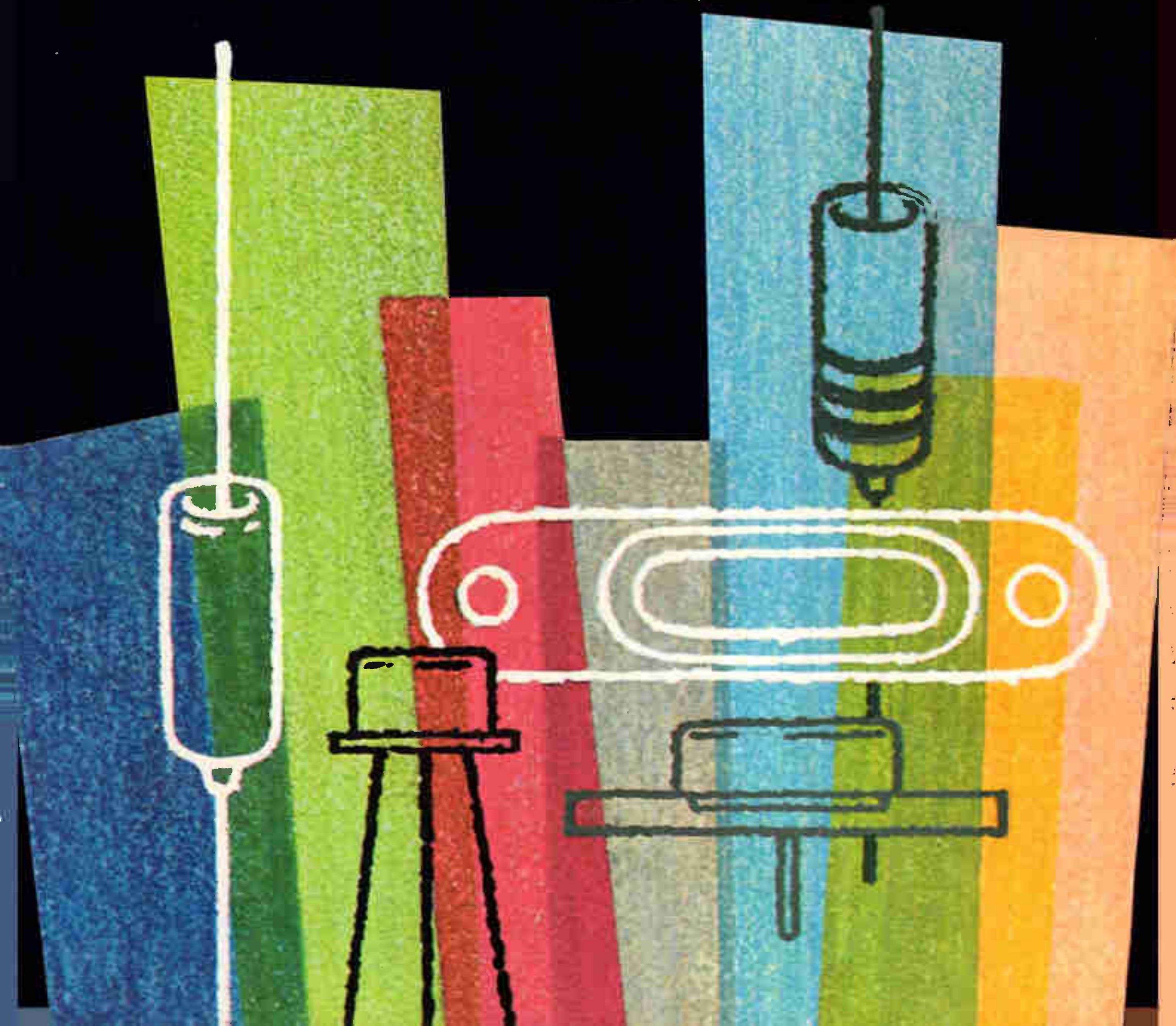


How to select power transistors

by RICHARD F. MOREY, JR.

Manager, Applications Engineering, Clevite Transistor Division of Clevite Corporation

A basic understanding of the interrelationship of transistor design parameters facilitates selection of the most advantageous unit for a given application.

Transistor characteristics depend upon each other. Consequently, a design change in the manufacture of a transistor directly affects a number of its electrical characteristics.

As a guide to users of power transistors, several of the important design elements and the electrical characteristics they influence have been summarized in chart form (fig. 1).

The curves (figs. 2-5), show typical characteristics for two power transistors of quite different design. Clevite's 2N1762, for example, is a 3 ampere unit having the following design parameters: Small junction area; high resistivity germanium; moderate germanium lifetime; average wafer thickness and no emitter doping.

In contrast, Clevite's 2N1146C is a 15 ampere power transistor which has several quite different parameters based upon a higher current and power requirement; large junction area several times the size of the 3 ampere unit; identical base width and resistivity but longer germanium lifetime and thicker wafer plus aluminum doping to increase emitter efficiency.

Working with the chart in figure 1 and the table, figure 6, we see that the comparative design elements of the two transistors result in the 15 ampere unit exhibiting:

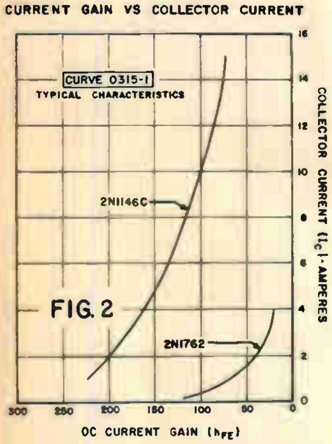
- lower thermal resistance and higher leakage currents because of its large junction area.
- slightly lower collector to base voltage.
- higher gain because of the emitter doping and higher lifetime.
- very linear current gain out to high currents because of its large area and special emitter doping.
- lower collector to emitter breakdown voltages because of its higher gain and lower collector to base voltage.
- much lower saturation voltage and base input voltage because of its high gain and thicker wafer and larger area.
- low common emitter frequency response because of its high gain and large area.

Effect of Transistor Design on Characteristics

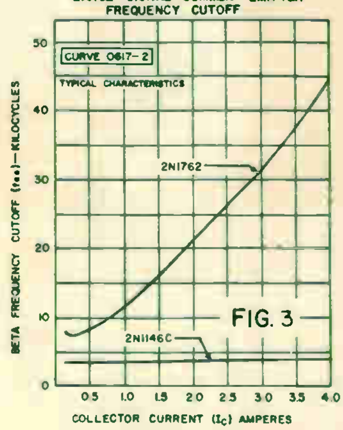
DESIGN PARAMETER	Addition of Emitter Doping	Increase in Wafer Thickness	Reduction in GE material lifetime	Increase in GE material resistivity	Reduction in Base Width	Increase in Junction Area
THERMAL RESISTANCE R_T	—	—	—	—	—	decrease
COLLECTOR LEAKAGE CURRENT I_{CBO}	—	decrease	increase	increase	—	increase
COLLECTOR BASE VOLTAGE V_{CB}	—	—	—	increase	—	decrease slightly
COLLECTOR EMITTER VOLTAGE V_{CE}	decrease	—	increase	increase	decrease	decrease slightly
D.C. CURRENT GAIN h_{FE}	increase	—	decrease	—	increase	—
LINEARITY OF h_{FE}	better	—	—	—	—	better
SATURATION VOLTAGE $V_{CE(SAT)}$	decrease	decrease	increase	increase	decrease	decrease
BETA CUTOFF FREQUENCY $f_{\alpha e}$	decrease	—	increase	—	increase	decrease
PUNCH THROUGH VOLTAGE V_{PT}	—	—	—	decrease	decrease	—
SECONDARY BREAKDOWN CURRENT I_m	increase	increase	—	decrease	—	increase

Figure 1.

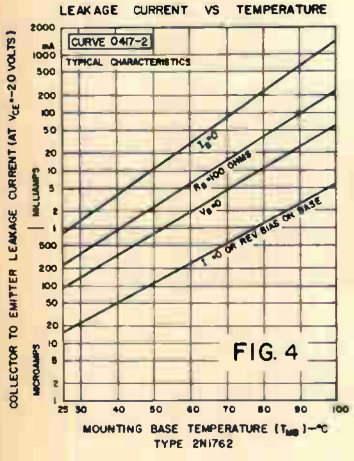
CURRENT GAIN VS COLLECTOR CURRENT



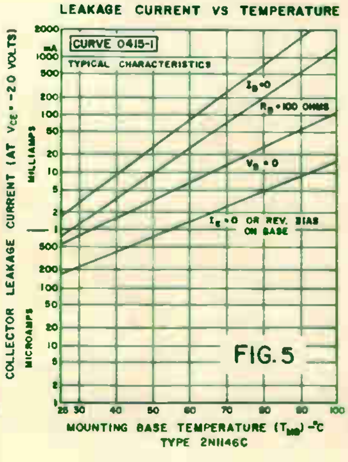
LARGE SIGNAL COMMON EMITTER FREQUENCY CUTOFF



LEAKAGE CURRENT VS TEMPERATURE



LEAKAGE CURRENT VS TEMPERATURE

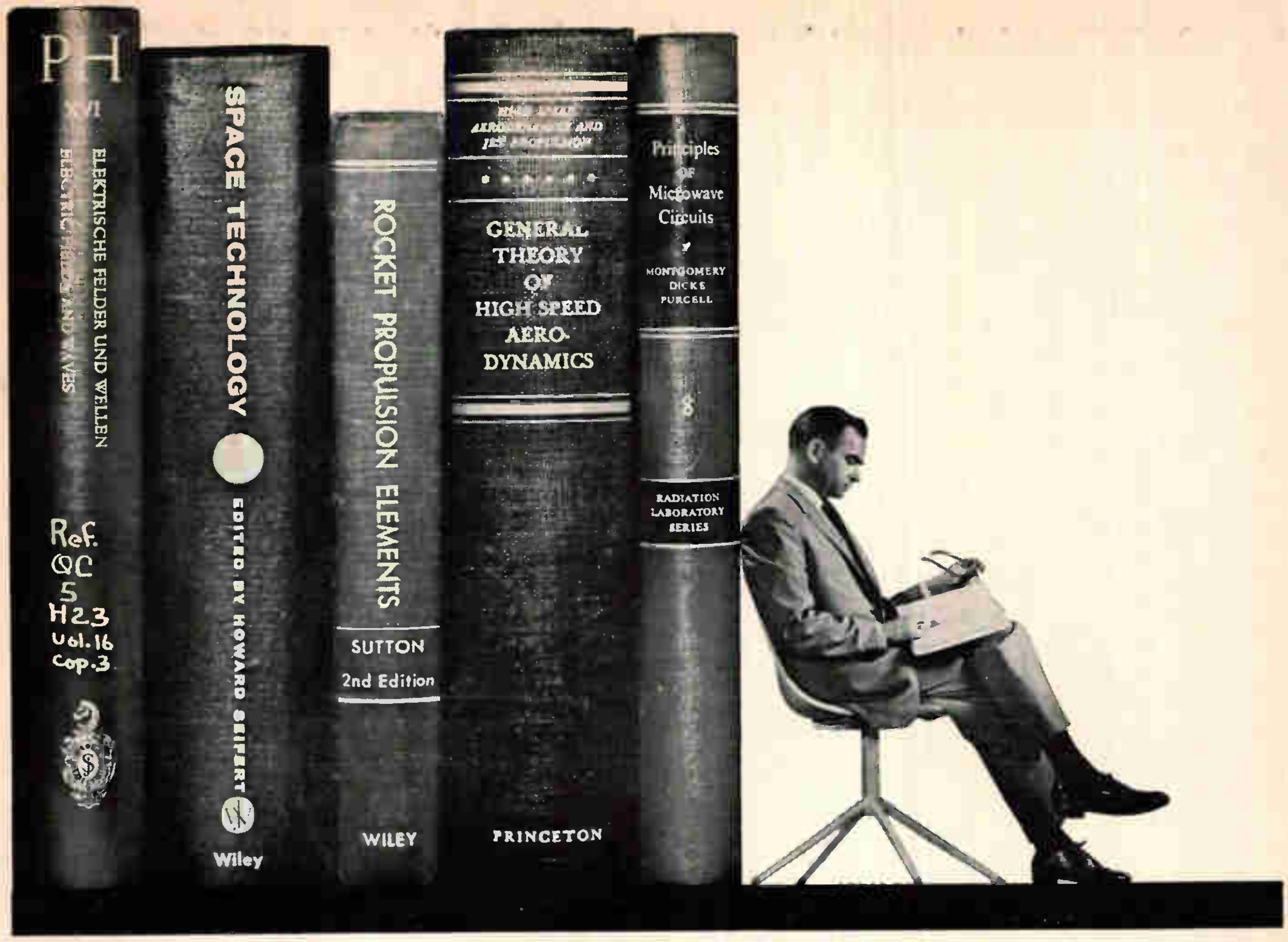


Comparison of Characteristics — Two different designs

Characteristic	2N1762 Typical Value 3 Amp. Device	2N1146C Typical Value 15 Amp. Device	Units
Thermal Resistance	1.4	0.5	°C/watt
I_{CBO} at 100V at 85°C	3	15	mA
I_{CBO} at 100V at 25°C	1	4	mA
BV_{CBO}	130	120	Volts
$V_{CEO(sus)}$	70	50	Volts
Current Gain at I_C = 1 Amp.	60	220	
Current Gain at I_C = 5 Amps.	15	140	
Current Gain at I_C = 15 Amps.	—	75	
Saturation Voltage at 3 Amps.	0.3	0.2	Volts
Saturation Voltage at 15 Amps.	—	0.4	Volts
Saturation Resistance	100	26	Milliohms
Frequency Cutoff at 1 Amp.	18	4	kc.

Figure 6

In order for circuit designers and users of power transistors to obtain the best combination of electrical characteristics, the requirements for the application must be well known and be matched to the transistors available on the market. Therefore, an elementary knowledge of the existing relationships between transistor characteristics is a useful design tool. A tabular summary of characteristics for Clevite's complete line of power transistors is available. Ask for Bulletin 61-A.



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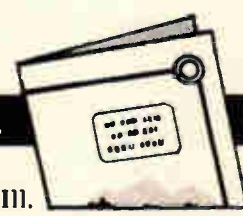

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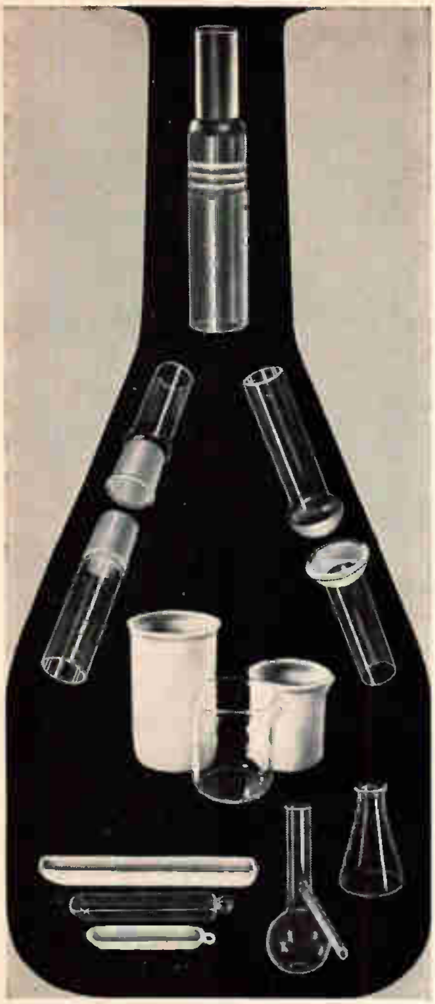

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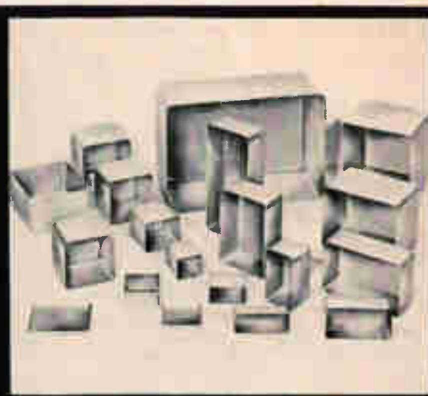

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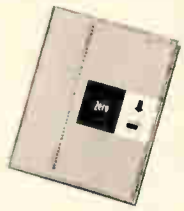

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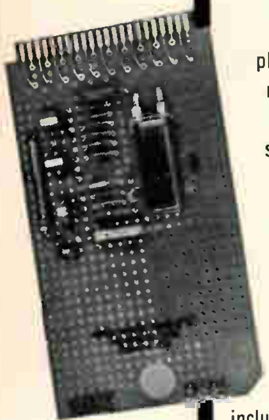

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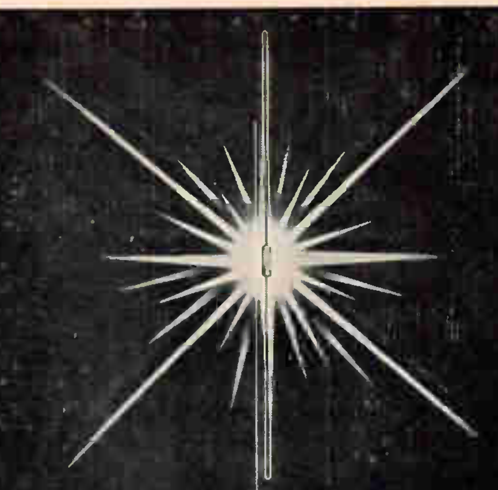

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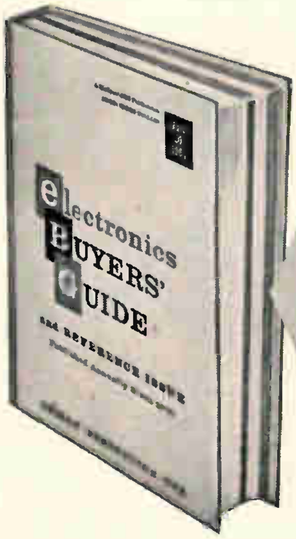

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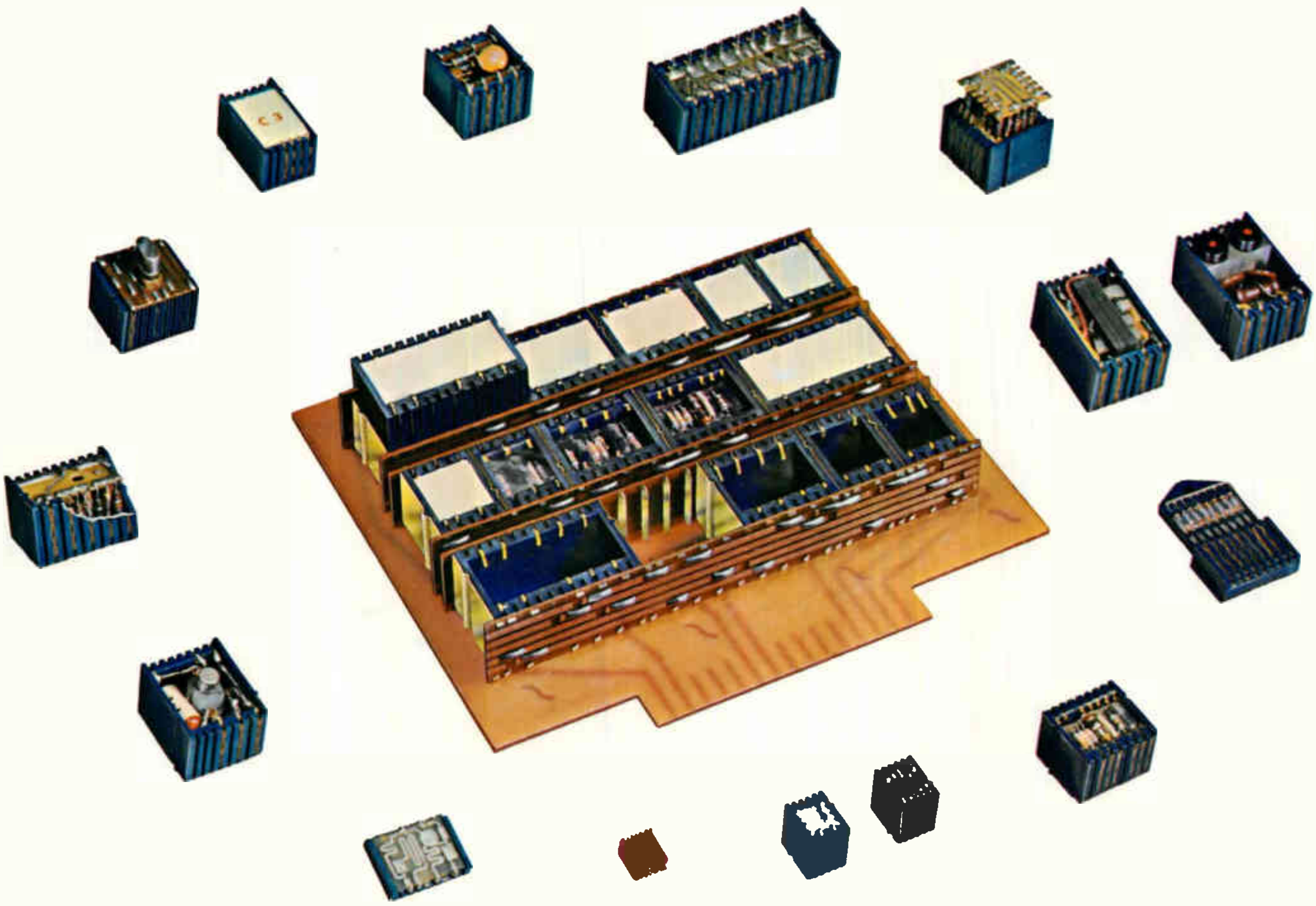

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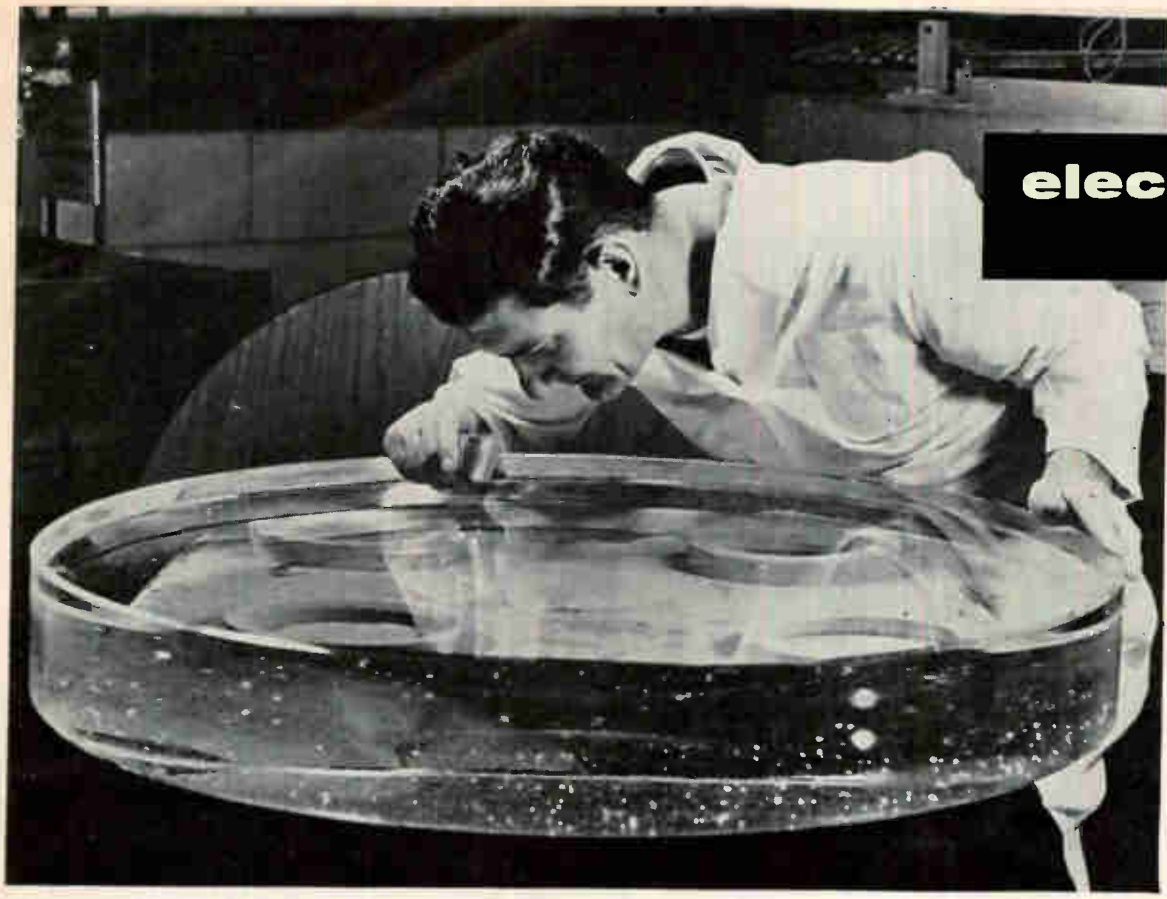

Thirty-six inch, f/4 paraboloid mirror to be used in Stratoscope II balloon-borne telescope is polished to an accuracy of one-millionth of an inch at Perkin-Elmer Corp.

electronics
October 20, 1961

OPTICAL TECHNIQUES

For Electronic Engineers

Developments in infrared, millimeter waves and optical masers are helping consummate the marriage of electronics and optics. Here is a summary of optical principles and techniques useful to electronic engineers

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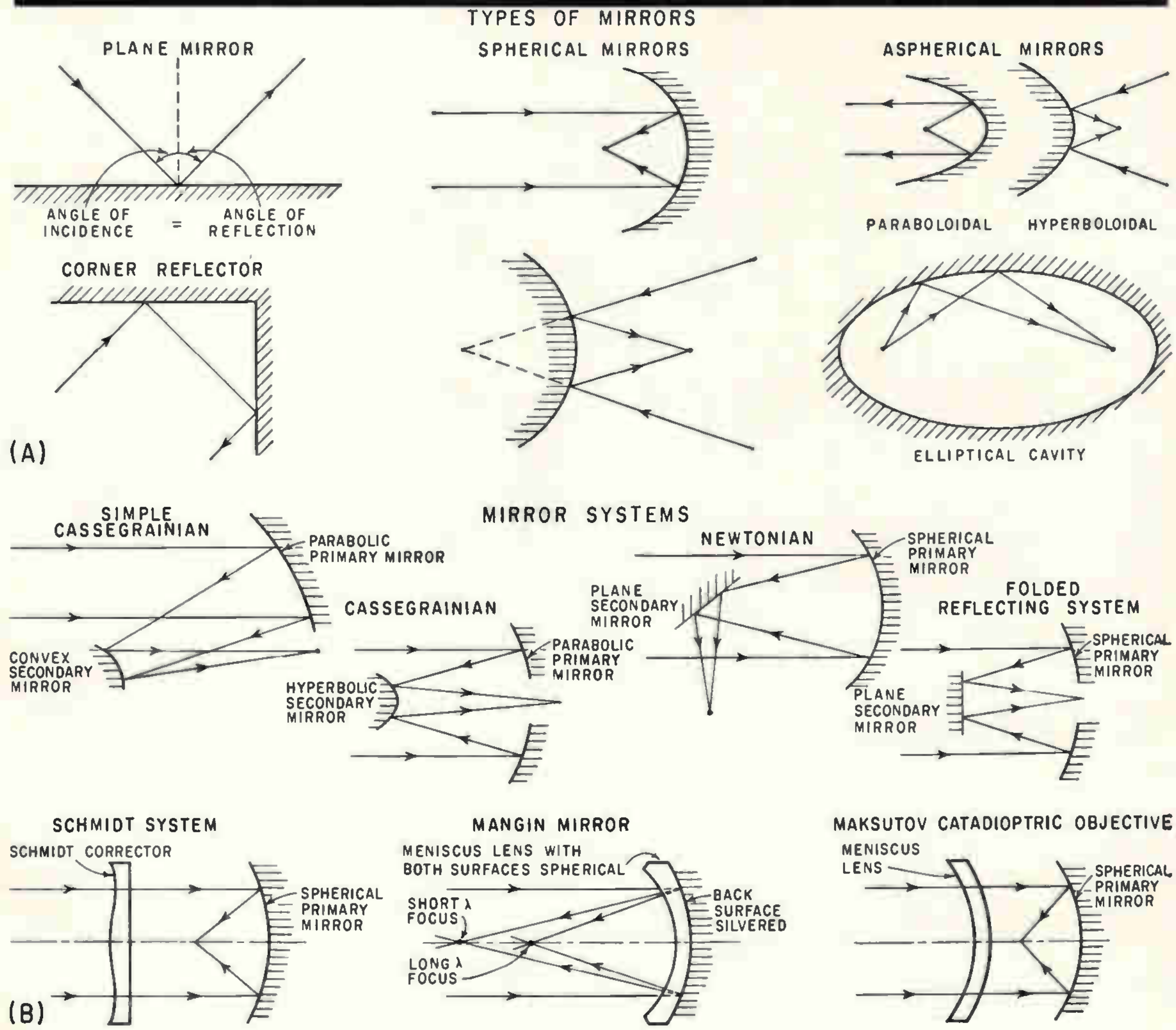
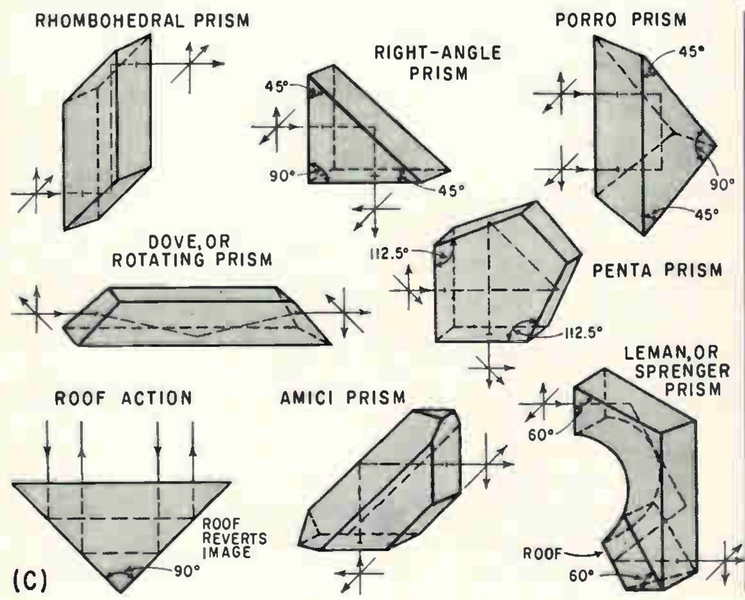
OPTICS refers to the combination of physical and mathematical sciences pertaining to the nature, properties, generation and control of electromagnetic radiation, and to the phenomenon of vision. The breadth of this definition is wide, and departs from the classical approach of pigeon-holing small segments of the electromagnetic spectrum under categories such as infrared, microwave and visual regions. Today it is difficult to split the spectrum into small segments because it is almost impossible to establish the necessarily arbitrary boundary lines. So-called optical phenomena including reflection and refraction are used to guide microwave radiation, while the direct extension of the microwave waveguide . . . fiber optics . . . is used to channel light beams. The recent development of the optical maser, or laser, has demonstrated the ability to produce electromagnetic radiation across an enormous spectral range, from microwave through visual, using modifications of a single device: the maser.

The science of classical optics was developed to explain the phenomena observed when visible light interacted with matter. Visible light has no special significance in the spectrum, except in denoting the boundaries of the human senses. The founders of optical science were certainly unaware of the manifold ways in which energy can be transmitted, and assumed they were limited to those that could be observed by man. They developed optical principles along a narrow path, and followed a descriptive and practical engineering approach. Only when the continuity of the wave-energy concept was realized were these optical principles applied to other regions of the

COMPONENTS FOR REFLECTING OPTICAL SYSTEMS





PROPERTIES TABLE	DEVIATION	INVERSION	REVERSION	COMMENTS
RHOMBOHEDRAL	0°	NO	NO	DISPLACES BEAM; NO OTHER CHANGES
RIGHT ANGLE	90°	NO	YES	
PORRO	180°	NO	YES	SAME AS RIGHT ANGLE, BUT TURNED SIDEWAYS
DOVE	0°	NO	YES	ROTATES IMAGE WITHOUT DISPLACING IT
PENTA	90°	NO	NO	SEE GLOSSARY
AMICI	90°	YES	NO	
LEMAN (SPRENGER)	0°	YES	NO	LATERALLY DISPLACES BEAM
ROOF ACTION	0°	NO	YES	USED IN MANY TYPES OF PRISMS

spectrum. To develop electron optics, optical techniques were applied to X-rays and even to the wave motion associated with moving particles.

Design methods used by optical engineers to develop new optical systems are often familiar to the electrical engineer. Space-frequency concepts coupled with two-dimensional Fourier analysis and transform methods can be used to predict the quality of optical components, and digital computers are commonly used to cut through the rigor of lens design.

Prior to World War II, optics was an important field of research in many areas of science and engineering. Spectroscopy was developed as a science in itself, sophisticated astronomical instruments were designed and built, and the foundations of electro-optics were laid with the development of image-converter tubes, image orthicons and multiplier phototubes. The military importance of high-quality optical and electro-optical systems were obvious. It was often claimed the war would be won by the country possessing the finest submarine periscope, most accurate bombsight and most efficient aircraft spotter.

Two developments upset this picture and temporarily relegated optics to the back of the academic shelf: radar and atomic energy. Radar could do most of the things sophisticated optical systems could and it wasn't affected by the bug-a-boo of optical devices, atmospheric aberration. The electronics industry exploded with the new technologies of radar, and long range radar quickly replaced line-of-sight optical ranging instruments.

In an equally violent revolution, the atomic bomb turned the interests of physicists, and especially graduate students working on doctorate theses, away from optics and toward nuclear physics. Optics has been considered a closed and completed science in recent years, and more often than not engineering schools teach a descriptive optics course more out of historical interest than academic importance.

The electro-optical industry developed in recent years through the marriage of electronics and optics. Human observers on the receiving end of an optical system are not capable of performing the tasks electronic systems can. Early electro-optical systems consisted of conventional and straightforward optical systems tacked to an electronic system with some sort of light-to-electric energy transducer. The optical system either improved the sensitivity of the transducer, as with a lens in front of a phototube, or the electronic system converted the transducer output to a useful form, as in a photoelectric relay. Each system was conventional and required no special technology, either optical or electrical.

Modern systems are more highly integrated, and the combination of electronic and optical components is chosen with the aim of carefully matching characteristics of optical and electronic portions to enable the system as a whole to best perform some task. Development of infrared technology has produced a wide range of new electro-optical devices.

Emphasis on space technology has triggered new growth in optical and electro-optical technology. With the atmosphere eliminated, atmospheric attenuation and abberration are no longer problems. Optical antennas of a given resolving capability are many times smaller than their microwave counterparts and optical frequencies offer much greater bandwdith for communications. The recently developed optical maser shows promise in communications and ranging applications and possibly as a power transmitting element.

New applications for optical techniques are being found daily in many areas, and the electronic engineers will certainly have to have a wide background to keep up with the electro-optical industry.

Classical methods. The engineer will usually be concerned with practical and applied optics, and with the techniques often included in the broad heading of classical optics. Geometrical optics that discusses the action of lenses, prisms and mirrors on beams or rays of light, and physical optics that treats light as wave motion and deals with interference, diffraction and polarization, both fall in the field of classical optics.

In practice, geometrical optics is usually applied in the design of simple imaging systems, and in fact most problems can be solved by applying the three basic laws of geometrical optics: rectilinear propagation of light, the principle of reflection and the principle of refraction.

The most familiar element in simple imaging systems is the lens, although it is often the most difficult part of a system to design. Because of the many variables involved, ranging from surface curvature to types of optical glass, lens design has been until recently more of an art than a science. The cut-and-try approach was often used as the only means to escape the mountains of mathematics required to deal with all variables, and except for certain simple cases there have been no unique solutions to lens design problems.

The most important recent advances in lens design have been made through the introduction of new analytical techniques, new glasses, and aspheric surfaces, and the use of digital computers to analyze and synthesize lens systems.

Materials research to find substances transparent to infrared is extending the usefulness of lens technique to the longer wavelength areas of the optical spectrum.

Optical Quality. Ideally an optical system should guide, direct, or focus incident radiation, but not introduce any extraneous distortions or aberrations. A heavily mathematical theory of lens and mirror system aberrations has been developed, and with digital computers aberration free systems have been designed.

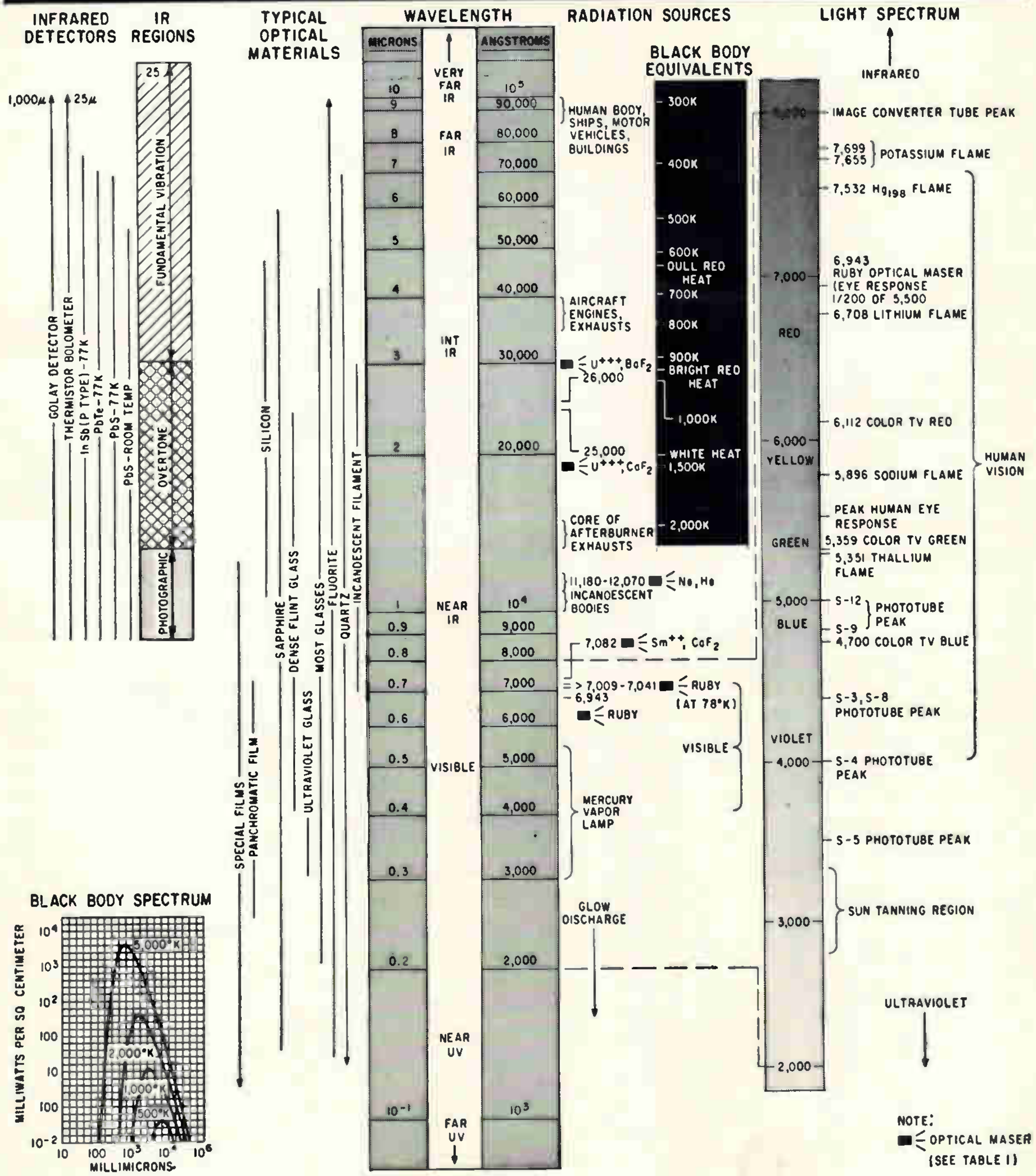
Difficulties arise when theory is put into practice due to defects and imperfections in optical materials. Everyone is familiar with the dispersing property of a simple right angle prism, and has seen the spectrum emitted from one face when white light is incident on another. This effect is caused by varying refractive indices for different wave lengths of incident light, and although pretty to look at, it introduces undesirable chromatic aberration in lens systems. In general, the focal length of a lens is greater for red light (long wavelengths) than for blue light (short wavelengths). Mirrors and reflection optics are free from chromatic aberration, hence their wide use in ir systems where the large range of ir wavelengths would introduce severe focusing problems.

Optical materials must be free from obvious defects such as bubbles, undissolved fragments and cloudiness, as well as less obvious nonuniformities such as striae and strain. Striae are streaks running through a material that differ slightly from average in respect to optical properties. The index of refraction of striae is usually lower than the surrounding material, and refraction can occur within the element. The difference in index of refraction is usually confined to the fourth decimal place, however, the shimmering observable over a heated radiator results from changes in the index of refraction of air in the fifth decimal place.

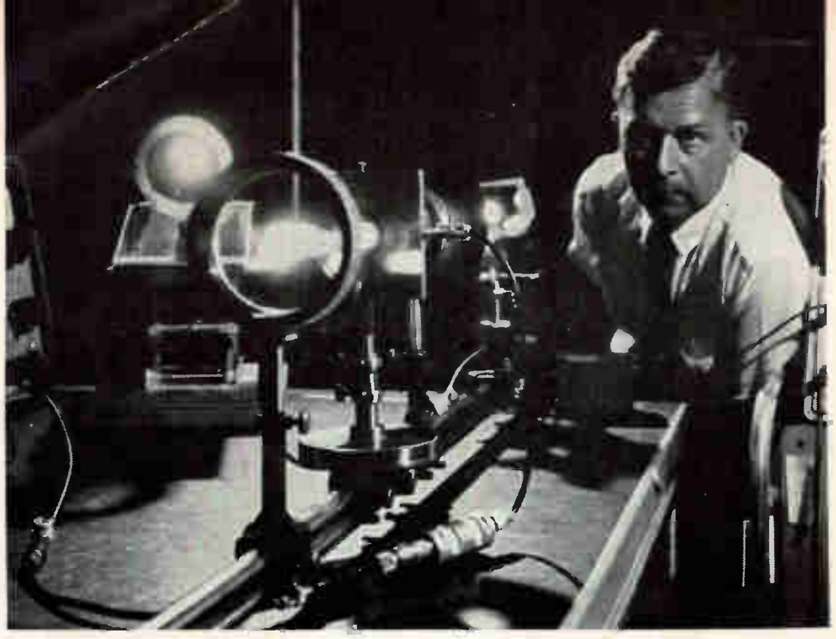
Strain occurs when a hot piece of glass or other optical material cools nonuniformly, and can be removed by an annealing process. A piece of strained glass could conceivably shatter at any moment because of internal stress. Strain will introduce birefringence, creating different indices of refraction in different directions in the material.

Diffraction-Limited Optics. The resolving capabilities of any optical system is ultimately limited by diffraction phenomena. If the system is ideal in design and construction, and all aberrations have been corrected the system is considered to be diffraction limited. The extent that systems performance is affected by diffraction depends on the size of apertures throughout the system, and the wave length of the radiation passing through. A perfect optical system will produce an image of a monochromatic point

THE USEFUL OPTICAL SPECTRUM



source that consists of a central disk (Airy disk) surrounded by a concentric pattern of alternately dark and light rings. The angular diameter of the central maximum is given by: $\delta = 1.22\lambda/D$ where δ measured in radians. Quantity D. is the diameter of the aperture, and λ is the wavelength of the transmitted light. The relation holds only for monochromatic or near monochromatic light. Alternate light and dark rings produced by the various components of transmitted white light would overlap, and merge into a hazy halo surrounding a central maximum. Thus, no optical system can produce a perfectly sharp image of a point source.



Sperry engineer aligns complicated lens system for use at input to electronic equipment. He is using an optical test bench setup

Diffraction results from the interaction between portions of a light wave front and solid obstacles, where the interaction alters the direction of propagation. Thus the edges of opaque objects do not form absolutely sharp shadows, as some of the light is diffracted into the edge of the shadow. Diffraction is also observable in the spreading of the output beam from a ruby optical maser. The angle of the light cone is given by the diffraction equation, and is approximately 70 microradians for a half-inch-diameter ruby rod.

Diffraction phenomena can be explained only by assuming a wave character for light, and by dispensing with the postulate of rectilinear propagation of light as assumed in geometrical optics. Geometrical optics in general represents a limiting situation where the wavelength being discussed is allowed to approach zero.

Interference. The superposition of two or more light waves having a simple fixed phase relationship among themselves results in a variation of the net wave amplitude with distance and time. Interference is characterized by local maxima and minima where the waves reinforce each other (constructive interference) or attenuate each other (destructive interference). Constructive interference occurs when the phases and amplitudes of the superposed waves are in a relationship that increases the square of the net amplitude above the sum of the squared component amplitudes. Destructive interference occurs when the component phase and amplitude relationships decrease the square of the amplitude below the sum of the squares of the interfering waves.

Interference effects are applied practically in several classes of optical devices. The most straightforward is the interferometer, an instrument used to measure small linear and angular displacements, optical path length differences and wavelength of light radiation. The Michelson interferometer is familiar; other interferometric devices operate on the same basic principle. Light from a single source is split into two or more parts by mirror arrangements, and the parts are later recombined after having traversed different path lengths. Different path lengths introduce phase shifts among the components, and they interfere upon recombination. In general, light from a single source must be split and recombined to observe interference. Radiation from two distinct separate sources will not interfere because the phase relationship between the two radiations is not simple, but is constantly changing (see COHERENCE).

Transparent dielectric coatings applied to lens surfaces to cut reflection use the interference effect.

Light impinging on the optical element undergoes a multiple reflection within the dielectric material. Through destructive interference, light that would normally be reflected back from the base glass surface is attenuated. Antireflection coatings are observable on most quality camera lenses as a blue or pink tinge when the lens is viewed from an angle.

Selective reflection and transmission filters using multilayer dielectric coatings are the optical counterpart of RLC filters.

Single or double-layer filters are stacked to achieve greater selectivities. Multilayer reflective coatings do not absorb radiation as do metallic coatings, an important consideration if light levels are small.

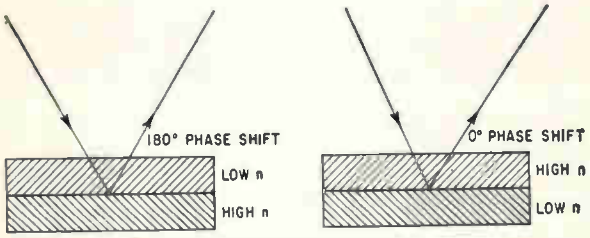
Optical Maser. If any single device could be given credit for stimulating the new growth of the electro-optical industry it would have to be the optical maser, or laser. Although present research models are little more than temperamental sources of highly coherent almost monochromatic light, applications suggested for the device are in fields ranging from medical electronics to space communications. The property of coherence makes it easy to transmit a maser beam over great distances, and focus it to a sharp point to achieve enormous power-per-unit-area values, and the high optical frequencies give wide bandwidths for communications.

Optical masers in use or development today fall into two categories: solid state and gaseous; all work on roughly the same idea. The majority of a small number of optically active atoms in a host crystal lattice (solid state) or in a gas discharge tube (gaseous) are raised to a high semistable (metastable) energy level by some pumping scheme. The geometrical design of the device is such that when a few atoms fall to lower energy levels randomly, the emitted radiation stimulates in-phase radiation from the other atoms. The output is a highly collimated beam of sharply defined frequency.

Optically speaking the solid-state device is the simpler of the two as it comprises its own optical system. Operation of a solid-state optical maser is closely linked to the property of fluorescence, and proposed maser materials are first studied on the basis of their fluorescence. The pumping scheme for a solid-state device is optical, using an electronic flash to raise the energy levels of the optically active atoms. Repetitive flashing of the pump would be necessary to maintain continuous output radiation, but heating effects will not usually permit this. Hence solid-state masers are lim-

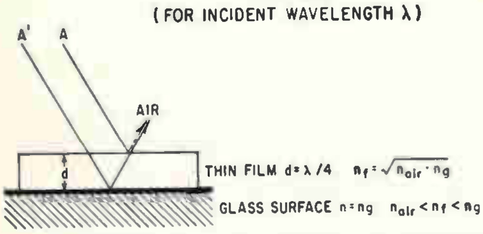
THIN-FILM OPTICAL COATINGS

BOUNDARY CONDITIONS



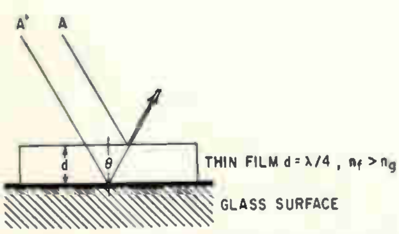
UPON REFLECTION AT INTERFACE BETWEEN TWO MEDIA, INCIDENT LIGHT UNDEGOES PHASE SHIFT OF 180° IF FIRST MEDIUM IS LESS DENSE THAN SECOND; 0° IF FIRST IS DENSER THAN SECOND

ANTI-REFLECTION COATING (FOR INCIDENT WAVELENGTH λ)



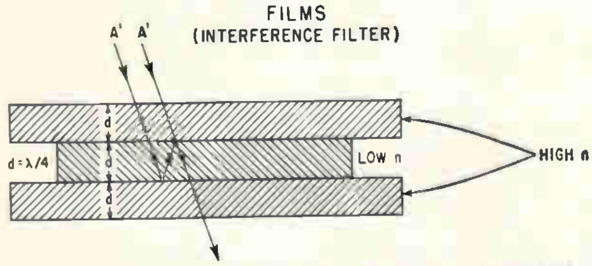
AT AIR-FILM INTERFACE WAVE A' REFLECTED FROM GLASS SURFACE IS EXACTLY 1/2 WAVELENGTH OUT OF PHASE WITH WAVE A REFLECTED FROM FILM SURFACE AND DESTRUCTIVE INTERFERENCE OCCURS ELIMINATING REFLECTED BEAM

HIGH REFLECTION COATINGS



FOR INCIDENT WAVELENGTH λ OR MULTIPLES OF λ , A AND A' INTERFERE CONSTRUCTIVELY, PRODUCING HIGH REFLECTANCE

TRANSMISSION FILMS (INTERFERENCE FILTER)



FOR INCIDENT WAVELENGTHS OF λ OR MULTIPLES OF λ A AND A' INTERFERE CONSTRUCTIVELY PRODUCING TRANSMISSION. OTHER WAVELENGTHS INTERFERE DESTRUCTIVELY

TABULATION OF OPTICAL MASER WAVELENGTHS

(DEVICES OPERATING AT TIME OF PUBLICATION)

TYPE	MATERIAL	PRINCIPAL ABSORPTION WAVELENGTH	RADIATION WAVELENGTH
SOLID STATE OPTICAL PUMPING	Cr^{+++} DOPED Al_2O_3 (RUBY)	5,600 A°	6,943 A°
SOLID STATE OPTICAL PUMPING	Cr^{+++} DOPED Al_2O_3 (COOLED TO 78° K)	5,600 A°	7,009 A° 7,041 A°
SOLID STATE OPTICAL PUMPING	Sm^{++} DOPED CaF_2	CENTERED AT 6,320 A°	7,082 A°
SOLID STATE OPTICAL PUMPING	U^{+++} DOPED CaF_2	CENTERED AT 5,500 A°	2,5000 A°
SOLID STATE OPTICAL PUMPING	U^{+++} DOPED BaF_2	NOT AVAILABLE	26,000 A°
GASEOUS	He — Ne MIXTURE	SEE TEXT	11,530 A (STRONGEST) 11,180 A 11,600 A 11,990 A 12,070 A

	ANGSTROM UNIT	MILLIMICRON	MICRON	MIL	CENTIMETER	METER	KILOMETER	INCH
ANGSTROM UNIT Å	1	10^{-1}	10^{-4}	3.9370×10^{-6}	10^{-8}	10^{-10}	10^{-13}	3.9370×10^{-9}
MILLIMICRON	10	1	10^{-3}	3.9370×10^{-5}	10^{-7}	10^{-9}	10^{-12}	3.9370×10^{-8}
MICRON	10^{4}	10^{3}	1	3.9370×10^{-2}	10^{-4}	10^{-6}	10^{-9}	3.9370×10^{-5}
MIL	2.5400×10^{5}	2.5400×10^{-4}	25.4000	1	2.5400×10^{-3}	2.5400×10^{-5}	2.5400×10^{-8}	10^{-3}
CENTIMETER	10^{8}	10^{7}	10^{4}	3.9370×10^{2}	1	10^{-2}	10^{-5}	0.3937
METER	10^{10}	10^{9}	10^{6}	3.9370×10^{4}	10^{2}	1	10^{-3}	39.3700
KILOMETER	10^{13}	10^{12}	10^{9}	3.9370×10^{7}	10^{5}	10^{3}	1	3.9370×10^{4}
INCH	2.5400×10^{8}	2.5400×10^{7}	2.5400×10^{4}	10^{3}	2.5400	2.5400×10^{-2}	2.5400×10^{-5}	1

ited to pulsed operation.

The gas optical maser is similar to an ordinary gas discharge tube. A mixture of neon and helium in a quartz tube is excited by an r-f generator and the helium is raised to a high energy level. Collisions between the excited helium and low-energy neon raise the neon to the metastable energy level. The gaseous optical maser has the advantage of continuous operation; however it is complicated to assemble and align and requires expensive components.

Coherence. The term coherence appears in every discussion of optical masers since maser output is considered a highly coherent beam of light. Too often however, coherence is taken solely as a synonym for monochromatic, which is not strictly true. For, although all true coherent light sources are monochromatic, a monochromatic source is not necessarily coherent. W. Louis Hyde of J. W. Fecker Inc., Pittsburgh, suggests the following working definition for coherence: "Two beams of light are coherent if the phase relationship between them is simple. If a simple phase relationship exists, then the beams can be made to interfere with each other. The two beams may be adjacent parts of the same wave front in which case we say that we have a coherent wave front; or the beams may follow each other at an interval of time at the same point in space. Conventional light sources are coherent for times on the order of 10^{-12} second, and even the best interferometric conventional sources are coherent for times of the order of 10^{-7} second. This time corresponds to about 10 meters separation along a beam of light. Thus interference effects can be observed for distances of this magnitude. Optical masers are coherent for times of the order of 10^{-2} second so that interference can be observed over thousands of miles."

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Glossary definitions were supplied by the American Institute of Physics

GLOSSARY OF COMMONLY USED OPTICAL TERMS

ABERRATION—In an optical system, any systematic departure from an idealized path of light rays forming an image, causing the image to be imperfect. In physical optics, any systematic departure of a wave front from its ideal plane or sphercial form. Common aberrations include spherical and chromatic aberration, coma, distortion of image, curvature of field, and astigmatism.

ABSORPTION—The transference of some or all of the energy contained in electromagnetic waves to the substance they transverse or are incident upon. Absorbed energy from incident or transmitted light waves is converted into energy of other forms, usually heat, within the medium with a resultant weakening of the light beam.

ACHROMATIC—Free from color or hue. Used to describe an optical system free from chromatic aberration. An achromat is a compound lens corrected to have the same focal length for two or more wavelengths.

ANISOTROPIC—Having different characteristics in different directions. Two identical light beams propagating through an anisotropic material in different directions will be affected in different manners.

ANTENNA, LIGHT—A system of reflecting and refracting optical components arranged to guide or direct a light beam.

ASTIGMATISM—An aberration of a lens or lens system that causes an off-axis point to be imaged as two separated lines perpendicular to each other.

AXIS, OPTICAL—The axis of symmetry, or the line joining the centers of curvatures of the surfaces of an optical system.

BEAM—A parallel, diverging or converging flow of electromagnetic radiation. In light, refers to a directed bundle of light rays.

BIREFRINGENCE—Splitting of a light beam into two divergent components upon passage through a doubly refracting medium. The two components travel at different velocities in the medium. (see text)

BLACK BODY—An ideal body that would absorb all radiation incident on it. When heated by external means the spectral energy distribution of radaited energy would follow the curves shown on the optical spectrum chart.

COHERENT—(See text)

COLLIMATOR—An optical system that transforms convergent or divergent light rays into beams of parallel rays.

DEVIATION, ANGLE OF—The angular change in direction of a light ray after crossing the interface between two different media.

DISPERSION—Separating the components of a complex radiation on the basis of some characteristic. A prism disperses the components of white light by deviating each wavelength a different amount.

DISTORTION—An aberration of spherical surface optical systems due to the variation in magnification with distance from the optical axis.

ELECTRON OPTICS—The directing and guiding of electron beams using electric fields in the same manner as lenses are used on light beams. Image-converter tubes and electron microscopes are two examples of electron-optical devices.

FABRY-PEROT INTERFEROMETER — A high-resolution multiple-beam interferometer consisting of two optically flat and parallel glass or quartz plates held a short fixed and known distance apart. The adjacent surfaces of the plates or interferometer flats are made almost totally reflecting by a thin silver film or multilayer dielectric coating. (See text)

FIBER OPTICS—A transparent fiber of a homogeneous and transparent material such as glass or plastic when enclosed within a material having a lower index of refraction will transmit light by a series of internal reflections, or if its cross section is suitably small, in the manner of a wave guide. If many such fibers are assembled in a bundle, each individual fiber encased in a surrounding meduim of lower index of refraction, an entire image can be transmitted when it is formed on the entrance end of the fiber bundle. Each fiber transmits only one element of the composite emergent image. As the definition in the output image depends on the smallness of each element composing it, it is desirable to keep the cross-section of the individual fibers as small as possible. If the spacing of the fibers increases towards the output end of the bundle, the image is magnified; if spacing is reduced the image is reduced in size. By crossing the fibres systematically or randomly the image is scrambled, and can be recovered by retransmitting it backwards through the same or equivalent fiber bundle.

FILM, MULTILAYER DIELECTRIC — See text.

FILTER, OPTICAL—A component or group of components placed in an optical system to reduce or eliminate certain selected wave-lengths while leaving others relatively unchanged, or to modify the intensity or polarization of light.

FOCAL LENGTH—The distance from a lens, or some point therein, or from a mirror, to the image of a small, infinitely distant source of light. This image point is referred to as the focal point.

GRATING, DIFFRACTION—A large number of narrow, close, equally spaced rulings upon a transparent or reflecting substrate capable fo dispersing light into its spectrum.

INTERFERENCE — The systematic reinforcement and attenuation of two or more light waves when they are superimposed. (See text and FABRY-PEROT INTERFEROMENTER)

LASER—See Maser, Optical

LENS—An optical component made of one or more pieces of a material transparent to the radiation passing through the optical system having curved surfaces, that is capable of forming an image, either real or virtual, of the object source of the radiation. At least one of the curved surfaces is convex or concave, normally spherical but sometimes aspheric. A simple lens consists of a single piece of transparent material.

MAGNIFICATION—The ratio of the size of any linear dimension of the image to that of the object in some optical system.

MASER, OPTICAL—A source of nearly monocromatic and coherent radiation produced by the synchronous and cooperative emission of optically pumped ions introduced into a crystal host lattice or gas atoms excited in a discharge tube. The radiation has a sharply defined frequency and propagates in an intense highly directional beam. (See text)

MIRROR—A flat or curved surface optically ground and polished on a reflecting material or a transparent material that is coated to make it reflecting, used for reflecting light. A beam splitting mirror has a lightly deposited metallic coating that transmits a portion of the incident light and reflects the remainder.

MONOCHROMATOR—An instrument for isolating narrow portions of the spectrum, by means of dispersion of light into its component colors.

OPTICS, COATED—Optical refracting and reflecting surfaces that have been coated with one or more layers of dielectric or metallic material for reducing or increasing reflection from the surfaces, either totally or for selected wavelengths and for protecting the surfaces from abrasion and corrosion.

OPTICS, GEOMETRICAL—The optics of light rays, which follow mathematically defined paths in passing through optical elements such as lenses and prisms and optical media that refract, reflect, or transmit electromagnetic radiation.

OPTICS, PHYSICAL—Branch of optics treating light as a form of wave motion, in which energy is propagated by wave fronts.

POLARIZER—An optical device capable of transforming unpolarized or natural light into polarized light, or altering the polarization of polarized light.

PRISM, PENTA—Prism having unique property of diverting a beam ninety degrees in the principal plane even if the beam does not strike the end faces exactly normally.

SNELL'S LAW—The laws of reflection and refraction that state: The incident ray, the normal to the surface at the point of incidence of the ray all lie in a single plane. The angle between the incident ray and the normal is equal in magnitude to the angle between the reflected ray and the normal. The ratio of the sine of the angle between the normal and the incident ray to the sing of the angle between the normal and the refracted ray is a constant.

STARK EFFECT—The splitting of spectral lines by an applied electric field.

WAVELENGTH—The distance from a point on one wave to the corresponding point on the next wave. Wavelength determines the color of light.

ZEEMAN EFFECT—The splitting of spectral lines by an applied magnetic field.

How to Select an Adequate COOLING

Ten basic ways to maintain the proper thermal environment to ensure maximum

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RELIABILITY can be achieved only if electronic, thermal, and mechanical design are all well executed. Once a circuit design has been established, most of the components to be used are known. Failure rate-temperature data from such publications as BuShips Report TR-1100 show that it is, in general, necessary to shield components from a hostile ambient environment.

While the details of component deterioration vary from one component to another, equipment that functions adequately at one temperature level will be less reliable at elevated temperatures. Reliability is not solely a matter of avoiding the excessive temperatures to which the failure rates are asymptotic; at any operating range a reduction in temperature is reflected by lower failure rates. Thus, for a given circuit in a given configuration and a given vibrational environment, reliability is almost entirely a function of the thermal environment.

Environmental conditioning of electronic equipment is necessary for the proper functioning of electronic systems. This conditioning may be so simple as to provide for component spacing to allow for free convection cooling, or it may be so complex as to require a pressurized container in which the components are submerged in a dielectric fluid that boils on the hot spots and condenses on a cooling surface.

Figure *1* reviews and defines the thermal relationships.

In heat transfer by conduction, if a temperature potential $(T_1 - T_2)$ exists across a material of thickness d and thermal conductivity K, the heat flux q per unit area between the hot and cold surface is directly proportional to the temperature potential and the thermal conductivity, and inversely proportional to the thickness. In this mode of heat transfer, thermal energy is transferred by crystal-lattice vibration and electron movement. Metallic conductors have a large amount of heat transferred by electron conductions while insulators predominantly conduct heat by crystal-lattice vibration. Semiconductors use about equal amounts of both modes of energy transfer.

Heat transfer by convection is expressed mathematically identical to conduction with the coefficient of convection h equal to K/D for conduction. Convection coefficients are defined on the bulk mean temperature of the fluid and the wall temperature across which the fluid is moving. There are two modes of convection heat transfer: turbulence, in which the heat is transferred mainly by mixing of hot and cold fluid particles; and laminar, a mode of heat transfer analogous to conduction. There is always a laminar boundary close to the wall, which controls the value of h. In heat exchanger design, the item attacked is this boundary layer, which by proper design can be kept small, thereby maintaining a large value of h. This boundary layer is reduced by supplying energy to the fluid that in turn results in a fluid pressure drop. This means that for a given unit, more power is required for cooling as the thermal design problem becomes more doubtful. This point is clarified later.

Heat transfer by radiation uses electromagnetic waves as the means of energy transfer. The hot surface can be thought of as an infinite surface of electromagnetic transmitters with the thermal energy of vibration transferred to the electromagnetic energy at the surface. The mathematical expression is an expression of radiation balance between the hot and cold surfaces where E_1 and E_2 are the emissivities of surfaces at temperatures

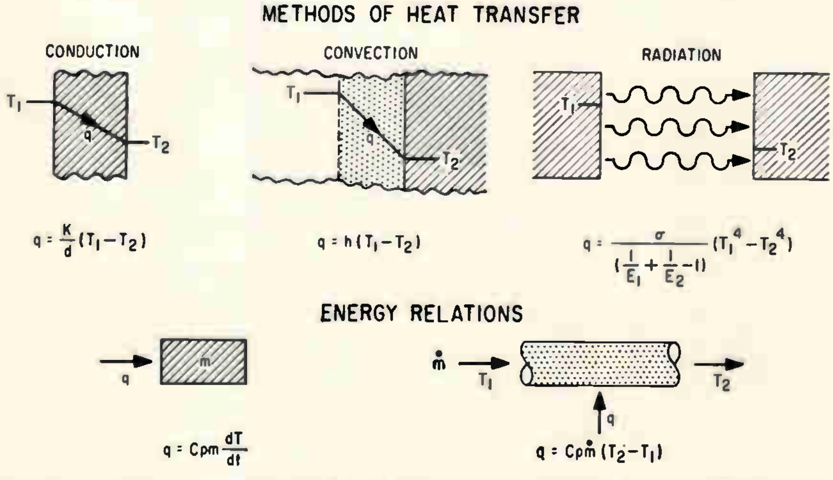


FIG. 1—Basic relations and the three methods of heat transfer are tabulated. All three are used in cooling electronic systems

SYSTEM

system reliability

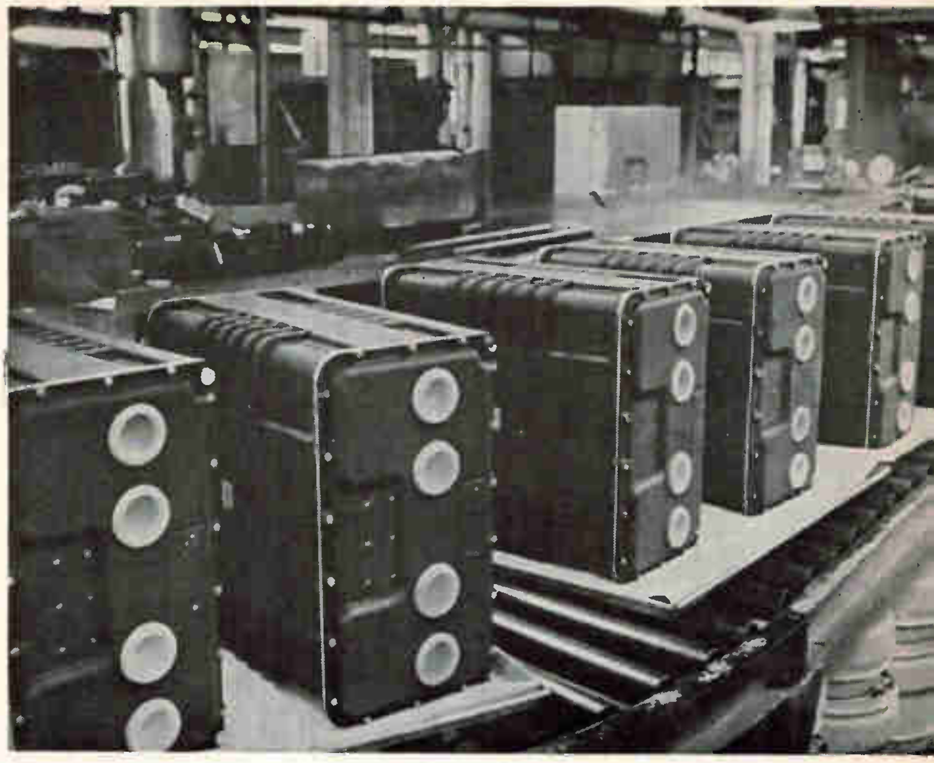
T_1 and T_2, respectively. The Stefan-Boltzmann constant σ is a function of the dimensional system. The expression is further complicated in application by the viewing factors that account for the geometry of the radiating bodies.

Two energy relations are used. One expresses the increase in temperature of a body of mass m when heat is added at a rate Q; the other expresses the increase in temperature of a fluid stream from T_1 to T_2 when heat is added at a rate Q. These equations are also presented in Fig. 1.

Typical modes of heat transfer for both internal and external configurations are presented in Fig. 2. For each system a representative thermal density for the electronic assembly being cooled is listed. These figures are general, being based on typical problem statements with a 40-deg C temperature gradient between the internal and the external temperatures. The rating, watts per cubic inch, refers to the electronic assembly itself and not the overall envelope.

Figure 3 summarizes the heat sinks available for the disposition of heat. In a design problem the form in which this heat sink is made available to the electronic equipment dictates the type of conditioning. If a choice of forms exists, one is usually superior from the viewpoint of electronic equipment manufacture; however, the various heat sinks may have associated with them various weight and drag factors. Therefore, it is necessary to evaluate the choice of heat sink on the basis of the whole system.

Occasionally the temperature level at which the heat sink is available is above the temperature level required by the electronic



Housings for airborne electronic units incorporate an air-to-air heat exchanger; air inside is hermetically isolated from ambient atmosphere

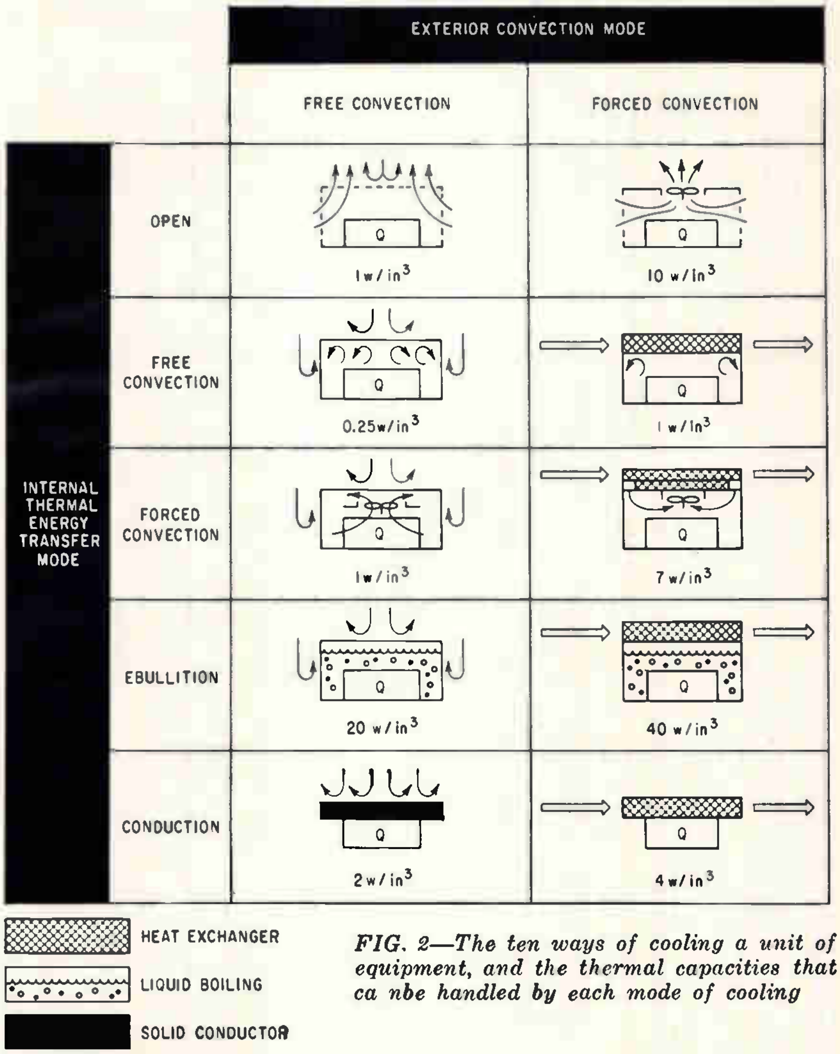


FIG. 2—The ten ways of cooling a unit of equipment, and the thermal capacities that ca nbe handled by each mode of cooling

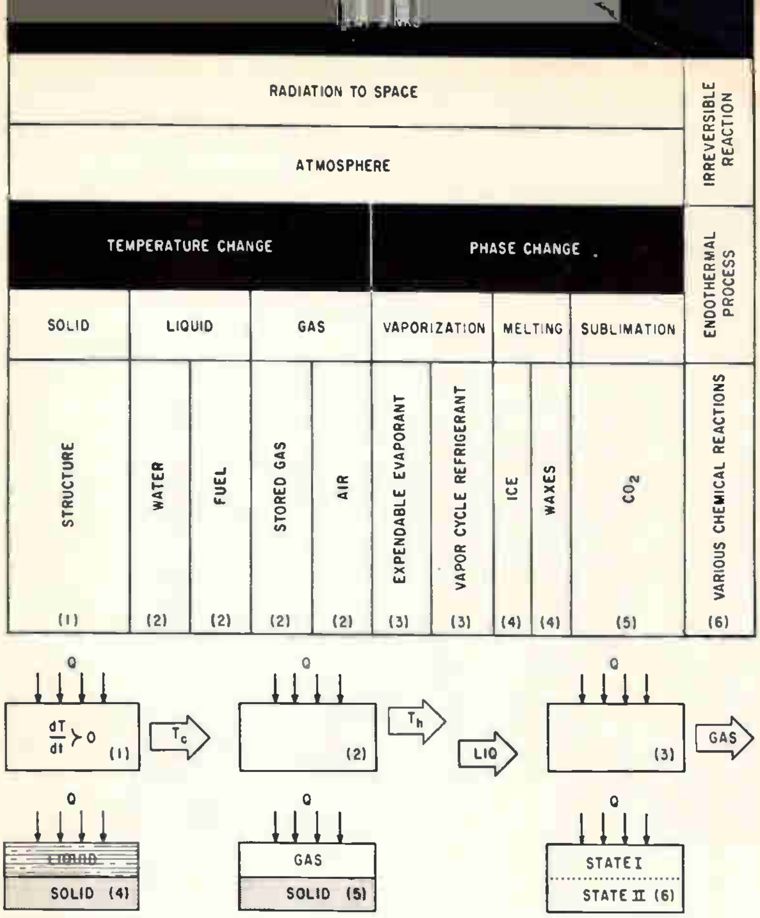


FIG. 3—Ways in which a heat sink may be made available to a cooling system, and the processes that dispose of heat

equipment. There are a number of methods for solving this problem, the more practical being presented in Fig. 4.

The gas cycle system, of which the air cycle system used on large commercial aircraft is a common example, requires a compressor, turbine, heat exchanger to transfer the heat from the hot compressed gas to the heat sink, device for adding power into the compressor to allow the system to function, and a heat exchanger to transfer the heat from the thermal source to the working fluid. Typical performance relations are tabulated.

The vapor cycle system, such as used in household refrigerators and air conditioning systems, requires a gas compressor, a gas-to-liquid condenser that rejects heat to the ambient, a liquid expansion valve that flashes the hot liquid to a lower pressure and a cooler two-phase state, and an evaporator that absorbs the heat from the thermal source by evaporating the remain-

GLOSSARY

- C — Fluid flow rate, ft³/min
- C_e — Specific heat of liquid, Btu lb^{-1} °F^{-1}
- C_g — Specific heat of gas, Btu lb^{-1} °F^{-1}
- COP — Coeffience of performance
- C_p — Specific heat, Btu lb^{-1} °F^{-1} (Constant Pressure)
- C_v — Specific heat, Btu lb^{-1} °F^{-1} (Constant Volume)
- d — Thickness, inches
- E — Emissivity
- h — Convection coefficient, Btu min^{-1} °F^{-1} ft^{-2}
- K — Thermal conducting, Btu in min^{-1} °F^{-1} ft^{2}
- L — Latent heat of vaporization of refrigerent Btu lb^{-1}
- m — Mass, lb.
- $\dot{m}$ — Mass flow rate, lb min^{-1}
- N — N-type semiconductor
- P — P-type semiconductor
- P — Pressure, lb in^{-2}
- Q — Thermal energy, Btu min^{-1} ft^{-2}
- q — Thermal energy flux Btu min^{-1} ft^{-2} or watts
- T — Temperature (Radiator Only)
- T_e — Source temperature °K
- T_s — Sink temperature °K
- W — Power, watts
- Z — Material property, °K^{-1}
- γ — Ratio of specific heats

APPLICATIONS FOR ELECTRONIC EQUIP

FIELD OF APPLICATION	EQUIPMENT	REQUIRED ENVIRONMENT
Guidance	(1) Gyroscopes (2) Accelerometers (3) Servo motors (4) Motor-driven potentiometers (5) Related hardware	(1) 5-micron maximum free particle (2) Low constant humidity (3) Constant pressure (4) Stable, uniform temperature (5) Low density thermal dissipation (100 watts/ft³)
Detection	(1) Airborne radar transmitter (2) Airborne sonar system	(1) Low humidity (2) Relatively high fluid pressures (3) Moderate temperature (4) High density thermal dissipation (1,000 watts/ft³)
Communication	(1) Airborne communication receivers (2) Data-link hardware	Same as above
Control	(1) Fire-control systems with servo amplifiers (2) Solid-state computers (3) Electromechanical transducers	(1) 5-micron maximum free particle (2) Low constant humidity (3) Minimum pressure limit (4) Low temperature gradient within structure (5) Moderate density thermal dissipation (500 watts/ft³)
Ground Support	(1) Microwave tubes (2) Related equipment	(1) Liquid coolant or circulated air, depending on the device to be cooled (2) High density thermal dissipation (1,000 to 3,000 watts/ft³)

ing liquid to the gaseous state.

The thermoelectric system uses electron current as a working fluid, and the relative energy states of the electron in *p*- and *n*-type semiconductors to cause the heat pumping. For an electron to be in thermal equilibrium when passing from the *p* leg to the *n* leg, it must absorb energy. When passing from the *n* leg to the *p* leg, the electron must give up energy. When a current flows, the *p-n* junction becomes hot, the *n-p* junction becomes cold, and heat is pumped from the *n-p* to the *p-n* junction. Devices using this phenomenon are in production in specialized applications and promise to become more important as manufacturing techniques improve.

From the description of forced-convection heat transfer described, there is a relation between heat transfer and fluid friction. By manipulation of the heat transfer and fluid flow relations, it is possible to devise two equations relating face area, fluid flow rate, pressure drop or power, heat transfer and fluid properties. These equations, shown in Fig. 4, give insight into the size of the heat-transfer hardware required for a problem.

The field of environmental conditioning of electronic equipment can be divided into five categories which aid in the formulation of design philosophy. These five categories (guidance, detection, communication, control, and ground support) are described on the tables listing type of equipment, required environment, available ambient and problem statement.

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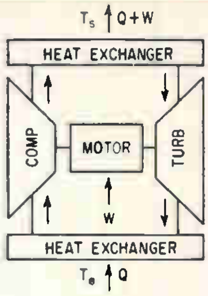
MENT ENVIRONMENTAL CONDITIONING

AVAILABLE AMBIENT	PROBLEM STATEMENT
(1) Sand and dust (2) Humidity: 0 to 100 percent (3) Pressure: 1 to 60 in. Hg (4) Temperature: −130 F to +130 F (5) Heat sink: Ambient air or provided coolant, with variable but relatively large thermal sink available	(1) Environmental shield: (a) To eliminate contamination from sand, dust, and humidity (b) To maintain pressure (2) Provisions for heating and/or cooling to maintain constant temperature with low thermal energy dissipation
Same as above	(1) Environmental shield: (a) To eliminate moisture (b) To maintain pressure (2) Provisions for cooling (3) Provisions to eliminate arcover due to high voltages.
(1) Pressure: 5 to 30 in. Hg (2) Temperature: −65 F to +120 F (3) Tends to utilize environment with moderately preconditioning air or other coolant, usually exhaust to ambient	(1) Sealed pressurized environment (2) Provisions for circulation of fluid: (a) To allow high local thermal density (b) To provide stable dielectric for capacitors
Same as above	(1) Sealed pressurized environment (2) Provisions for fluid cirdulation and distribution
Either as above or with a liquid sink, as provided aboard ships	(1) Provisions for liquid cooling of specified components, with safety interlocks, or (2) Provisions for use of liquid for cooling or air circulated through electrical components

GAS CYCLE



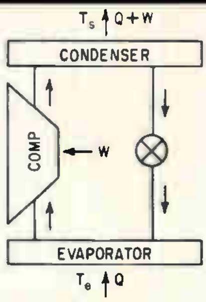
$$COP = \frac{Q}{W} \text{ (COEFFICIENT OF PERFORMANCE)} = \frac{1}{\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1}$$

P_1 = GAS PRESSURE IN COLD EXCHANGER

P_2 = GAS PRESSURE IN HOT EXCHANGER

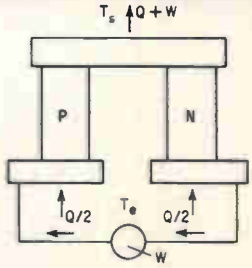
$\gamma = \frac{C_p}{C_v}$ = RATIO OF GAS SPECIFIC HEATS

VAPOR CYCLE



$$COP = \frac{Q}{W} \text{ (COEFFICIENT OF PERFORMANCE)} = \frac{\frac{L}{C_g T_e} - \frac{C_e}{C_g}\left[\frac{T_s}{T_e} - 1\right]}{\left[\frac{T_s}{T_e}\right](1-\frac{C_e}{C_g})\left[\frac{L}{C_g T_e}(1-\frac{T_e}{T_s}) - (1-\frac{C_l}{C_g})(1-\frac{T_e}{T_s})\right] - 1}$$

THERMOELECTRICS



$$COP = \frac{Q}{W} \text{ (COEFFICIENT OF PERFORMANCE)} = \frac{T_e}{T_s - T_e}\left(\frac{\sqrt{1+Z\bar{T}} - \frac{T_s}{T_e}}{\sqrt{1+Z\bar{T}} + 1}\right)$$

$$\bar{T} = \frac{T_e + T_s}{2}$$

$Z \simeq 3 \times 10^{-3}/°K$ (FIGURE OF MERIT)

FIG. 4—The three heat-pump processes and their equations. Depending on design considerations, any of the three cycles may be the most suitable in a problem

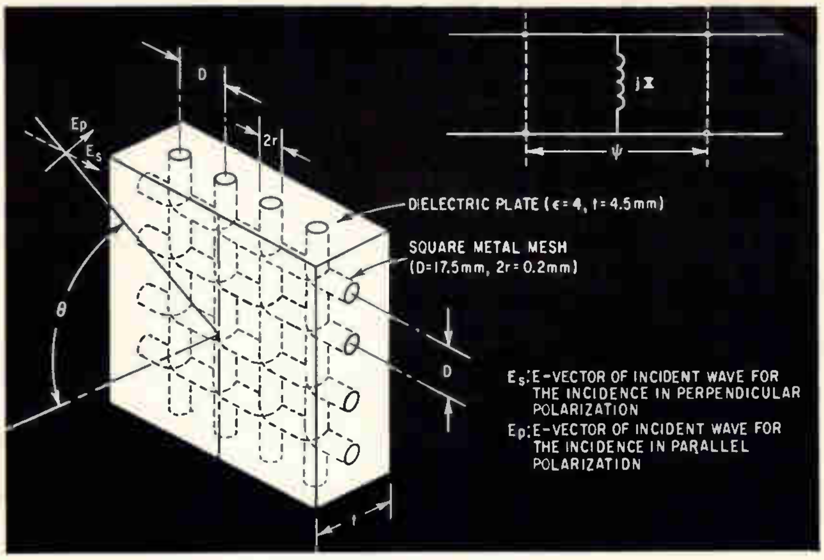


FIG. 1—Structure of metal-mesh panel with equivalent circuit. Figures in parentheses are typical design values

Table I — REFLECTION AND TRANSMISSION IN THE WORST COMBINATIONS (3,950 MC, VERTICAL INCIDENCE)

Combinations	Radome Becomes Capacitive $\epsilon = 4.4$, $t = 6.5$ mm, $2r = 0.18$ mm, $D = 20.5$ mm, $\tan\delta = 0.02$	Radome Becomes Inductive $\epsilon = 3.6$, $t = 3.5$ mm, $2r = 0.22$ mm, $D = 14.5$ mm, $\tan\delta = 0.02$
Voltage (power) reflection coefficient	31.2% (9.7%)	41.5% (17.2%)
Reduction of transmitted power due to dielectric lens	2.2%	1.1%
Transmission coefficient	88.1% (−0.55 db)	81.7% (−0.87 db)
Phase angle of transmitted wave compared to free space propagation (lead +, lag −)	−21.05° (−1/17 λ)	24.25° (+1/15 λ)
Voltage (power) reflection coefficient of dielectric plate without metal mesh	59.0% (34.9%)	33.8% (11.4%)
Power transmission coefficient in the above case	63.7% (−1.96 db)	87.7% (−0.57 db)

Table II — REDUCTION OF ANTENNA GAIN BY RADOME (IN DB)

Antenna Number	3,700 Mc	3,950 Mc	4,200 Mc	Average
1	−0.81	−1.03	−0.87	−0.90
2	−0.56	−0.45	−0.44	−0.48
3	−0.67	−0.72	−0.78	−0.72
4	−0.78	−0.60	−0.39	−0.59
5	−0.76	−0.81	−0.96	−0.84
Average	−0.72	−0.72	−0.69	−0.71

Metal-Mesh

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CIRCULARLY POLARIZED wave antennas using this metal-mesh embedded dielectric radome are now being used on a 4,000 Mc multichannel relay link in Japan. The structure of the radome panel and its equivalent circuit are shown in Fig. 1. This radome has a shape symmetrical with its paraboloidal mirror and has a diameter of 3.3 meters.

The dielectric is made of glass fiber reinforced polyester resin with a thickness of 4.5 mm and is designed to withstand wind velocities of 60 meters per second.

If the equivalent parallel reactance of the mesh (shown in Fig. 1) is X, the reflection and transmission coefficients of the panel are

$$R = \frac{-(\epsilon'+1)-(\cos\psi-2X\sin\psi)(\epsilon'-1)}{(\epsilon'-1)+(\cos\psi-2X\sin\psi)(\epsilon'+1)+2j\sqrt{\epsilon'}\,(\sin\psi+2X\cos\psi)}$$

$$T = \frac{4j\sqrt{\epsilon'}\,X}{\text{(same denominator as } R)} \quad (1)$$

where the incidence in perpendicular polarization is $\epsilon' = (\epsilon - \sin^2\theta)/(\cos^2\theta)$, the incidence in parallel polarization is equal to $(\epsilon^2\cos^2\theta)/(\epsilon - \sin^2\theta)$, $\psi = (2\pi t/\lambda)\sqrt{\epsilon - \sin^2\theta}$, t is the panel thickness, ϵ is the specific dielectric constant, θ is the angle of incidence and λ is the free space wavelength.

The radome may be designed so that R vanishes at a specified angle of incidence ($\theta = 0$).

Reactance (X) of the mesh is related to wire spacing D and wire radius r by

$$X^{\binom{s}{p}} \simeq \frac{D}{\lambda}\sqrt{\epsilon - \sin^2\theta}\left\{\ln\left(\frac{D}{2\pi r}\right) + 0.601\left(\frac{D}{\lambda}\right)^2 \begin{pmatrix}\epsilon + 2\sin^2\theta \\ \epsilon - \sin^2\theta\end{pmatrix}\right\} \quad (2)$$

where the upper expression (s) is perpendicular polarization and the lower expression (p) is the parallel polarization.

This equation is for the incidence plane parallel to one of the constituent parallel wires of Fig. 1

Embedded Dielectric Radome

Design of a special type of radome in which the capacitive reflection of the panel is cancelled by the inductive reflection of an embedded metal mesh

and analagous formulae can be worked out for other planes of incidence. Equation 2 can be derived on the assumption of r/D, $D/\lambda << 1$ and the nonexistence of higher mode interferences between the mesh and the panel surface. Wire spacing D should be chosen so that higher mode waves produced on the mesh are sufficiently attenuated during the propagation between the mesh and penel surface. For design dimensions illustrated in Fig. 1, Eq. 2 has been estimated to be in error by less than a few percent of its value.

Some examples of calculations using Eqs. 1 and 2 are shown in Fig. 2. Figure 2A shows the frequency and incidence angle dependences of the panel with the design dimensions of Fig. 1. Figures 2B and 2C illustrate the effects of manufacturing errors, with Fig. 2B showing errors with respect to the dielectric panel and Fig. 2C with respect to the metal mesh. The limits of manufacturing errors are such to cover the range of actual errors with a sufficient factor of safety.

To estimate the worst possible gain reduction of the antenna due to the radome, the individual manufacturing errors are combined so that the reflection coefficients add in the same direction on the complex reflection coefficient chart as shown in Figs. 2B and 2C. There are two extreme unfavorable cases where the radome as a whole becomes capacitive or inductive. Table I shows the resulting data for such cases together with those for the panel without metal-mesh compensation.

Manufacturing errors may cause a transmission loss of within 1 db at the center frequency and at the vertical incidence for the radome with metal-mesh compensation while the radome without metal-mesh compensation reduces the antenna gain by about 2 db. The extent of phase irregularities of the transmitted wave can also be seen in the table, but its effect on antenna gain may be disregarded because the value near $\pm\lambda/16$ is the same order of magnitude as expected on a mirror antenna with the mirror surface accuracy of $\pm\lambda/32$ tolerance generally approved.

Table II tabulates measured gain reductions due to the radomes. It is evident from the table that gain reductions by the radomes are less than that expected for radomes without metal-mesh compensation. However, they do not differ much from those expected for the metal-mesh compensated panel with the worst accumulation of manufacturing errors. There might have been other causes to reduce the apparent gain of the antenna such as the forward bending of the antenna mounting tower when the radome was mounted—the weight of the radome is 130 Kg compared with a net antenna weight of 420 Kg and the weight of direction setting rack of about 150 Kg.

For these first practical radomes, the strict suppression of reflection has not been required because the antennas are to use circularly-polarized waves. Further, the reflected wave from the radome will not directly return to the feedhorn owing to the special shape of the radome. No special efforts were made to reduce manufacturing errors on these radomes to the minimum possible values, but following the analysis discussed in this article, the transmission line loss can be reduced to less than 0.3 db by strict control of manufacturing errors.

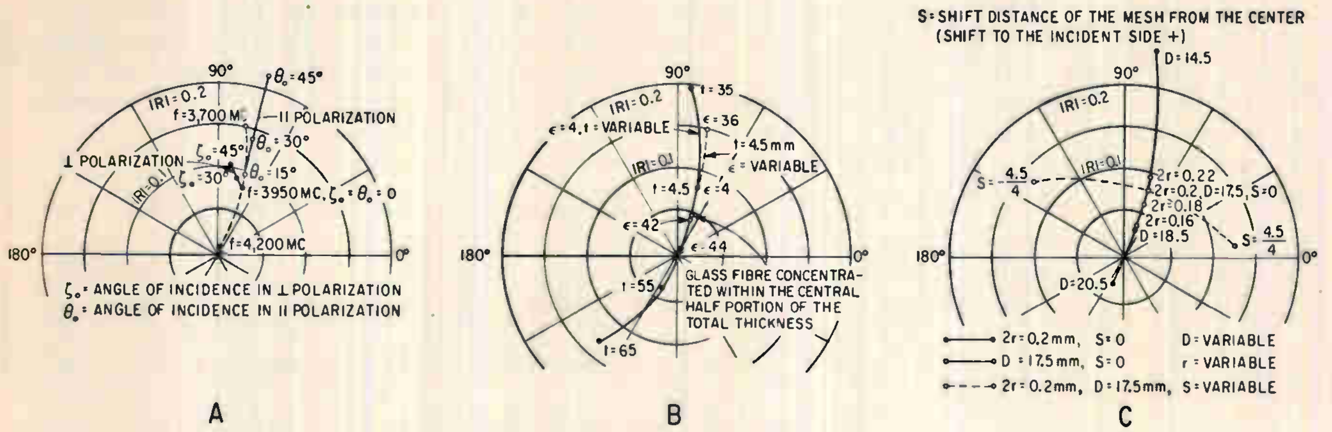

FIG. 2—Calculated voltage reflection coefficient of radome (A). Dielectric constant of plate thickness versus calculated voltage reflection coefficient, 3,950 Mc vertical incidence, mesh dimensions as designed with ϵ and t varied (B). Mesh dimensions versus calculated reflection coefficient, 3,950 Mc, vertical incidence, dielectric plate remaining as designed with r, D and S varied (C). In all three, phase angle refers to incident-side surface of dielectric plate

Applications of the

Experimental diode reduces the effect of varying supply voltages and spurious feedback in low-frequency transistor circuits. In many cases the diode replaces several transistors and associated components

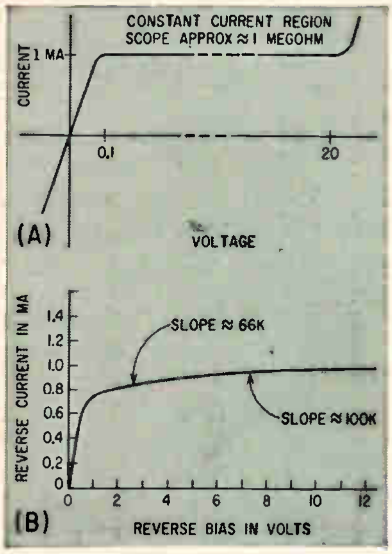

FIG. 1—Characteristics of a typical constant-current diode (A) compared with a germanium junction diode (B)

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THE CONSTANT-CURRENT-DIODE was first introduced at the British Physical Society Exhibition in 1960 but to date circuit designers have shown little interest in this device.

Although true constant-current-diodes are presently unobtainable, most of the applications described here have been tested experimentally and the results quoted. This has been possible because a satisfactory substitute is available, although suitable only at laboratory temperatures.

The results show that improvements in many low-frequency circuits can be obtained. In some cases, such as audio amplifiers, the amount of circuitry required to meet a given specification can be greatly reduced. In decoupling circuits and voltage stabilizers, results which were hitherto out of the question are easily obtained.

A typical constant-current diode characteristic is shown in Fig. 1A. The important parameters are the lowest operating voltage, the current passed throughout the constant current region, the highest operating voltage and the slope resistance. In Fig. 1A these values are 0.1, 1 ma, 20 v and 1 megohm respectively.

Since little work has been done with regard to manufacturing in quantity, these figures might be quite different in production.

As the reverse leakage current of a large germanium junction diode may be of the order of 1 ma and constant over a wide range of applied voltage, this is a suitable substitute for the constant-current-diode. It is not a completely satisfactory substitute, since a physically large diode is required to obtain useful amounts of current, and its characteristics are extremely temperature-dependent.

In most applications, the actual value of the constant current is unimportant and a drift of ± 30 percent can be tolerated. Although high-temperature operation is impracticable with the substitute, normal laboratory temperature variations can be tolerated. This substitute has proved invaluable for the practical work required to confirm some of the predictions made.

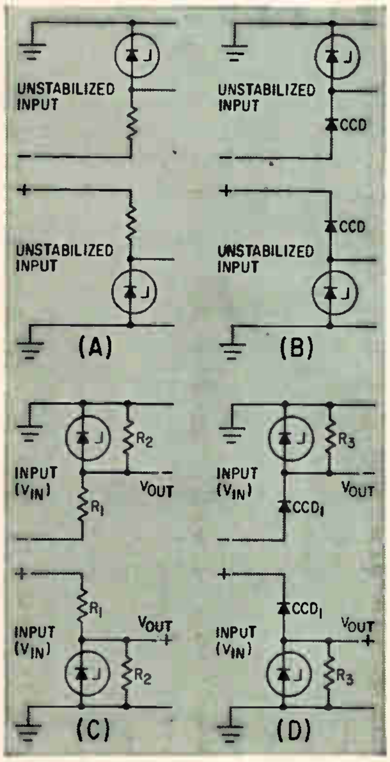
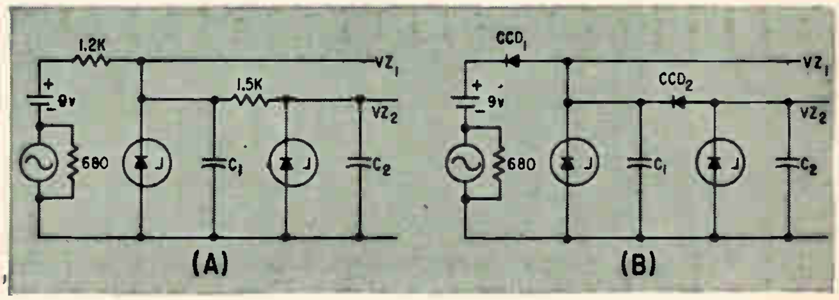


FIG. 2—Unmodified (A) and modified (B) reference circuits. Unmodified (C) and modified (D) low-power stabilizers

FIG. 3—Cascaded decoupling circuits with resistor feed (A) and constant-current diode feed (B)



Constant-Current Diode

The diode used for all the experimental work was the VA713E germanium junction diode for which a typical characteristic is shown in Fig. 1B. In this case, the slope is about 100,000 ohms which is not up to the expected slope of the original constant current diode, thus the circuit results obtained are slightly pessimistic.

In a conventional transistorized voltage stabilizer circuit the reference voltage, with which the final output is compared, is obtained by a Zener diode as shown in Fig. 2A.

If the final output from the stabilizer loop is of lower voltage than that of the Zener diode, diode current has to be supplied from the unstabilized bus. As this varies, the Zener diode current varies and causes a change in Zener voltage so that the stabilized output varies as the input voltage varies. Compensation can be applied by coupling a fraction of the unstabilized input into the loop amplifier so as to cancel the Zener variation. This has the disadvantage that the coupling must be adjusted on every unit, as Zener diode impedances differ.

The constant-current-diode may be used to solve this problem as shown in Fig. 2B, where it replaces the Zener diode feed resistor. Zener current is now constant for wide variations in applied voltage. An even more convincing case is shown in Figs. 2C and 2D where the Zener diode is used as a low power stabilizer.

The choice of R_1 in Fig. 2C is governed by the minimum value of V_{in} and the value of R_2. In fact, the current in R_1 must exceed that in R_2. Similarly, in Fig. 2D the constant-current diode current must exceed the current in R_3.

Two advantages of Fig. 2D against Fig. 2C are that maximum permissible V_{in} is determined by the maximum constant-current diode voltage, rather than maximum Zener dissipation (which is low and constant in Fig. 2D) and that variations in V_{in} have virtually no effect.

The two circuits have been compared experimentally using Zener diode SX68 (6.8 v), a 12,000-ohm load, and R_1 of 1,000 ohms. For V_{in} below 7.3 v in Fig. 2C, the Zener current falls to zero and the diode loses control. At V_{in} of 50 v, Zener voltage will rise considerably and dissipation approaches 300 mw. In Fig. 2D, the current passed by CCD_1 will be reasonably constant for V_{in} above 6.9 v, and virtually no variation in Zener voltage will take place. Experiments have confirmed this reasoning.

As the impedance of a Zener diode is constant over a wide range of frequencies, it follows from these results that the circuit of Fig. 2D is effective for decoupling signal circuits and reducing power supply ripple. At high frequencies, the constant-current diode impedance falls owing to its capacitance and the decoupling performance is then worse. A capacitor of 1 μf in parallel with the Zener diode will remedy this condition. Since little d-c voltage need be lost across the constant-current diode, it is quite practicable to use two such circuits in cascade as in Fig. 3B. The essential design condition is that CCD_1 should pass more current than CCD_2.

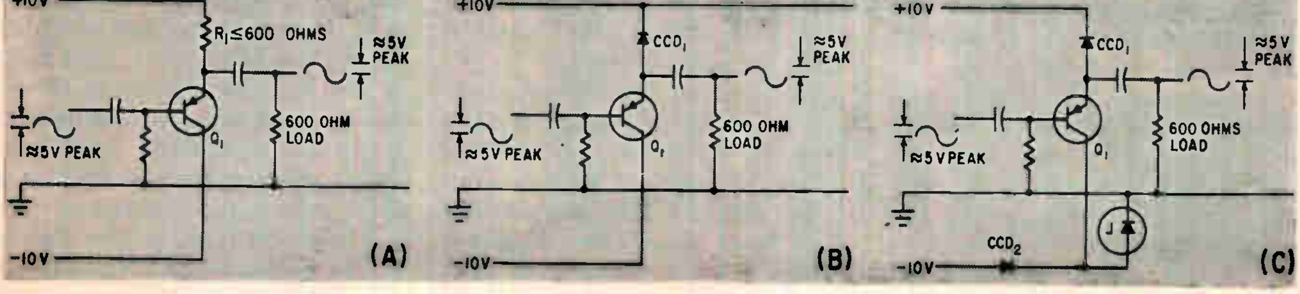
The decoupling performance of this circuit in comparison with the similar circuit using resistors (Fig. 3A) has been measured and the performance of Fig. 3B found to be consistently good at all frequencies up to 200 kc giving an attenuation of about 100 db. The Fig. 3A version becomes comparable only at high frequencies where C_1 and C_2 become low reactances, and has a typical attenuation of 40 db at low frequencies.

The form of decoupling illustrated by Fig. 3B is particularly useful for preventing spurious feedback in amplifiers caused by phase shift introduced by an r-c filter, and where normal Zener diode decoupling is insufficient or gives too great a d-c voltage drop.

The emitter resistor of amplifying stages and emitter followers can often be replaced by constant-current diodes, resulting in much less dependence of working point on supply voltage. In the case of emitter followers, a gain closer to unity is obtained; in emitter-coupled pairs, improved rejection of push-push signals applied to the bases is obtained as well as more equal outputs from the two collectors.

A less obvious result is a lower transistor dissipation when used as

FIG. 4—Use of constant-current diode in emitter-follower output stages with conventional circuit (A) and modified circuits (B) and (C)



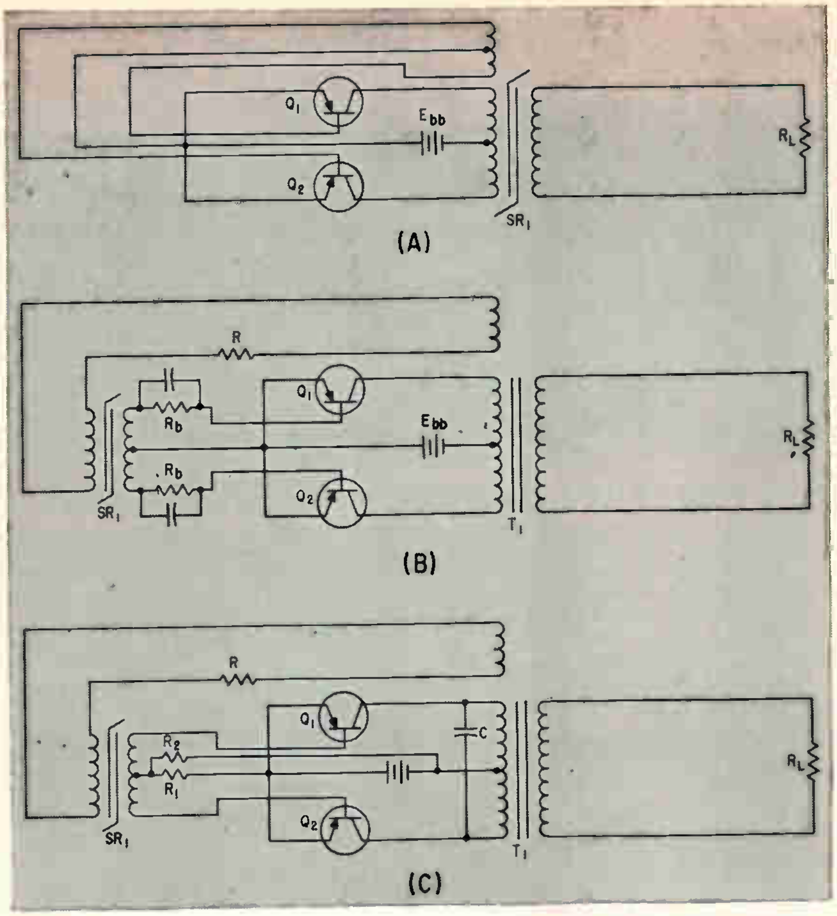
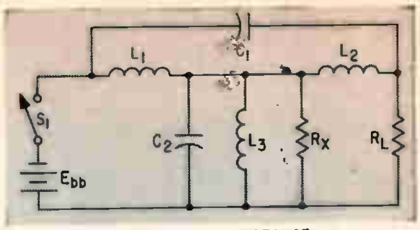


FIG. 1—*Basic d-c to d-c converter circuits include Royer (A), Jensen (B) and modified Jensen (C)*



L_1 PRIMARY LEAKAGE INDUCTANCE
L_2 SECONDARY LEAKAGE INDUCTANCE
L_3 OPEN CIRCUIT INDUCTANCE
C_1 SHUNT CAPACITANCE
R_x EXCITING LOSSES
R_L REFERRED LOAD RESISTANCE
E_{bb} BATTERY VOLTAGE
S_1 IDEALIZED TRANSISTOR
C_2 INTEGRATING CAPACITOR

FIG. 2—*Equivalent of Jensen output circuit*

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Reducing Spikes in D-C to

MANY APPLICATIONS require a high voltage from some low voltage d-c source and a d-c to d-c converter is the obvious circuit selection. However, one aspect of converter use is detrimental to circuit operation—spike content in the filtered output. This converter was designed to change 30 v d-c to 325 v d-c with a minimum peak-to-peak spike content in the output.

The simple converter has a typical spike output on the order of 100 mv p-p and is not suitable for this application.[1] A slightly more sophisticated converter produced spike contents about half that of the simple circuit.[2] The circuit used is a modification of the Jensen circuit and is shown in Fig. 1.

Causes of spike generation are leakage inductance in the transformer, storage time in the transistors, shunt capacitance and rectifier switching or commutation in the output rectifier circuit. The best design approach is to minimize these effects and obtain less abrupt switching in the power transistors while still getting reasonable operating efficiencies. Filtering out the spikes is no simple matter because of frequency spectrum composition of the spikes and cost considerations. The best way to minimize amplitude is to prevent spike generation rather than filtering.

The equivalent circuit of the Jensen converter, Fig. 2, shows that the leakage inductance of the coupling transformer is one of the main causes of switching spikes. Spike amplitude at the output is $-L\ di/dt$ times the turns ratio of the transformer, a ten-to-one step up. The abruptness of the switching transition has a direct bearing on this spike. This suggests that integration of the square wave would sufficiently soften the switching characteristic and reduce spike content.

An energy storage element (C_2) for the transformer's collapsing field after a transistor has switched state and low-leakage, low-capacitance transformer design bring about a sufficient decrease in spike content to make the supply useful.

In the final circuit (Fig. 3) transistors with a high alpha cut-off frequency and loading networks across the output bridge rectifiers help reduce spike content. The networks reduce diode switching effects.

The timing transformer saturates at the proper volt-second product to achieve 1-kc timing. This saturable transformer was designed around a material with a fairly low B_r/B_s ratio. A more "square" material gives greater spike content because of more abrupt core switching. Linear coupling transformer T_1 uses C-core construction to give a large primary inductance, aiding the integration effect of C_1 and C_2 across the primary of the transformer.

Constant-Current Diode

The diode used for all the experimental work was the VA713E germanium junction diode for which a typical characteristic is shown in Fig. 1B. In this case, the slope is about 100,000 ohms which is not up to the expected slope of the original constant current diode, thus the circuit results obtained are slightly pessimistic.

In a conventional transistorized voltage stabilizer circuit the reference voltage, with which the final output is compared, is obtained by a Zener diode as shown in Fig. 2A.

If the final output from the stabilizer loop is of lower voltage than that of the Zener diode, diode current has to be supplied from the unstabilized bus. As this varies, the Zener diode current varies and causes a change in Zener voltage so that the stabilized output varies as the input voltage varies. Compensation can be applied by coupling a fraction of the unstabilized input into the loop amplifier so as to cancel the Zener variation. This has the disadvantage that the coupling must be adjusted on every unit, as Zener diode impedances differ.

The constant-current-diode may be used to solve this problem as shown in Fig. 2B, where it replaces the Zener diode feed resistor. Zener current is now constant for wide variations in applied voltage. An even more convincing case is shown in Figs. 2C and 2D where the Zener diode is used as a low power stabilizer.

The choice of R_1 in Fig. 2C is governed by the minimum value of V_{in} and the value of R_2. In fact, the current in R_1 must exceed that in R_2. Similarly, in Fig. 2D the constant-current diode current must exceed the current in R_3.

Two advantages of Fig. 2D against Fig. 2C are that maximum permissible V_{in} is determined by the maximum constant-current diode voltage, rather than maximum Zener dissipation (which is low and constant in Fig. 2D) and that variations in V_{in} have virtually no effect.

The two circuits have been compared experimentally using Zener diode SX68 (6.8 v), a 12,000-ohm load, and R_1 of 1,000 ohms. For V_{in} below 7.3 v in Fig. 2C, the Zener current falls to zero and the diode loses control. At V_{in} of 50 v, Zener voltage will rise considerably and dissipation approaches 300 mw. In Fig. 2D, the current passed by CCD_1 will be reasonably constant for V_{in} above 6.9 v, and virtually no variation in Zener voltage will take place. Experiments have confirmed this reasoning.

As the impedance of a Zener diode is constant over a wide range of frequencies, it follows from these results that the circuit of Fig. 2D is effective for decoupling signal circuits and reducing power supply ripple. At high frequencies, the constant-current diode impedance falls owing to its capacitance and the decoupling performance is then worse. A capacitor of 1 μf in parallel with the Zener diode will remedy this condition. Since little d-c voltage need be lost across the constant-current diode, it is quite practicable to use two such circuits in cascade as in Fig. 3B. The essential design condition is that CCD_1 should pass more current than CCD_2.

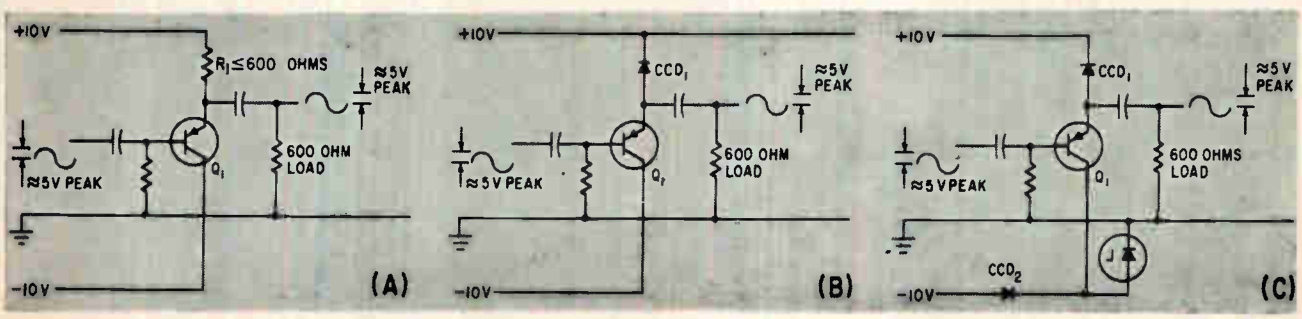
The decoupling performance of this circuit in comparison with the similar circuit using resistors (Fig. 3A) has been measured and the performance of Fig. 3B found to be consistently good at all frequencies up to 200 kc giving an attenuation of about 100 db. The Fig. 3A version becomes comparable only at high frequencies where C_1 and C_2 become low reactances, and has a typical attenuation of 40 db at low frequencies.

The form of decoupling illustrated by Fig. 3B is particularly useful for preventing spurious feedback in amplifiers caused by phase shift introduced by an r-c filter, and where normal Zener diode decoupling is insufficient or gives too great a d-c voltage drop.

The emitter resistor of amplifying stages and emitter followers can often be replaced by constant-current diodes, resulting in much less dependence of working point on supply voltage. In the case of emitter followers, a gain closer to unity is obtained; in emitter-coupled pairs, improved rejection of push-push signals applied to the bases is obtained as well as more equal outputs from the two collectors.

A less obvious result is a lower transistor dissipation when used as

FIG. 4—Use of constant-current diode in emitter-follower output stages with conventional circuit (A) and modified circuits (B) and (C)



an emitter follower supplying a heavy external load. Figure 4A shows an example where an output of 5 v peak is required in a 600-ohm load, with ± 10 v supplies. When the input signal reaches its positive peak of + 5 v the load current is 8.33 ma. The drop across R_1 is now 5 v and in order that Q_1 is not cut off, R_1 must pass more than 8.33 ma. Thus, R_1 should be less than 600 ohms. Under quiescent conditions, Q_1 emitter is near zero and so standing current is 16.7 ma and transistor dissipation 166 mw.

In Fig. 4B, R_1 is replaced by CCD_1 which must pass 8.33 ma as explained previously. In this case quiescent dissipation will be 83 mw. Thus, power consumption is halved and as the signal load is 600 ohms instead of 300 ohms the voltage gain is nearer unity (typically 0.975 instead of 0.95 for an OC72 in the circuit described).

Finally, one of the main difficulties associated with a high current output stage of this type is the amount of ripple produced on the supply lines. This can be overcome by a further simple modification illustrated in Fig. 4C. The current values of CCD_1 and CDD_2 are chosen so that neither the transistor nor the Zener diode cuts off on positive and negative input swings respectively.

The circuits described have been tried only at low current values owing to the limited currents available from the VA713 diodes used.

In amplifier circuits where the collector voltage is defined by an external loop, the collector load can be replaced by a constant-current diode to give greatly increased gain. The gain of a grounded-emitter amplifier with a large collector load approaches r_c divided by r_b (using T equivalent circuit parameters), a value of 700 to 1,000 for most small-signal transistors. This is the order of gain achieved in practice using the constant-current diode as described. The test circuit is shown in Fig. 5.

In most cases, the amplifier supplies an external load which appears in parallel with the constant-current diode and reduces the gain. This effect can be removed by isolating the load from the collector circuit with emitter followers, but in some applications it would be more economical to use the transistors in two normal amplifying stages.

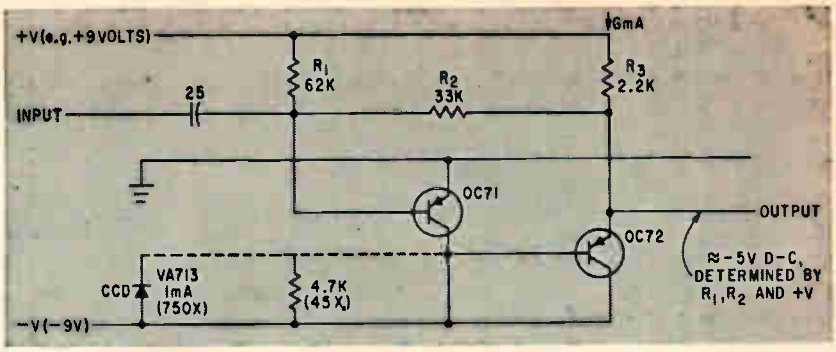


FIG. 5—With resistive load, gain is 45; with constant-current diode load, gain increases to 750

However, where emitter followers must be present for other reasons, advantage can be taken of the new circuit. One such circuit is the conventional voltage stabilizer, where the main amplifier has to be followed by emitter followers to reduce the fraction of d-c load current flowing in the collector load of the amplifier. A typical circuit is shown in Fig. 6A; here the gain of the amplifier is typically about 30. If a lower output resistance is required, the only successful modification (other than applying positive feedback within the amplifier, which reduces the bandwidth) is to add an additional amplifier. When coupling losses are taken into account, the overall gain will hardly exceed 500.

The simple modification shown in Fig. 6B immediately raises the gain to about 700. The disadvantage is that frequency response is reduced owing to capacitance strays (particularly collector capacitance) in parallel with the collector load, which now approaches 1-megohm. However, with transistor types usually employed in this kind of circuit, frequency response is mainly determined by cutoff frequency, even with such a high collector load, so that little deterioration is actually observed.

Note that in this stabilizer circuit, the collector voltage of Q_2 is defined by the overall loop connected back to its base. If this were not so, the quiescent collector potential of Q_2 would be unknown, as at any voltage over a wide range CCD_1 would still pass the same current.

The problem illustrated in Fig. 7A is the familiar requirement of a large output voltage swing with limited supply voltages. The usual solution is to operate the final transistor near the positive supply voltage, thus allowing the collector a large swing. The difficulty lies in coupling signals into this transistor. The illustrated Zener diode coupling is usual but the necessity for resistor R causes a drop in gain of the previous stage unless an emitter follower is inserted.

Replacing of R by a constant-current diode immediately solves the problem. If R_1, R_2 and R_3 are also replaced by constant-current diodes, the circuit is independent of the positive line and spurious feedback over this line eliminated.

Figure 7B shows a simple circuit for producing a ramp function from an input step. Using this principle, almost any circuit for producing exponential waveforms can be made to give linear functions without the use of Miller or bootstrap circuits. The use of two diodes in series, back to back, enables either direction of current to be handled.

A somewhat similar application for a clipping circuit is shown in Fig. 7C where a Zener diode is being used as the clipping element. Normally a series resistor is used, but for sine-wave inputs this results in curved upper and lower limits on the output signal. This is due to the variation in Zener current during input peaks and troughs. A constant-current-diode provides a simple solution, the resulting waveform being quite square.

Figure 7D is a modified version of the conventional stabilizer cir-

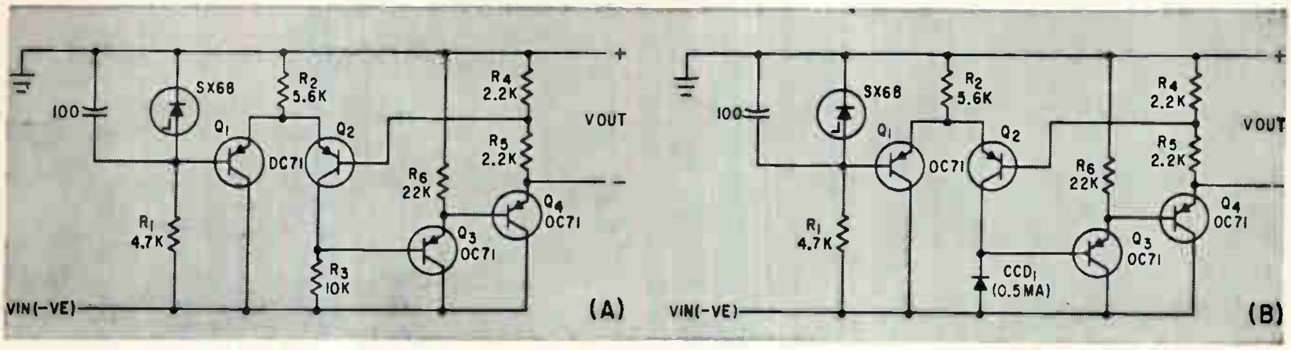


FIG. 6— Voltage stabilizer (A) and high-gain voltage stabilizer (B) showing use of constant-current diode as a collector load

cuit of Fig. 6A, using many of the features described above. With the circuit values shown in Fig. 6A and Fig. 7D, the performance of each circuit is shown graphically in Fig. 8.

The improvement is obvious, and to achieve a similar result with conventional techniques, at least one extra stage of gain would be required in Fig. 6A with consequent complications in preventing oscillations round the feedback loop.

Further advantage of the use of constant-current-diodes in this type of circuit become evident when considering the typical requirement of an adjustable stabilized output voltage. In Fig. 6A there are two ways of achieving a variable output. One is to place a potentiometer in parallel with the Zener diode and take the base of Q_1 to the slider. Another is to vary the ratio of R_1 to R_3.

The first method has a serious disadvantage. As the output is adjusted to a low level (near ground) the current in R_2 is reduced and the current in R_3 is increased. As soon as these currents become equal, Q_1 cuts off and stabilization is lost. Thus, the possible range of control by this means is limited.

The second method has the equally troublesome feature that the gain of the feedback loop and therefore the phase angle and magnitude of the output impedance vary according to the output voltage setting. In Fig. 7D, the first method can be used with no disadvantage as the currents in CCD_2 and CDD_3 remain constant and the minimum possible stabilized output will be determined only by the minimum operating voltage (approximately 0.1 v) of diode CCD_2.

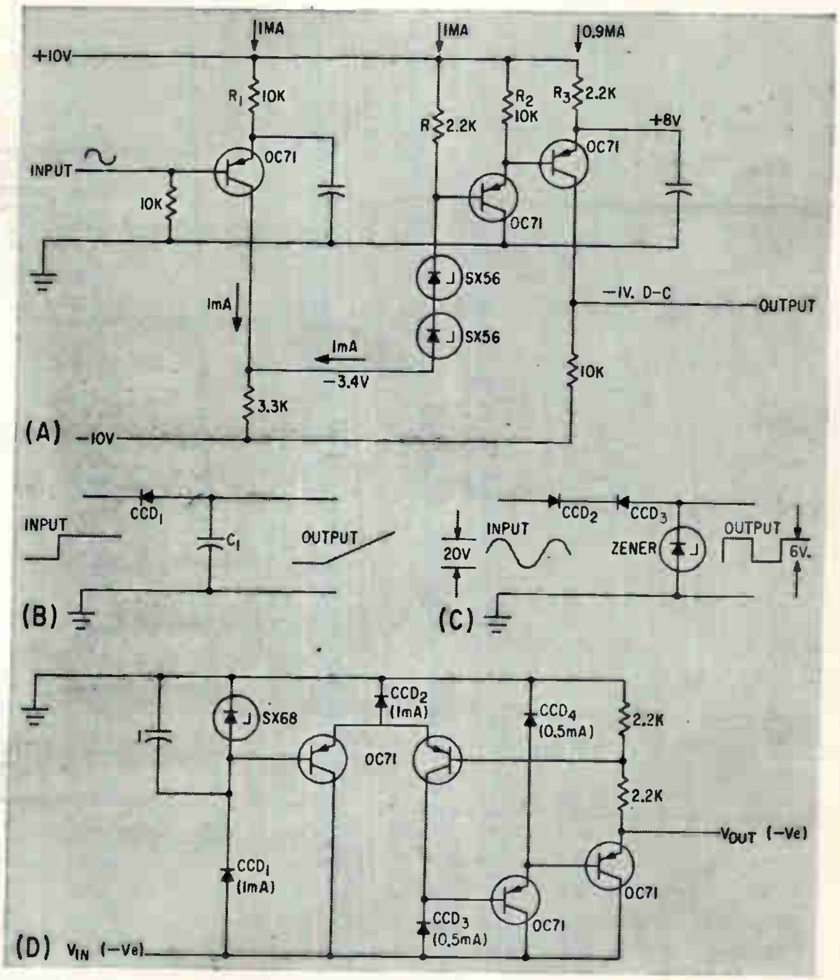
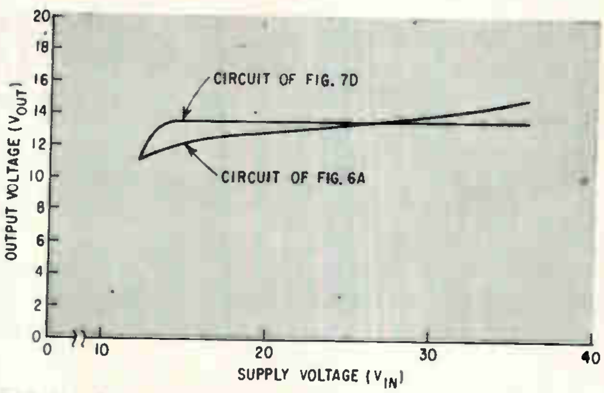


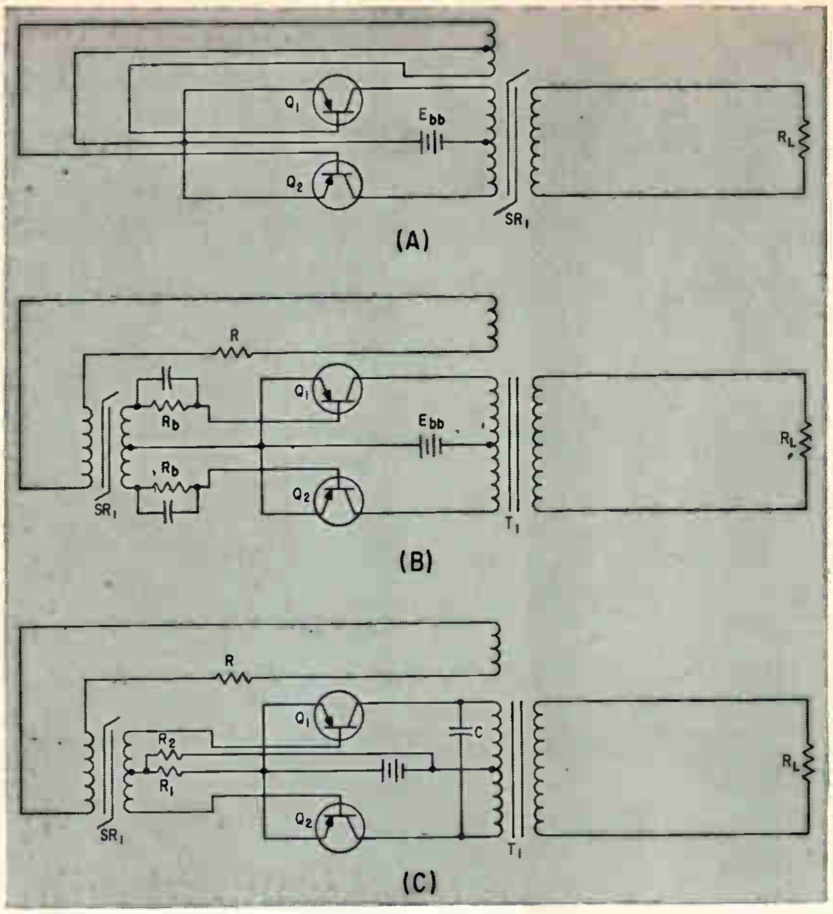
FIG. 7—Typical interstage coupling problem (A). Constant-current diode as linear charger (B) and as clipper (C). Voltage stabilizer showing several applications of constant-current diode (D)

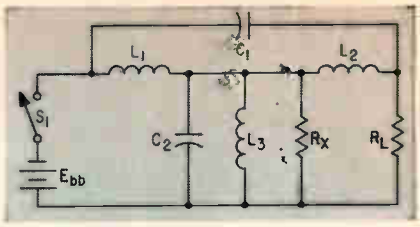


OUTPUT RESISTANCE (APPROX)	
CIRCUIT OF FIG. 7D	0.1 Ω
CIRCUIT OF FIG. 6A	2 Ω

% CHANGE IN V_{IN} / % CHANGE IN $_{OUT}$	
CIRCUIT OF FIG. 7D	>600
CIRCUIT OF FIG. 6A	≃ 5

FIG. 8—Comparative performance of two stabilizer circuits





L_1 PRIMARY LEAKAGE INDUCTANCE
L_2 SECONDARY LEAKAGE INDUCTANCE
L_3 OPEN CIRCUIT INDUCTANCE
C_1 SHUNT CAPACITANCE
R_x EXCITING LOSSES
R_L REFERRED LOAD RESISTANCE
E_{bb} BATTERY VOLTAGE
S_1 IDEALIZED TRANSISTOR
C_2 INTEGRATING CAPACITOR

FIG. 2—Equivalent of Jensen output circuit

FIG. 1—Basic d-c to d-c converter circuits include Royer (A), Jensen (B) and modified Jensen (C)

By C. J. BIGGERSTAFF,
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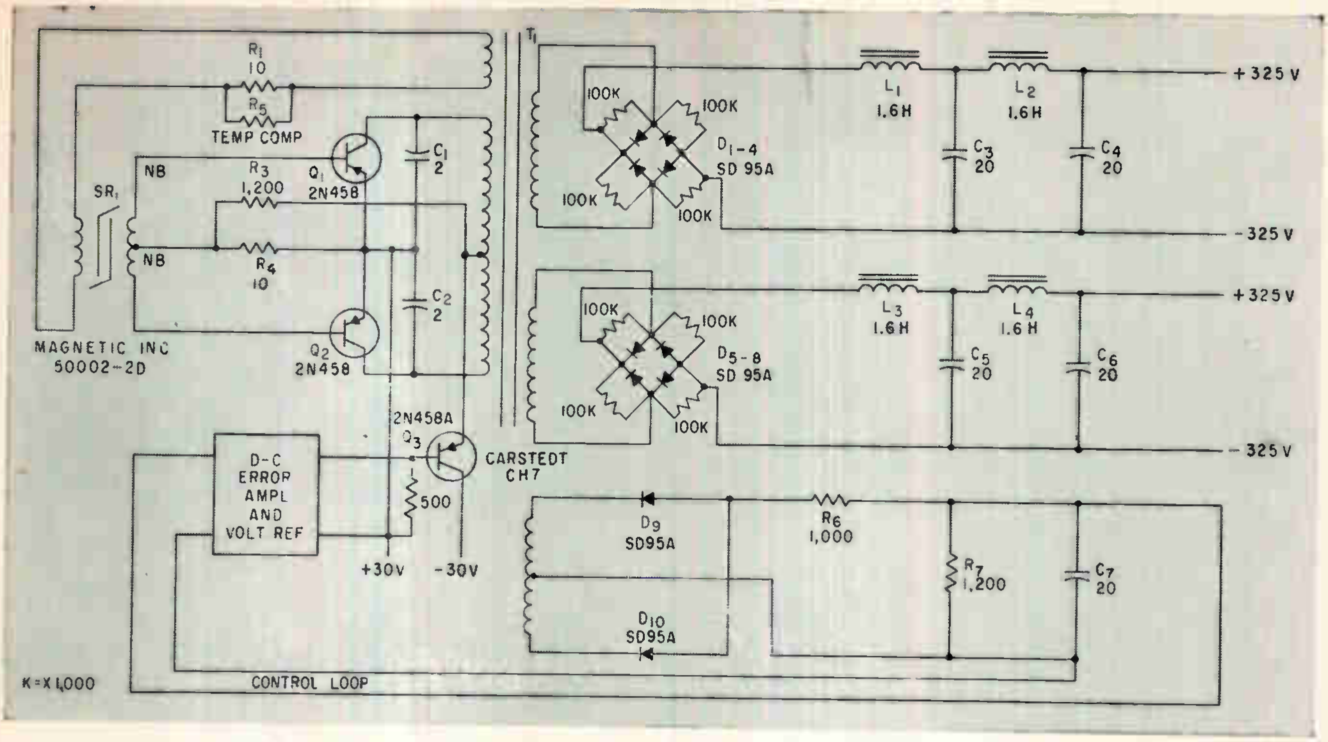

FIG. 3—Output of the two 325-v supplies totals 12 watts. Voltage varies ± 10 volts

D-C Converter Outputs

Loop gain of the Jensen converter is adjusted for optimum oscillatory conditions over the temperature range by R_5. The R-C speed-up networks in the base circuits of Q_1 and Q_2 were deleted. Current limiting is obtained by starting resistor R_1. The secondary winding resistance of SR_1 is purposely made high to aid in base current limiting.

Time constant of the integrator consisting of the primary inductance of T_1 and C_1 and C_2 is sufficient to reduce the output spike from 45 mv to 4 mv peak to peak. The rms content at the output is approximately one-sixth of this figure. Filtered frequency is about 2 kc depending upon input voltage.

Overall regulation of the output is achieved through the control loop amplifier. The a-c error voltage from the output transformer is rectified and filtered. In the d-c amplifier this filtered output is compared to a Zener diode reference. Output of the d-c amplifier controls Q_3. Regulation is a function of loop amplifier gain and reference stability.

Coupling transformer T_1 is, in effect, a pulse transformer. Its primary inductance must be chosen on the basis of waveform droop (percent droop = $50\, R_L(t\text{-}t_o)/L_p$). Here, R_L is the reflected load impedance, $(t\text{-}t_o)$ the switching time and L_p the desired primary inductance.[3] A satisfactory droop is 10 percent. Once the primary inductance is known, then the value of the capacitance may be found by calculating the amount of integration or slow-up desired. Overall effect of integration must be determined experimentally because of the large number of variables. Minimizing both leakage flux and capacitive coupling are incompatible, however several approaches achieve an acceptable compromise.

Selection of the core for minimum core loss and maximum permeability is the first requisite. A C-type core of 2 or 4-mil gage thickness, can be used. Since both leakage and capacitive problems are a function of the core-coil geometry, care must be given to the winding layout. A double-coil arrangement using both legs of the C-core should be used. Two identical coils are wound. On each coil ¼ the total secondary turns is wound above and below ½ the total primary turns. Then after assembly of the core, the two coils are tied together so that both sections of the primary and all four of the secondary sections are in series. Electrostatic shielding of 1 or 2-mil copper foil is used between each section of the primary and secondary windings.

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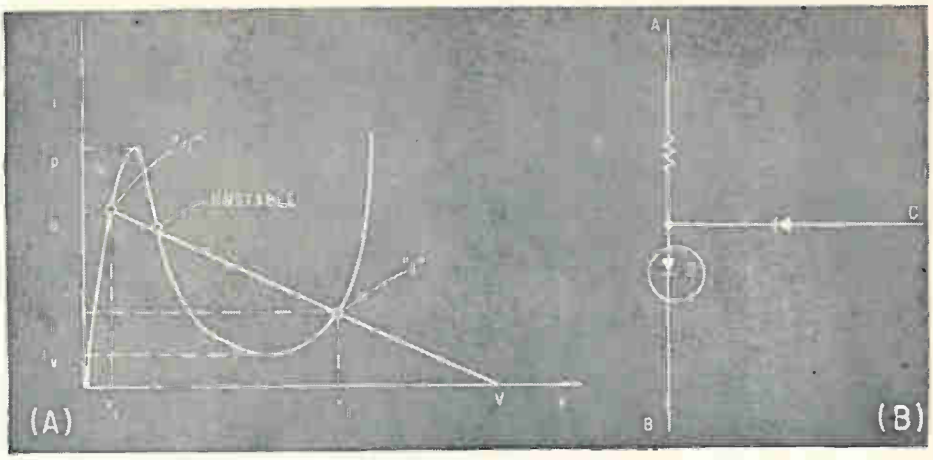
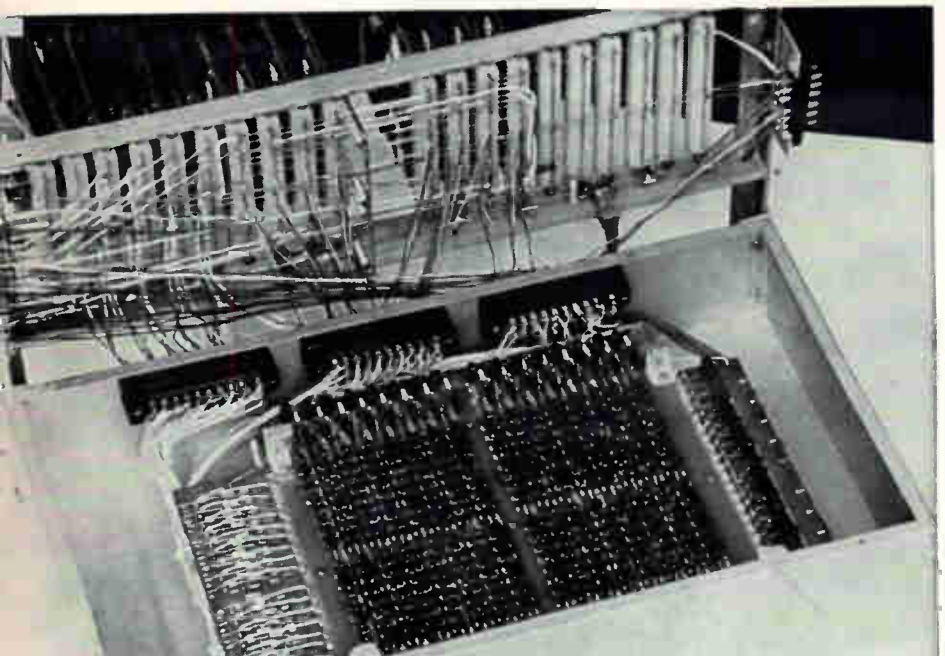


FIG. 1—Typical voltage-current characteristic of the tunnel diode, (A); the basic three-terminal memory element using tunnel diode and ordinary diode, (B)

High-Speed Memory



Modern computer memory with 272-bit capacity operates at 5 megacycles, uses tunnel diodes in bistable three-terminal arrangement

By SHIGERU TAKAHASHI and OSAMU ISHII,
Electrotechnical Laboratory, Tokyo, Japan

DIGITAL COMPUTER speed has always been memory-limited. In these days 10-Mc logical circuits are common, but 1-Mc operation of a ferrite core storage matrix is still difficult. Computers of newer design, therefore, tend to have small-capacity high-speed memories such as diodes and capacitors, thin magnetic films, or multipath biased ferrite cores, besides their main core storage.

The ETL Mk-6, a high-speed computer under development at the Governmental Electrotechnical Laboratory of Japan, will also use such a high-speed memory for storing a program segment, intermediate data and indexes. This is a tunnel-diode memory that operates at 5 Mc. A pilot model of the Mk-6 (Mk-6P) is under construction to experiment with a memory of this type as well as other new devices such as Kilburn's adder and a capacitance-type fixed memory. The photograph shows the Mk-6P's tunnel-diode memory of 272-bit capacity (16 words of 17 bits each).

The tunnel diode has a well-known voltage-current characteristic with a negative-resistance region as shown in Fig. 1A. A simple bistable circuit consisting of one tunnel diode and one resistor to store one bit of information can be obtained by choosing appropriate bias voltage and resistance. The

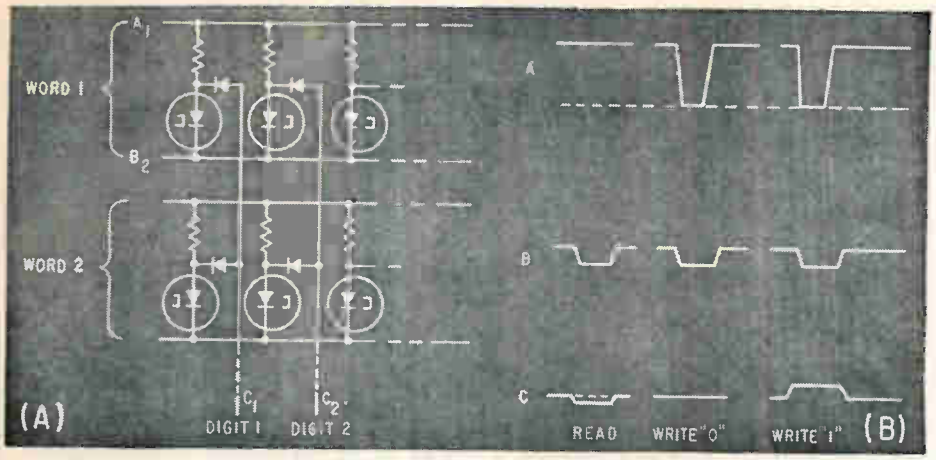


FIG. 2—Matrix configuration of the memory (A); access is through word lines A, B and digit lines C; waveforms appearing at the three terminals, (B), for the "read", "write 0" and "write 1" positions

Uses Tunnel Diode Circuit

authors proposed a three-terminal memory element as shown in Fig. 1B[1,2]. The third terminal *C* is tied to a read-out amplifier and the ordinary point-contact diode at this terminal provides means of selection among all the elements connected to the same amplifier.

A matrix consisting of the above elements was also proposed by the authors, and an improved version, shown in Fig. 2A, was proposed by K. Nakazawa and K. Murata of Hitachi, Ltd.[3] All the *A* terminals of the elements of a word are connected to a word line *A*, and all the *B* terminals to a word line *B*, all the *C* terminals of the elements at the same bit position are connected to a digit line *C*. Lines *A*, *B* and *C* are connected to the respective drivers, and line *C* is also tied to a read-out amplifier.

Figure 2B shows waveforms that appear on these lines during writing-in and reading-out. Consider first the read-out process. In accordance with the address signal, a word line driver *B* is selected and a negative pulse is applied to the corresponding word line. When an element stores zero, its selection diode is turned on with the result that the potential of the corresponding digit line *C* drops. When an element stores one, its selection diode remains cut off and nothing happens. The change of the digit line potential is detected by the read-out amplifier. The operation does not destroy the memory content if the pulse amplitude on line *B* is appropriate. (Fig. 3A).

Next, consider the writing-in operation. The same negative pulse is applied to the selected word line *B*, but at the same time the voltage source feeding the corresponding word line *A* is cut off. After all the elements connected to these word lines are thus reset to zero, a positive pulse is applied to the digit line *C* which has the element that should be written in as one. The amplitude of this pulse must be so chosen that for the selected element it is sufficient to give a

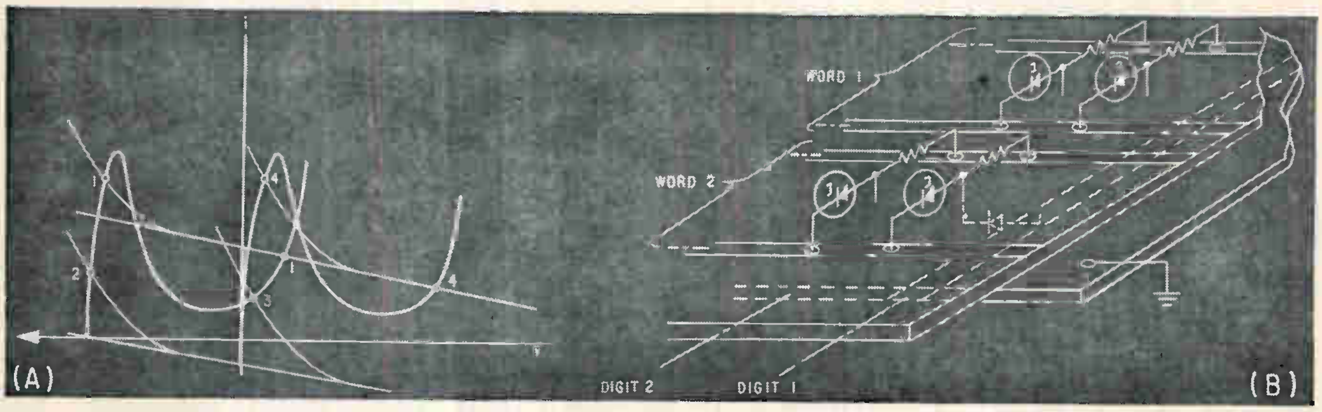


FIG. 3—Voltage-current excursions during the reading-out and writing-in process, (A): "read" is point 1 on the curves; "write ZERO*" is point 2; "write* ONE*" is point 3; and half-select is point 4. In positions 1, 2 and 3 the tunnel diode is forward biased by positive voltage on word line A; this is shown by displacing the characteristic curve with respect to that for position 4. Schematic drawing of memory-plane structure and word lines, (B)*

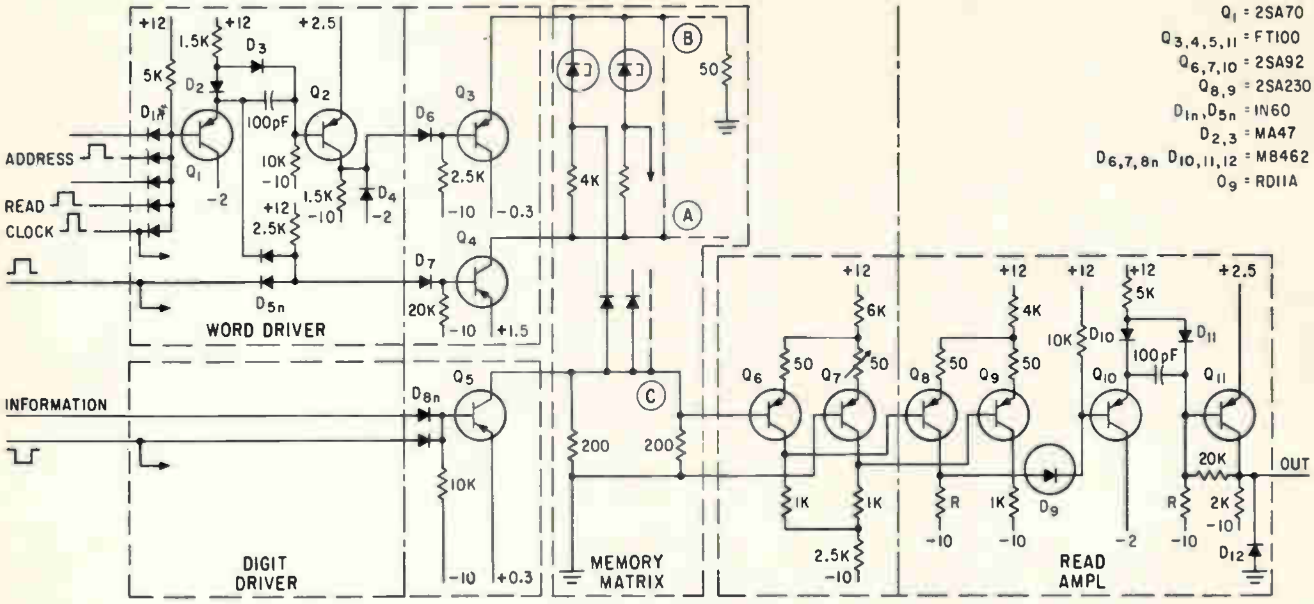


FIG. 4—Circuit of driver and readout amplifiers, showing where connections are made to the word and digit lines

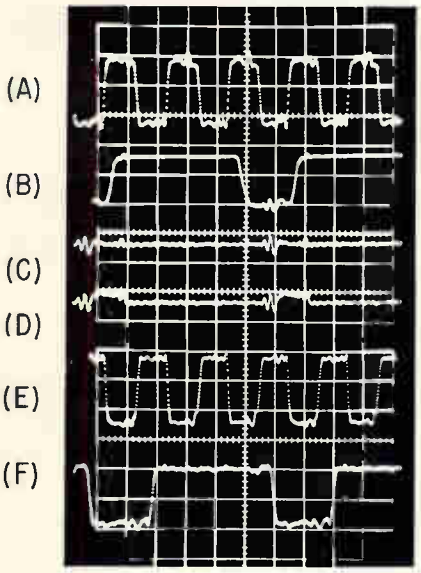


FIG. 5 — Waveforms at various points of memory operation: Read or write order, (A); clock I, (B); ZERO *signal, (C);* ONE *signal, (D);* ZERO *output, (E); clock II, (F). Horizontal scale is 100 nanoseconds per division*

tunnel-diode current exceeding I_p (Fig. 1A) and for the unselected element it is small enough to keep it below I_p.

Figure 3B shows the actual structure of the matrix plane. All the word and digit lines are asymmetric micro-strip lines printed on epoxide boards.

Line impedances of *A*, *B* and *C* are 150, 50 and 200 ohms respectively, including the effect of stray capacitances of elements and backward capacitances of selection diodes.

The size of the matrix plane is 17.5 × 22.5 cm. In this experiment larger tunnel diodes were employed because of the lack of stability in smaller units. However, smaller tunnel diodes with improved stability are now available, and the siz of the matrix plane for the same capacity can be decreased to 9.5 × 8.5 cm.

Figure 4 shows the circuit detail of the driver and read-out amplifier.

In this memory, as in almost all thin magnetic film memories, the speed is circuit-limited. The memory element can be set or reset within 10 nanoseconds, but the access time including the circuit delay is 100 ns and the cycle time is 200 ns.

Figure 5 shows the waveforms at various points in the memory system.

Since the basic circuit of Mk-6P is synchronized to 5-Mc two-phase clock pulses, the cycle time is deliberately chosen to be equal to the clock pulse interval.

One of the strong points of this type of memory is that both the input signal level to the read-out amplifier and the power level required at the digit line driver do not depend as much upon the size of memory as they do in the tunnel diode memories previously reported[1, 5]. Therefore the memory speed is limited only by its physical size.

In ETL Mk-6 this type of memory of 128-word capacity will be employed.

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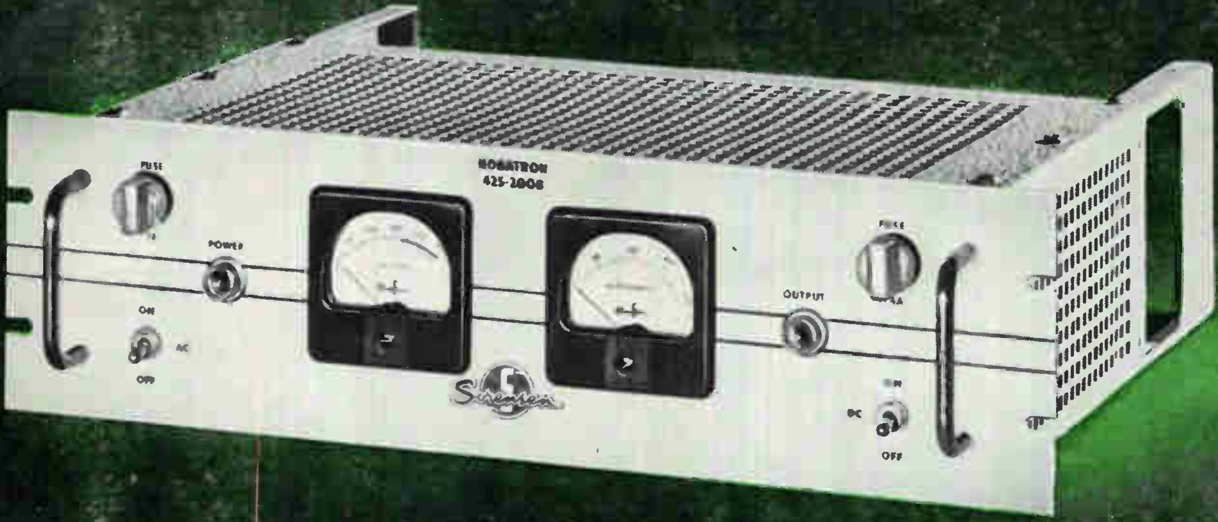

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SPECIFICATIONS

INPUT VOLTS:	105-125 volts AC 50-400 Cycles All Models
DC OUTPUT VOLTS:	125-325 V DC or 325-525 V DC
DC OUTPUT CURRENT (MA):	200, 400 or 800
LINE & LOAD REGULATION COMBINED:	±(0.1% + .05 V)
RIPPLE:	3 millivolts RMS
AC OUTPUT VOLTS (unregulated):	6.5 V (at full load, 115 V AC Input)

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CIRCLE 69 ON READER SERVICE CARD

Observing Missile Plumes With Image Tubes

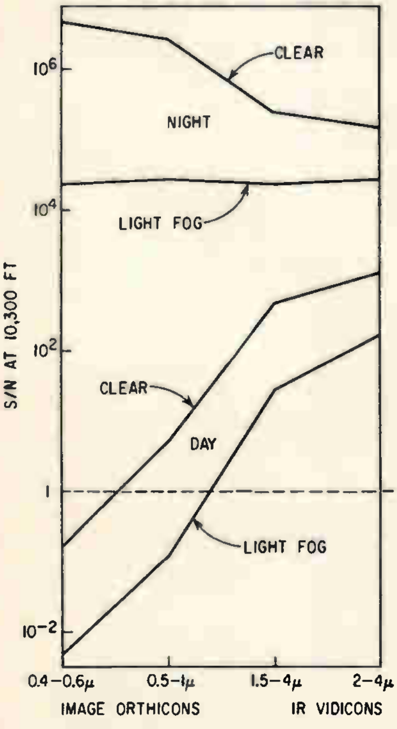
By M. E. SEYMOUR
General Electric Co.,
Advanced Electronics Center,
Ithaca, N. Y.

MISSILE LAUNCH OBSERVATIONS

	S17	S1	GeCu	GeCu
$\Delta\lambda$ (microns)	0.4–0.6	0.5–1	1.5–4	2–4
NEP (watts)	3×10^{-15}	1×10^{-13}	1×10^{-11}	1×10^{-11}
J (Kw/ster)	2	70	580	370
J_a (Kw/ster)	1.4	30	260	140
H_T (w/cm²)—R_1	1.4×10^{-10}	3×10^{-9}	2.6×10^{-8}	1.4×10^{-8}
—R_2	1.4×10^{-12}	3×10^{-11}	2.6×10^{-10}	1.4×10^{-10}
H_B (w/cm²)—blue sky	8.6×10^{-10}	5.3×10^{-10}	5.3×10^{-11}	1.3×10^{-11}
—broken overcast	1.5×10^{-10}	2.7×10^{-10}	7.5×10^{-11}	1.5×10^{-11}
—gray overcast	1.0×10^{-10}	1.6×10^{-10}	1.2×10^{-12}	1.8×10^{-14}
Attenuation Factor—light fog	1/200	1/100	1/12	1/5
—heavy fog	4×10^{-12}	4×10^{-12}	4×10^{-12}	4×10^{-12}
S/N at R_1—day, clear	0.16	5.6	490	1,100
—day, light fog	0.0047	0.11	29	180
—night, clear	4.7×10^{6}	3×10^{6}	2.6×10^{5}	1.4×10^{5}
—night, light fog	2.3×10^{4}	3×10^{4}	2.2×10^{4}	2.8×10^{4}
S/N at R_2—day, clear			4.9	11
—day, light fog			0.29	1.8
—night, clear	47,000	30,000	2600	1,100
—night, light fog	230	300	220	280

FEASIBILITY of low-altitude applications of visible and infrared image tubes can be predicted to some extent. Relative spectral characteristics of a missile target and sky background irradiance and of atmospheric absorption and scattering losses vary over wide ranges of values. These factors are complex functions of many other parameters, and experimental data is not fully explained by theories. Although feasibility would be best determined experimentally, consideration of some factors permits limited prediction of feasibility in low-altitude applications.

Present knowledge of ballistics missile radiation based on theory and field measurements is limited. Radiation during the launch phase is not well understood because atmospheric effects cannot be corrected in the strong absorption bands which correspond closely to the plume emission bands where radiation intensity is highest. Radiation from present missiles is considerably greater than that expected from advanced models.



Signal-to-noise ratio of image tubes is shown as a function of wavelength

At low altitudes, plume radiation intensity from combustion of carbonaceous fuels in a large booster appears typically to be in the megawatt-per-steradian range. It has more of a blackbody-type spectral distribution than at high altitudes. Other type fuels produce band radiation of lesser intensity.

Plume structure changes markedly with altitude but little data has been obtained about it, particularly as a function of wavelength. It is generally agreed that the infrared plume is larger than the visible plume, and typical plume temperature is 2,000 K.

Spectral distribution of sky and cloud background is not much different from the solar spectrum at wavelengths below 3 microns. Clear-sky radiance near the sun falls off more rapidly with angular distance from the sun at longer wavelengths, but some effects of scattering are still evident at wavelengths beyond 3 microns.

Brightness during heavy overcasts is apparently reduced at wavelengths below 0.7 microns and above 1.4 microns. Sky radiance varies at least an order of magnitude at different geographical locations, even for the same angles from the sun and the zenith. Altitude and dust in the air are significant, with large quantities of dust or haze producing a spectrum not as steep as the solar spectrum.

Sky radiation beyond 4 microns approaches a blackbody spectrum at the temperature of the atmosphere, particularly at low elevation angles and during overcasts. Data from all available references are in substantial agreement but only one bridges the spectral range from visible to near infrared. The general conclusion[1, 2] that infrared has no advantage over visible wavelengths in typical heavy fog still seems valid. The advantage becomes significant only with better visibility.

Recent comparisons of theory and measurements are interesting for haze conditions.[3, 4] In a cloudless atmosphere, the region around 3.7 microns seems to have the highest absolute transmissivity considering both molecular absorption by carbon dioxide and scattering from water and haze.

Two image orthicons and two

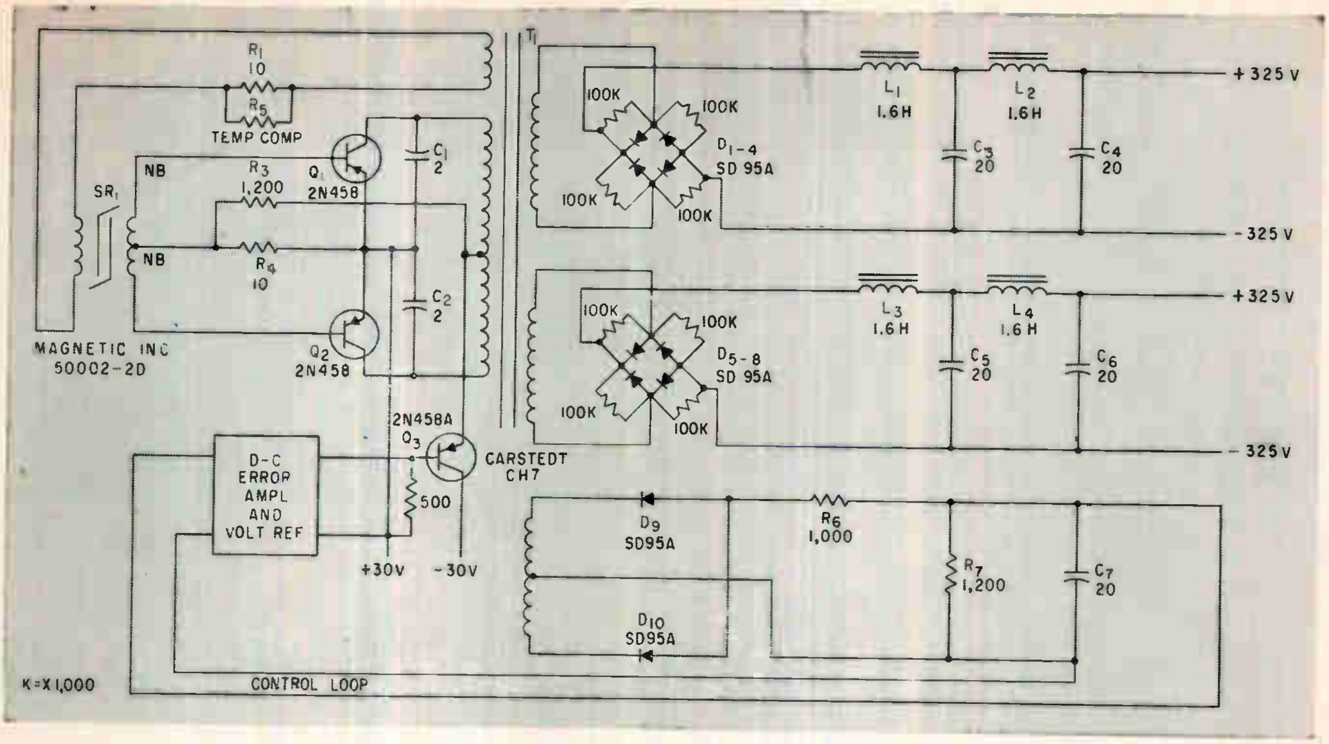


FIG. 3—Output of the two 325-v supplies totals 12 watts. Voltage varies ± 10 volts

D-C Converter Outputs

Loop gain of the Jensen converter is adjusted for optimum oscillatory conditions over the temperature range by R_5. The R-C speed-up networks in the base circuits of Q_1 and Q_2 were deleted. Current limiting is obtained by starting resistor R_1. The secondary winding resistance of SR_1 is purposely made high to aid in base current limiting.

Time constant of the integrator consisting of the primary inductance of T_1 and C_1 and C_2 is sufficient to reduce the output spike from 45 mv to 4 mv peak to peak. The rms content at the output is approximately one-sixth of this figure. Filtered frequency is about 2 kc depending upon input voltage.

Overall regulation of the output is achieved through the control loop amplifier. The a-c error voltage from the output transformer is rectified and filtered. In the d-c amplifier this filtered output is compared to a Zener diode reference. Output of the d-c amplifier controls Q_3. Regulation is a function of loop amplifier gain and reference stability.

Coupling transformer T_1 is, in effect, a pulse transformer. Its primary inductance must be chosen on the basis of waveform droop (percent droop $= 50\, R_L(t\text{-}t_o)/L_p$). Here, R_L is the reflected load impedance, $(t\text{-}t_o)$ the switching time and L_p the desired primary inductance.[3] A satisfactory droop is 10 percent. Once the primary inductance is known, then the value of the capacitance may be found by calculating the amount of integration or slow-up desired. Overall effect of integration must be determined experimentally because of the large number of variables. Minimizing both leakage flux and capacitive coupling are incompatible, however several approaches achieve an acceptable compromise.

Selection of the core for minimum core loss and maximum permeability is the first requisite. A C-type core of 2 or 4-mil gage thickness, can be used. Since both leakage and capacitive problems are a function of the core-coil geometry, care must be given to the winding layout. A double-coil arrangement using both legs of the C-core should be used. Two identical coils are wound. On each coil ¼ the total secondary turns is wound above and below ½ the total primary turns. Then after assembly of the core, the two coils are tied together so that both sections of the primary and all four of the secondary sections are in series. Electrostatic shielding of 1 or 2-mil copper foil is used between each section of the primary and secondary windings.

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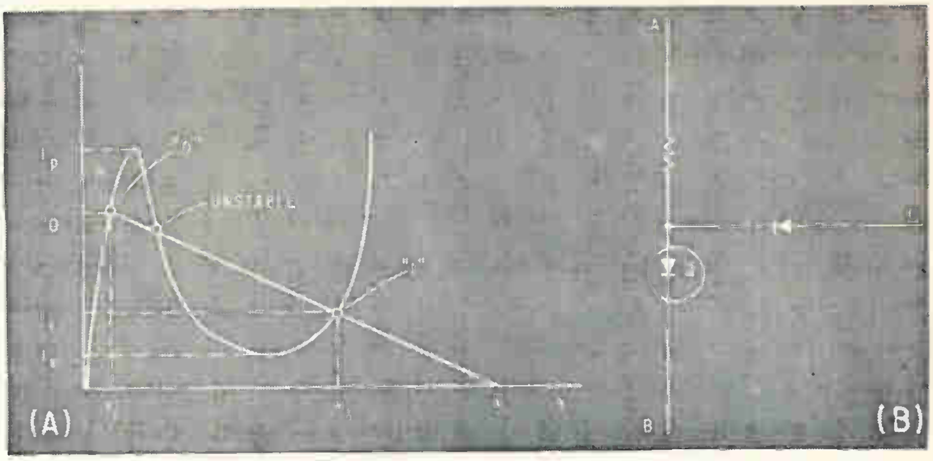
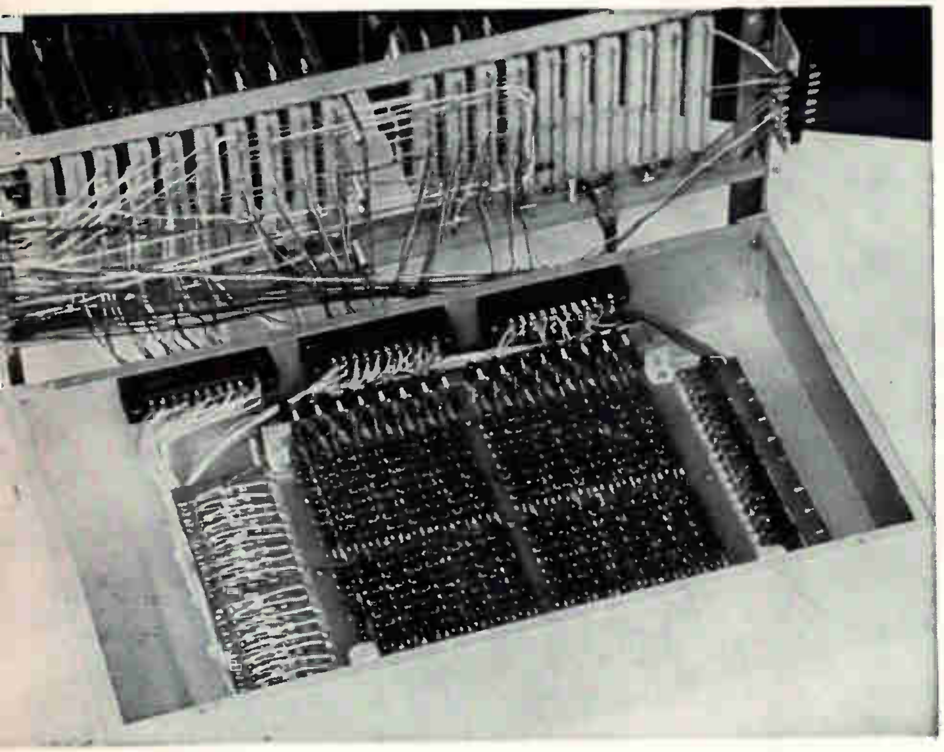


FIG. 1—Typical voltage-current characteristic of the tunnel diode, (A); the basic three-terminal memory element using tunnel diode and ordinary diode, (B)

High-Speed Memory



Modern computer memory with 272-bit capacity operates at 5 megacycles, uses tunnel diodes in bistable three-terminal arrangement

By SHIGERU TAKAHASHI and OSAMU ISHII,
Electrotechnical Laboratory, Tokyo, Japan

DIGITAL COMPUTER speed has always been memory-limited. In these days 10-Mc logical circuits are common, but 1-Mc operation of a ferrite core storage matrix is still difficult. Computers of newer design, therefore, tend to have small-capacity high-speed memories such as diodes and capacitors, thin magnetic films, or multipath biased ferrite cores, besides their main core storage.

The ETL Mk-6, a high-speed computer under development at the Governmental Electrotechnical Laboratory of Japan, will also use such a high-speed memory for storing a program segment, intermediate data and indexes. This is a tunnel-diode memory that operates at 5 Mc. A pilot model of the Mk-6 (Mk-6P) is under construction to experiment with a memory of this type as well as other new devices such as Kilburn's adder and a capacitance-type fixed memory. The photograph shows the Mk-6P's tunnel-diode memory of 272-bit capacity (16 words of 17 bits each).

The tunnel diode has a well-known voltage-current characteristic with a negative-resistance region as shown in Fig. 1A. A simple bistable circuit consisting of one tunnel diode and one resistor to store one bit of information can be obtained by choosing appropriate bias voltage and resistance. The

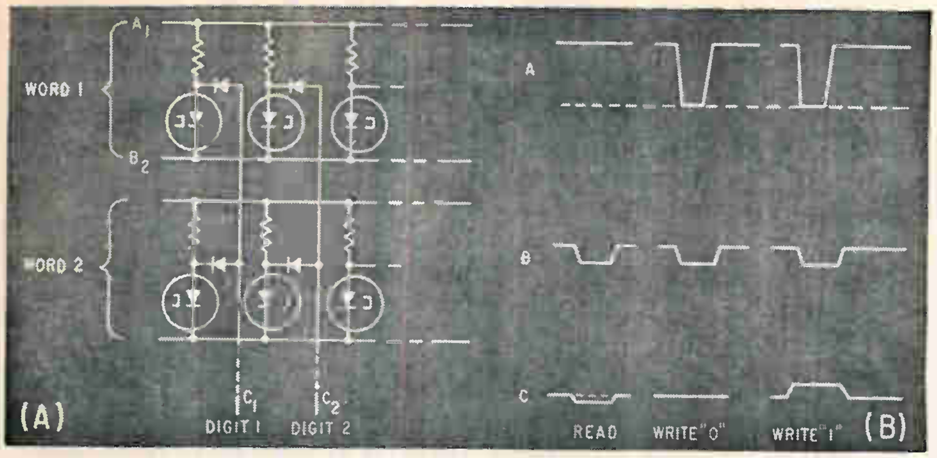


FIG. 2—Matrix configuration of the memory (A); access is through word lines A, B and digit lines C; waveforms appearing at the three terminals, (B), for the "read", "write 0" and "write 1" positions

Uses Tunnel Diode Circuit

authors proposed a three-terminal memory element as shown in Fig. 1B[1, 2]. The third terminal C is tied to a read-out amplifier and the ordinary point-contact diode at this terminal provides means of selection among all the elements connected to the same amplifier.

A matrix consisting of the above elements was also proposed by the authors, and an improved version, shown in Fig. 2A, was proposed by K. Nakazawa and K. Murata of Hitachi, Ltd.[3] All the A terminals of the elements of a word are connected to a word line A, and all the B terminals to a word line B, all the C terminals of the elements at the same bit position are connected to a digit line C. Lines A, B and C are connected to the respective drivers, and line C is also tied to a read-out amplifier.

Figure 2B shows waveforms that appear on these lines during writing-in and reading-out. Consider first the read-out process. In accordance with the address signal, a word line driver B is selected and a negative pulse is applied to the corresponding word line. When an element stores zero, its selection diode is turned on with the result that the potential of the corresponding digit line C drops. When an element stores one, its selection diode remains cut off and nothing happens. The change of the digit line potential is detected by the read-out amplifier. The operation does not destroy the memory content if the pulse amplitude on line B is appropriate. (Fig. 3A).

Next, consider the writing-in operation. The same negative pulse is applied to the selected word line B, but at the same time the voltage source feeding the corresponding word line A is cut off. After all the elements connected to these word lines are thus reset to zero, a positive pulse is applied to the digit line C which has the element that should be written in as one. The amplitude of this pulse must be so chosen that for the selected element it is sufficient to give a

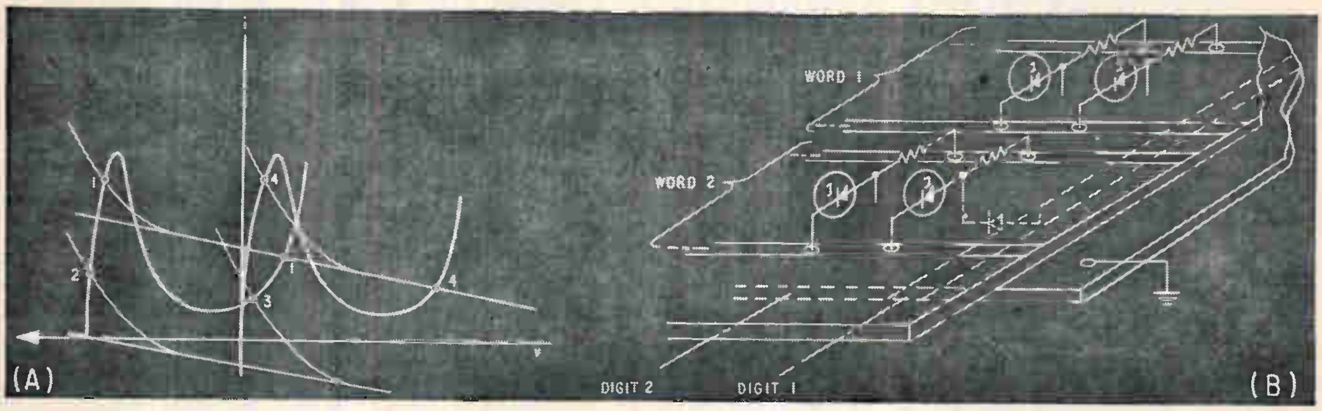


FIG. 3—Voltage-current excursions during the reading-out and writing-in process, (A): "read" is point 1 on the curves; "write ZERO*" is point 2; "write* ONE*" is point 3; and half-select is point 4. In positions 1, 2 and 3 the tunnel diode is forward biased by positive voltage on word line A; this is shown by displacing the characteristic curve with respect to that for position 4. Schematic drawing of memory-plane structure and word lines, (B)*

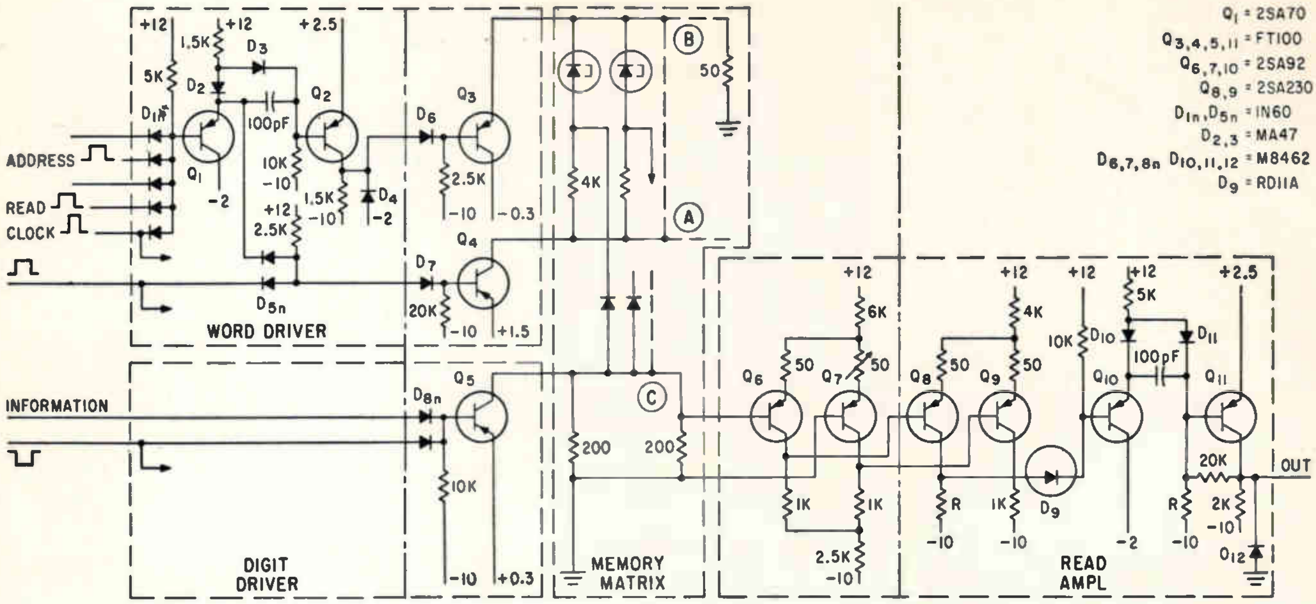


FIG. 4—Circuit of driver and readout amplifiers, showing where connections are made to the word and digit lines

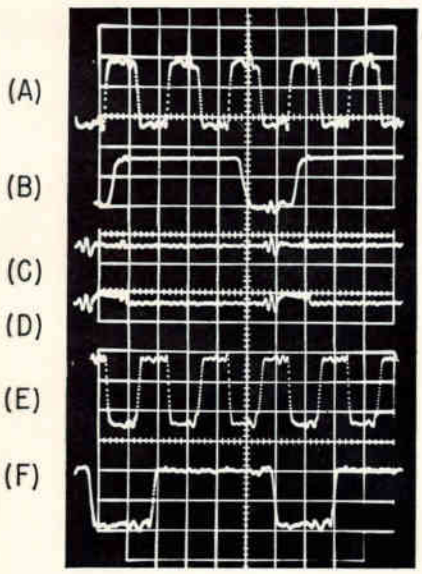


FIG. 5 — Waveforms at various points of memory operation: Read or write order, (A); clock I, (B); ZERO *signal, (C);* ONE *signal, (D);* ZERO *output, (E); clock II, (F). Horizontal scale is 100 nanoseconds per division*

tunnel-diode current exceeding I_p (Fig. 1A) and for the unselected element it is small enough to keep it below I_p.

Figure 3B shows the actual structure of the matrix plane. All the word and digit lines are asymmetric micro-strip lines printed on epoxide boards.

Line impedances of *A*, *B* and *C* are 150, 50 and 200 ohms respectively, including the effect of stray capacitances of elements and backward capacitances of selection diodes.

The size of the matrix plane is 17.5 × 22.5 cm. In this experiment larger tunnel diodes were employed because of the lack of stability in smaller units. However, smaller tunnel diodes with improved stability are now available, and the siz of the matrix plane for the same capacity can be decreased to 9.5 × 8.5 cm.

Figure 4 shows the circuit detail of the driver and read-out amplifier.

In this memory, as in almost all thin magnetic film memories, the speed is circuit-limited. The memory element can be set or reset within 10 nanoseconds, but the access time including the circuit delay is 100 ns and the cycle time is 200 ns.

Figure 5 shows the waveforms at various points in the memory system.

Since the basic circuit of Mk-6P is synchronized to 5-Mc two-phase clock pulses, the cycle time is deliberately chosen to be equal to the clock pulse interval.

One of the strong points of this type of memory is that both the input signal level to the read-out amplifier and the power level required at the digit line driver do not depend as much upon the size of memory as they do in the tunnel diode memories previously reported[4, 5]. Therefore the memory speed is limited only by its physical size.

In ETL Mk-6 this type of memory of 128-word capacity will be employed.

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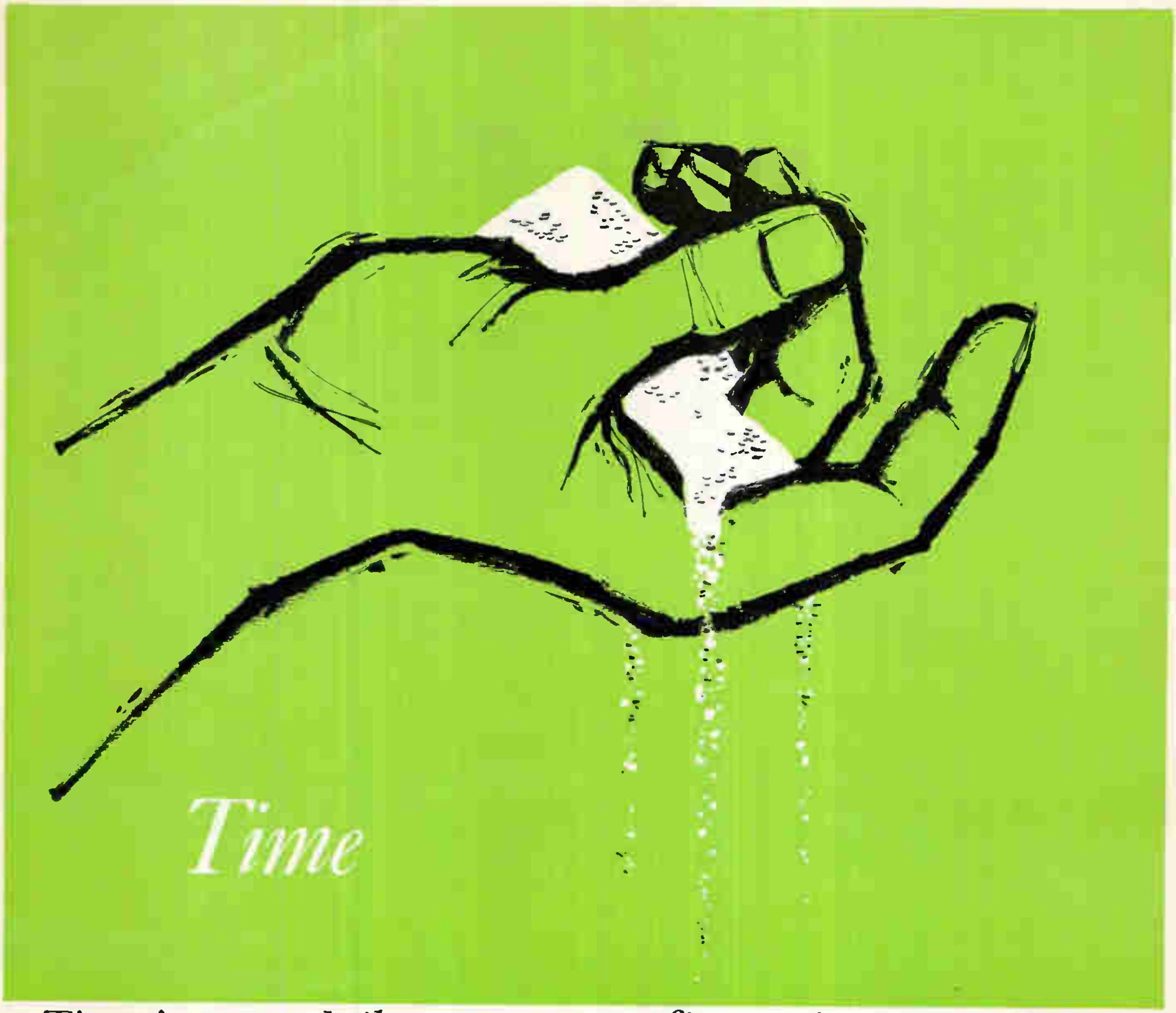

Time is a sandpile we run our fingers in . . . Sandburg

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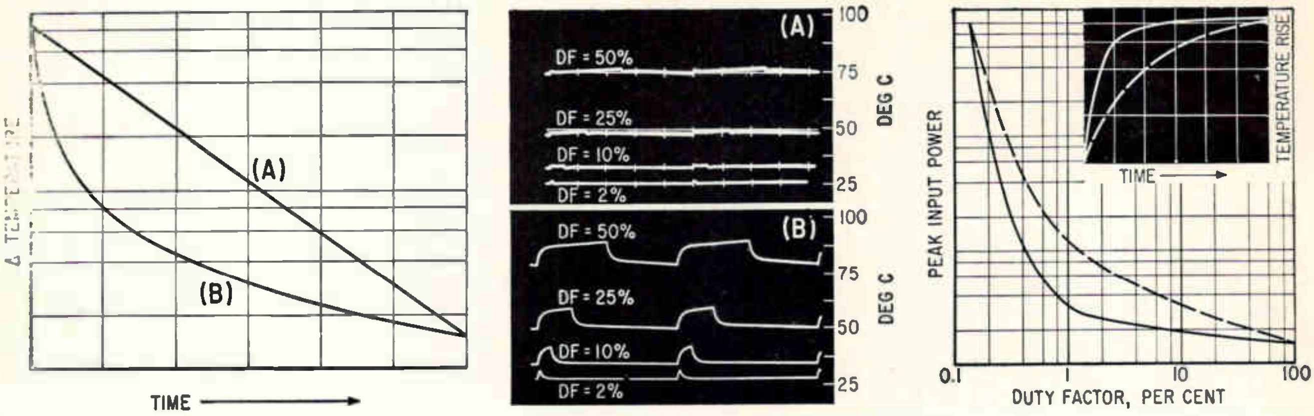

FIG. 1—Straight line in graph at top left represents temperature decay of single RC pair model, curved line represents the decay of a series string. Center graph shows thermal response of 2N335 junction to a constant-peak-power square wave input. At right, large graph shows peak input power as a function of duty factor to produce a constant junction temperature. Small graph insert at right shows transistor junction thermal response to a step-power input

How To Use Transistor Thermal Specs

By H. T. GRUBER,
Battelle Memorial Institute,
Columbus, Ohio

DESIGNERS of transistorized equipment have been aware of the need for transistor thermal specifications for some time. As the part density of equipment has increased, accurate thermal specifications have become a necessity for reliable equipment design. Transistor manufacturers are beginning to supply thermal specifications with their products, but beware of the single thermal resistance and single thermal time constant.

The use of a single thermal resistance and time constant assumes that the thermal response of a transistor may be represented by the expression,

$$T = T_o \exp(-\ t/RC).$$

The thermal responses of transistors are actually infinite exponential series which converge quickly. The difference between the two representations is shown graphically in Fig. 1 (left). The straight line represents the decay of a single RC pair model of a transistor, and the curved line represents the decay of a series string of RC pairs

To illustrate the errors that can result from the use of single thermal resistances and time constants, two electrical models of the thermal operation of a 2N335 were constructed. One model consisted of a single RC pair (A), and the other model consisted of a series string of RC pairs (B)[1]. The total thermal resistance and the total thermal time constant of each of the two models were equal. Current passing through the models is equivalent to heat flow (power input), and the voltage across the models is equivalent to the junction temperature rise above ambient temperature. The two models were subjected to constant peak-power square-wave inputs, with the duty factor varied.

The results obtained from the two models are shown in Fig. 1 (center). The series string of RC pairs model (B), indicates a peak junction temperature of about 90 degrees for a 50 per cent duty factor. Under the same conditions, the single RC pair model (A) indicates a peak junction temperature of 73 C. This error would be even greater if the leakage power dissipation were included in the models, by the use of a feedback loop. This is particularly true of germanium transistors which have higher leakage currents.

The information contained in Fig. 1 (center) may be plotted in a different form which is more useful to equipment designers. The general appearance of this presentation is shown in Fig. 1 (right) for two transistor types having thermal responses to step power inputs shown in the small graph. The larger graph in Fig. 1 (right) is a plot of the peak input power, for a particular wave shape, required to produce a constant peak junction temperature rise, as a function of duty factor. The same type of plot may be made for single pulse inputs as a function of pulse duration. The transistor represented by the solid curves has a faster initial thermal response than the transistor represented by the dashed curves. To put this another way, the transistor represented by the solid curves may be described by an exponential series with some terms having very small time constants. The transistor with the faster thermal response requires a lower peak input power to produce a given junction temperature rise because of the faster initial portion of the response curve.

The use of single thermal resistances and single thermal time constants for transistors can result in expensive errors during the design and development of equipment. Suppose, for example, we are designing a switching circuit. In either the *on* or *off* condition, the power dissipation of the transistor is only a small percentage of the allowable d-c power dissipation of the transistor. However, in the transient condition the power dissi-

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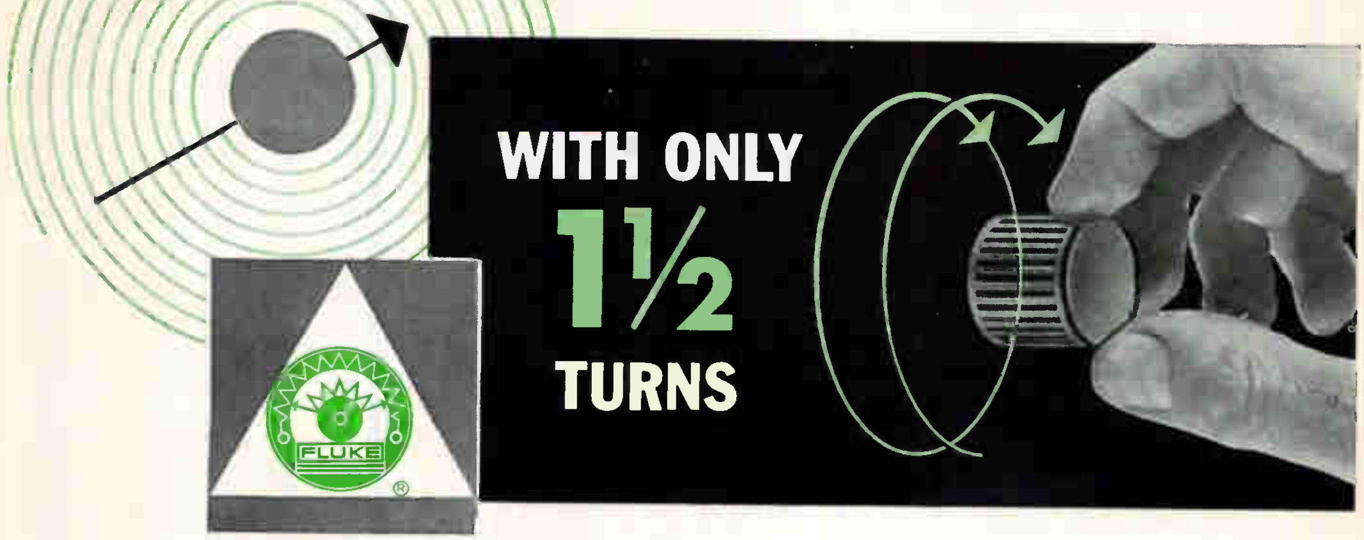

–*Save: Time-Space-Effort-Cost*

The **FLUKE** Model 20A Vernier Potentiometer provides resolution equivalent to that of 10 turn helical potentiometers with only 550° of shaft rotation. At the same time, the 20A requires only a fraction of the space occupied by helical potentiometers, and, in fact, occupies less space than many single turn, low resolution potentiometers.

This high resolution, small size, and ease of operation, is achieved by a unique **FLUKE** patented design. A schematic of the Model 20A is shown below. Basically, the Model 20A consists of a main resistance element and a concentric smaller vernier. The vernier element is connected to the main element through two contacts spaced 30° apart. This spreads any 30° segment of the main winding over the 270° of vernier rotation. The vernier slider is rotated by the potentiometer shaft. As the shaft is turned and the vernier slider completes its rotation, a mechanical stop causes the vernier frame to turn, moving the spaced vernier contacts along the main element. This method provides a coarse adjustment at either end of the vernier adjustment.

This unique design results in a versatile, high performance potentiometer. For example, thin card-type windings reduce residual reactance and allow operation at much higher frequencies than other potentiometers with similar DC specifications. The one and one-half turn control of the entire adjustment range allows substantial time savings in frequently adjusted or multiple potentiometer installations such as analog computers and data logging systems. Equipped with a screwdriver slotted shaft, the Model 20A also makes an ideal high resolution trimmer.

The Model 20A is available from stock in resistance values ranging from 100 ohms to 25 K ohms, and can be provided with a calibrated readout dial and lock-type knob.

If greater resistance values are required, write for information on the **FLUKE** Models 21A, 22A, and 30A. The Model 21A and 22A have increased power ratings and are available in resistance values to 100 K. The Model 30A features resolution of 20 times that of the 20A series, resistance values from 1 K to 100 K, and a power rating of 5 watts.

MODEL 20A PARTIAL SPECIFICATIONS

Standard Tolerance: ±5%, available to ±1% on special order Linearity ±0.5%.

Resolution: 1000 ohms, 1 part in 5600. Increased resolution for higher values.

Power Rating: 2 watts at 20° C, derated to 0 at 100° C.

Price: As shown, $8.50.

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Vernier Potentiometer

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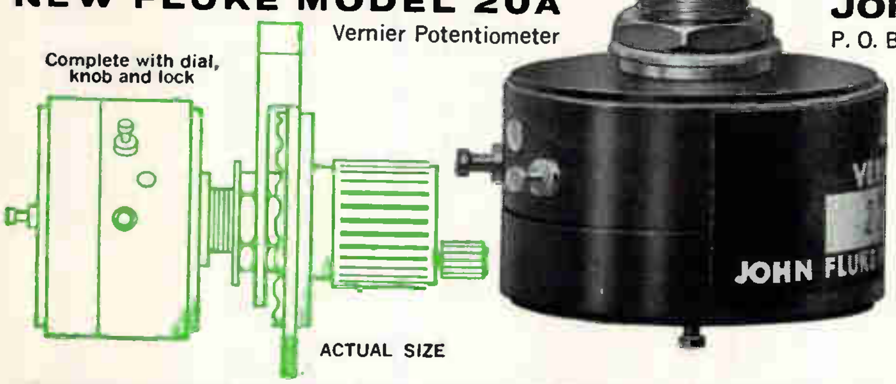
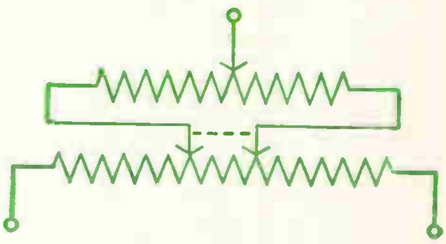


ACTUAL SIZE



SCHEMATIC

MANUFACTURERS OF ELECTRONIC TEST AND MEASURING INSTRUMENTS FOR LABORATORY—PRODUCTION LINE

pation is 200 per cent of rated. The total thermal time constant of the transistor is 200 milliseconds and the switching time is 1 millisecond. Computations indicate that the peak junction temperature will not exceed 150 C during the 1 millisecond switching time, if the ambient temperature of the equipment is less than 100 C. Both the electrical and mechanical equipment design are based upon an inadequate thermal specification; several terms of the exponential series describing the thermal response of the transistor have time constants of less than 0.01 milliseconds. Either a different transistor must be used or the maximum ambient operating temperature of the equipment reduced. The result is a redesign that is costly in both dollars and time.

The thermal model of the 2N335, used for the illustration above, was obtained in the following manner. The transistor was mounted on an infinite heat sink. The junction was heated by dissipating power within the transistor until the junction temperature stabilized. The heating power was removed and a reverse bias applied to the collector-base junction. The leakage current decay curve was recorded. The leakage current curve was converted to a junction temperature cooling curve from a previous calibration of I_{CBO}. The series string of RC pairs equivalent circuit constants were computed from the temperature decay curve[1]. The thermal units were converted to electrical units.

The switching from the junction heating circuit to the I_{CBO} measuring circuit was accomplished by mercury wetted relays and required about one millisecond. Experimental work indicates that a large portion of the junction cooling occurs during this millisecond and considerable information is lost. What is required is equipment that will switch from the loading to the measuring circuit in much less time. Very probably, some other parameter should be used to indicate the transistor junction temperature. The practical lower limit for the switching time is the time required to clear the carriers from the junction area.

Because of the variability of both electrical and thermal characteristics among transistors of the same type, it is desirable that transistor manufacturers determine the thermal characteristics of their products and also supply statistical information on distribution.

Once accurate thermal specifications are available, the thermal response of transistors to particular inputs may be determined by analog techniques. Digital solutions are possible in some cases, but considerable arithmetic drudgery is involved. Through proper analog techniques, the thermal responses of the transistor may be related to the ambient temperature, the thermal characteristics of the transistor mounting and the chassis, and to the circuit being used.[2]

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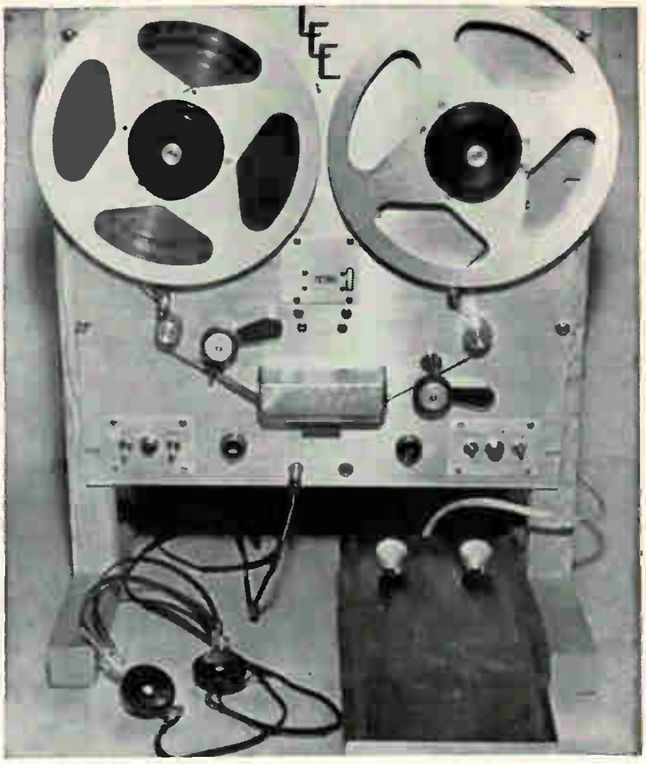
Thin-Film Sandwich

TEN-DIAMETER enlargement of recent configuration of MIA (Metal Interface Amplier) as developed earlier this year by Philco Corporation Research Division. Announced first in Phys. Rev. Letters, April 1, 1961, development of the device continues in the Basic Science and Technology Department of the division. Co-inventors are James P. Spratt, Ruth M. Schwarz, Walter M. Kane. November 8 is date scheduled for more public discussion of both device and circuit technologies when Philco plays host to a joint meeting of Philadelphia Section and Lehigh Valley Subsection of the IRE. Meeting will be held at Philco's Research Center, Bluebell, Pa.

Audio-visual production aids increase production substantially and reduce wiring errors



Recording unit uses foot switches to control instructions. Background music and signals to control a slide projector can be put on the tape

Audio-Visual Systems Step Up Production

By THOMAS J. GRIFFIN, JR.
L. E. E. Inc., Washington, D. C.

PRODUCTION INCREASES of about 50 percent are claimed by most users of audio-visual systems. Defective circuits, or defects per unit, caused by incorrect wiring, are decreased by at least an equal percentage.

Several factors contribute to the increase in quality and quantity. Elimination of written instructions —prints or wiring lists—allows the worker to keep his attention more fully on the work, instead of constantly shifting his attention and eye-focus between instructions and work. The tape recording presents the worker with the best sequence for building up the circuit; older methods generally allow the worker to follow his own sequence. Lightweight earphones help increase attention by subduing background noise and conversation. Background music, often placed on the tape between assembly instructions, also makes a contribution.

The visual presentation is usually made by a small screen and an automatic 35 mm slide projector actuated by signals on the tape. Hughes Aircraft Co., one of the first to make formalized studies of the audio-visual combinations, has reportedly achieved results beyond their expectations.

As an official of one company stated, audio-visual aids to production are 10 percent machine and 90 percent technique. If the method is to be used successfully, several basic rules must be followed.

1. The work station must be in optimum order. Every tool and part must have its specific place: tools in slots or holding fixtures, components in specifically marked bins.

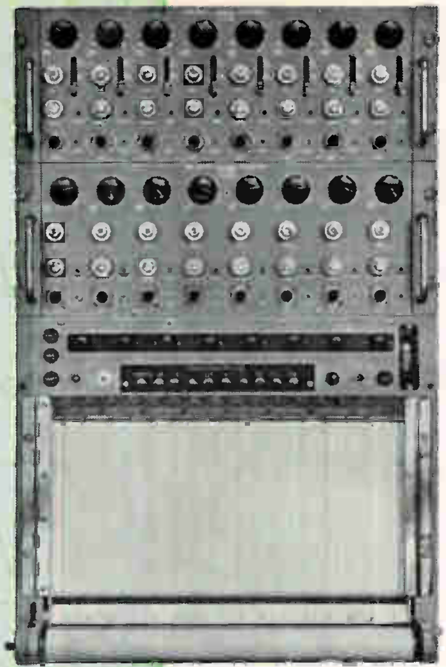
2. Instruction tapes, and photos or slides, must use the assembly or wiring sequence that will give maximum results.

3. The production worker, his supervisor, and all key personnel must be indoctrinated to the method in such a way as to obtain wholehearted support and cooperation. It must be emphasized over and over again that the system in no way jeopardizes jobs or rates.

4. The system is not adaptable to every type of manufacture or to every complexity. It does not pay, to use the technique with any unit that can be wired from memory. The more complicated the assembly the more suitable it is.

There are two different methods of presenting information to the operator. In the paced method the time to accomplish an instruction is indicated on the tape by silence or background music, with music favored. Usually a warning tone tells the operator that the next instruction is about to be heard. If the operator has not finished the work allotted, he can stop the machine until he is ready again. The other method is known as call, or demand. The tape is stopped either by the operator or automatically. When the operator finishes a step he starts the tape for the next sequence. Both the paced and the demand methods are in use.

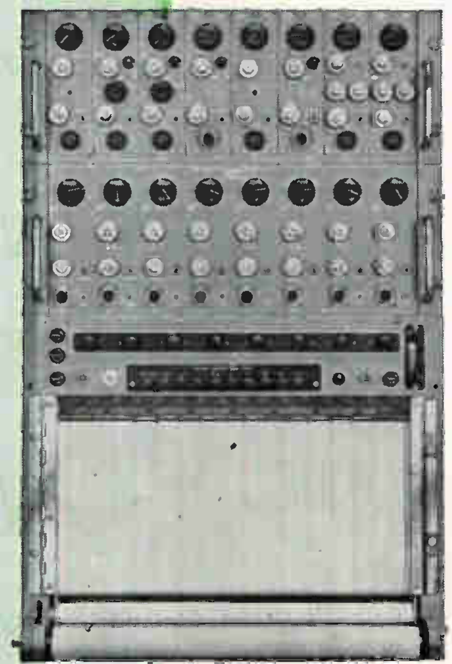
Much has already been published



. . . with Sanborn® High, Medium or Low Gain 8-Channel Amplifiers and Flush-Front Recorder in only 32″ of panel space

In the 32″ panel space version, Sanborn 16-channel direct writing systems use a flush-front 358-16 Recorder and *any two* "950" series 8-channel amplifiers — available in transistorized high and medium gain types with floating and guarded inputs, low gain with high resistance balanced to ground inputs. Max. sensitivities are 20 uv/mm, 1 mv/mm and 20 mv/mm for high, medium and low gain systems. Frequency response ranges for the three are 100, 125 and 125 cps. Recorder has 9 chart speeds, 8″ of visible record, inkless recording in true rectangular coordinates on Sanborn Permapaper® charts.

RECORD 16 VARIABLES
on a single 16″ chart



. . . with 8 channels identical, 8 more with miniature plug-in preamplifiers for greater flexibility

Eight interchangeable, plug-in "850" preamplifiers, each with 7″ x 2″ panel, plug into chassis with common power supply. Available types are Phase-Sensitive Demodulator, DC Coupling, Carrier and Low Level; MOPA available for Carrier and Low Level excitation. Frequency response is DC to 125 cps, 3 db down at 10 mm peak-to-peak depending on type of preamplifier. Linearity is better than 0.5%. Inputs are single-ended, floating and guarded, or push-pull, depending on type of "850" preamplifier used. Remaining eight channels can comprise any 8-channel "950" amplifier.

With each of these systems, you have a choice of vertical or horizontal chart plane recorders. Flush-front vertical recorder ("350" style) has electrical speed shift, requires only 17½″ vertical panel space. Horizontal recorder facilitates viewing and making notations on record, occupies 21½″ of panel space, has mechanical speed shift. Both recorders have velocity feedback-damped galvanometers . . . automatic stylus heat control . . . separate timer/marker stylus . . . inkless direct writing on quick loading, rectangular coordinate charts with 20 mm wide channels.

For complete specifications and application engineering assistance, contact your nearest Sanborn Sales-Engineering Representative. Offices throughout the U. S., Canada and foreign countries.

INDUSTRIAL DIVISION
SANBORN COMPANY
175 Wyman St., Waltham 54, Mass.

CIRCLE 79 ON READER SERVICE CARD

about the new technique, but there are few references to the attitude of the production line worker other than "greater employee morale". Furthermore, several questions arise concerning the tryouts or feasibility tests conducted by several well-known companies.

How much of the increase in productivity is due to the "halo" effect?

The famed Hawthorne experiments of The Western Electric Co. established that employees getting special attention (as in a production-line experiment), increase their efforts regardless of the variables injected into the experiment. Increase the lighting, production goes up; decrease the lighting and production still goes up. In audio-visual system tests employees are each given a tape-deck, projection-screen, and earphones. They receive special training about a technique that will help them to produce more, and with less mistakes; then time-and-motion analysts or data-takers are brought in. Does this situation create a "halo"? It must to some extent, but how much of the increase is due to the psychological factor of spotlighting the group testing the new method? How long does this halo effect last? Longer than the feasibility study being conducted?

Were proper work-stations in existence before the feasibility tests began? If not, how much of the savings is due to the improved work situation?

As a prerequisite for audio-visual production, the work-place of the operator must be set up in perfect order. Any good time-and-motion economy book rates the work-place situation high on the list of efficient production requirements.

Does the technique, because of the earphones, cause isolation?

For years the rule in industry has been to create a social environment within the production-line group, to allow the workers to talk and even to sing together while working. What is the psychological effect of shutting the operators off from one another?

Was background music in existence on the lines where the experiments were conducted before the tests were initiated? If not, then *how much of the savings credited to the audio-visual system is actually due to background music?*

Suppliers of this type of music claim production increases of 5 to 20 percent due to the music alone.

Which visual presentation is best?

Increases in production using the different methods of visual presentation show very small differences; balancing this with costs for the different methods, (actual models, draftsman sketches, photographs on a flip-board, and 35 mm projection), which is the most economical method? In one feasibility report, a company claims that the basic improvement is caused by increased operator concentration on the work-object. This company used an actual model of the unit being wired as the operator's example for harness and component placement. Their increase was approximately 50 percent. Another company used exploded views as a guide to component placement; their increase was also about 50 percent. Yet another company uses 8 × 10 inch photographs and report the same increase. The majority use 35 mm color slides projected onto a small screen; claims: around 50 percent.

How much of the increase is due to audio alone?

None of the reports so far have indicated any comparison tests, but in the majority of units being manufactured (excepting extremely critical ones), could the placement of components be described verbally, and thus eliminate the greater number of photographs or slides? Could one to four photographs suffice?

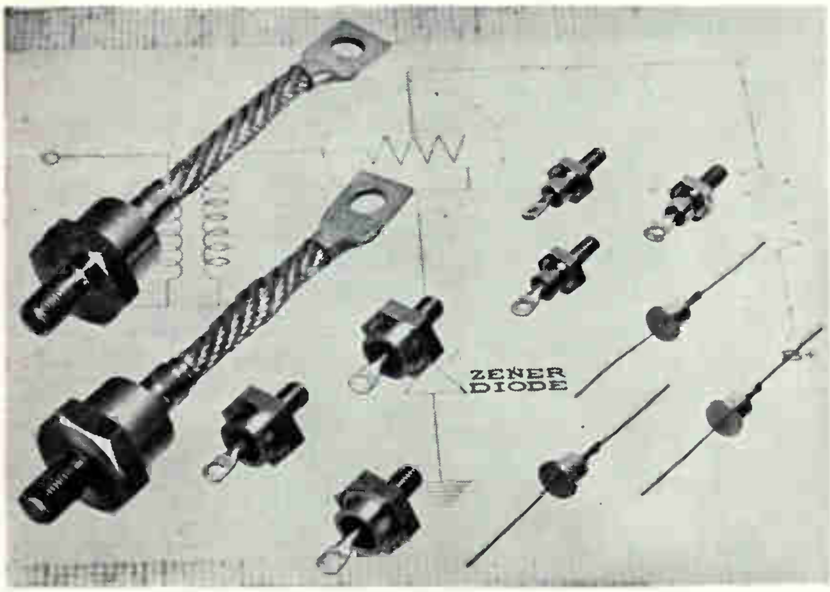
Perhaps the feasibility tests conducted by the various groups did control such factors as isolation, music versus non-music, social environment in the work situation, halo effect, the union's attitude towards pacing, etc. However, a detailed study involving all these factors is needed. There is no doubt, however, that the technique greatly improves production line assembly, wiring, and inspection procedures. Even conservative estimates on increases in production and quality warrant a trial run by every manufacturer of electronic components and assemblies.

New On The Market

Circuit Builder
SPEEDS BREADBOARDING

CIRCUIT STRUCTURES LAB., P. O. Box 36, Laguna Beach, Calif. Quick assembly, rearrangement and disassembly of experimental circuits, without use of solder, spring clips or jumper wires, is possible with the Circuit Builder, which is composed of 108 gold-plated cells spaced 1 in. apart in 9 horizontal rows of 12. Each cell has an elastic rubber core protruding through it. Smaller components are connected into the cells by pulling up on the rubber core, inserting the component pigtail and releasing the core. Larger components are equipped with permanent leads.

CIRCLE 301 ON READER SERVICE CARD



Silicon Zener Diodes
DIFFUSED JUNCTION DEVICES

SYNTRON CO., Homer City, Pa., introduces a line of silicon junction Zener diodes for voltage regulation applications. In a complete range of ratings from 250 mw through 50 w power dissipation, the units are suited for use in power supplies to provide any desired constant voltages at a high degree of accuracy. Individual series of devices are rated for 250 and 750 mw, and 1, 3.5, 10, 25, and 50 w dissipation. All series are standard 10 percent tolerance devices.

CIRCLE 302 ON READER SERVICE CARD

Miniature Gyro
FLUID SPHERE

SPERRY GYROSCOPE CO., Div. of Sperry Rand Corp., Great Neck, N. Y. Fluid sphere gyroscope has a spinning mass of liquid in place of the conventional rotating wheel. The SYG-2000 can detect the most minute motion, making it suitable for stabilizing space platforms carrying extremely delicate equipment. Unit requires no precision parts or involved assembly techniques. It can be stored or operated at temperatures from − 65 F to 200 F. Quantities can be produced for sale at less than $2,000 per unit.

CIRCLE 303 ON READER SERVICE CARD

Digital Recorder
WITH INPUT STORAGE

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Model 562A transistorized, electromechanical recorder can print up to five 11 digit lines per sec. A storage feature allows data transfer to the unit in 2 millisec, after which the driving source is released to gather

HOLD IT!

THERE'S NO SUBSTITUTE FOR AN ELECTRONIC MEASUREMENTS CONSTANT-CURRENT POWER SUPPLY

what every engineer knows about constant-current power supplies . . .

How do you check the peak inverse voltage rating of a solid state junction? the breakdown voltage of a reference diode at a specified current? the dynamic impedance of a reference diode? and the many other parameters that are so easily checked with constant-current power supplies?

It's an easy matter to convert some voltage-regulated power supplies to current-regulated operation. At least it's easy with an E/M® Regatron Programmable Power Supply. But for true constant-current performance, there's no substitute for a power supply specifically designed for constant-current operation.

Take Electronic Measurements' Model C638A shown here. It's an easy matter to set the current control to any value desired—from a few microamperes up to 100 ma—manually or programmably. And there's no juggling with makeshift, extra circuity. Then you can adjust the voltage compliance to any value from 0 to 1500 V. There's no fear that the voltage may be too great or not enough; the voltage control sets the upper limit.

Here are some additional features of the C638A: Output impedance is 10^4 megohms at 0.5 μa to 0.5 megohms at 100 ma. Above 2.2 μa, regulation is better than 0.15%, line or load, Ripple is less than 0.01%+ 1 μa rms. A modulation input is provided.

But to get back to the point; to check the peak inverse voltage rating of a solid state junction, simply set the output current control of an E/M Constant-Current Power Supply at the specified current. Connect the output to the junction, turn the power supply on, and measure the voltage drop across the junction. What could be easier? And other measurements can be made almost as easily.

For a complete discussion of constant-current power supplies with ratings up to 1A, ask for Specification Sheet 3072B. It lists all the models and specifications, too.

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E/M

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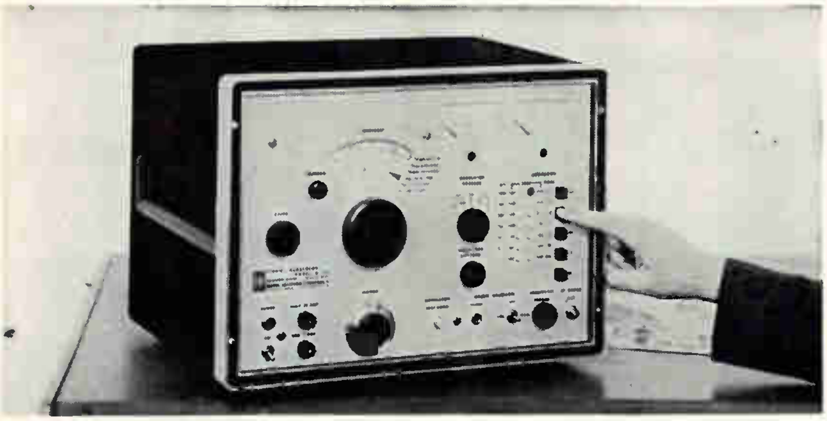
COMPANY, INCORPORATED
EATONTOWN • NEW JERSEY

more information. Internal connectors route parallel-entry data to any desired digit, and different input codes may be used for each digit. Standard input is a 4-line BCD(1-2-2-4). Other 4-line codes may be used by substituting plug-in cards.

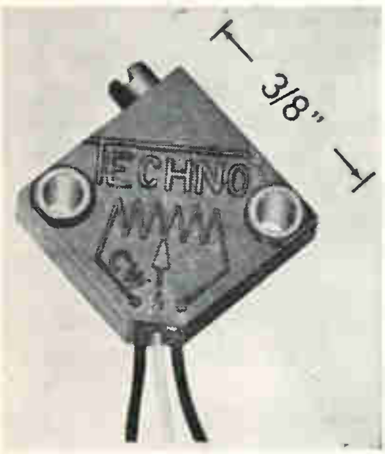
CIRCLE 304 ON READER SERVICE CARD



Signal Generator
PUSH-BUTTON ATTENUATION

BORG-WARNER CONTROLS, P. O. Box 1679, Santa Ana., Calif. Model G-101 h-f signal generator has a push-button attenuator system for fast, accurate signal-light readout. Among its applications is measuring gain of i-f circuits or receivers. Covering a frequency range of 50 Kc to 65 Mc, selected in six bands, the generator provides an r-f output at any frequency within its range at a continuously adjustable amplitude between 0.1 μv and 3 v. Price is $1,350.

CIRCLE 305 ON READER SERVICE CARD



Trimming Pot
MILITARY TYPE

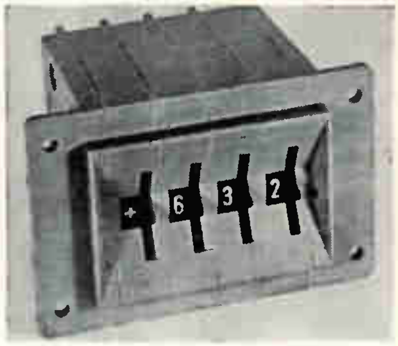
TECHNO-COMPONENTS CORP., 18232 Parthenia St., Northridge, Calif. A 3/8 in. square trimming pot weighs 3/4 gram and is rated at 1/2 w at 50 C, derating to zero at 105 C. Wire wound resistance elements provide a resistance range of 100 ohms to 20,000 ohms at operating temperatures of — 55 to 105 C. Trimmer withstands vibration of 50 g from 10 to 2,000 cps and has a temperature coefficient of 50 parts per million/deg C. It has a resistance tolerance of ± 10 percent and dielectric strength of 500 v a-c for one minute.

CIRCLE 306 ON READER SERVICE CARD

Relay Module
COMPACT DEVICE

D. RANDALL CO., Div. of Westerly Electronics, Inc., 6 Pawcatuck Ave., Westerly, R. I. A compact relay-module for easy installation in printed-wiring systems makes use of a dry-reed switch contacting element to provide high speed and long life. The basic Doranic module consists of a spst, normally open reed switch rated at 12 v-a up to 250 v a-c, resistive load. Up to 12 switches can be operated by the same coil. Entire assembly is 3/8 in. square by 7/8 in. long.

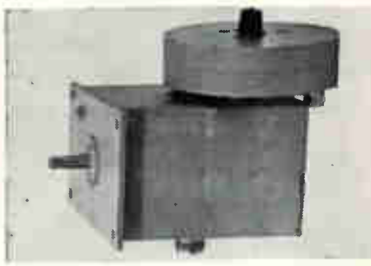
CIRCLE 307 ON READER SERVICE CARD



Digital Switch
THUMBWHEEL TYPE

THE SIEGLER CORP., Magnetic Amplifiers Div., 632 Tinton Ave., New York 55, N. Y. The Decaswitch, a low-cost digital thumbwheel switch, occupies a minimum space and can be stacked up to 15 sections in a panel slot only 8 in. by 1 9/16 in. Sections are available in single pole 10-position, single pole 11-position, plus/minus, binary and 2-pole, 5-position models. Switch is suited for incorporation into computers, meters, power supplies and decade boxes.

CIRCLE 308 ON READER SERVICE CARD



Receiver Front Ends
IN L, S, AND C-BANDS

FREQUENCY ENGINEERING LABORATORIES, P.O. Box 504, Asbury Park, N.J. Line of low noise microwave receiver front ends consists of tunable preselectors and coaxial balanced mixers. Units are available in L, S, and C-bands with a noise figure of 7.5 db max measured with

new! NARDA ferrite isolators

designed and manufactured by NARDA MICROWAVE!

• broadband coaxial ferrite isolators

Excellent electrical characteristics with extreme versatility! ⅞" coaxial line construction allows higher power operation with ⅞" connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, ⅜" connectors; 10 kw peak, 10 watts average.) Features 15 db isolation and 1 db max. insertion loss. VSWR is 1.25 max. based on 2:1 load mismatch; 1.15 max. into matched load. Model 1233: 2.0–4.0 kmc; model 1233-1: 3.0–5.5 kmc; $450. each.

• low power broadband waveguide ferrite isolators

Provide maximum load isolation and minimum insertion loss over full standard waveguide frequency ranges. Extremely useful for maintaining signal source stability and eliminating long line and frequency pulling effects. Front-to-back ratios are the highest available on the market today: C Band—26:1, $250; XN Band—25:1, $225; XB Band—30:1, $235; X Band—30:1, $220.

• high power broadband waveguide ferrite isolators

The only line of high power isolators that covers all of X Band with just two models (8.2-10.0 kmc and 10.0-12.4 kmc), each with front/back ratio of 40:1. Input power rating: 250 kw peak, 300 watts average, achieved through use of special high Curie temperature ferrite materials. VSWR is 1.05 max. with matched load; 1.10 max. with 3:1 mismatch. Only $175 each. Model with same VSWR, 28:1 front/back ratio, 300 kw peak, and 300 watts average, for 7.05-10.0 kmc, $195.

• other ferrite devices—consult NARDA for:

• Circulators • Phase shifters • Modulators • Attenuators • Special Isolators

For more information, write to Dept. E-1.

the narda microwave corporation

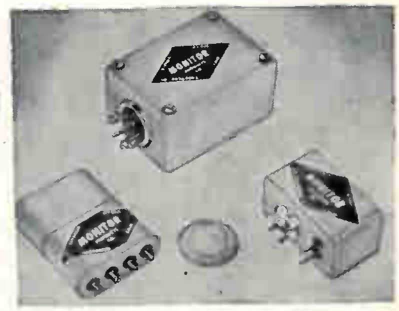
PLAINVIEW, L. I., NEW YORK AREA CODE 516 GE 3-9000 a 1.5 db i-f amplifier including the insertion loss of the preselector. Preselector is gang-tuned over a range of 10 percent. Mixers are coaxial ring hybrids with integral holders for the mixer diodes.

CIRCLE 309 ON READER SERVICE CARD

D-C Power Supplies
SOLID STATE

DYNEX INDUSTRIES, INC., 123 Eileen Way, Syosset, N. Y. Model PS150, applicable to filament supply and computers, provides 6.3 v d-c, 5 amp with input of 105-135 v a-c. Regulation is 0.05 percent for ±10 percent line voltage change, 0-5 amp load; ripple, 1 mv rms max; weight, 6 lb; size, 2½ by 8 by 5 in. Units meet military specifications.

CIRCLE 310 ON READER SERVICE CARD



Miniature Ovens
CONTROL TEMPERATURE

MONITOR PRODUCTS CO., INC., 815 Fremont Ave., S. Pasadena, Calif. Ovens enable the temperature of a crystal, transistor, etc. mounted in the oven cavity to remain constant through a wide temperature ambient. The SO-1042 holds components or crystals; SO-1047, one HC18/U crystal; SO-1064, two HC18/U crystals. Temperature stability is ± 1 C.

CIRCLE 311 ON READER SERVICE CARD

Servo Preamplifier

SERVO DEVELOPMENT CORP., 2 Willis Court, Hicksville, L. I., N. Y. A 0.48 cu in. transistorized servo preamplifier provides a gain impedance product of 3.6×10^6.

CIRCLE 312 ON READER SERVICE CARD

Pyrex Capillaries
PRECISION DRAWN

DIOTRAN PACIFIC, 1015 Alma St., Palo Alto, Calif., announces a line of Pyrex glass capillary tubes for thermal compression semiconductor lead bonding machines. They are precision drawn to accommodate wire diameter sizes ranging from 0.0005 in. through 0.005 in. Smaller or larger sizes can be made to order.

CIRCLE 313 ON READER SERVICE CARD

Controls Analyzer
FOR SERVO CHECKING

SUPERIOR MFG. & INSTRUMENT CORP., 36-07 20th Ave., Long Island City 5, N. Y., offers model 440 controls analyzer for the complete checking of servomechanisms and feedback controls system. Heart of the instrument is a brushless rotating transducer, invented at Superior for developing sinusoidal and sinusoidally modulated carrier test signal adjustable from 0.03 to 300 cps.

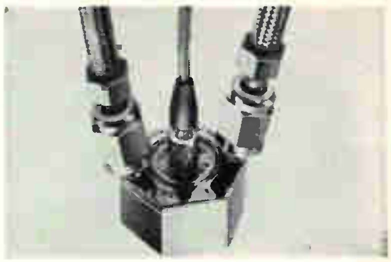
CIRCLE 314 ON READER SERVICE CARD

Power Supplies

ACOPIAN TECHNICAL CO., 927 Spruce St., Easton, Pa. Transistorized plug-in power supplies have voltage ratings ranging from 0.8 to 30 v

and current ratings from 50 ma to 200 ma.

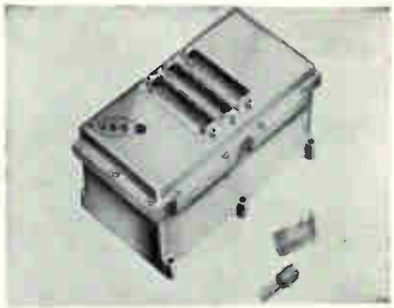
CIRCLE 315 ON READER SERVICE CARD



Accelerometer
LIQUID COOLED

ENDEVCO CORP., 161 E. California Blvd., Pasadena, Calif. Model 2206 is a small, high-temperature shock and vibration transducer, especially suited for dynamic measurements in rocket motors, combustion chambers, turbines, and the like. It can operate continuously on surfaces with temperatures up to 2,200 F, maintaining performance characteristics comparable to those of lower temperature Endevco models.

CIRCLE 316 ON READER SERVICE CARD



Commutator
LOW-LEVEL

UNITED ELECTRODYNAMICS, INC., 200 Allendale Road, Pasadena, Calif., offers a low-level electronic commutator featuring high reliability, long life, and high speed capability. Contact resistance averages 12 ohms. Reverse current is less than 1 nanoampere per channel, and special shielding has achieved a common mode rejection of better than one million to one. It will operate reliably and within specification at + 125 C.

CIRCLE 317 ON READER SERVICE CARD

Transistor Chopper

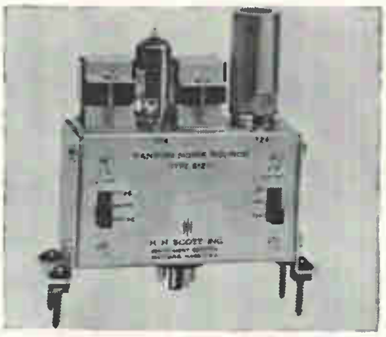
AIRPAX ELECTRONICS, INC., Cambridge, Md. Miniature transistor chopper with self-contained drive transformer is designed for use in p-c applications.

CIRCLE 318 ON READER SERVICE CARD

Complex Ratio Bridge
ALL SOLID STATE

GERTSCH PRODUCTS, INC., 3211 S. LaCienega Blvd., Los Angeles, Calif. Precision voltage and phase comparator measures both in-phase and voltage ratios of any 3- or 4-terminal network. Accuracy of in-phase measurements is greater than 0.01 percent of range. Quadrature accuracy: greater than 0.1 percent of range. Model CRB-4 features a self-contained, phase-sensitive null indicator for rapid measurements. Unit operates over a range of 380-420 cps.

CIRCLE 319 ON READER SERVICE CARD



Random Noise Sources
THREE MODELS

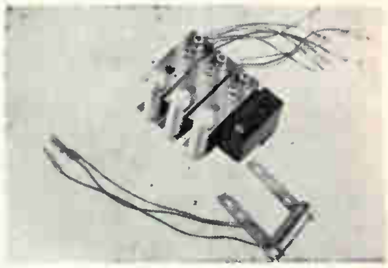
H. H. SCOTT, INC., 111 Powdermill Road, Maynard, Mass. The 812, 813 and 814 random noise sources provide random "white" noise with Gaussian amplitude distribution. Units utilize an octal socket for both standard console power input and random noise output. Thus the ultimate in design flexibility is available for system and laboratory applications.

CIRCLE 320 ON READER SERVICE CARD

Casting Resin

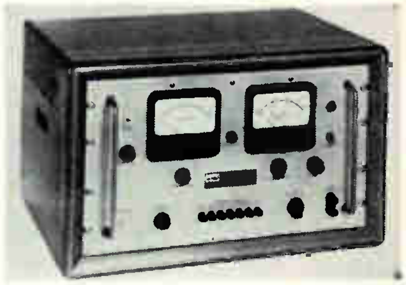
EMERSON & CUMING, INC., Canton, Mass. Stycast TPM-6 is a cross-

linked polyethylene type formulation, moderate in cost, readily machined and possessed of excellent electrical and physical properties.
CIRCLE 321 ON READER SERVICE CARD



Flying Heads
FOR MAGNETIC DRUMS

BRYANT COMPUTER PRODUCTS DIVISION, Ex-Cell-O Corp., Walled Lake, Mich. New flying magnetic head design promises to solve the problem of environmental and accidental magnetic storage drum damage. The units are designed on a non-contact, start-stop, double-reed principle. The heads sell for $12.60, $35 installed on a Bryant drum.
CIRCLE 322 ON READER SERVICE CARD



Deviation Calibrator
FOR F-M MONITOR USE

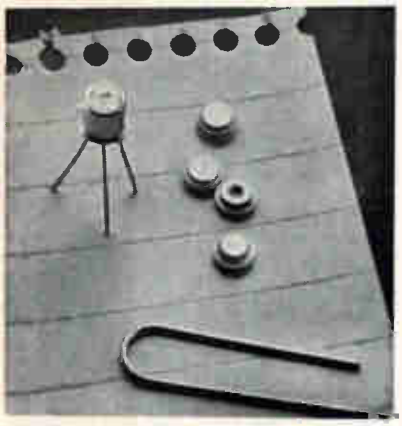
ADVANCED MEASUREMENT INSTRUMENTS, INC., 109 Dover St., Somerville, Mass. The Monocal 500 f-m monitor deviation calibrator provides better than 0.5 percent deviation accuracy. It combines the functions of five separate instruments previously required to determine the peak deviation of an f-m signal by the carrier-dropout method. Unit can be used directly with any f-m monitor tuning to 12 Mc or equipped with a 12 Mc i-f strip.
CIRCLE 323 ON READER SERVICE CARD

Mesa Transistors

TEXAS INSTRUMENTS INC., P.O. Box 5012, Dallas 22, Texas. Line of

Dalmesa transistors for industrial communications offer extremely low l-f noise corner and high alpha cut-off frequency.

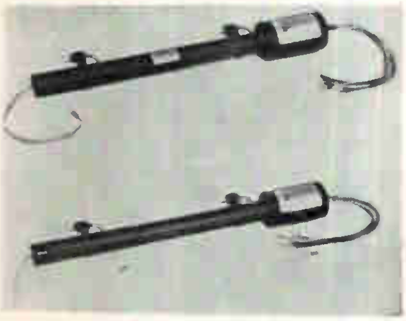
CIRCLE 324 ON READER SERVICE CARD



Tunnel Diodes
MINIATURE PACKAGE

GENERAL ELECTRIC CO., Syracuse, N.Y., offers four miniature microwave frequency germanium tunnel diodes. Featuring tightly controlled, low peak currents, their resulting high negative resistance better answers the impedance matching requirements of many microwave systems. They are also designed for use in radar, vhf amplifiers and oscillators and other S-band equipment.

CIRCLE 325 ON READER SERVICE CARD



L-Band Amplifiers
P-M FOCUSED

SYLVANIA ELECTRIC PRODUCTS INC., 1100 Main St., Buffalo 9, N.Y. Type TW-4267 ($3\frac{1}{2}$ lb) provides over 15 mw r-f output power and 35 db gain from 1,000 to 2,000 Mc. Type TW-4268 (4 lb) operates over the same range with more than 1 w r-f output power and 30 db gain. Tubes have a max diameter of $2\frac{1}{4}$ in. Small quantity price for both types is $925.

CIRCLE 326 ON READER SERVICE CARD

CIRCLE 91 ON READER SERVICE CARD

PRODUCT BRIEFS

POWER SUPPLIES noise-free. Raytheon Co., Sorensen Products, South Norwalk, Conn. (327)

CAPACITOR PACKAGES resin encapsulated mica. Cornell-Dubilier Electronics Division, 50 Paris St., Newark, N. J. (328)

MOUNTING CHASSIS high flexibility. Vent-Rak, Inc., 525 South Webster St., Indianapolis 19, Ind. (329)

BOOSTER AMPLIFIER solid state. Philbrick Researches, Inc., 127 Clarendon St., Boston, Mass. (330)

WAVEGUIDE TEES cover 2.6 to 40.0 Gc range. Waveline, Inc., Caldwell, N. J. (331)

PULSE COUNTING SYSTEMS single and dual channel. Harvey-Wells Electronics, Inc., 14 Huron Drive, Natick, Mass. (332)

FERRITE ISOLATOR x-band. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y. (333)

A-C PREAMPLIFIER very low noise. Keithley Instruments, 12415 Euclid Ave., Cleveland 6, Ohio. (334)

METER CALIBRATOR portable, low cost. Twinco Inc., 10 Cheney St., Roxbury 21, Mass. (335)

RELAY high voltage. Resitron Laboratories, Inc., 2908 Nebraska Ave., Santa Monica, Calif. (336)

TOROID WINDER for small coils. Controlomag Laboratories, Box 16, Ottsville, Pa. (337)

POWER SUPPLY adjustable-response-time. Perkin Electronics Corp., El Segundo, Calif. (338)

TRANSISTOR VOLTMETER phase sensitive. Trio Laboratories, Inc., Plainview, L. I., N. Y. (339)

MICROMINIATURE CERAMIC CAPACITOR axial leads. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. (340)

SERVO MOTOR viscous damped. Kearfott Division, General Precision, Inc., 1150 McBride Ave., Little Falls, N. J. (341)

VOLTAGE-TUNABLE MAGNETRON for L-band. General Electric Co., Schenectady 5, N. Y. (342)

Literature of the Week

MINIATURE TUBES Raytheon Co., 55 Chapel St., Newton 58, Mass. Handbook contains complete descriptions of 142 miniature vacuum electron tubes. (343)

TELEMETRY RECEIVER Defense Electronics, Inc., 5451-B Randolph Rd., Rockville, Md., offers a data sheet on model TMR-6 136 Mc telemetry receiver. (344)

GYROS Kearfott Division, General Precision, Inc., 1150 McBride Ave., Little Falls, N. J., has issued a revised edition (60 pages) of "Technical Information for the Engineer —Gyros." (345)

PAPER-TAPE REELER Omnitronics, Inc., 511 N. Broad St., Philadelphia 23, Pa. Bulletin gives specifications for model RS-400 high-speed paper-tape reeler. (346)

D-C AMPLIFIER KinTel Division of Cohu Electronics, Inc., 5725 Kearny Villa Road, San Diego, 12, Calif. Data sheet 2-96 discusses model 114C differential d-c amplifier. (347)

CONTROL PEDESTALS Anelex Corp., 150 Causeway St., Boston, Mass. Brochure describes control pedestals for series 4-1000 high speed line printers. (348)

TRANSIENT DETECTORS Regent Controls, Inc., Harvard Ave., Stamford, Conn. Bulletins cover transient detectors—one with meter, the other with potentiometer readout. (349)

BASIC SWITCHES Micro Switch, Freeport, Ill. Data sheet describes a 22-ampere steady state current capacity switch type. (350)

P-C CONNECTOR Lionel Electronic Laboratories, 1226 Flushing Ave., Brooklyn 37, N. Y., has issued a data sheet on type 310 dip solder printed circuit connector. (351)

SILICON DIODES Computer Diode Corp., 250 Garibaldi Ave., Lodi, N. J. Specifications of five high-current silicon diodes are contained in catalog D-101. (352)

THICKNESS GAGE Dawe Instruments Ltd., Harlequin Ave., Great

West Road, Brentford, Middlesex, England. Catalog leaflet describes a transistorized ultrasonic thickness gage. **(353)**

SWITCHES & THERMOSTATS Metals & Controls Inc., a corporate division of Texas Instruments Inc., 34 Forest St., Attleboro, Mass. Two bulletins show 42 representative switch and thermostat packages respectively. **(354)**

WAVEGUIDE MATERIAL Emerson & Cuming, Inc., Canton, Mass. Multicolored chart with photographs of end-products tabulates rod and sheet stock available. **(355)**

COMMERCIAL CAPACITORS General Electric Co., Schenectady 5, N. Y. GEZ-3368, two pages, describes tubular Lectrofilm capacitors for commercial applications. **(356)**

TWT'S & BWO'S Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y., has available a traveling-wave tube/backward-wave oscillator catalog. **(357)**

GERMANIUM DIODES National Transistor Mfg., Inc., 500 Broadway, Lawrence, Mass., has issued a catalog on high-reliability germanium diodes. **(358)**

TERMINALS & FEED THROUGHS Metalizing Industries, Inc., 338 Hudson St., Hackensack, N. J. Bulletin describes high temperature metalized ceramic terminals and feed throughs. **(359)**

HERMETIC SEALS The Carborundum Co., P. O. Box 268, Perth Amboy, N. J. Brochure covers custom-made metal-bonded ceramic-metal assemblies and metal bonded ceramics. **(360)**

FIXED PAD ATTENUATORS Applied Research, Inc., 76 S. Bayles Ave., Port Washington, N. Y. Fixed pad attenuators, terminations and impedance transformers are covered in a brochure. **(361)**

VACUUM TUBE TECHNOLOGY Litton Engineering Laboratories, P. O. Box 949, Grass Valley, Calif., has published a 4-page brochure on its products and facilities in the field of vacuum tube technology. **(362)**

DIODES & RECTIFIERS Erie Resistor Corp., 644 W. 12th St., Erie, Pa. Bulletin describes a line of silicon diodes and rectifiers. **(363)**

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Absolute Maximum Ratings:	V_{CE} Vdc	V_{CB} Vdc	I_C Adc	P_C* W	T_{stg} °C	T_j °C
2N1651	60	60	25	100	−60 to +110	110
2N1652	100	100	25	100	−60 to +110	110
2N1653	120	120	25	100	−60 to +110	110

*P_C is the maximum average power dissipation. It can be exceeded during the switching time.

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AMPLIFIER: 60db gain on 1mv range; response +0, −3db from 8cps to 800kc; output to 5V rms undistorted, variable down to zero by attenuator control at output; input impedance 10MΩ, output impedance 5KΩ; hum & noise −40db for signal inputs above 2mv.

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NEW BOOKS

Essentials of Radio-Electronics

By MORRIS SLURZBERG and WILLIAM OSTERHELD

McGraw-Hill Book Co., Inc., New York, Second Ed., 1961, 716 *p*, $10.

"ESSENTIALS OF RADIO", the 1948 first edition of this book, has now been brought up to date with some of the most important recent developments such as the transistor circuit.

The text is aimed at students in junior colleges, technical institutes, and for home study by non-technical people. For this reason the mathematics is kept to a minimum; however, the explanations are very thorough and detailed. Numerous examples and illustrations relate the principles to everyday items such as radio receivers and high-fidelity sets. Questionnaires and numerical examples after each chapter test the students progress.

For the technician, youngster, or science enthusiast, this book will supply an excellent background understanding of electronics.—G.V.N.

Wave Propagation and Group Velocity

By LEON BRILLOUIN

Academic Press, New York and London, 154 *p*, $6.

THIS BOOK is very helpful and authoritative for physicists and engineers who are interested in obtaining a thorough understanding of the subject of wave propagation velocities of dispersive media. Phase velocity, the group velocity of Lord Rayleigh, the signal velocity of Sommerfeld, and the velocity of energy transfer in dispersive media are defined and subjected to detailed comparisons.

In the first chapter the situation

preceding 1910 is summarized. It was about this time that A. Sommerfeld started discussing the problem. He set the mathematical basis for later work by Brillouin and others. An authorized translation of an important paper by Sommerfeld constitutes Chapter 2.

In Chapter 3 the use of the saddle-point methods of integration of an integral in the complex plane is discussed. This integral was derived by Sommerfeld as a representation of a signal which is terminated on one side only. A physical interpretation of the results is then given.

Chapter 4 is devoted to a discussion of propagation of electromagnetic waves in material media. The problem is stated in general terms and an attempt is made to see how much can be proved in this way. In Chapter 5 the properties of a dielective medium are are specified and are applied to the general formulas which were developed in Chapter 4.

The last chapter is devoted to examples of the application of the methods developed. Acoustic waves are discussed first. This is followed by a discussion of electromagnetic guided waves.

The definitions given in this book play an important role in many problems in wave propagation, including wave mechanics. A variety of examples in which these definitions come into play is given in another book by the same author entitled "Wave Propagation in Periodic Structures." — ROBERT E. BEAM, *Professor of Electrical Engineering, Northwestern University, Evanston, Illinois.*

Nondestructive Testing

By WARREN J. McGONNAGLE

McGraw-Hill Book Co., New York, 1961, 455 *p.* $15.

THE AUTHOR is a physicist in charge of nondestructive testing in the metallurgy division of Argonne National Laboratory. He has, however, succeeded in broadening his scope far beyond the testing of nuclear reactor components. Most of the methods described are pertinent to industry in general, particularly those producing metals and metal parts. An added bonus for the electronics industry is that

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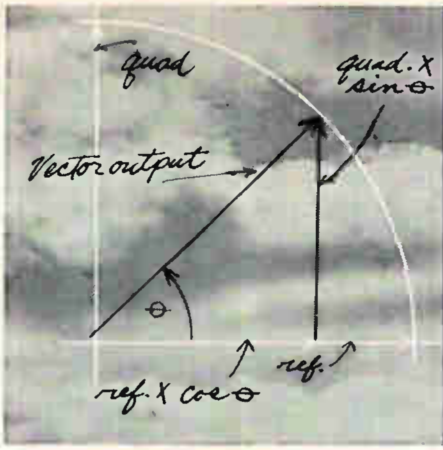

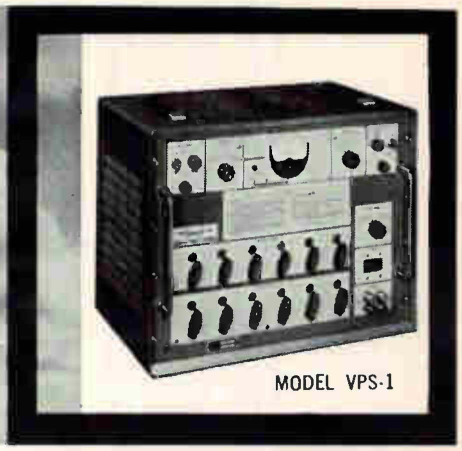

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3211 South La Cienega Boulevard, Los Angeles 16, California / UPton 0-2761 – VErmont 9-2201 as the reader is acquainted with the principles of the test equipment, much of it electronic. Equipment designers and manufacturers are also provided with a survey of needs and developments in this field.

There are dozens of methods that can be used singly or in combination to detect flaws, measure physical properties and define nonuniformities without damaging materials or parts. These range from relatively simple methods like temperature crayons and magnetic particle inspections to other visual and optical techniques, pressure and leak testing, liquid penetrants, x-ray and gamma radiography, ultrasonics, dynamic testing, magnetic methods, electric and eddy current instruments and techniques, and a variety of others. Thickness measurement is also surveyed.

There are many examples of solutions to specific problems. More importantly, the author explains the physical principles of each test method, enabling the reader to devise applications of the method to novel problems.—G.S.

Linear Systems Analysis

By P. E. PFEIFFER

McGraw-Hill Book Co., Inc., New York, 1961, 538 *p*, $12.50

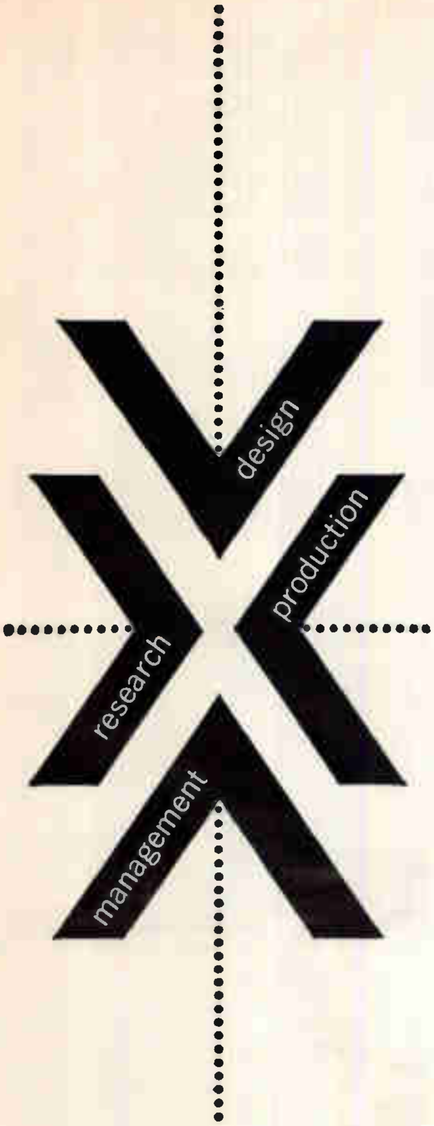
THE ENGINEER without formal training in linear systems will find the theory necessary for application in the first half of this text. Covered are complex variables, polynomial and rational functions, determinents, Fourier series, Laplace transformation and systems with various degree of freedom. The rest of the book covers transfer function, matrices, signal-flow graphs and feedback theorems.

The Consulting Engineer

By C.M. STANLEY

John Wiley & Sons, Inc., New York, 1961, 258 *p*, $5.95

NONTECHNICAL aspects of the consulting engineer's professional life are covered in this book. Topics include organizing a consulting firm, typical accounting and billing procedures, contracts, ethics, and relations with clients and colleagues. This is a useful guide for a consultant getting started or an engineer contemplating striking out on his own.—J.C.



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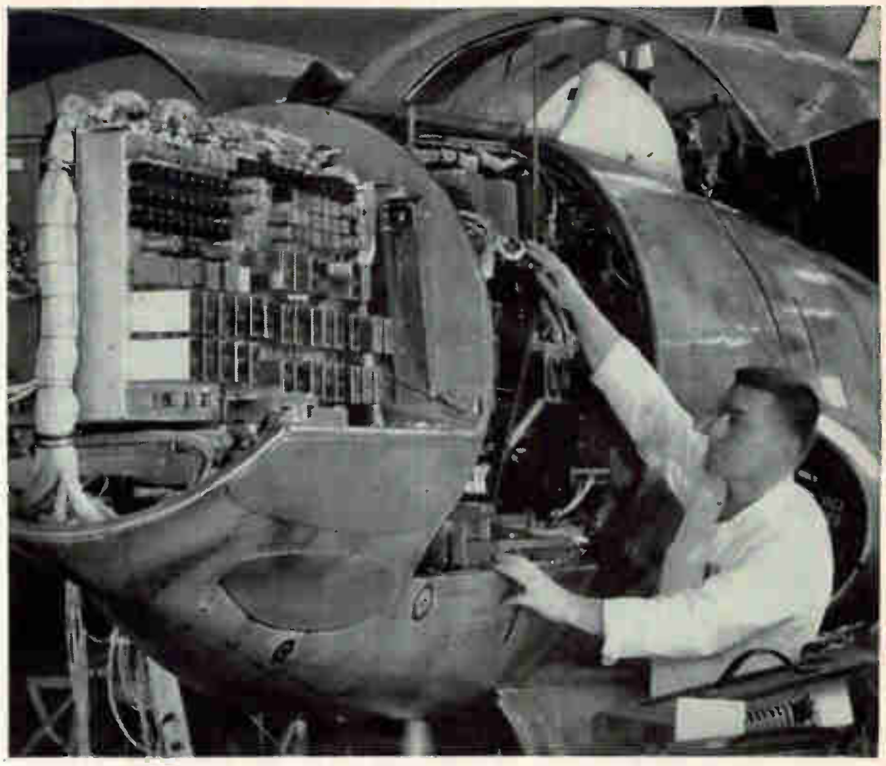

Aircraft flight simulator at Cornell Aeronautical Laboratory puts new aircraft designs through their paces, saving countless dollars of Air Force development costs. Analog computer circuitry can pre-evaluate stability and control characteristics in advance of flight.

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Holmes: Get the Job Done

"He proved what he can do when he ran the Bmews project and he'll do the same on this job!"

This was one of many favorable comments made by friends and colleagues when they learned of the appointment of D. Brainerd Holmes to head NASA's $20 billion moon/space project. The job Holmes is undertaking has been called by high government officials the most difficult, complex and costly technical enterprise ever undertaken by the U. S. Its aim—send a three-man expedition to the moon.

Taking over his new job this month, Holmes leaves his RCA post as general manager of the Major Defense Systems Division. The six-foot, 185-pound Cornell graduate (EE-1943) quipped that a problem involved with his new duties will be to find a good school in Washington for his two daughters (12 and 16) plus a house for his family. "I guess if I'm expected to get a man on the moon by 1970, I should be able to find a house by the end of this month," he said, smiling.

Men who have worked with Holmes in the past say his Bmews experience will serve him well now. In 1957 he faced the problem of tapping the resources of almost 3,000 companies, assembling men and materials in quantities unequalled since the days following Pearl Harbor, and getting deliveries made to Greenland exactly as needed. Despite the difficulties imposed by weather and logistics, Holmes got the job done.

Besides Bmews, Holmes has to his credit supervision of the ground support for Talos and countdown time reduction on Atlas from several hours to a matter of minutes.

Holmes says his appointment to the job of "Mr. Moon" came as a complete surprise to him. Two weeks before he was named, he had been to Washington to report on his Bmews experiences to a panel of space experts. Unknown to him, he was being evaluated for the new post while speaking. His conduct during the presentation clinched the NASA decision.

Holmes thinks fast on his feet and can field rapid-fire questions. When someone recently asked him if $20 billion wasn't a lot of money to be tossed away on an attempted moon landing despite the many things such an amount could do in health, housing or welfare, his answer came in seconds.

"We have no choice," he said, "but to go ahead with a project of this nature. It is unlikely that we will continue to grow as a great world power unless we do so. This country couldn't possibly turn its back on a program of this kind because it has ramifications that affect the entire American economy."

The 40-year old executive has resigned from RCA and divested himself of all financial interest in the company. He says his family has given their enthusiastic support to the new venture despite the reduction in income. His busy life has left Holmes little time for hobbies and social activities and he expects little if any additional leisure on his new job. He sums up his philosophy on his immediate future by saying:

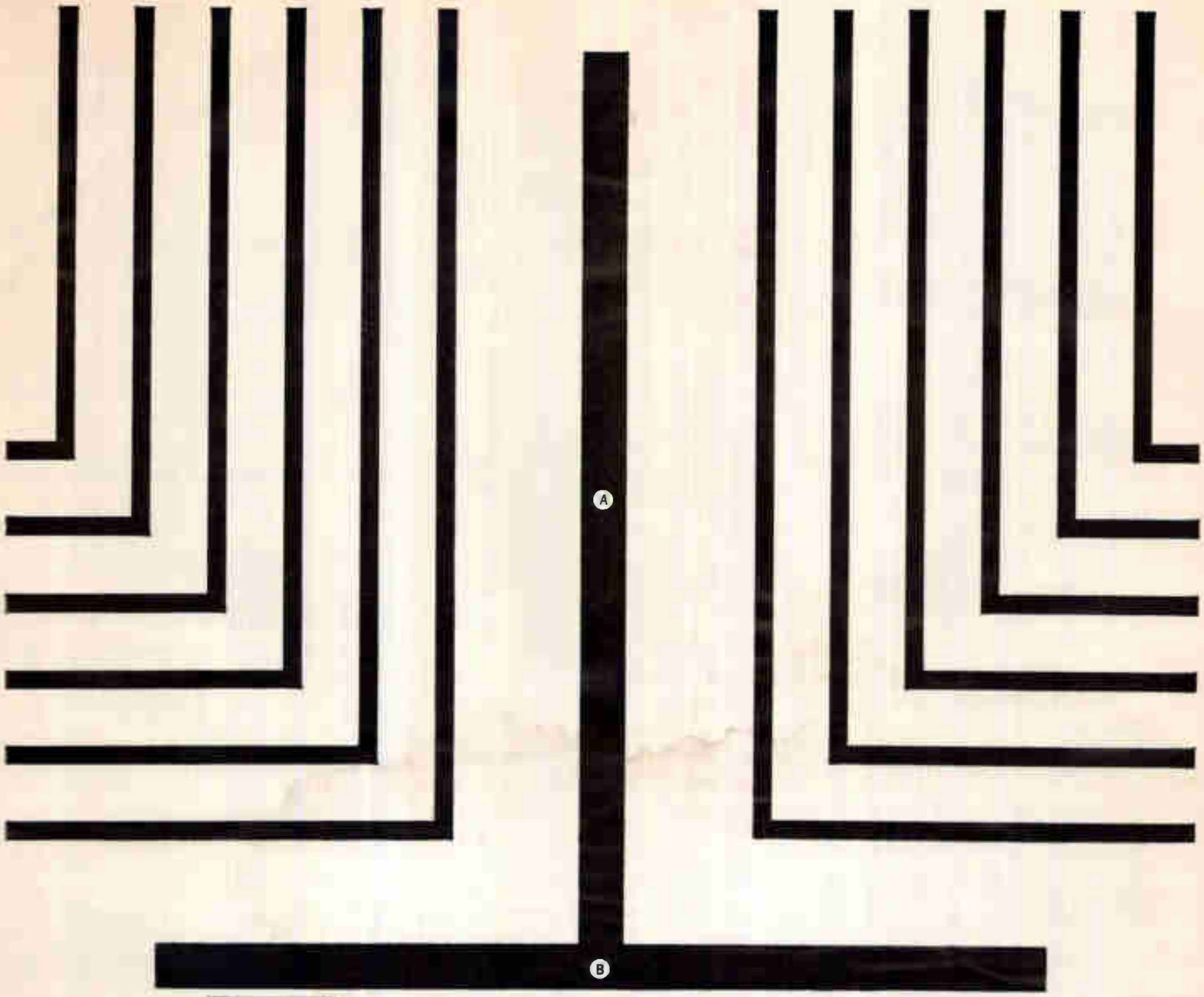
"It isn't important that I was chosen for this job. What is important is that we quickly assemble 400 or 500 people like myself to get the job done."

GPI's Link Division Promotes McGowan

JAMES M. McGOWAN has been promoted to the position of manager of simulator engineering at Link Division of General Precision, Inc., in Binghamton, N. Y. He was formerly manager of commercial projects in the simulator engineering department.

Amphenol-Borg Combines Divisions

AMPHENOL-BORG ELECTRONICS CORP., Broadview, Ill., has announced an expansion in the field of radio frequency energy, with emphasis on the microwave portion of the spec-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trum. As part of the program the company's two divisions in the field, FXR and RF Products, have been combined into an enlarged unit to be known as FXR, with Neil M. Blair as president.

Blair headed the former RF Products division and was operating director of the FXR factory complex.

The new division will have headquarters in Danbury, Conn.

ICF Names Davies Technical Advisor

GOMER L. DAVIES has been named technical advisor at Instrument Corp. of Florida, Melbourne, Fla. He is a consulting engineer specializing in instrumentation applications of magnetic tape.

ICF designs and develops photogrammetric and electronic instrumentation.

Avien Appoints Operations V-P

APPOINTMENT of Clifford E. Willis as vice president of operations, a newly created post at Avien, Inc., Woodside, N. Y., has been announced by Leo A. Weiss, president.

At the same time Weiss announced the establishment of four new divisions: Antenna, responsible for the patented Avien-Borgner antennas and antenna systems;

Electronics and Instruments, which includes Avien-Woodside and the Colvin Laboratories and Pressure Elements subsidiaries; Hydro-mechanical, encompassing Avien's Farmingdale, Long Island Research Center and Electrol, Inc., a subsidiary; and Systems, responsible for coordination of all systems management projects of the corporation.

Before joining Avien, Willis headed up his own business management consultant firm.

Margosian Rejoins Polarad Electronics

JOHN W. MARGOSIAN has rejoined Polarad Electronics Corp., Long Island City, N. Y., after an absence of a year, to assume the position of technical assistant to the vice president in charge of the Defense Products division.

Margosian's previous affiliation with Polarad was as electronic systems manager engaged in the development of special purpose miniaturized receiving and data storage systems for the Air Force. Prior to his return he was vice president and director of engineering of Microwave Dynamics Corp.

IFI Promotes A. M. Barbella

ANTHONY M. BARBELLA, staff engineer of Instruments for Industry, Inc., Hicksville, N. Y., developer of electronic systems, amplifiers, precision potentiometers and related components, has been promoted to chief systems engineer.

He will be in charge of complete projects under primary contracts.

Columbus Process Changes Name

COLUMBUS PROCESS CO., INC., of Columbus, Ind., announces a change in corporate name to CP Electronics, Inc.

CP Electronics manufactures audio amplifiers, specialty power supplies, and transformers for radio, tv, and stereo. Other electromagnetic components are made for military communication and missile applications.

PEOPLE IN BRIEF

Martin-Orlando promotes **Herman R. Staudt** to director, Pershing ballistic missile system program. **William J. Vallette** moves up to manager, industrial engineering, of Itek Electro-Products Co. **Charles Bartell,** ex-W. R. Grace & Co., appointed director of R & D of Mystik Adhesive Products, Inc. **Marcus L. Cox,** formerly with Radiation, Inc., joins Instrument Corp. of Florida as chief engineer. **William J. Perry** advances to director of Sylvania's Electronic Defense Laboratories. **Stephen W. Moulton** and **Robert F. Dressler** of Philco Research Division assume the new posts of associate director and assistant director of research, respectively. **Wendell F. Smith** leaves GE to become a senior member of the advanced planning staff of Electro-Optical Systems, Inc. **Lawrence A. Feidelman** and **Joseph Reymann, Jr.,** previously with Philco and Hazeltine, respectively, have been added to the technical staff of Auerbach Electronics Corp. **N. Greig Cranna,** ex-CBS Laboratories, named to head microcircuit development at Microwave Associates, Inc. **Joe D. Spradlin,** formerly with General Dynamics, joins Dorsett Electronics, Inc., as chief engineer for its Electronics Laboratories div.

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Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
A C SPARK PLUG Electronics Div. of General Motors Corp. Milwaukee, Wisconsin	99*	1
ESQUIRE PERSONNEL Chicago, Illinois	112	2
GENERAL PRECISION LABS. GPL Division Pleasantville, New York	112	3
IBM DEVELOPMENT LABORATORY Poughkeepsie, New York	105*	4
LAWRENCE RADIATION LAB. University of California Livermore, California	105*	5
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	105*	6
PAN AMERICAN WORLD AIRWAYS, INC. Guided Missiles Range Div. Patrick AFB, Florida	73	7
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	111	8
REPUBLIC AVIATION Farmingdale, L.I., New York	110	9
TEXAS INSTRUMENTS INC. Apparatus Div. Dallas, Texas	101	10
UNION CARBIDE NUCLEAR CO. Oak Ridge, Tennessee	112	11

* These advertisements appeared in the 10/13/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

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

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S)..................................

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

10201

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

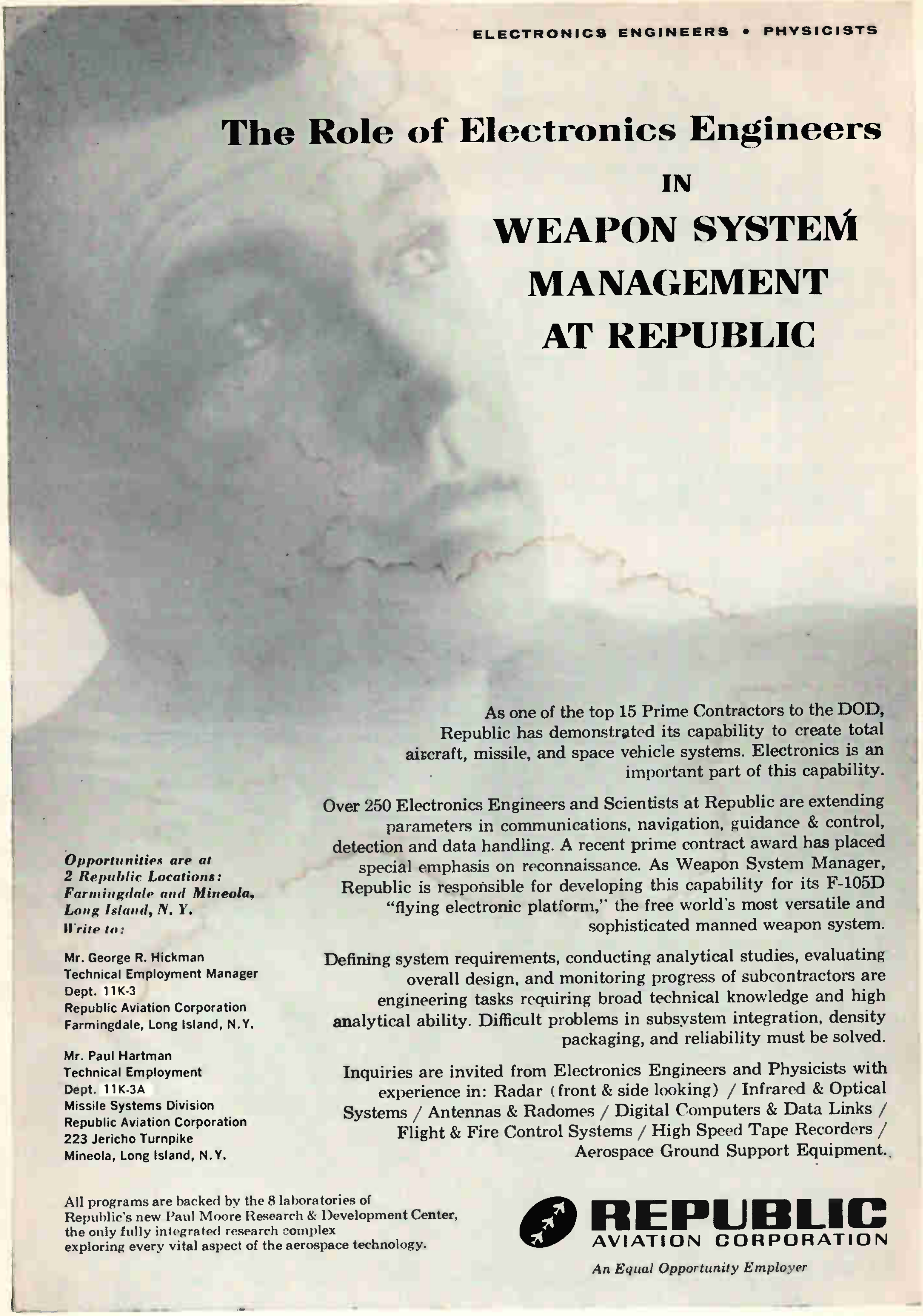
CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25


ELECTRONICS ENGINEERS • PHYSICISTS
The Role of Electronics Engineers
IN
WEAPON SYSTEM
MANAGEMENT
AT REPUBLIC
As one of the top 15 Prime Contractors to the DOD, Republic has demonstrated its capability to create total aircraft, missile, and space vehicle systems. Electronics is an important part of this capability.
Over 250 Electronics Engineers and Scientists at Republic are extending parameters in communications, navigation, guidance & control, detection and data handling. A recent prime contract award has placed special emphasis on reconnaissance. As Weapon System Manager, Republic is responsible for developing this capability for its F-105D "flying electronic platform," the free world's most versatile and sophisticated manned weapon system.
Defining system requirements, conducting analytical studies, evaluating overall design, and monitoring progress of subcontractors are engineering tasks requiring broad technical knowledge and high analytical ability. Difficult problems in subsystem integration, density packaging, and reliability must be solved.
Inquiries are invited from Electronics Engineers and Physicists with experience in: Radar (front & side looking) / Infrared & Optical Systems / Antennas & Radomes / Digital Computers & Data Links / Flight & Fire Control Systems / High Speed Tape Recorders / Aerospace Ground Support Equipment.
Opportunities are at 2 Republic Locations: Farmingdale and Mineola, Long Island, N. Y.
Write to:
Mr. George R. Hickman
Technical Employment Manager
Dept. 11K-3
Republic Aviation Corporation
Farmingdale, Long Island, N.Y.
Mr. Paul Hartman
Technical Employment
Dept. 11K-3A
Missile Systems Division
Republic Aviation Corporation
223 Jericho Turnpike
Mineola, Long Island, N.Y.
All programs are backed by the 8 laboratories of Republic's new Paul Moore Research & Development Center, the only fully integrated research complex exploring every vital aspect of the aerospace technology.
REPUBLIC
AVIATION CORPORATION
An Equal Opportunity Employer

Philco WDL has immediate and challenging engineering positions open in Discoverer, Midas and Advent programs in these categories:

Data systems engineering

Technical Staff — communications and data systems

Systems test planning

Systems reliability analysis

Design Engineering—surface and vehicle electronics

Human factors and operations analysis

Field tracking station activation

Tracking and control systems design

Logistics and station support

And others

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin; U. S. citizenship or current transferable Department of Defense clearance required.

if your future is for growing...

People at Philco's Western Development Laboratories are proud of their achievements, secure in the steady growth of their company, enthusiastic about their future.

In just four years, Philco WDL has expanded from a staff of 18 to more than 2,000. At the end of this year WDL will open a new 250,000-square-foot facility which will accommodate a continually expanding complement of engineers, scientists and supporting staff members.

Philco WDL, the space organization which designed and built the Courier satellite, conducts an ever-growing development program in tracking, satellite instrumentation, communications, data processing and command—moving hand in hand with the federal government in space exploration and space age defense.

Your growth with a growing company, ideal living on the Northern California Peninsula, professional and monetary advancement commensurate with your own ability—these are some of the advantages and satisfactions of working at Philco Western Development Laboratories.

If yours is one of the fields listed at the left, write today to Mr. W. E. Daly, in confidence, of course, Department E-10.

This new 250,000-square-foot addition to Philco Western Development Labs will open by the end of the year.

PHILCO *Famous for Quality the World Over*

WESTERN DEVELOPMENT LABORATORIES
3875 Fabian Way, Palo Alto, California

What do you need to know about

PURE FERRIC OXIDES

MAGNETIC IRON OXIDES

Since the final quality of your production of ferrites and magnetic recording media depends on the proper use of specialized iron oxides—you'll find it mighty helpful to have the latest, authoritative technical data describing the physical and chemical characteristics of these materials. This information is available to you just for the asking. Meanwhile, here are the highlights.

PURE FERRIC OXIDES—For the production of ferrites, both hard and soft, we manufacture a complete range of iron oxides having the required chemical and physical properties. They are produced in both the spheroidal and acicular shapes with average particle diameters from 0.2 to 0.8 microns. Impurities such as soluble salts, silica, alumina and calcium are at a minimum while Fe_2O_3 assay is 99.5+%. A Tech Report tabulating complete chemical analysis, particle shape, particle size distribution, surface area, etc., of several types of ferric oxides, hydrated ferric oxide, and ferroso-ferric oxide is available.

MAGNETIC IRON OXIDES—For magnetic recording—audio, video, computer, and instrumentation tapes; memory drums; cinema film striping; magnetic inks; carbon transfers; etc.—we produce special magnetic iron oxides with a range of controlled magnetic properties. Both the black ferroso-ferric and brown gamma ferric oxides are described in a Data Sheet listing magnetic properties of six grades.

If you have problems involving any of these materials, please let us go to work for you. We maintain fully equipped laboratories for the development of new and better inorganic materials. Write, stating your problem, to C.K. Williams&Co., Dept. 25, 640 N. 13th St., Easton, Pa.

WILLIAMS
COLORS & PIGMENTS

Pigment Technology at its best

E.ST. LOUIS, ILL. · EASTON, PENNA. · EMERYVILLE, CALIF.

CIRCLE 112 ON READER SERVICE CARD

EMPLOYMENT OPPORTUNITIES

TV QUALITY CONTROL ENGINEER

To design test equipment, prepare test procedures, review test data. Evaluate closed circuit TV equipment designed and manufactured by GPL.

Education: Equivalent of EE degree required. Must have 2-3 years' experience in operation and maintenance of studio or industrial TV equipment.

Please write or submit resume indicating current earnings, to: Raymond S. F. Oakley.

GPL DIVISION
GENERAL PRECISION, INC.

63 Bedford Road, Pleasantville, N. Y.

An equal opportunity employer.

Electronic Instrument Mechanics
The Oak Ridge National Laboratory
Operated by
Union Carbide Nuclear Company
at
Oak Ridge, Tennessee
Has openings for

Highly skilled electronic instrument mechanics to work with electronic engineers in the development, installation and maintenance of electronic systems. Digital data handling, transistorized pulse height analyzers, analog and digital computer systems are only a few examples.
Minimum high school education, with additional training in electronics and at least three years' experience in installation and maintenance of complex electronic systems.

Excellent Working Conditions
and
Employee Benefit Plans

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

Send detailed resume' to:
Central Employment Office
Union Carbide Nuclear Company
Post Office Box M
Oak Ridge, Tennessee

WANTED
Electrical, Mechanical or Chemical Engineering Graduates

. . . to be trained as Sales Engineers for Cleveland, New York, Chicago, and Richmond, Virginia. We also have an opening for man with technical background for inside office work at Los Angeles. Prefer men between 25 and 32 years of age who have had industrial process experience. Successful applicants will be given a three-month factory course starting February 1, 1962.

Write Harry E. Beane, Vice President
THE BRISTOL COMPANY
Waterbury 20, Connecticut

PRODUCT ELECTRICAL ENGINEER
$12,000 per Year

2-5 years electronic design experience. Prefer knowledge of transistor circuit design. This position is in the design of new or modified electronic units with digital or analog recorders. Client assumes all expenses.

ESQUIRE PERSONNEL
202 South State St., Chicago 4, Illinois

SEARCHLIGHT SECTION
(Classified Advertising)
BUSINESS OPPORTUNITIES
EQUIPMENT - USED or RESALE

AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS
3 & 10 CM. SCR. 584 AUTOTRACK RADARS.
AN/TPS-10 SEARCH. AN/TPS-10 HT. FINDERS.
AN/FPN-32GCA. AN/APS-10 NAVIG. & WEATHER.
AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
AN/APS-31A SEARCH. DOZENS MORE.
.5-1-2 MEGAWATT HIGH POWER PULSERS.
MICROWAVE PLUMBING—TEST EQUIP.
LARGEST RADAR STOCK IN U.S.A.
RADIO RESEARCH INSTRUMENT CO.
550 Fifth Ave. New York Judson 6-4691
RADAR SYSTEMS & COMPONENTS / IMMEDIATE DELIVERY

CIRCLE 460 ON READER SERVICE CARD

POSITIONS VACANT

Sales Engineer/Manager with exp. In electronic instruments, delay lines. Excel. opportunity with well known Mfg. Ad-Yu Electronics Lab., Passaic, N. J.

Engineering Opportunities — Broadcast Equipment Sales Engineer, Broadcast Equipment Design Engineer, Tuner Design Engineer, Sales Engineer (Tuner) Research Chemist. Midwest location. E. M. Sears, Box 62, Bloomington, Indiana.

QUICK SOLUTION TO MANPOWER PROBLEMS . . .

through the EMPLOYMENT OPPORTUNITIES Section of this publication. The market place for those offering or wanting the services of men on engineering, technical and executive level.

This section offers a quick, effective solution to your manpower problems, because its readership is confined to just the type of men you need . . . Waste circulation is avoided . . . You reach only the men you want.

Classified Advertising Div.
ELECTRONICS
P.O. Box 12, New York 36, N. Y.

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CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

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electronics

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Associated Business Publications

Audited Paid Circulation

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Advertising Sales Manager

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The KIN TEL Model 501B 4-digit, over-ranging digital voltmeter measures DC from ±0.0001 to ±1000.0 volts to an accuracy within 0.01% of reading ±1 digit. An extra fifth digit in the left decade indicates "0" or "1" to provide ten times greater resolution at decade (1, 10, 100) voltage points than standard 4-digit voltmeters. Ranging and polarity indication are entirely automatic. The measured voltage, decimal point and polarity symbol are displayed on an in-line readout in a single plane – no superimposed outlines of "off" digits.

An adjustable sensitivity control permits decreasing sensitivity to allow measurement of noisy signals. Ten-line, parallel input printers can be driven directly, and converters are available for driving other types of printers, typewriters, and card or tape punches. The input impedance is 10 megohms at null on any range, and an input filter attenuates power-frequency ripple by 60 db. Stepping switches are DC-driven (as in telephone service) at 20 steps per second, are guaranteed to give at least two years of trouble-free service without maintenance.

The 501B is one of a complete line of KIN TEL digital instruments. Others include AC converters, AC and DC preamplifiers, ratiometers, comparators, and multi-channel input scanners.

IMPORTANT SPECIFICATIONS

Display...Six decades display 5 digits (Left digit "0" or "1" only), decimal point, polarity symbol. Ranging and polarity indication are automatic. Projection system readout employs bayonet-base lamps with 3000-hour minimum life rating. Readout contains no electronic circuitry and can be remotely mounted.

Automatic Ranges...±0.0001 to ±1000.0 volts DC in four ranges: 0.0001 to 1.9999; 02.000 to 19.999; 020.00 to 199.99; 0200.0 to 1000.0

Accuracy...0.01% ±1 digit (of reading).

Input Impedance...10 megohms on all ranges at null.

Reference Voltage...Chopper-stabilized supply, continually and automatically referenced to standard cell.

Stepping-Switch Drive...DC voltage within stepping-switch manufacturers rating applied by transistor drive circuit at rate of approximately 20 steps per second.

Controls...Three: on-off; sensitivity; and mode of operation (standby, normal, print auto, print remote).

Printer Drive...Built-in for parallel input printers. Automatic or remote.

Dimensions and Net Weights...Control unit: 45 lbs, 5¼" H x 19" W x 16" D. Readout: 10 lbs, 3½"H x 19"W x 9"D.

Price: $2995

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

COHU ELECTRONICS, INC
KIN TEL DIVISION

5725 Kearny Villa Road, San Diego 11, California, Phone: BRowning 7-6700