Electronics®

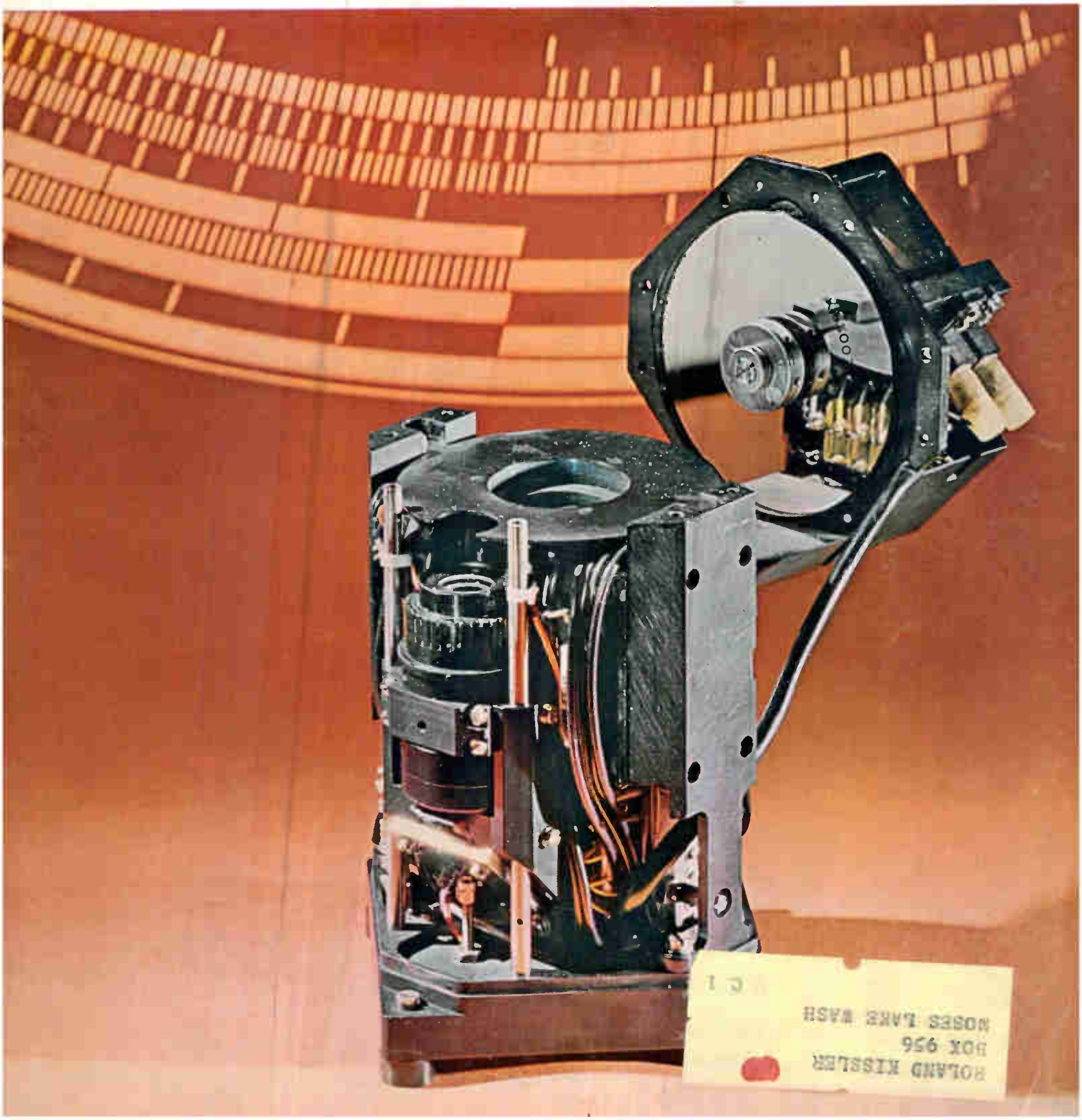
Characteristics of thin-film transistors: page 53

East-West electronic spying: page 74

All-channel tv's impact on design: page 90

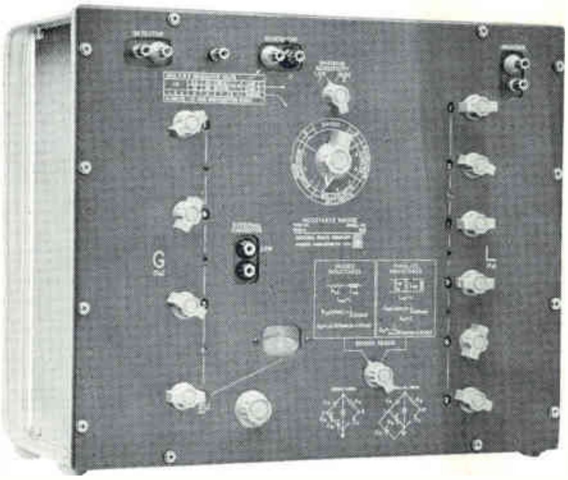
April 20, 1964
75 cents
A McGraw-Hill Publication

Below: new permanent optical memory for computer, page 64



FOR MEASUREMENTS OF

Inductance



Type 1632-A Inductance Bridge . . . $950

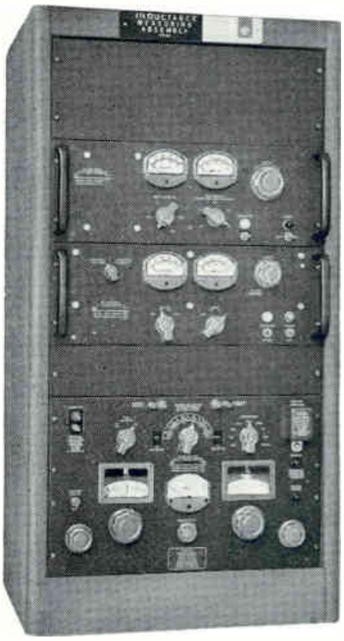
The ideal bridge for rapid, precise L and G measurements, and for calibration of inductance standards

It has a wide range, 0.0001 μh to 1111 h, with 0.1% direct-reading accuracy and six-figure resolution. Contains easy, fool-proof readout with in-line decade readings and indicated decimal points. Measures series or parallel inductance; circuits and instructions are engraved on its panel. Designed for use at 1 kc and lower, but usable to 10 kc. External generator and null detector required.

Type 1633-A Incremental-Inductance Bridge . . . $1050

An invaluable tool for measuring magnetic properties of silicon steel, magnetic alloys, ferrites, chokes, transformers, and filters

Accurately and conveniently measures inductance under different conditions of dc and ac excitation. These incremental inductance measurements can be made while the inductor is operating in the circuit. Accuracy of ±1% for L; ±2% for R and Q. Has wide impedance ranges: L — 0.1 μh to 1000 h; R — 10 mΩ to 1 MΩ. Indicates Q or R of inductor directly at any of nine frequencies between 50 c and 15.75 kc. Accepts applied signal of up to 1250 v (ac or dc) at 7 amps; up to 50 amps with Type 1633-P1 Range-Extension Unit ($125).



COMPLETE SYSTEMS

. . . for measuring the inductance and loss of coils with ferromagnetic cores at high dc and ac excitation levels. Each assembly includes a bridge, two 200-voltampere power supplies, rack, and interconnecting cables.

Type 1630-AL
Inductance-Measuring Assembly . . . $2660

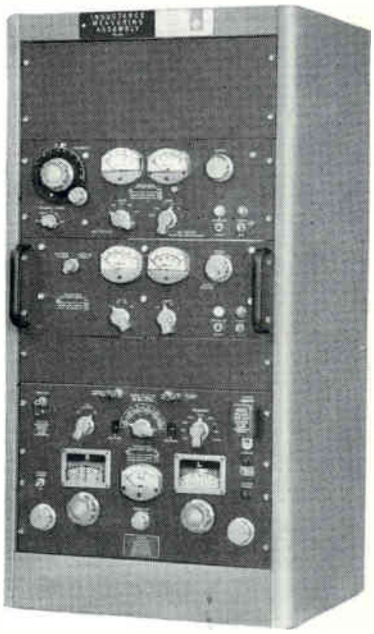
For 60-cycle measurements

Contains: Type 1633-A Incremental-Inductance Bridge
Type 1265-A Adjustable DC Power Supply
Type 1266-A Adjustable AC Power Supply

Type 1630-AV
Inductance-Measuring Assembly . . . $3450

For measurements at 9 frequencies from 50 c to 15.75 kc

Contains: Type 1633-A Incremental-Inductance Bridge
Type 1265-A Adjustable DC Power Supply
Type 1308-A Audio Oscillator and Power Amplifier



Write for complete information on any of these instruments

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

IN CANADA: Toronto 247-2171, Montreal (Mt. Royal) 737-3673
IN EUROPE: General Radio Overseas, Zurich, Switzerland

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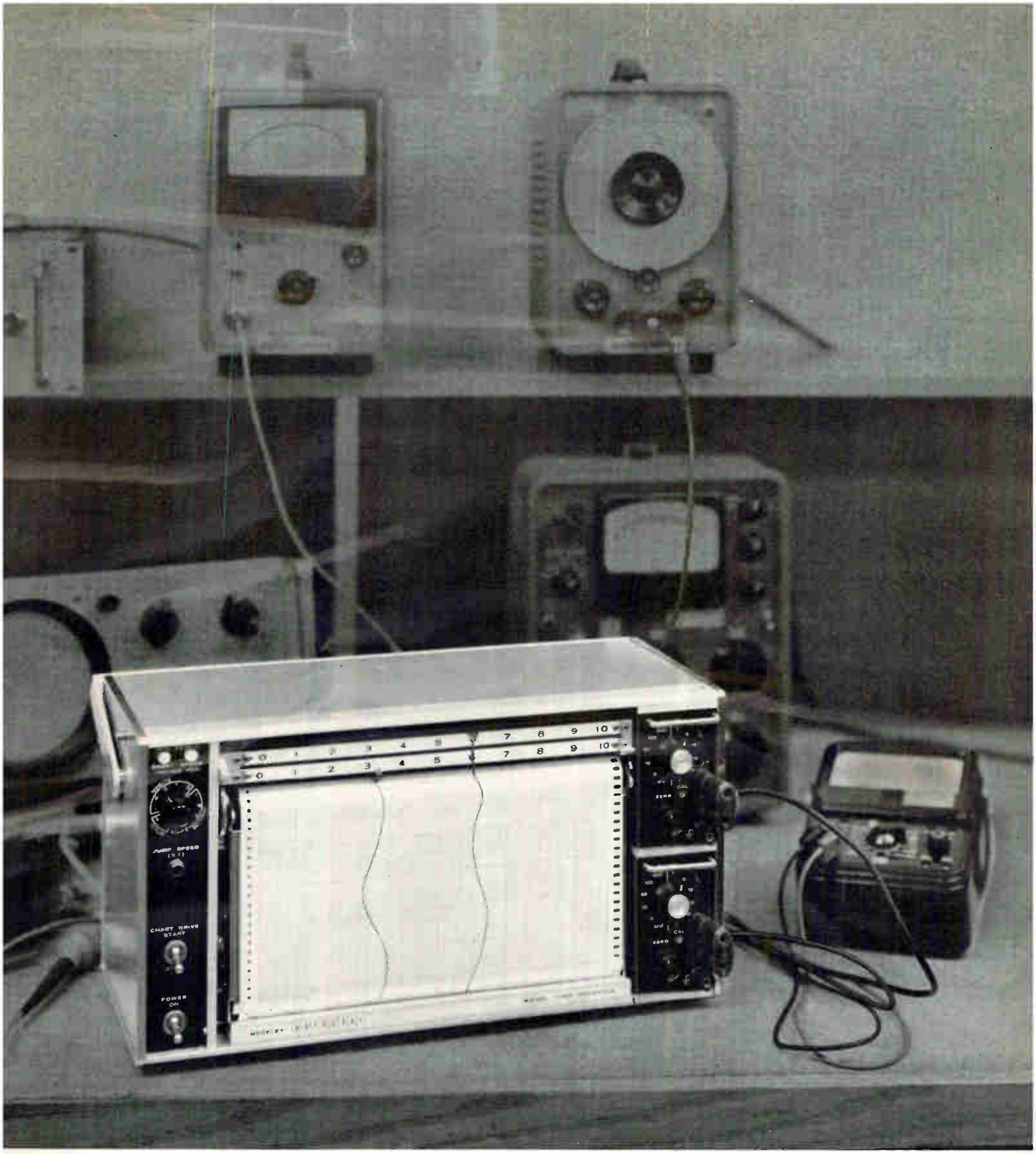
Circle 900 on reader service card



1 MEG INPUT IMPEDANCE
INSTANT CHART-SPEED CHANGE
EASY-LOADING MAGAZINE
TOTAL MEASURING VERSATILITY

MOSELEY hp
an affiliate of Hewlett-Packard

New MOSELEY 7100A (two-pen) and 7101A (single-pen) 10" Strip Chart Recorders provide high impedance at null on all ranges, shift chart speeds in milliseconds with an exclusive 12-speed changer (10:1 remotely-controlled jump speeds optional) and make life easier with an exclusive modular loading system for 120' chart rolls. Circuitry is rugged, compact, solid state, cool running; offers better than 0.2% accuracy and 120 db DC common mode rejection. Half-second balance time, 10 calibrated input ranges, level continuously variable from 5 mv to 100 v (1 mv optional). Ample power to drive retransmitting pots, event markers, limit or alarm switches. Model 7100A, $1800; Model 7101A, $1390. Try on your bench or in your rack; call your Moseley/Hewlett-Packard field engineer. F. L. MOSELEY CO., 409 N. Fair Oaks Avenue, Pasadena, California.

Circle 1 on reader service card

Two new amplifiers from Hewlett-Packard Whether you're interested in amplifying pulses or other signals from audio to vhf, one of these new amplifiers from Hewlett-Packard will suit your purpose. The 461A is a general purpose amplifier with an essentially flat frequency response from 1 kc to 150 mc; the 462A is a pulse amplifier with less than 4 nanosecond rise and fall times. Both amplifiers have 20 and 40 db gain, are completely solid state and have exceptional stability. Check the specs; then call your nearest hp field sales office for a demonstration.

Specifications

461A

Frequency Range:
1 kc to 150 mc

Frequency Response:
±1 db from 500 kc reference

Gain at 500 kc:
20 or 40 db ±0.5 db selected by front panel switch

Input Impedance:
Nominal 50 ohms

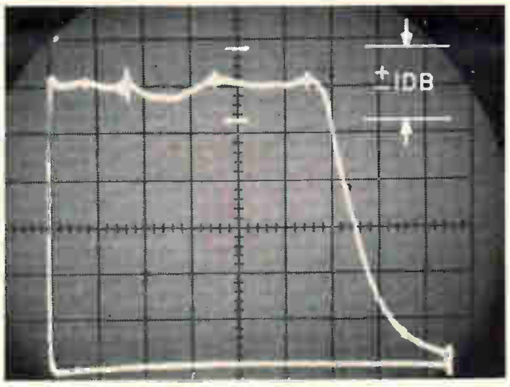
Output:
½ v rms into 50 ohm resistive load

Noise:
Less than 40 μv referred to input

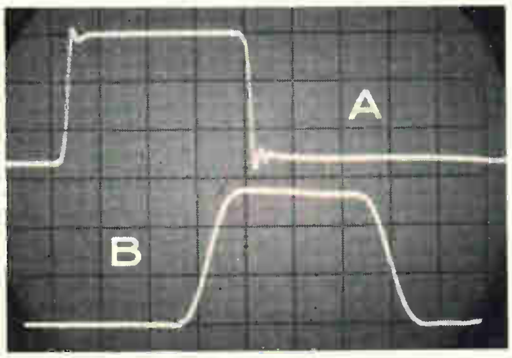
Distortion:
Less than 5% at maximum output and rated load

Price:
$325

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



461A Frequency response curve: markers at 50, 100, 150 and 200 mc; 40 db gain.
462A a) Input pulse (5 mv p-p); b) Output pulse (500 mv p-p) 40 db gain; sweep speed 5 ns/cm



462A

Pulse Response:
Rise and fall times for both leading and trailing edges, less than 4 ns; overshoot less than 5%

Pulse Overload Recovery:
Less than 1 μsec for 10 times overload

Pulse Duration:
30 μsec for 10% droop

Noise:
Less than 40 μv referred to input

Input Impedance:
Nominal 50 ohms

Gain:
20 or 40 db selected by front panel switch

Output:
1 v p-p into 50 ohm resistive load

Price:
$325

GENERAL

Size:
3-14/32" x 5-1/8" x 11"

Weight:
4 lbs.

Power Supply:
115 or 230 v ±10%, 50 to 1000 cycles

An extra measure of quality

5008

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April 20, 1964
Volume 37, Number 14

Electronics

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Probing the news

Technical articles

I. Design

II. Applications

Electronics

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Readers Comment

Dictatorship

Your Feb. 28 Crosstalk item [p. 5] on DOD was well stated. The entire defense of the U. S. should not be under one man's dictatorship—regardless of his competence.

Paul C. Sheretz
San Diego, Calif.

Amen

I should like to add a resounding "Amen" to B. F. Miessner's comments in the March 13 issue [p. 6].

H.B. Tilton
Tucson, Arizona

Radar beeps

I was pleased to see on p. 17 in the Feb. 28 issue that you have taken the wraps off a big problem—perhaps a lot bigger than your box-statement suggests.

The question of basic policy implied by the Air Force use of superpower radar near large cities may be just as horrendous as those raised by you concerning DOD on page 5 of the same issue—and, indeed, are very closely related.

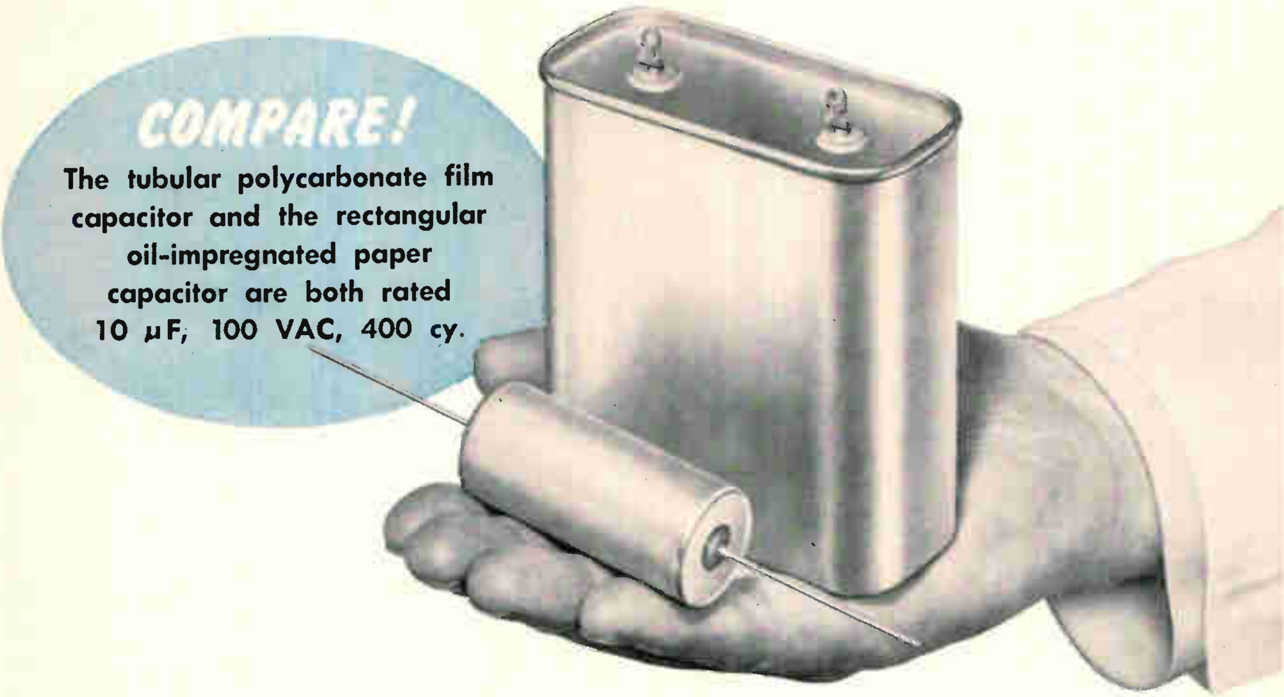
The rumors in Pittsburgh differ from your newsletter. The Federal Communications Commission at Buffalo is said to be much concerned about the Air Force radar interference and is not inclined to class 100 megawatts blanketing a city as equivalent to a ham radio next door. But where the military is in control what can they do?

There is nothing secret about the radar parameters. The beam shape can be estimated from the time-duration of the beep and by inspecting the dish and feed from a couple of miles. But why bother—anyone can drive to within 300 feet of the open antenna. From a couple of miles at a suitable elevation one can estimate the power and wavelength with Lecher wires. The max range one gets by matching the beep with the living-room piano, and the pulse width is visible on the family tv by expanding the horizontal sweep.

There are a lot of questions that an engineer would want to ask.

New from Sprague!

For extreme size reduction and unusual capacitance stability . . .



FILMITE® 'K' POLYCARBONATE FILM CAPACITORS

- New Filmite 'K' Polycarbonate Film Capacitors are *more than 13 times smaller than paper capacitors of equivalent capacitance value and voltage rating!*

- Polycarbonate film dielectric provides exceptionally high capacitance stability over the entire temperature range, due to inherently low coefficient of expansion of polycarbonate film and a dielectric constant which is nearly independent of temperature.

- Filmite 'K' Capacitors exhibit almost no capacitance change with temperature—dramatically better than polyester-film types, they even surpass polystyrene capacitors.

- Low dissipation factor (high *Q*) makes these capacitors extremely desirable where high current capabilities are required, as in SCR commutating capacitor applications.

- Low dielectric absorption (considerably lower than that of many other commonly-used film dielectrics) over a broad frequency/temperature spectrum makes Filmite 'K' Capacitors ideal for timing and integrating.

- Extremely high insulation resistance, especially at higher temperatures. Superior to many other commonly-used film dielectrics.

- Close capacitance tolerances—available to ±0.25%!

- Filmite 'K' Capacitors are excellent for critical applications including tuned circuits, analog and digital computers, precision timing and integrating circuits because of the unusual properties of the polycarbonate film dielectric.

Type 260P *Filmite 'K' Capacitors are metallized, utilizing non-inductive construction. They feature special self-healing characteristics, in the rare event of capacitor dielectric breakdown. Designed for operation at full rated voltage over the temperature range of −55 C to +105 C, these metal-clad capacitors are hermetically-sealed and are available with both standard and weldable wire leads or solder tabs in a variety of mounting styles.*

Types 237P and 238P *Filmite 'K' Capacitors are of high-purity foil construction, and are hermetically sealed in metal cases. Operating temp. range, −55 C to +125 C.*

For complete technical data on Type 260P and on Type 237P and 238P Capacitors, write for Engineering Bulletins 2705 and 2700, respectively, to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
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INTERFERENCE FILTERS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

4SC-4110

SPRAGUE®
THE MARK OF RELIABILITY

Circle 5 on reader service card

Why are they using this long wavelength which is extremely difficult to shield against (as compared to microwaves) and which went out of radar use at the beginning of World War II? Probable answers: to reduce rain response, to avoid radial blind speeds, and to obtain high coherent power for moving target indication. But these are lazy reasons. There must be many other ways of solving these engineering problems.

Why locate these sets next to big cities? Ostensibly, to control Nike missiles without video relaying. Probable real reason: this military net is being sold as a civilian air-traffic control system! ! When you take a close look at the military arguments, the future civilian use will be given as an excuse. But when you point out that this method of traffic control was obsolescent at the end of World War II, you will be told of the military need. The evident hope of the military is to get so much money tied up that it will be too late to blow the whistle.

Do we really have to pay this kind of price for protection against sub-sonic bombers? It is one thing to jazz up the economy and allay the neurotic anxiety of the populace by building up a Maginot line named Distant Early Warning. It is something else to use taxpayers money to tie up the technological future of this country in little knots.

I could be wrong, but my guess is that these decisions were made by military and civilian bureaucrats whose technological learning stopped at the end of World War II and who have been busy building a personal empire ever since.

One reason why I think so: I visited the Pittsburgh radar set-up. Everything I saw was World War II vintage. This is a new installation costing over $20 million. Rooms filled with racks of smoking-hot vacuum tubes! Video displays that were inadequate for heavy traffic when designed at Massachusetts Institute of Technology in 1944. If a computer manufacturer tried to sell this stuff, he would be laughed into bankruptcy. . . .

Why is the Air Force getting away with this in Pittsburgh? The answer: Pittsburgh is a hilly town and less than five percent of the population is being hit—a feature well known in the siting of long-wave radar. I predict that when they set up such a search radar near a flat city so that 50 percent of the people are annoyed, the military will be hoist on their own petard—at the taxpayer's expense. . . .

(Name Withheld)

▪ More recently, Name Withheld told us that the situation is much worse than the fact that the Russians have 800 low-speed bombers; he believes it involves the "nth country problem." Right now, n equals four, because four countries possess atomic weapons capabilities. In the future, "some small nth country might hijack an ordinary commercial airliner and drop an atomic bomb where it pleases." The military would then have to be able to protect against "a devil of a problem," by identifying the airliner in a hurry and shooting it down. In this situation, our reader adds, Nike missile sites near cities do make sense.

Abbreviations

Regarding your request for an abbreviation for optoelectronic technology [Jan. 24, p. 5], how about Optron or Optech? Or Optronology? Or Opticology?

Mrs. Thomas W. Newmyer
Greensburg, Pa.

Alignment

There were some errors in my article (Aligning Saturn missile's guidance system) in the Feb. 21 issue [p 26]:

Page 26, column 1, third paragraph, line 3 should read "a five-sided prism."

Page 26, column 2, first paragraph, line 11 should read "lens," not lense.

Same column, eighth line from bottom, chopping frequency is 266 cps.

Page 27, fourth line from end, first prism response is 0.7 to 1.35 microns.

Fig. 2, R_6 should be a variable resistor, and the 5,760-ohm resistor should be connected to —28 volts.

Walter S. Zukowsky
Perkin-Elmer Corp.
Norwalk, Conn.

New miniature cycle-controlled crimping tool!

6¾" from end to end. 10 ounces, total weight. Open handle span, 4". These are the facts behind this unique new Buchanan® miniature cycle-controlled crimping tool . . . that crimps miniature removable pin and socket contacts in a multitude of sizes and designs.

Now crimp in confined areas. Now crimp with much less fatigue. (Low hand pressure makes it ideal for female operators.) Now get all the operating advantages of the Buchanan MS-3191-A crimping tool — in half the size!

And what features: one tool and inexpensive positioners can crimp almost any contact . . . #20 or smaller, in wire sizes #20 through #30. There are no operator adjustments. By selecting the proper positioner, you program the tool to provide the correct crimp depth, crimp location and point of ratchet release . . . under-crimping or over-crimping are virtually impossible. The four-indent crimp provides the most uniform displacement of wire and contact material over a wide range of contact and wire sizes.

Get all the facts on this exciting new miniature cycle-controlled crimping tool by Buchanan.

Write today for complete crimping library and the new catalog

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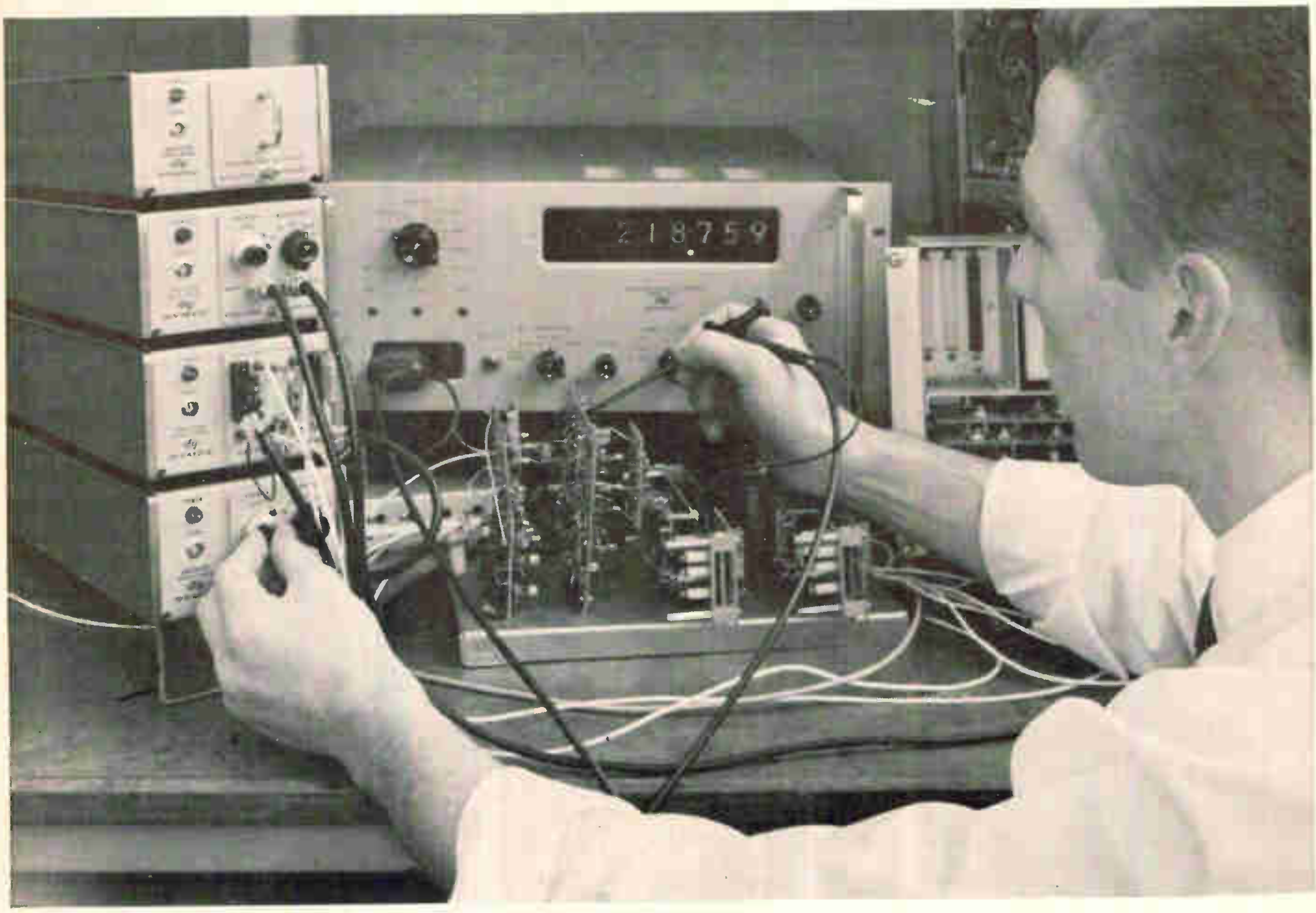
a subsidiary of Elastic Stop Nut Corporation of America

People

William H. C. Higgins, executive director of Bell Telephone Laboratories Electronic Switching Division, will be the top executive of the company's proposed mammoth Communications Development Center near Chicago [Electronics, April 6, 1964, p. 17]. Higgins, who is 56 this month, joined American Telephone and Telegraph Co. right after graduation from Purdue University in 1929 and went to the Bell Laboratories technical staff in 1934. His first jobs were with development of ship-to-shore and ground-to-air radio telephone equipment. He was later concerned with the development of radar, missile and communications systems, including the Nike-Ajax guided missile system, the Distant Early Warning Line and the command guidance system for the Titan intercontinental ballistic missile.

Jonas M. Shapiro, 48-year-old vice president and technical adviser of Hallicrafters Co., has been named president of Manson Laboratories, Inc., Hallicrafters' military communications subsidiary. Shapiro got his electrical engineering degree from the City College of New York, after attending night classes for 10 years while holding daytime electronics jobs. He joined Manson in 1953. Before that, he held communications positions with Link Radio Co., the U. S. Army Signal Corps and the California Division of Highways. He developed a radio frequency synthesizer for the Bureau of Ships and was instrumental in the production engineering of subminiature transceivers for the Signal Corps. He holds six patents and has 12 patents pending.

BREADBOARD
with this solid state operational amplifier



Use the DY-2460A as an active element of your newly designed circuits...

AMPLIFIER ■ SUMMER ■ HIGH IMPEDANCE ISOLATOR ■ INTEGRATOR ■ INVERTER

Check out new design concepts and ideas in a hurry with the DY-2460A DC Amplifier as a circuit element. This wideband, solid state instrument is ready-made for a wide variety of circuit applications which will save you time and effort.

The low-cost DY-2460A is designed for general purpose use. Amplitude and phase response are properly controlled beyond unity gain to permit a variety of feedback networks. *A self-contained power supply in each instrument provides highest isolation when operating a group of amplifiers at different potentials.* A non-synchronous photoconductive chopper eliminates all effects of ac pickup.

Plug-in design of the 2460A increases its versatility. A patch unit plug-in brings input, output, summing point and feedback circuit to the front panel; other plug-ins provide switchable gains in steps from 1 through 1000, vernier adjustment through 11,000, and a high-accuracy plus-one configuration with greater than 10^{10} ohms input resistance.

The 2460A will supply an output of $\pm$ 10 v peak at 10 ma. Zero drift is less than 1 μv per week, noise less than 4 μv peak to peak.

Ask your Dymec/Hewlett-Packard field engineer for all the details on how the DY-2460A can make your breadboarding easier.

Price: DY-2460A Amplifier, $395. DY-2461A-M1 Data Systems Plug-in, $85; DY-2461A-M2 Bench-use Plug-in, $125; DY-2461A-M3 Patch Unit Plug-in, $75; DY-2461A-M4 Plus-one Gain Plug-in, $35.

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

DYMEC

dy

A DIVISION OF HEWLETT-PACKARD COMPANY

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9047

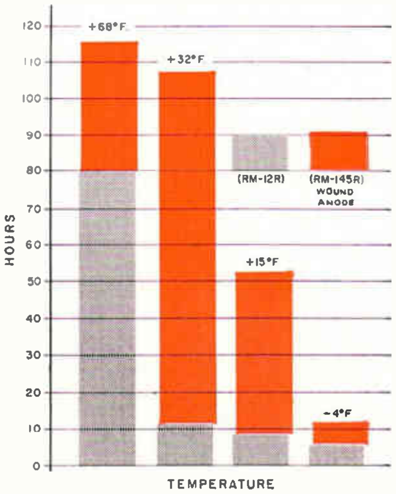
MALLORY

P. R. MALLORY & CO. INC., INDIANAPOLIS 6, INDIANA

Wound Anode Mercury Batteries have high energy at low temperatures

When temperatures drop to around 32°F, most dry batteries just don't put out the milliampere-hours the way they do at 70°F. And at 0°F, they practically give up.

Not so with our wound anode series of Mallory Mercury Batteries. As the chart shows, this construction of the famous mercury system pioneered by Mallory has 12 times as much capacity at 32°F as our standard (pressed anode) mercury cell . . . 6 times as much at +15°F. The wound anode cell at 32°F has 94% of its 68°F capacity . . . 46% at +15°F . . . and still has 10% capacity left at —4°F. And this is all the more remarkable when you consider that the Mallory mercury system has nearly four times the energy per pound of conventional Leclanché batteries.



We make the wound anode mercury system in four different cell sizes, with nominal capacities from 400 to 13,000 milliampere hours. Voltage is 1.35 volts per cell. We can either help you select a standard model or engineer a custom-designed power pack for your particular circuitry, space and capacity requirements.

CIRCLE 240 ON READER-SERVICE CARD

New Backing for Semiconductors

Looking for a backing plate for high power semiconductor devices? Then you've probably puzzled over getting a material that has good conductivity and a coefficient of expansion that matches silicon or germanium.

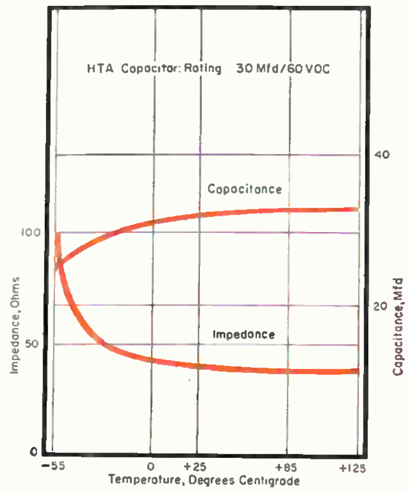
Our Elkonite® materials and other powder metal compositions of refractory constituents could be just what you need. By varying composition, we can tailor their coefficient of expansion to match closely with the semiconductor material. Their thermal conductivity is good, and they have excellent mechanical properties. And we can supply them as discs pressed and sintered to accurate dimensions . . . no more need to worry about close-tolerance cutting from bar stock.

CIRCLE 242 ON READER-SERVICE CARD

Need stability from −55° to +125°C? Try this new aluminum electrolytic

You can get broad-temperature stability and reliability in a new kind of capacitor we have developed . . . the Mallory Type HTA. This is an aluminum electrolytic that has plenty of life and stability at temperatures up to 125°C. And even at —55°C it retains about 85% of its original capacitance. That's temperature performance approaching tantalum . . . at aluminum prices!

The HTA comes in ratings of 8 to 300 mfd, 60 to 3 volts. Case diameter is 3/8"; case length, 13/16" to 1 5/8".



CIRCLE 241 ON READER-SERVICE CARD

DESIGNER'S FILE

Radiation-proof tantalum capacitors

The new XTG line of Mallory wet slug tantalum capacitors is designed to resist the effects of radiation. A group of sample capacitors recently passed a series of radiation exposure tests in the Ground Test Reactor of Lockheed Missiles and Space Company, Sunnyvale, California.

Capacitors were subjected to both gamma ray and neutron bombardment at 75°F. During 6744 minutes of reactor build-up time, the following dosage levels were reached:

Fast neutron bombardment: 6.579 x 10^{13} neutrons/cm^2, at energy level greater than 0.1 Mev.

Gamma radiation: 79.56 x 10^6 gamma rad. (C) from carbon source.

Capacitance, dissipation factor and DC leakage were measured for each capacitor at 120, 400 and 800 cps, both before and at the end of the dosage period. No detrimental changes in electrical characteristics occurred.

The XTG line uses special materials and construction to achieve radiation resistance. Temperature range is —55°C to +85°C. The line includes the same capacitance and voltage ratings as standard MIL-type Mallory wet slug tantalum capacitors, in all MIL terminal configurations.

CIRCLE 243 ON READER SERVICE CARD

High-precision cutting of "difficult" materials

How would you cut the molybdenum wave guide aperture shown here to highly accurate dimensions?

An excellent answer is EDM—electrical discharge machining. And where you need to maintain exceptionally close tolerances and accurate reproduction of complex contours, the electrode material to use is Elkonite® 10W3. On the part shown here, for instance, an Elkonite 10W3 electrode made it possible to hold slot width tolerances of 0.0001".

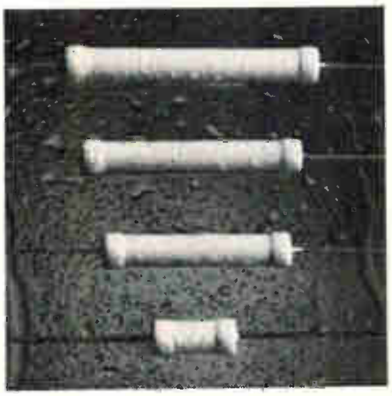
Any time you have a forming job that's difficult enough to warrant electrical discharge machining, it pays to consider Elkonite electrodes. Their ability to machine sharp corners and intricate contours in fine detail . . . their far longer service on the EDM machine . . . their ability to cut to extreme tolerances . . . will speed your production and reduce total machining costs.

CIRCLE 244 ON READER SERVICE CARD

Mallory Film Resistors stay stable in high humidity

A recent series of humidity exposure tests demonstrate the ability of Mallory Type MOL metal oxide film resistors to hold stable values of resistance when subjected to extreme moisture.

The tests were run on a group of 33,000-ohm, 3-watt MOL resistors with nominal 10% tolerance. First, the resistors were exposed to 95% relative humidity at 40°C for 100 hours at no load. Result: average change in resistance was +0.37% . . . maximum change was +0.51%.



Next, the resistors were held for 1000 hours in this same atmosphere, with full rated wattage applied. Result: average change in resistance was in the band from —0.7% to +0.62%; maximum changes were —1.2% and +1.6%.

Through all this high humidity test Mallory MOL resistors remained at resistance values well within their stated tolerances. On long-term load life tests—10,000 hours—they show equally fine stability, with resistance holding within 1% of initial values.

The MOL series comes in 2, 3, 4, 5 and 7 watt ratings, with resistance values ranging from 30 ohms minimum on the 2 watt to a maximum of 125K ohms for the 7 watt unit. Standard tolerance is 10%; other tolerances can be supplied.

CIRCLE 245 ON READER SERVICE CARD

Meetings

Spring Joint Computer Conference, American Federation of Information Processing Societies; Sheraton-Park Hotel, Washington, D.C., **April 21-23.**

Southwestern IEEE Show, Southwestern IEEE; Dallas Memorial Auditorium, Dallas, Texas, **April 22-24.**

Photographic Science and Engineering International Conference, Society of Photographic Scientists & Engineers; Hotel Americana, New York, N.Y. **April 27-May 1.**

Magnetic Inductance Core Conference, Magnetic Powder Core Association of the Metal Powder Industries Federation; Chicago, Illinois, **April 28.**

Annual National Relay Conference, NARM, Oklahoma State University, Okla. State Univ., Stillwater, Okla., **April 28-30.**

Region 6 Annual Conference, IEEE; Hotel Utah Motor Lodge Convention Center, Salt Lake City, Utah, **April 29-May 1.**

Frequency Control Annual Symposium, U. S. Army Electronics Research & Development Labs.; Shelburne Hotel, Atlantic City, N.J., **May 4-6.**

IEEE Packaging Industry Subcommittee Technical Conference, IEEE; Nassau Inn, Princeton, N.J., **May 4-6.**

ISA Biomedical Sciences Instrumentation National Symposium, ISA; University of New Mexico, Albuquerque, New Mexico, **May 4-6.**

EIA Workshop on Maintainability, EIA; Sheraton-Jefferson Hotel, St. Louis, Mo., **May 5-7.**

Electronic Components Conference, EIA, IEEE; The Marriott Twin Bridges Motor Hotel, Wash., D.C., **May 5-7.**

Aerospace Electronics Annual Conference, PTG-ANE, Dayton Section of IEEE; Biltmore Hotel, Dayton, Ohio, **May 11-13.**

Electronic Parts Distributors Show, Electronic Industry Show Corp.; Conrad Hilton Hotel, Chicago, **May 18-20.**

PTG-MITT International Symposium, IEEE; International Hotel, J.F.K. International Airport, New York, N.Y., **May 19-21.**

Organic Solid State Annual Symposium, Franklin Institute Labs; Philadelphia, Pa., **May 25.**

Tenth Annual Radar Symposium, Army, Navy, Air Force, University of Michigan Inst. of Science and Technology; Fort Monmouth, N.J., **May 26-28.**

Analysis Instrumentation Symposium, ISA; Sheraton Palace Hotel, San Francisco, Calif., **June 1-3.**

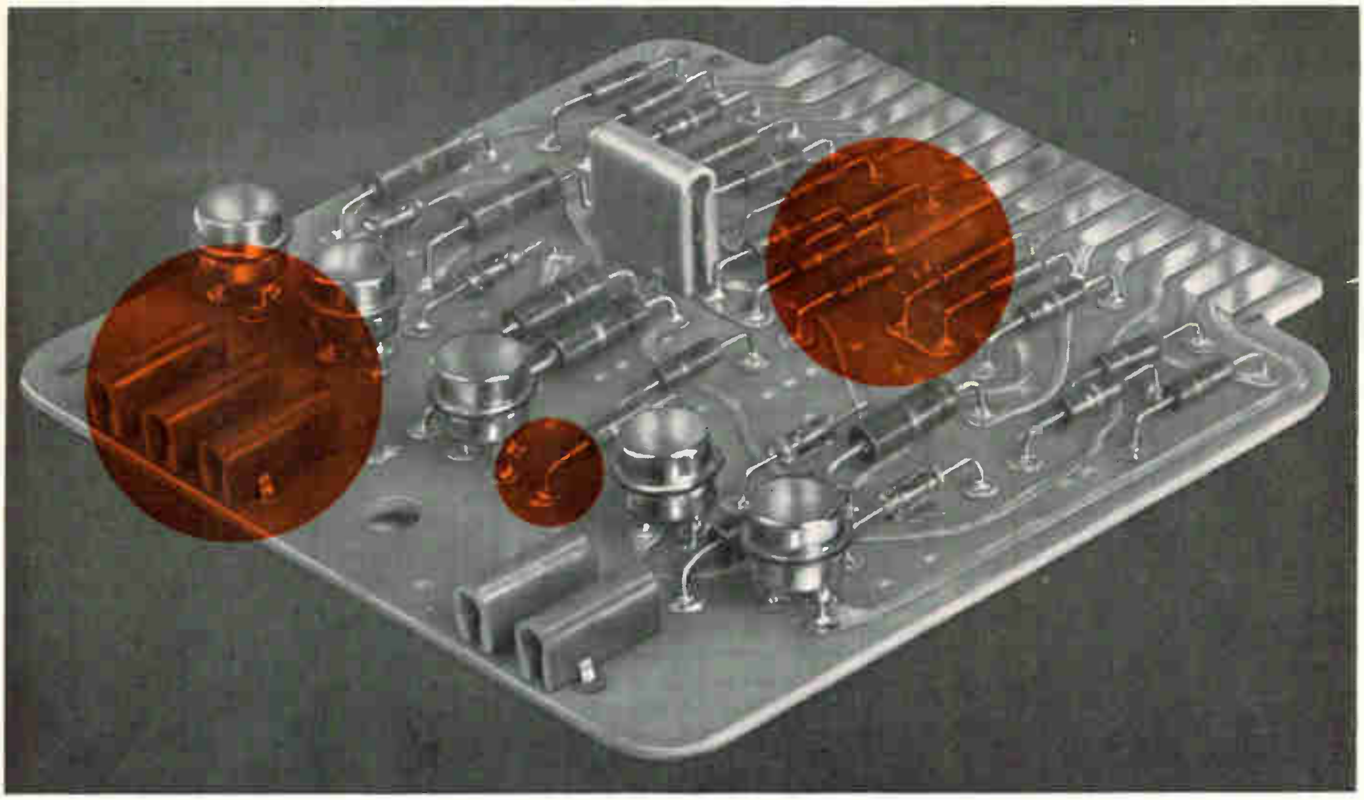
Electromagnetic Windows Symposium, The Antenna Lab., Dept. of Electrical Engineering, Ohio State Univ., in conjunction with US Air Force; Ohio State Univ., Columbus, Ohio, **June 2-3.**

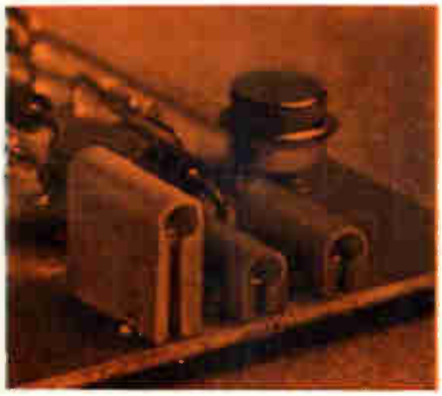
Telemetering National Conference, AIAA; Biltmore Hotel, Los Angeles, Calif., **June 2-4.**

Call for papers

Northeast Electronics Research and Engineering Meeting (NEREM), New England Section of IEEE, Northeast Electronics Research and Engineering; Commonwealth Armory and the Somerset Hotel, Boston, Mass., November 4-6. June 30 is deadline for submitting 600-1000 word summary in triplicate, plus 35-40 word abstract containing author(s) name(s), affiliation(s), business and home address, and telephone contact(s) to James E. Storer, Boston Section, IEEE, 313 Washington Street, Newton 58, Mass. Papers invited for presentation should describe significant original advancements in research and development.

Automotive Electrical & Electronic Engineering Conference, Southeastern Michigan Section and PTG-IECI of IEEE, University of Michigan, Michigan State University, Wayne State University and University of Detroit; McGregor Memorial Center of Wayne State University, Detroit, Michigan, September 22-23. Deadline is July 15 for submitting a 500-1000 word abstract indicating length of time required for presentation, to E. A. Hanysz, Chairman of the Papers Committee General Motors Research Labs., G. M. Tech. Center, Warren, Michigan. Topics covering effective development of automotive transportation, both in vehicles and highways, requiring extensive developments in electrical and electronic equipment and devices will be considered.





Some spots can be changed!

Take, for instance, mounting components for testing. That's one spot. The others? Testing circuits, and readying components on the board for soldering. They *all* can be changed for the better with our printed circuit board accessories.

Our Reusable Component Receptacle permits hand insertion of components to be tested. No need to solder them. That means, no damaged boards or components. Plus:

- single hole size—.089″—accepts jack
- jack accepts component leads ranging from .018″ to .040″ diameter
- up to 100 insertions without loss of retention

The Test Probe Receptacle offers:

- testing without removing board from connector
- tall version for clearance anywhere on board
- probing from front or rear
- "V" shaped legs promote capillary action during soldering
- all versions use standard .052″ hole size AMP standard gold over nickel plating

Our CIRCUITIP★ terminals offer a common denominator for all component leads regardless of type or stock size. Once formulated, the same solder schedule holds true for all components. In addition, you get:

- positive retention of components prior to soldering
- uniform solder fillets
- elimination of plated-through or eyeletted holes
- automatic trimming and bending of leads
- high speed application for lowest applied cost

There are many more good reasons why it pays to change these spots in your printed circuit boards and they're available on request. Send for them today.

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Harrisburg, Pennsylvania

INDUSTRIAL SALES DIVISION

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany

Circle 13 on reader service card

RF Power Standards

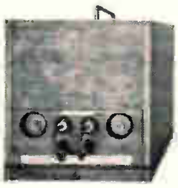
FOR THE LABORATORY

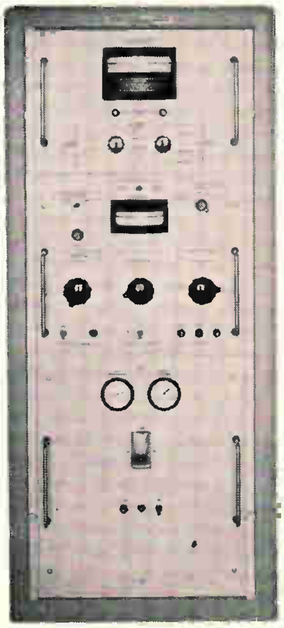
When you need to measure r-f power within a percent of 100% right, you'll be right in turning to a Sierra Model 290C. No other commercial calorimeter comes closer to achieving absolute measuring accuracy between 30 and 1000 watts. And, for measuring r-f power above 10 watts, it is regarded as industry's primary reference by the nation's leading standards labs. These specs tell why:

Power Range: 30-1000 watts	**Accuracy:** 99% assured, 99.35% probable
10-1500 watts	97% assured

In league with a Sierra Model 286B Dual Water Load, Model 290C spans a frequency range of DC to 4 Gc. Other loads in the Sierra line expand its coverage to 12.4 Gc.

Ability to pick your measuring mode — **null-balance** for best accuracy, **direct-reading** for 30 to 60 second readouts, or **differential** for expanded-scale readings — gives you a test instrument with unusual versatility. Model 290's price, excluding Dual Water Loads, is $4,500. The technical bulletin contains complete system prices with loads plus a comprehensive statistical analysis of performance.





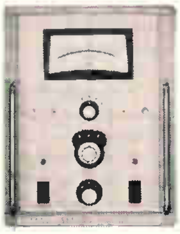
FOR THE FIELD

If you're reading power levels of 10 watts and greater with a bolometer or thermistor bridge, a power splitter, and possibly an attenuator, you're courting potential errors of 10% or more. Witness this simplified tabulation:

Bolometer or thermistor	2-3% limit of error
Directional Coupler	2-3% limit of error
Attenuator	2-3% limit of error
Error contribution due to drifts in calibration	1-5% limit of error
Total limit of error	7-14%

This kind of guessing game could have embarrassing results. Contrast it with the predictable end results you could enjoy with Sierra's compact Model 430A RF Calorimeter. This trim little 58 pounder reads from 50 to 1500 watts with 97% accuracy — guaranteed! And, you'll probably be getting 98% or better. A precision internal a-c wattmeter provides a built-in standard.

With the Model 430A, Sierra offers a group of five Coaxial and Waveguide Water Loads covering the frequency range of DC to 12.4 Gc. They range in price from $725 to $925. Price of the Model 430A is $2,300. For full information, write to us, or get in touch with your Sierra sales representative.



SIERRA ELECTRONIC DIV.
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Sierra Electronic Division/3875 Bohannon Drive/Menlo Park, California

Editorial

Who needs whom?

On page 104, we probe a complex subject: Should American firms trade with the Soviet Union and its satellites?

The question is particularly timely for electronic companies. Faced with a decline in military business, many firms would like to find new outlets for their products and capabilities The Eastern Bloc looks like a natural.

Certainly the Russians would be delighted to have a chance to buy American electronic components, instruments, subassemblies and systems. We asked Don Winston, the McGraw-Hill bureau chief in Moscow, to explore the subject with the Soviet counterpart of a chamber of commerce.

Its position: "We want to trade with you. Actually we want to trade with anyone who is willing to make honorable deals. Our shopping list is vast and our credit is good. We know about competition and how to bargain. So you are invited to sit down with us. However, if you don't want to bargain because you feel your precious security is involved, we will not dry up and blow away because of it. We will trade with other capitalist nations who will then receive the business your firms have lost."

That the Russians already do a considerable business with some of the United States' allies is certainly true. And a lot of United States firms chafe under the restrictions the State Department imposes on such trade while European companies chalk up the sales.

But the problem is not as simple as it may seem. More than dollars are involved. If the U. S. were to obtain markets for its electronics companies at the risk of the country's security, it would be a bad bargain indeed.

Although our relations with the Russians are relatively cordial today, history shows they could well freeze again tomorrow. Communist doctrine still preaches that any means is worth the end when dealing with capitalist countries. History has shown that Soviet methods include deceit, fraud, treaty abrogation and downright lies.

Electronic equipment poses more of a dilemma than most other products. Apparently there is no such thing as nonmilitary electronics in the Soviet Union. The Soviets are believed to put 90% of their electronics output into military and space programs. The remaining 10% falls far short, in volume and technology, of satisfying the country's hunger for industrial electronics.

What the Soviets would like, of course, is a chance to buy U. S. industrial electronics to expand and modernize Russian industry. Such purchases would take the pressure off the Soviet production machine.

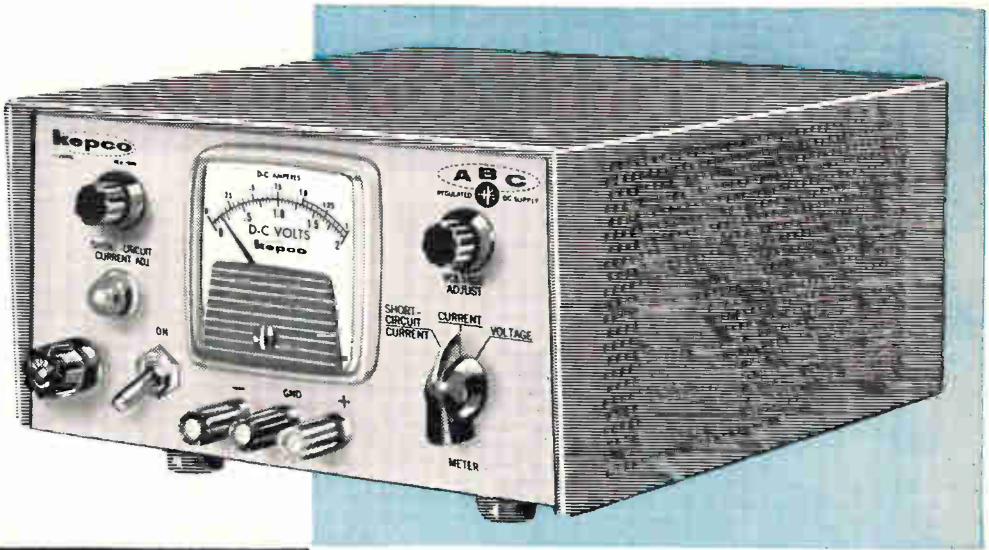
How much electronic gear, and of what type, should be sold to Russia? Most company officials are willing to let the State Department make the decision. And certainly the department should.

Most executives are realistic enough, and patriotic enough, to let government experts set the policy. But they have a right to expect that decision to be based on a comprehensive study of all the relevant factors, and not influenced by emotional, political or special-interest pressures.

The Administration should begin such a study now.

12 'ABC' POWER SUPPLIES

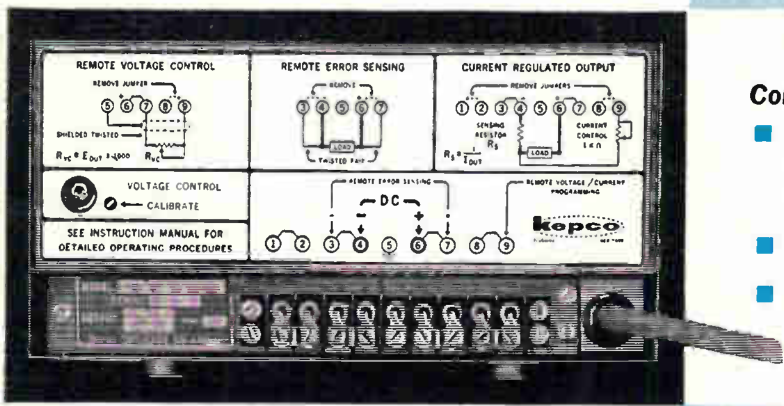
FLEXIBILITY • HIGH QUALITY • LOW COST



CHECK KEPCO

ABC
REGULATED DC SUPPLY
GROUP

from 0-2V/1A to 0-2500V/2ma



VOLTAGE/CURRENT REGULATED

Connections provide for:

- REMOTE PROGRAMMING OF VOLTAGE OR CURRENT BY RESISTANCE OR VOLTAGE
- REMOTE ERROR SENSING
- PARALLEL AND SERIES CONNECTION

PROMPT DELIVERY MOST MODELS FROM STOCK

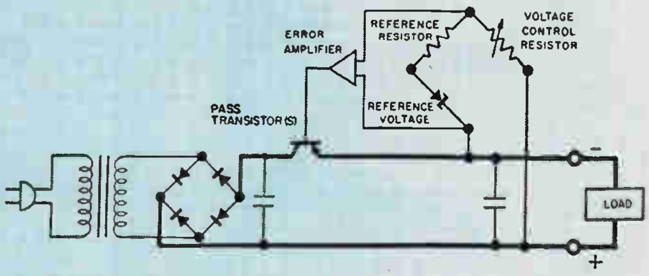
0.05% REGULATION and STABILITY

ALL-TRANSISTOR MODELS

DC OUTPUT VOLTS	DC OUTPUT AMPS	RIPPLE RMS MV	PRICE	*METERED MODEL
0–2	0–1	0.25	$ 179.00	ABC 2–1M
0–7.5	0–2	0.25	159.00	ABC 7.5–2M
0–10	0–0.75	0.25	119.00	ABC 10–0.75M
0–15	0–1	0.25	159.00	ABC 15–1M
0–18	0–0.5	0.25	119.00	ABC 18–0.5M
0–30	0–0.3	0.25	119.00	ABC 30–0.3M
0–40	0–0.5	0.25	159.00	ABC 40–0.5M
HYBRID MODELS				
0–200	0–0.1	0.5	199.00	ABC 200M
0–425	0–0.05	0.5	199.00	ABC 425M
0–1000	0–0.02	1.0	274.00	ABC 1000M
0–1500	0–0.005	1.0	274.00	ABC 1500M
0–2500	0–0.002	1.0	334.00	ABC 2500M

INPUT REQUIREMENTS: 105-125V AC, 50-440 cycles.

All-Transistor Circuit is illustrated below. The Hybrid Circuit is a unique design which achieves high efficiency and reliability through the use of Transistorized Reference and Amplifiers combined with a Vacuum Tube series pass element for reliable high voltage operation.



All models are designed for continuous operation without derating under all specified line, load and temperature conditions.

* UNITS are available without volt/amp meter; delete suffix "M" from model number and deduct $20.00 from price (ABC 2500M, ABC 1500M, ABC 1000M voltmeter only; deduct $15.00).

RACK MOUNTING ADAPTER (5-1/4" H x 19" W):
Model RA-4: for mounting 2 units $15.00
Model RA-5: for single unit $15.00

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Electronics Newsletter

April 20, 1964

Early warning of earthquakes

The earthquake that rocked Alaska on Good Friday also inspired a $1 million program of earthquake diagnosis and prediction. The Coast and Geodetic Survey wants lasers, monitors, electronic clocks and other electronic equipment for a **pilot program to see if enough can be learned about pre-earthquake signals to set up an early warning system.** The agency has been using optical tiltmeters and other equipment in a low-budget program of quake analysis, but now it plans an all-out effort—if funds are made available.

Paired lasers would be aimed at sensors across a known geodetic fault, for constant monitoring of distances across the fault. **Tiny changes in distance may signal oncoming disturbances, and lasers are ideal for precise measurement of distance.** Geophysicists of the Geodetic Survey are also planning to plant sensitive geophones to monitor sounds in the earth before, during and after a quake. A chain of such readings might discover a pattern of warning signals before a quake and could set the stage for a worldwide system of deep-placed geophones.

The agency is also establishing a $6 million worldwide network of about 125 seismic stations for routine monitoring of earthquakes. Almost 100 of these stations are already established. The network is expected to cost $1 million a year to operate.

Phase shift to "rotate" radar

An inertialess scanning system for antennas that could provide 360° radar views is being developed in England. It is based on a method of **modulating the frequency of the incoming signal with a varying phase shift so that the static antenna array acts like a rotating antenna.** D.E.N. Davies of Birmingham University, who worked out the modulation system, feels it will be possible to scan within the time between pulses and to obtain continuously bright radar display. **Scan rotational frequencies will be in the order of several hundred kilocycles and possibly up to a megacycle.** At present, Davies is working at radio frequencies of about 400 Mc, but this is more for convenience (since all antenna dimensions are in small scale) than because of operational requirements.

Little missile market grows

While the market for long-range strategic missiles and their components is declining, the Army and Navy are pushing ahead with work on new short-range tactical missiles.

The Army has ordered into production the shoulder-fired, bazooka-like Redeye. The 30-pound missile is designed for battlefield use against low-flying planes. The smallest of the U. S. guided missiles, it uses an infrared system to home in on the heat of an attacking airplane's engine. A $13-million contract went to the General Dynamics Corp. at Pomona, Calif. Redeye will be used by the Marine Corps as well as the Army.

The Army has also **selected two contractor teams to conduct competitive component development programs for the Army Air Defense System for the 1970's (AADS-70's).** One team is headed by Hughes Aircraft Co. and the other by the Radio Corp. of America.

AADS-70 will be a mobile battlefield system, designed to knock down short-range tactical ballistic missiles, air and submarine-launched missiles and aircraft. **It would replace the Nike-Hercules and Hawk missiles now** used and could also complement the Nike-X antimissile missile, if Nike-X is ever put into use. Army will not identify components to be studied under the present contracts, but they probably include advanced guidance and radar.

The Navy, meanwhile, has received proposals from 12 company teams for an Advanced Surface Missile System. This missile would be a follow-on, in the 1970's, to the Terrier, Tartar and Talos surface-to-air missiles. The missile that had been under development, Typhon, was cancelled because of technical problems, rising costs and complexity. Navy hopes to award feasibility contracts to as many as four prime contractors by July. Program definition study awards would be made six months later. A single contractor would be picked for a design study by the beginning of 1966.

Admiral deciding on color tubes

The Admiral Corp. is reported to be nearly ready to announce that it will manufacture its own color-tv tubes. At the company's annual meeting this month, Ross Siragusa, board chairman, said that "we will come to a decision about making our own color tubes in a few weeks, and we may be in production within two years." But the industry believes that Admiral will be in production a lot sooner than that.

Meanwhile Admiral, like the rest of the television industry, is set to sell only all-channel tv sets in interstate commerce after April 30. The company gave the Federal Communications Commission some worries a few months ago when a vhf-only set appeared in its 1965 tv line. The FCC is now confident of a smooth transition from very-high frequency to all-channel tv receivers.

New contender in home-taped tv

A world race for the home television tape-recorder market was declared this month when the Fairchild Camera and Instrument Corp. demonstrated a recorder it expects to sell for $500. In December, a British recorder called Telcame, backed financially by Cinerama, Inc., was shown in this country. But enthusiasm for Telcan was dampened by picture instability. There are also reports that the Sony Corp., of Japan, is developing a home recorder.

The Fairchild recorder may reach the retail stores in 18 months, as a factory-built-in accessory to tv sets. With a portable tv camera—this should cost about $150, Fairchild says—a family could tape its own tv movies.

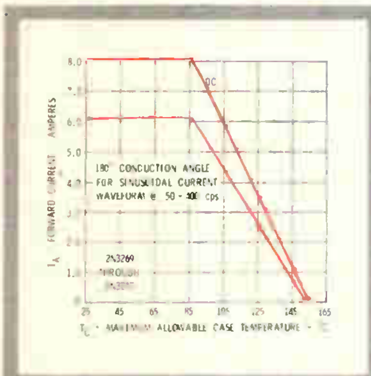
Fairchild's prototype was designed by Wayne Johnson, director of research at the Winston Research Corp., a subsidiary in Los Angeles. It was Johnson who sparked development of a broadcast tv-tape machine for Bing Crosby Enterprises, in the 1950's.

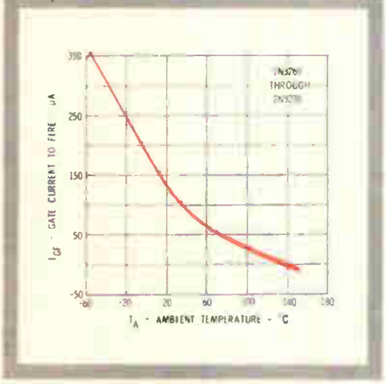
Demonstrated picture quality was good, even though Johnson used an inexpensive tape transport and narrow bandwidth. He said that wow and flutter are eliminated electronically, but didn't disclose how, and that "information theory enhancement" provides acceptable resolution in a bandwidth of 2.25 megacycles. Audio, video and synchronization signals are combined through a recording head. On playback through a second head, the signals are separated again and fed to appropriate points in the tv set. An 11-inch spool of ½-mil tape, four-track and a quarter-inch wide, plays for an hour.

NEW! PLANAR SCR WITH HIGH CURRENT: 8 AMPS CONTINUOUS

2N3272 ALSO FEATURES 200μA GATE SENSITIVITY

PLANAR: A PATENTED FAIRCHILD PROCESS





- **8 amps continuous forward current to +85°C**
- **I_{GF} (gate sensitivity)—200μA max**
- **Low forward and reverse leakage—200nA max @25°C./400V; 200μA max @150°C./400V**
- **High breakdown voltage—400V**
- **Operation to 150°C. with no voltage derating**

The new 2N3272 leads off a brand new Fairchild line of Planar SCR's featuring high current, high power capabilities as well as high gate sensitivity. The table below illustrates eight new types designed primarily for military service. Typical applications include capacitive discharge or line type modulators, deflection circuits, inverters, pre-regulation for power supplies, phase control circuits, time delay circuits, squib firing circuits. For further information, write for data sheets and application notes.

7/16" Hexagonal Stud
Gate P_d—0.5W
Average forward current—6.0 amps
Continuous forward current—8.0 amps

TYPE	FORWARD BLOCKING VOLTAGE
2N3269	100V
2N3270	200V
2N3271	300V
2N3272	400V

JEDEC TO-5
Gate P_d—0.1W
Average forward current—1.7 amps
Continuous forward current—2.2 amps

TYPE	FORWARD BLOCKING VOLTAGE
2N3273	100V
2N3274	200V
2N3275	300V
2N3276	400V

AVAILABLE DIRECTLY FROM DISTRIBUTOR STOCKS

FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR/A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION/545 WHISMAN ROAD, MOUNTAIN VIEW, CALIF./962-5011/TWX: 415-969-9165

actual size

Radiation Incorporated now provides the most versatile and reliable line of logic modules available today. Superior electrical design and unusual stability have been proved through use in a wide range of digital applications. Calculated mean time before failure indicates a significant breakthrough in high reliability design. For example: based on extensive tests, MTBF for Radiation's low-speed NOR Module is in excess of 2,940,000 hours!

LOGIC...

New line of digital modules offers flexibility, economy and high packaging density

FLEXIBILITY . . .

Two sets of fully compatible resistor-transistor logic circuitry are available. One operates at bit rates up to 200 kc, the other at rates up to 1 Mc. More than a dozen standard modules are available from stock. Types include: 4-input NOR; Counter Shift Register; Power Inverter; Emitter Follower; Complementary Driver; Differential; and Filter (Decoupler).

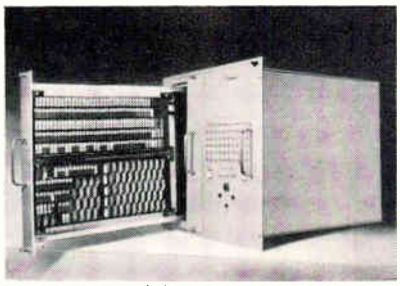
ECONOMY . . .

Radiation Logic Modules provide unusual economy of use. Each module represents a fraction of the entire digital system, and is designed for easy interrogation. Replacement or circuit changes is achieved by simply plugging in another unit. Downtime is greatly reduced, and bench work is completely eliminated!

PACKAGING DENSITY . . .

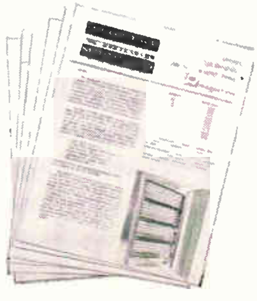
Construction consists of welded circuitry molded in epoxy, and mounted with high-density module connectors on cast aluminum frames. The resulting positive-contact module measures only 0.4x1x1.1 inches, with a ¼-inch pin protrusion. This configuration permits packaging densities of 113 to 137 modules per inch of panel space in standard racks. In addition, the units may be mounted in any manner—vertical or horizontal drawer, removable or fixed.

horizontal drawer mounting

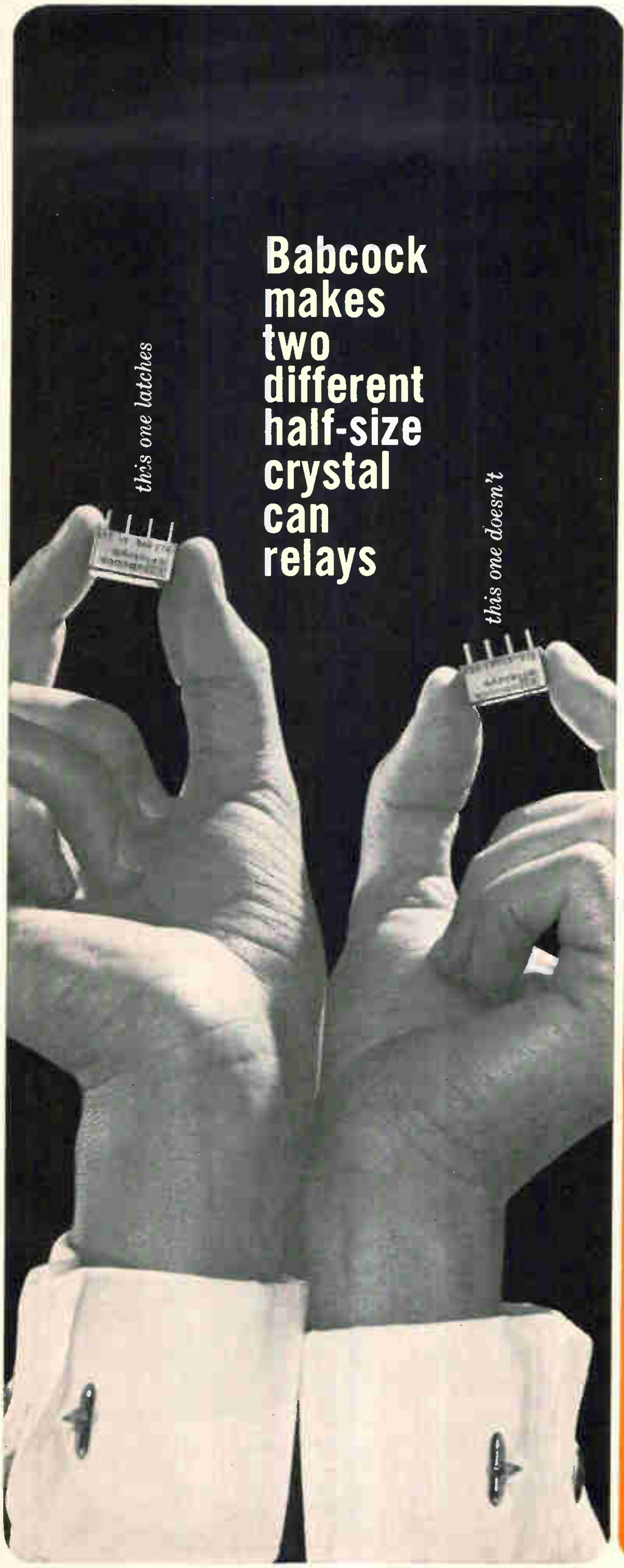


vertical drawer mounting

Write or phone for technical information on these unique logic modules. Radiation offers the services of its experienced engineering staff in the application of logic modules. We will also be glad to help solve your unique data problems. Radiation Incorporated, Products Division, Dept. EL-04, Melbourne, Florida. Telephone: (305) 723-1511.



RADIATION
INCORPORATED



Designed for low profile mounting, Babcock's new half-size crystal can relays are available for latching (BR-17) and non latching (BR-16) application. Both types feature exceptionally high sensitivity and durability. Remarkably efficient coil operation requires only 175 mw pull-in power to switch any load from dry circuit to 2 amps. Predicted failure rate on the BR-16 and BR-17 is less than 0.1% in 10,000 operations with a 90% confidence factor.

These exclusive Babcock high reliability features are the reasons why:

High-flux armature action. [illegible]

Heat sink magnetic flux conductor. [illegible] of high permeability alloy lowers heat [illegible] through improved magnetic circuit [illegible] while functioning [illegible] as heat [illegible] radiator.

Activated Vycor getter. [illegible]

Welded-header construction. [illegible]

Self-wiping, gold-plated contacts. [illegible] AgMgNi alloy with specially designed [illegible]

The BR-16 is available in SPDT and DPDT versions, the BR-17 as DPDT only. Various mounting arrangements and either plug-in or solder hook terminals can be supplied as standard. Send for complete details.

BABCOCK
BR RELAYS

A DIVISION OF BABCOCK ELECTRONICS CORPORATION
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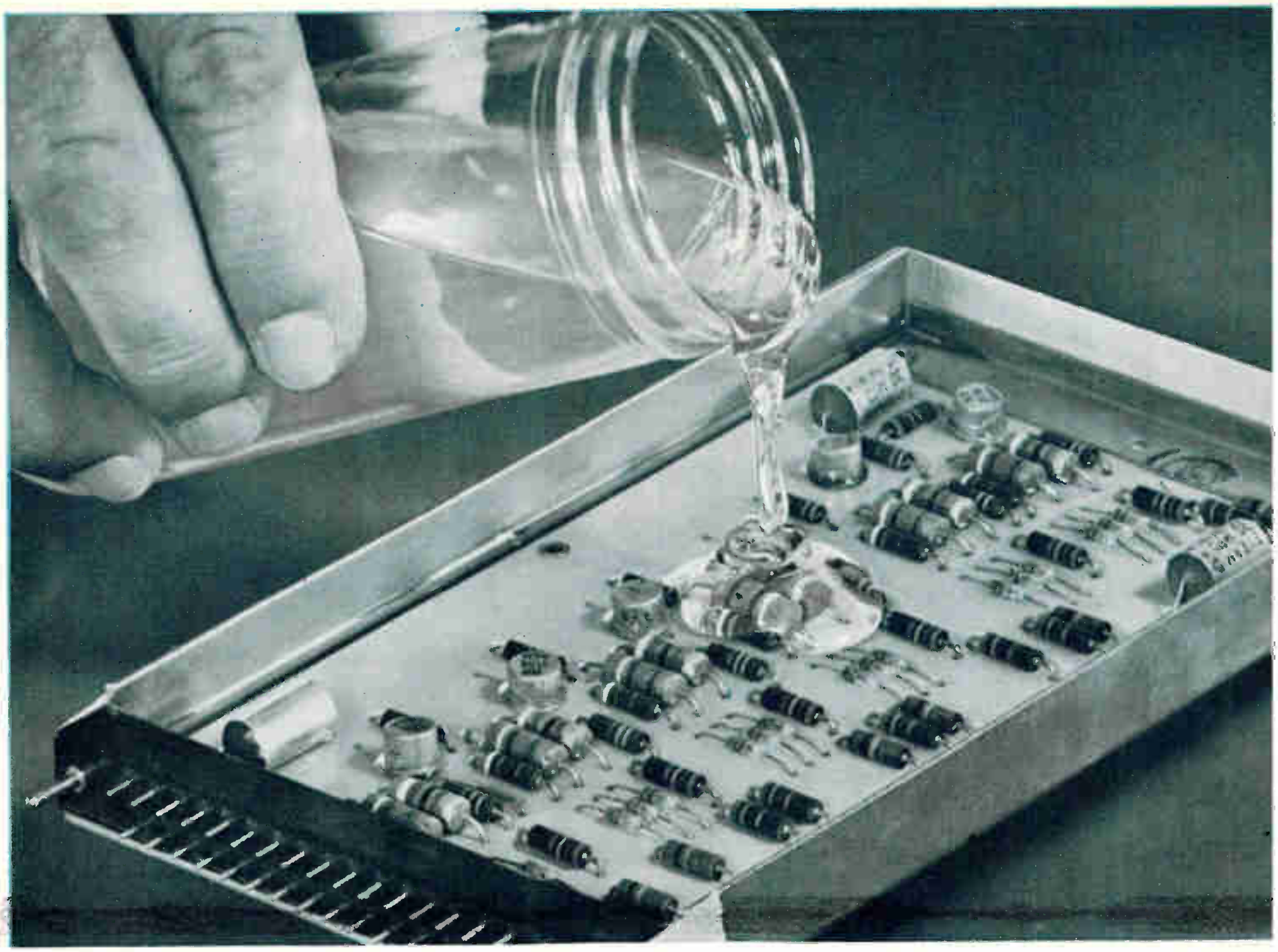
Circle 23 on reader service card



News Briefs

Room temperature curing Sylgard® 185 resin, companion product to Sylgard 184 resin, provides added heat conductance for circuit "hot spots" and opaqueness where transparency is not desired. A black, solventless silicone resin, it cures to form a tough, flexible embedment that assures environmental protection and cushioning for electronic components. Sylgard 185 resin cures in deep sections in 24 hours at room temperature . . . or in 15 minutes at 150 C.

CIRCLE 290 ON READER SERVICE CARD

Dip, brush or spray Dow Corning® 630 protective coating. This solution of silicone polymers air dries to a flexible, wax-like film that is highly water repellent. The excellent surface resistivity of the clear protective coating makes it ideal for the protection of printed circuit assemblies and components operating under heat and humidity conditions. High volume and surface resistivity are maintained even after prolonged exposure to harsh environmental conditions.

CIRCLE 291 ON READER SERVICE CARD

SILICONE NEWS from Dow Corning

Now... a room-temperature-curing transparent packaging material, that's easy to use, easy to repair

Transparent and tough . . . firm and flexible . . . new room-temperature-curing Sylgard® 184 resin cures without applied or exothermic heat. It can be used to package and protect the most heat-sensitive components.

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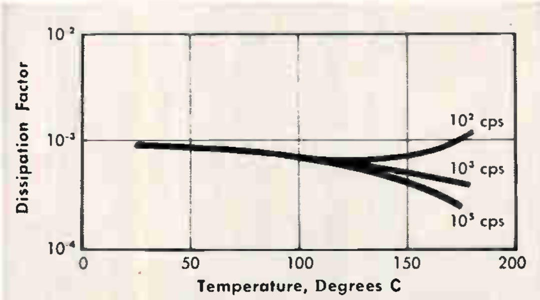
Sylgard 184 resin cushions and protects components from mechanical shock — can be twisted and bent . . . withstands elongation of nearly 100 percent. Its tensile strength ranges from 800 to 1000 psi, and it has a long service life at operating temperatures of −65 to 200 C.



Dissipation factor of cured Sylgard 184 resin at 10^2, 10^3 and 10^5 cps.

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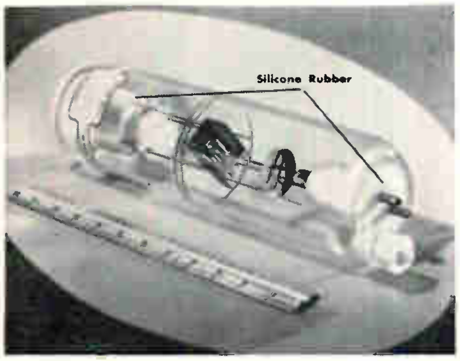

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Electronics Review

Volume 37
Number 14

Medical electronics

Another step closer

Lasers have been used, successfully, to kill certain types of skin cancer cells, but only in hopelessly ill patients.

Three patients, who subsequently died, volunteered for the laser treatment of malignant melanoma at the Pasadena (Calif.) Tumor Institute, where Dr. James T. Helsper has been conducting related cancer research on rabbits. In each of the three cases, the localized effect of the laser treatment was not sufficient to halt the cancer spread. But Helsper, who believes the experiments were the first in which humans were treated, is optimistic.

Research on the effects of laser energy on pigmented and non-pigmented cells in rabbits had disclosed that pigmented cells were completely destroyed by a single exposure to 25 joules per square centimeter, whereas similar non-pigmented cells were able to stand repeated firings without showing signs of tissue destruction or alteration.

Like the rabbits. The results with the three patients were exactly like the results with rabbits. The laser energy from a single firing killed the pigmented cancerous cells whereas the non-pigmented cells were resistant to at least 20 firings. "The big gimmick here is seeing the biological effect on the pigmented tissue," says Helsper. "From preliminary work in tissue culture, it appears that laser energy may have a biological effect over and above that of the physical energy imposed on cells."

Bigger laser. Helsper isn't sure what is next. He says that the laser firings helped only when small areas were treated. When larger areas were treated, there was no effect. Some thought is being given to trying a more powerful laser, but he has no definite plans. "We've been told that we need a more potent laser," he says. "Some say our use of this one is like taking a BB gun to a battleship."

The laser was donated to the Institute by the manufacturer, Hughes Aircraft Co.'s Electronics division. It is a pulsed ruby laser of relatively low energy, extended from a minimum of one to a maximum of two joules. Peak watt output is approximately 20,000 watts and power output is approximately 8 megawatts per square centimeter. Most firings were confined to a target of ¼ square millimeter. Pulses averaged about one millisecond.

The lens system used had a focal distance of about 1.8 centimeters from the lens. Doctors devised a small nylon cone which could be sterilized and placed over the lens system. The focal spot centered at the end of the cone permitted placement of tissue at the exact focal distance from the lens.

Consumer electronics

Big brother

The biggest crowd-stealer at the National Association of Broadcasters Show in Chicago was a mobile television snooper developed by the Tanner Engineering Co. of Wilmington, Calif.

Using methods smacking of military electronic reconnaissance, inventor James Tanner's little black truck drives through neighborhoods and records how many sets are tuned to what television channels.

Tanner's equipment does four jobs: receives station-broadcast tv signals on all channels, receives the weak signal radiated by every tv set's horizontal oscillator, compares horizontal synchronizing signals, and scores one count for a channel every time its signal coincides with the home-broadcast signal.

Three antennas. Two halo antennas, mounted on the roof of the truck, pick up a station's tv signals on all vhf and uhf channels. Radiation from receiving sets is received by an antenna on the hood. This antenna rotates about twice every three seconds, scanning both sides of the street in a corkscrew pattern 600 feet in diameter.

Broadcast and set signals go to a gating unit that scans each broadcast channel sequentially for 1/40 second.

While the gate is open, signals received from sets in homes are compared with the broadcast channel signal. If there is coincidence for four synchronizing cycles, a count of one is recorded for the channel being gated.

It is impossible to count the same

Truck cruises along residential street, picking up tv signals and recording the viewing choices of the residents.

←Circle 26 on reader service card

set twice, according to Tanner. To pass through the gating system, the two signals being compared have to be in phase. This can occur at only one point on the ground along the path of the snooper vehicle, Tanner says.

Tanner does not claim that his system counts every set within range. He says that out of 200 operating sets, only 100 to 150 may be counted. By picking up color-burst signals, he adds, the system can tell whether a color receiver is tuned to a color program.

Automatic counters. The prototype uses miniature receivers, made by the Sony Corp., to display all broadcasting channels and to generate the needed horizontal synchronizing signals. It has banks of electromechanical counters to tally the stations tuned in. An engineer operates the equipment while the truck is driven through the streets.

Future vehicles will have receivers that supply only the horizontal synchronizing signals and tape-record the coincidences. This system will only need to be turned on and off, a job that can be done by a relatively unskilled driver.

Broadcasters expressed curiosity and admiration about how the truck works. Comparing Tanner's method with usual rating techniques, the owner of a station in the South said, "I'd rather trust transistors than somebody's diary."

Communications

End of "Roger"

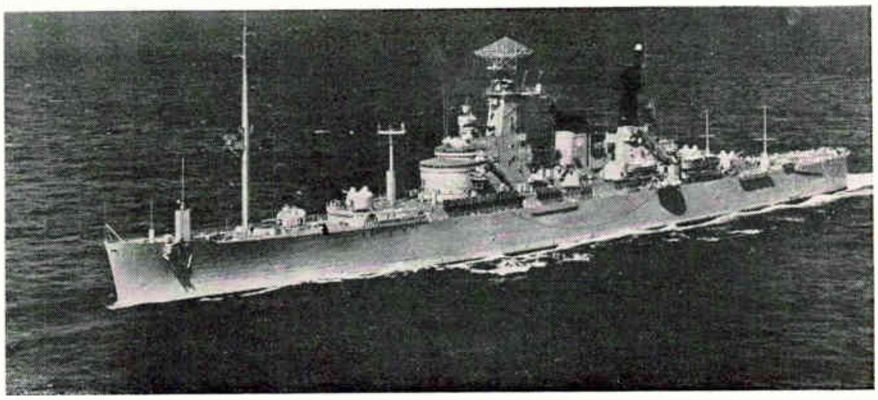
Complete automation of all communications between ground and aircraft is in the offing, following establishment of technical standards for digital techniques by the Radio Technical Commission for Aeronautics. Civil aircraft probably won't be affected for several years because of the high cost of installing new ground and air equipment, but the automation is just right for the supersonic transport.

One system. Digital systems are already being used by the military to control weapons-carrying aircraft and to provide greater speed and security for special-purpose aeronautical military communications. A powerful boost was given to the establishment of a single system when the Department of Defense agreed not to authorize any additional special-purpose digital communications. Future air-ground networks must work into the common-user system and also have provisions for future air traffic control. Implicit in the Defense Department's decision is a willingness to withdraw its previous strong support of Fieldata, the 64-character alphanumeric code used by most military digital systems.

Automation will almost completely eliminate oral communication by the pilot. Only in emergencies will voice communications override the normal data channel.

In the aircraft, output signals from automatic sensor devices like altimeters, temperature indicators and even fuel gauges can be converted to digital codes and sent automatically to the ground. From the ground, information fed into a computer both automatically from the air and by human traffic controllers on the ground can be triggered for transmission back to the aircraft. Instead of oral instructions, the pilot will receive standard canned messages from electromechanical devices or a printout similar to a teletypewriter message. Almost all of the normal air-ground traffic will be in record or display form, contributing to over-all safety. If necessary, the messages can be sent in cipher.

Standard code. The system will be based on the newly adopted American Standard Code for Information Interchange—X3.4-1963. Additional technical agreement provides for synchronization for both bits (individual on or off pulses) and characters (a minimum of seven bits). The use of standard code and label characters will permit sending canned or original messages either to a single receiver or several.

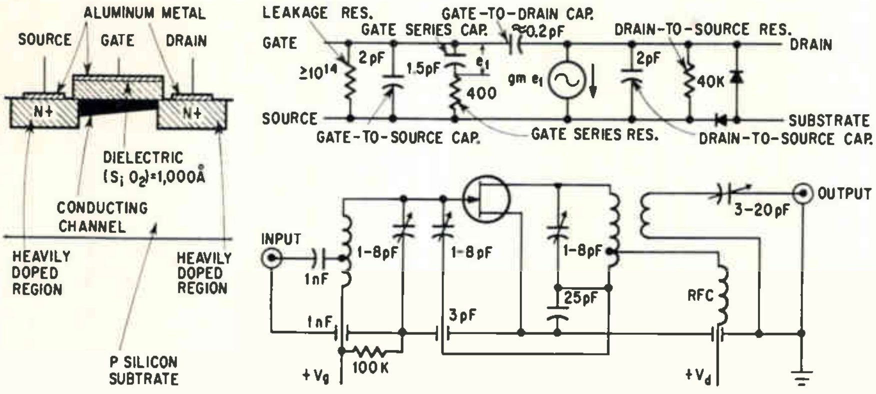


USS Northampton is the first ship to be equipped with tropospheric scatter communications equipment.

Saltwater tropo

Tropospheric scatter communications have finally gone to sea. The technique of bouncing radio waves off the troposphere to provide long-range multichannel communications at high frequencies has been used extensively on land. Now the first ship-to-shore troposcatter equipment has been installed aboard the USS Northampton, a CC-1 tactical command ship that is an integral part of the National Military Command System.

Engineers at Radio Engineering Laboratories, Inc. who supplied the equipment, are reluctant to discuss the range of fade-free reception, but admit it may be "hundreds of miles." Land stations in the Distant Early Warning Line operate over an average distance of 200 miles and a new installation to link Thule, Greenland, with the Line will span 591 miles. It seems likely, though, in view of the lower power and smaller antennas aboard ship, the Northampton's range is well under 500 miles.



Construction of TRW's insulated-gate field-effect transistor (left) and its equivalent circuit. At right, it's used in a 100-megacycle amplifier.

Babel on wheels

The Electronic Industries Association's monumental analysis of Federal Communications Commission license data for most of the radio transmitters used in vehicles will be completed before the first of May. It was started nearly eight months ago and covers some 1.9 million authorized stations, mostly in cars and trucks but with more than a sprinkling of fixed base stations. While not every license is in active use, a short listen to the bedlam on any of the police, taxi or other band receivers indicates intolerable crowding.

The FCC hasn't been much help mainly because it can not create new radio channels. Rapid growth of the land-mobile radio services has tended to outpace the economics, if not the engineering skills, of band-splitting—like making three channels exist where only two were used before.

Crowded air. Since overcrowding is often a geographical phenomenon (some Los Angeles channels have as many as 25 different occupants) the EIA study showing just how many transmitters, on what frequency and in what area they are, should help FCC do some sophisticated reshuffling. In fact, the agency sent three staff members to Los Angeles in late March for four days to delve into a typically bad situation.

EIA's statistical task has been complicated by the way FCC keeps its records. For example, some 200,000 mobile station authorizations cannot be immediately identified geographically; they go through the computer twice before the authorizations can be pro-rated to proper areas.

Another group, the National Association of Manufacturers, feels that unused channel assignments should not lie idle. Its communications committee has proposed a pilot test employing television channels 14 and 15, unused in the Los Angeles area. The proposal is comparable with those of EIA, American Automobile Association and Automobile Club of Southern California. If FCC approves, the radio space in the two tv channels (between 470 and 482 Mc) could theoretically accommodate almost 250 more mobile-radio channels to ease the city's overcrowded radio space.

New study. The Commission recently withheld action on the NAM proposal and slapped down another (sponsored in part by EIA) that would have reallocated frequencies between 25 and 890 Mc. However, FCC requested another study by EIA and the Joint Technical Advisory Committee, the group comprising representatives from industry and members of the Institute of Electrical and Electronics Engineers, to see if mobile radio channels can be fitted into television bands 2 through 13 (54 to 72, 75 to 88 and 170 to 216 Mc). Commissioner Kenneth A. Cox and chief engineer James E. Barr were appointed to head up this advisory committee for the Land Mobile Service.

Solid-state

Low-cost power booster

In solid-state electronics, the closest thing to a vacuum tube is the insulated-gate field-effect transistor. At least four major companies are working to perfect the device, sometimes called the metal-oxide-semiconductor transistor.

Engineering samples already are being offered by TRW Semiconductors Co., a division of Thompson Ramo Wooldridge Inc., the Norden division of the United Aircraft Corp., and the Radio Corp. of America. The semiconductor division of the Fairchild Camera & Instrument Corp. plans to offer samples this summer.

The insulated-gate field-effect transistor is simpler, and therefore potentially cheaper than an ordinary transistor. It consists of a silicon substrate with metal source and drain contacts, plus an insulated-gate electrode.

The big problem. The companies are seeking to get the problem of surface instability sufficiently controlled to go into full-scale production of the transistors. It is quite possible that the solution to this problem is not too far off.

Reports of excellent high-frequency characteristics point to its use as a general-purpose low-power device up to uhf. Present field-effect transistors appear limited to 10-20 megacycles. The transistor can handle signals of several volts and is inherently low in cross modulation distortion.

RCA has been letting customers sample the (TA 2330) transistor for about a year. This unit is useful up to 100 megacycles. RCA is also trying to develop versions for higher frequencies, and has produced a laboratory device that operates as an oscillator up to a gigacycle.

TRW speculates that the device could be the linear power amplifier of the future. The company plans to offer 300-milliwatt units initially and sees no problem in getting to one watt and, eventually, beyond. It has operated oscillators at 500 megacycles and obtained a 20-decibel power gain at 105 megacycles with the grounded source amplifier shown. Noise was less than 4 decibels. The high performance was made possible by the reduction of parasitics through construction to tolerances of 0.1 mil.

Norden is interested in the device for microelectronics applications, such as linear amplifiers, that will benefit from its high input impedance (10^{14} to 10^{15} ohms). Norden believes it has licked the stability problem, and is selling samples for breadboarding purposes.

The high-input impedance has aroused considerable interest among instrument companies. Both HP Associates and Tektronix, Inc., are researching the device and Crystalonics, Inc., feels it would be forced to build one should the high - frequency characteristics prove out.

Space electronics

Televising the Olympics

The Japan Broadcasting Corp. thinks it has a solution to the problem of transmitting television coverage of the Olympic Games from Tokyo to the United States [Electronics, April 6, 1964, p. 30].

The company plans to offer $3 million toward the cost of launching a satellite, Relay III. The rest of the $8 million cost would be paid by the U. S. National Aeronautics and Space Agency.

Japan, a country interested in business generally and in electronics specifically, has a big promotional stake in televising the Olympics in October. It would be especially beneficial if she could also claim a role in creating a space satellite.

If the Japanese were to advertise on American network tv in prime time, it would cost from $200,000 to $265,000 an hour. Two weeks of Olympic coverage would give the country some $5 million in advertising value.

Why Ranger failed

No one was home April 3, the day the Senate's Committee on Aeronautical and Space Sciences released the National Aeronautics and Space Administration report on what went wrong with Ranger 6 and how Ranger 7 was being corrected. NASA's Ranger project engineers were "at a meeting," and nobody answered the phone in the Ranger project office at the Radio Corp. of America.

The report summed up the opinion of the five-man NASA committee investigating the failure of Ranger 6 last February 2 to send close-up tv pictures of the lunar surface back to earth.

The committee issued five stinging indictments against Jet Propulsion Laboratory of the California Institute of Technology, the project manager, and its subcontractor, Radio Corp of America, builders of the tv camera systems. These were:

- "The two video systems were more complex than required" and some components common to both tv system were not completely independent.
- "Possibilities of failure were increased as a result of practices employed in the design and construction of the spacecraft." Cited were parts of the circuitry that were vulnerable to short circuits.
- The directional antenna had never been tested together with the high-power, 60-watt tv system.
- Complete preflight testing was not done for the 12 days before launch for fear of damage.
- Pre-flight ground testing "may have obscured potentially dangerous situations which could have enhanced accidental triggering of critical control circuits."

Corrective measures. NASA plans to launch Ranger 7 in late June after the spacecraft is redesigned so that the command turn-on functions of the two camera systems are separated. Originally, NASA wanted to scrap the entire tv subsystem and replace it with two newly-designed, completely independent camera chains, but this would have taken 12 to 18 months.

Cause unknown. The NASA review board said that "the most likely but not conclusively proven explanation for the failure was an unscheduled turn-on" of both the tv and channel 8 telemetry simultaneously two minutes after launch. If the tv was turned on before it entered space vacuum, arcing and corona discharge would have destroyed both tv systems.

Scapegoat? Jet Propulsion Laboratory can't defend itself. As a NASA contractor it must offer "no comment." But friends of JPL point out that NASA's own Office of Space Sciences and Applications had approved the system development and test procedures for Ranger 6 and that NASA's scheduling of four Ranger tv shots was a tacit admission of the complexity of the job. Some JPL supporters even feel that NASA is maneuvering to oust California Institute of Technology from its administrative position and take over the lab. And there is the inevitable speculation that NASA, looking for a scapegoat, pounced on JPL.

Advanced technology

Gas laser radar

A missile-ranging laser radar, probably one of the first practical applications of the continuous-wave gas laser, is nearing hardware form at the Perkin-Elmer Corp. in Norwalk, Conn.

Called Optical Direction and Ranging, the system is intended to provide highly precise real-time measurements of speed, altitude and range of missiles immediately after they have been launched. It can be adapted to perform other functions such as long-range missile tracking and rocket-sled measurements.

Perkin-Elmer developed the radar under a $250,000 development contract from the Rome Air Development Center and is hoping for a contract to install an operational system at Cape Kennedy.

The laser system uses a 100-milliwatt visible red beam at 6,238 angstroms. The continuous beam is

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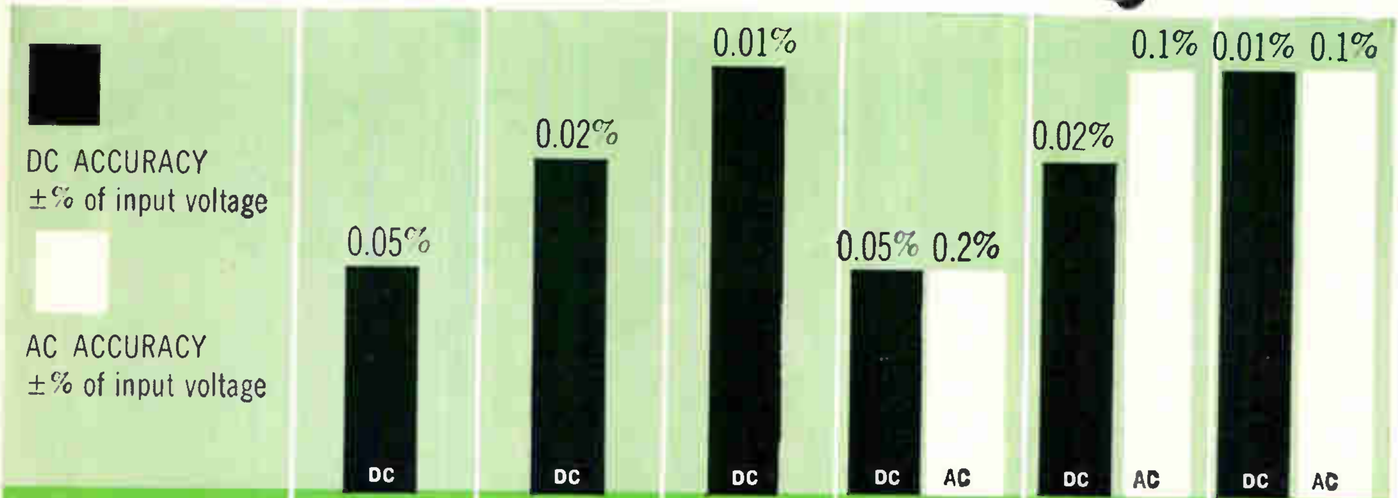

Models	801B	825A	821A	803B	803D	823A
INPUT RANGE	0-500V	0-500V	0-500V	0-500V	0-500V	0-500V
FREQUENCY RANGE	....	....	....	20 cps-10 kc	5 cps-100 kc	5 cps-100 kc
MAXIMUM FULL SCALE SENSITIVITY	10 mv	1 mv	1 mv	10 mv DC 1 mv AC	1 mv	1 mv
MAXIMUM METER RESOLUTION	50 uv	5 uv	5 uv	50 uv DC 5 uv AC	5 uv	5 uv
REFERENCE	Std. cell (zener diode optional)	Std. cell (zener diode optional)	Standard cell	Std. cell (zener diode optional)	Std. cell (zener diode optional)	Standard cell
PRICE Cabinet model Rack model	$485.00 $505.00	$590.00 $610.00	$795.00 $815.00	$875.00 $895.00	$1,100.00 $1,120.00	$1,300.00 $1,320.00

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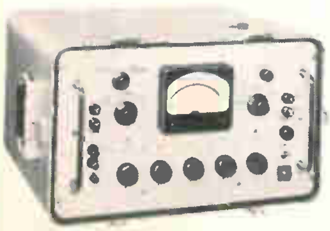

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NULL RANGES: ±10, ±1, ±0.1, ±0.01V
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modulated at 100 megacycles and diverges at 4.5 arc seconds toward the moving missile, giving a wider field of view. A 2.5-inch specially designed retro-mirror, mounted on the upper portion of the missile's first stage, reflects the beam back to the radar's receiving optics and photomultiplier. The return signal data, together with signals from two auxiliary angular readout systems, can be simultaneously recorded. This information allows computer reconstruction of the missile's trajectory to measure missile positions, velocity and acceleration for purposes of range safety, impact prediction and control.

Accuracy. The outstanding feature is accuracy: ±0.06 feet on measurement of distance from the instrument to the missile; ±0.92 second of arc on elevation and azimuth readings; and ±0.01 feet per second^2 in acceleration measurements. The altitude range is zero to 60,000 feet.

The high accuracy is made possible by the use of a continuous-wave laser. Unlike pulse-type laser radars, which have only moderate precision but long operating ranges, the gas laser is better adapted to continuous measurement with high resolution at moderate ranges. Pulsed lasers do not permit the same accuracy because the shape of their pulses has not been sufficiently defined, while the rise shape of the 1/20-nanosecond pulses with which the continuous-wave laser light beam is modulated permits precise time measurement.

Because the gas-laser beam can locate targets already within its reasonably wide angle of view, it can achieve second-of-arc accuracies without comparably precise mechanical tracking equipment. To achieve similar accuracy with a one-centimeter microwave doppler radar requires a 1,600-ft antenna.

Competition. Closest competition with the Perkin-Elmer system so far was announced by two Hallicrafters Co. engineers at the IEEE International Convention in March. The Hallicrafters experimental system intended for measuring target velocity in space, uses noncoherent light, also r-f modulated.

Army weapons sight using cascaded image-intensifier tubes will be in the hands of troops next year. It intensifies low-level light 80,000 times.

Military electronics

Night vision improves

American soldiers standing guard on the uneasy truce line in Korea, at the frontiers of a divided Germany or stationed in a host of other international trouble spots may soon see more clearly and safely in the dark.

The trend in Army night vision equipment is towards passive devices making use of low-level natural light and away from active devices such as the sniperscope that requires use of a powerful artificial light and infrared filter to illuminate the target—and also risks giving away our own positions.

The new passive devices make use of image-intensifier tubes as did the active devices before them. But now several tubes are combined to intensify light from stars, moon or skyglow by 80,000 times or more. An improved weapons sight using the passive equipment will soon be in the hands of troops. Soon to follow are binoculars, night viewers and telescopes. The image-intensifier tubes can be teamed up with vidicons or image orthicons for remote television viewing of a tactical situation.

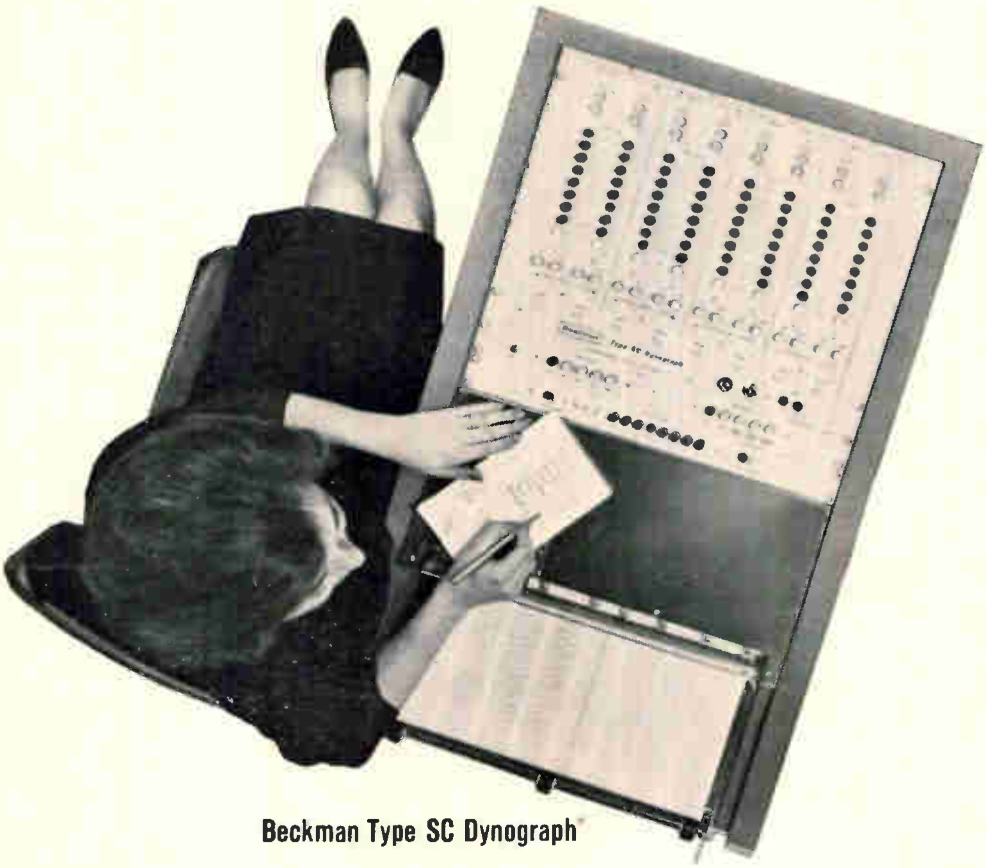
Cascaded intensity. An image intensifier consists of a glass membrane coated on the inside with a silver oxide-cesium film containing several special additive materials. When struck by light photons the film emits electrons into the evacuated tube. A simple ring-and-disk system of electron optics having an applied potential of 10 to 15 kilovolts focuses the electrons on a green-white phosphor screen. The output of one image intensifier forms the input to the next in a cascaded stack. Optical lenses are used at the input and output of the stack and a stack can subtend a field of view from 3° to 26°.

No electronic amplification is necessary except where the image intensifier feeds a vidicon or other television tube. The only electronic equipment usually required is a multivibrator-type d-c/d-c converter used to raise the output of a mercury wafer battery to the kilovolt level. The converter is now all solid state and use of microcircuits is under consideration. The image intensifiers can be used both for low-level visible light (in which case an S20 photoemissive surface is preferred) and for the near infrared—0.8 to 1.5 microns—(where an S1 photoemitter would be used).

Future devices. Still newer devices are under development for the far infrared—from 9 to 12 microns—where practically every living thing radiates energy. Here the target would be scanned with a single-point receiver utilizing a photoconductive substance such as lead telluride, lead sulphide, indium antimonide, germanium or antimony-germanium as an infrared-to-electrical transducer. The present approach is to use a mechanical raster scan. Later devices may use a mosaic of transducer elements or employ electronic scanning. Of course this equipment cannot provide direct viewing and electronic amplification is essential.

Active-device night vision equipment is currently out of favor in research and development. However, recent developments in that area reduced the weight of the sniperscope from 22 to 11 pounds and produced a dual-purpose infrared-visible light tank search light. A three-watt gallium arsenide infra-

New Ink Rectilinear Recorder for analog computer or telemetry write-out



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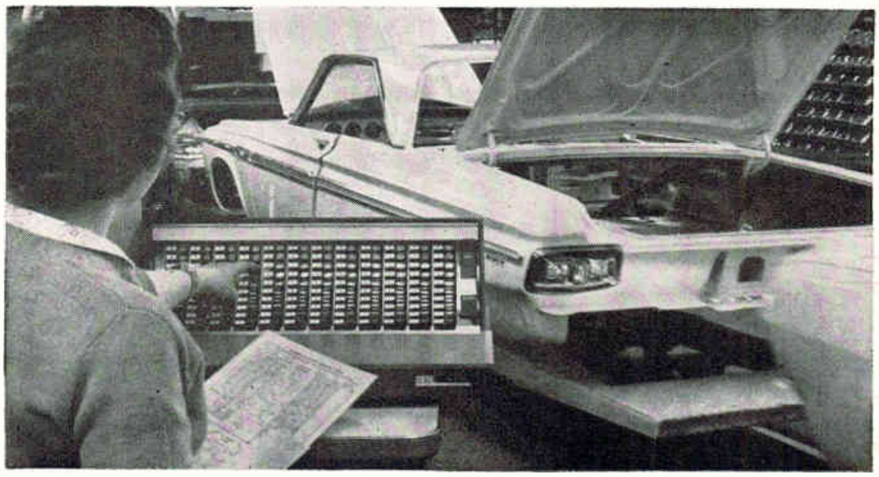
Center of the Army's night vision effort is the Engineer Research and Development Laboratories, Ft. Belvoir, Va.

Industrial electronics

Squeeze on lemons



In goes another report, maybe a loose bolt.

Catching lemons on the assembly line is a constant goal of auto makers. Now the Chrysler Corp. plans to use computers for quality control on all of its 1965 models.

The move will cost $2.4 million a year in leasing charges, according to Fred M. Glassford, a Chrysler vice president, but that comes to only about $1 a car. He says that IBM 1710 systems are already in use at the Dodge assembly plant in Mantramk, Mich., near Detroit, and at the Los Angeles plant where Plymouths, Valiants and Dodges are assembled.

How it works. At the newest installation—the Plymouth assembly plant in Detroit—the assembly line is broken down into seven major sections from body-weld to final water test. Each of the seven is subdivided into production, inspection and repair. Inspection report forms in the assembly sections are coded into three-digit numbers from 000 to 999 with each number representing an auto part.

If an inspector in the final line section notices that section personnel must tighten the inside handle of the right front door, he circles the proper code number on the form. When the vehicle and the form arrive at the data collection station at the end of the assembly section, the operator removes the form, places it in an appropriate slot and key-punches the code number. The data speeds to the computer and out through a teletypewriter in the office of the departmental superintendent, who can quickly note trends.

The system includes a PM Interface, developed by the Performance Measurements Co. of Detroit., which transmits computer data instantly to teletypewriters in the plant. This is said to eliminate complex cabling and to permit the computer to put out information at 10,000 characters a second.

Future applications of the system will include measuring performance capability of the car on the assembly line—or "closing the loop."

Instrumentation

Magnetic mysteries

The Russell Varian Castle Rock Observatory, to be built on a crest of the Santa Cruz mountains overlooking Saratoga, will be California's first geomagnetic observatory. It will be operated by the U. S. Coast and Geodetic Survey.

The land on which the observatory will be located is owned by the Varian Foundation, a nonprofit organization set up under the will of Russell Varian, who, with his brother Sigurd, invented the klystron and established Varian Associates, Palo Alto, Calif. Varian Associates will construct buildings and provide access roads and utilities. After construction, the company will transfer title to the foundation which will make the facility available to the Survey.

Only four geomagnetic survey stations are now located in the continental United States. They are at Fredericksburg, Va., Dallas, Texas, Boulder, Colo., and Tuscon, Ariz. The Varian Observatory will link an otherwise complete chain. Two other U. S. observatories are located in Hawaii and Alaska.

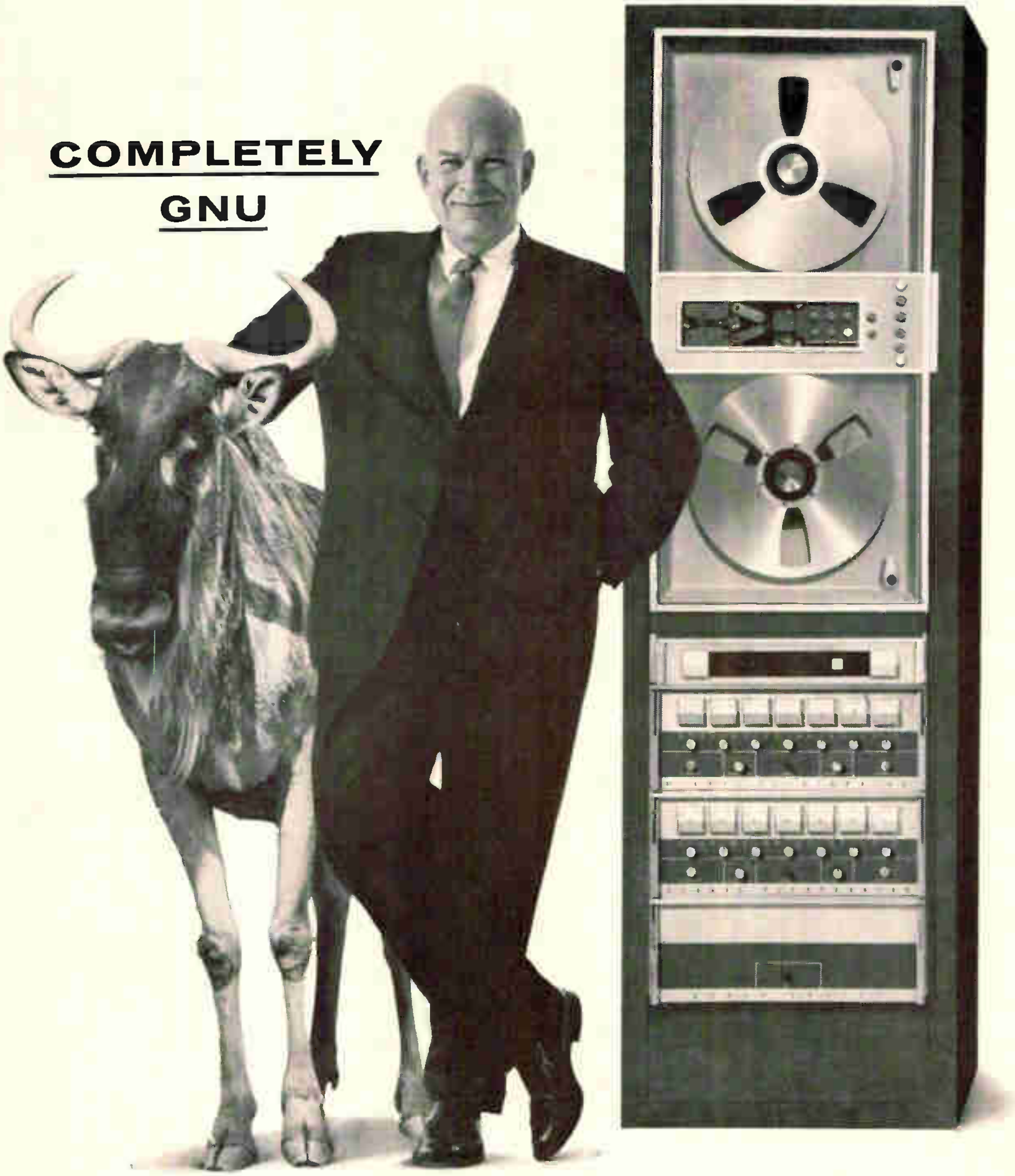
The new observatory will pioneer in the application of new instruments to geomagnetic research.

Magnetosphere. Interest and activity in magnetic field measurements has increased with space exploration activity.

There have been several theories attempting to explain magnetism around the earth. Latest is that there is a movement of currents through the earth's center. According to the theory, the earth's magnetism may even reverse, and in fact, some theorists claim that it has reversed several times in the past million years. However, some prominent physicists, while agreeing that currents passing through the earth cause the magnetic fields, do not go along with the reversal-of-field theory.

Isolation from outside electrical and magnetic disturbances was the prime consideration in choosing the location of the observatory. A bonus feature is that the observatory will be located very nearly on top of the San Andreas earthquake fault. To date there is no proof of correlation between earthquake activity and magnetic variations but scientists hope to gather some meaningful data on both of these disturbances.

COMPLETELY GNU



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A Wire Wound Resistor Failure Rate of 0.02%/1,000 Hours, on Full Power at 125° C!

The figures above are revolutionary in the technology of wire wound resistors. For this is a failure rate achieved under accelerated environmental conditions . . . with a failure being defined as any change in resistance in excess of ±0.5% on 1% tolerance units and 0.2% on .01% tolerance units when operated under full power at 125°C.

This is the fourth consecutive High Reliability Report by Daven in which a lowering of the failure rate has been achieved . . . and the progress continues!

Daven's High Reliability Resistor Program proceeds under a rigorously strict 100% testing program. Every resistor in this program is continuously tested, from the time the raw materials arrive at the plant through the multiple life tests that are conducted at full power for thousands of hours. Each test and production procedure is carefully documented. Resistors are vibration tested under power; have five temperature cycles; and are burned in for 100 hours at 125°C under full power. An IBM punched card facility collects, analyzes and tabulates data on every phase of the program. The confidence level for this program has been assumed to be 60%.

The Daven High Reliability Resistor Program provides production quantities of "documented reliability" units. This program strictly identifies part number, performance and production lot with traceability back to individual operations and operators.

As a result, Daven wire wound resistors now participate in virtually every major missile high reliability program, including Syncom, Apollo, Gemini, Saturn, Minuteman, Polaris, Titan and many others.

Daven high reliability wire wounds are available in the following specifications:

Daven Type	Dia. (Inches)	Length	Max. Watts	Max. Volts	Max. Res. .001" Dia. Wire	Lead AWG
HR1282	.125	.312	.05	100	16K	#22
HR1258	.250	.30	.125	100	127K	#22
HR1250	.250	.50	.15	200	226	#20
HR1195	.250	.75	.25	300	511	#20
HR1257	.312	.812	.50	300	750K	#20
HR1252	.375	1.0	.75	600	1.5 Meg.	#20
HR1172	.500	1.0	1.0	600	2.0 Meg.	#20

For complete details on these resistors, and the High Reliability Program, write to Daven today!

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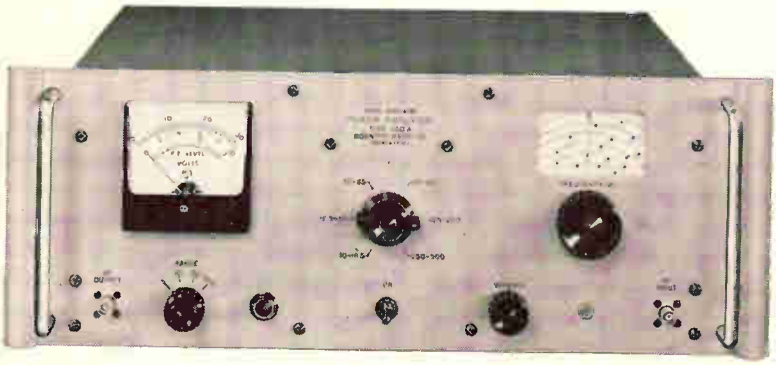
Type 230-A

10 to 500 MC POWER AMPLIFIER

— for Low-Level Applications



The BRC Power Amplifier Type 230-A is the ideal RF amplifier for low-level applications exhibiting a typical noise figure of 6 to 8 db. Three tuned, cascaded stages of grounded-grid amplification provide up to 30 db gain and a maximum power output of 5 watts. Typical applications include:

RECEIVER PRE-SELECTOR — The Type 230-A, when used as a pre-selector with conventional communications receivers, will readily provide fractional microvolt sensitivities.

TUNED SELECTIVE FILTER — BRC 230-A provides a convenient means for the selective amplification of RF signals in the 10 to 500 Mc. range with excellent rejection of undesired frequencies.

HARMONIC AMPLIFIER — The new power amplifier may be used to amplify desired harmonics in the output of signal generators and frequency synthesizers thereby extending their useful range.

FREQUENCY COUNTER PRE-AMPLIFIER — Type 230-A as a pre-amplifier for conventional frequency counters, such as the hp 524/525, will provide a 15 to 30 times improvement in input sensitivity. Remote, off-the-air frequency measurements of FM broadcast and communication transmitters may be readily performed.

RF MILLIVOLTMETER PRE-AMPLIFIER — When used as a pre-amplifier for RF millivoltmeters, such as the hp 411, the 230-A will provide 15 to 30 times improvement in sensitivity.

RF RANGE: 10 to 500 Mc.
BAND RANGES: 10-18.5 Mc., 18.5-35 Mc., 35-65 Mc., 65-125 Mc., 125-250 Mc., 250-500 Mc.

RF GAIN: 30 db (10-125 Mc.)
27 db (125-250 Mc.)
24 db (250-500 Mc.)

RF BANDWIDTH: $>$700 Kc.*(10-150 Mc.)
$>$1.4 Mc.*(150-500 Mc.)
*Frequency interval between points 3db down from max. response

RF OUTPUT:
RANGE: Up to 15 volts*
*Across external 50 ohm load
IMPEDANCE: 50 ohms.
CALIBRATION:
0.2 to 3 volts f.s.; increments of approx. 5%.
1.0 to 10 volts f.s.; increments of approx. 5%.
2.0 to 30 volts f.s.; increments of approx. 5%.
ACCURACY: $\pm$1.0 db of f.s. (10-250 Mc.).
$\pm$1.5 db of f.s. (250-500 Mc.).
LEAKAGE: Effective shielding is greater than 40 db.

RF INPUT:
LEVEL: $\leqslant$0.316 volts* (10-125 Mc.)
$\leqslant$0.446 volts* (125-250 Mc.)
$\leqslant$0.630 volts* (250-500 Mc.)
*For 10 volt output into 50 ohms
IMPEDANCE: 50 ohms

AM RANGE: Reproduces modulation of driving source 0-100% up to 5 volt max. carrier output

AM DISTORTION: $<$10% added to distortion of driving source

FM RANGE: Reproduces modulation of driving source except as limited by the RF bandwidth

FM DISTORTION: Negligible distortion added to distortion of driving source for deviations and modulation frequencies $<$150 Kc.

INCIDENTAL AM: $<$10% added to modulation of driving source at 150 Kc. deviation

MOUNTING: Cabinet for bench use; by removal of extruded strips suitable for 19" rack mounting

POWER REQUIREMENTS:
105-125/210-250 volts, 50-60 cps, 150 watts

Price: **$1200.00** F.O.B. Rockaway, N. J.

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New Termination Design now gives you wide choice of lead materials...

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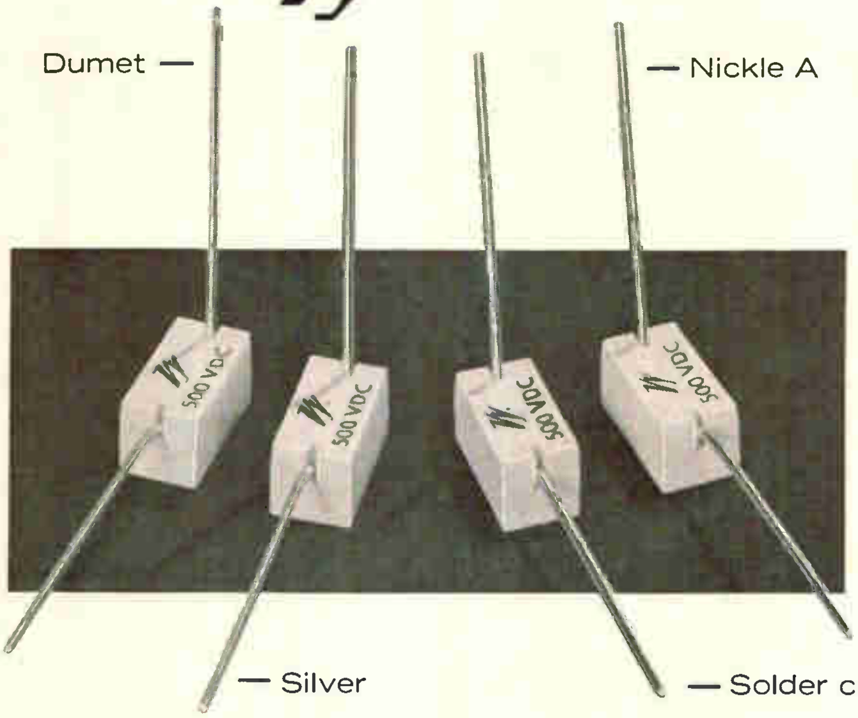

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✶ 300 and 500 vdc

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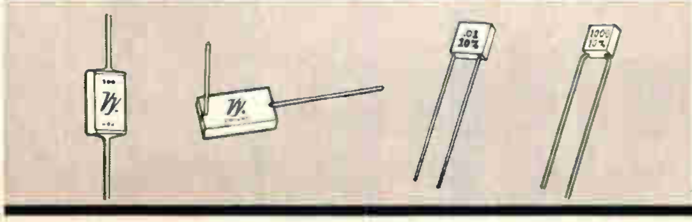
■ Now you can order these famous high reliability components with leads that are compatible with your connection requirements. New termination design guarantees positive contact and strengthens bond of leads to capacitor body. Axial-radial configuration saves board space, and gives greater flexibility to circuit wiring. Available with zero temperature coefficient as well as standard +105 ppm/°C . . . offers the exceptional electrical and physical characteristics inherent in all "VY" Capacitors. Write for data sheet containing complete specifications.



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KLEIN PLIERS *Speed up electronic wiring*

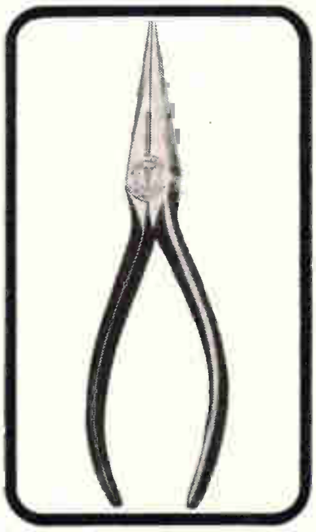
When the crystal set was a seven-day wonder, Klein long nose pliers were used to adjust the cat's whisker. Through the era of B and C battery sets, Klein kept pace by providing pliers specially adapted for electronic wiring.

Today, more than 100 different styles and sizes of Klein pliers are available to provide the exact tools needed for any job. Klein engineers have developed a special plier for wiring printed circuits; a high hardness plier for cutting nickel ribbon wire; a transverse end cutting plier for cutting closely in confined spaces; extremely small pliers for wiring midget assemblies—and many others.

Klein has also developed special pliers to do special jobs requested by electronic manufacturers.

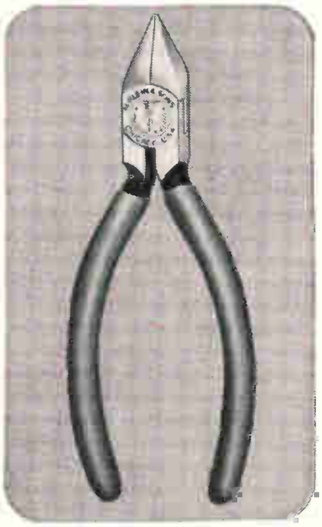
For better work done more quickly and at lower cost, be sure the pliers you use are exactly suited to the job . . . made by Klein, of course, "Since 1857."

202-5C Oblique Cutting Plier with narrow nose. Available with coil spring. 5½-, and 6-in. sizes.

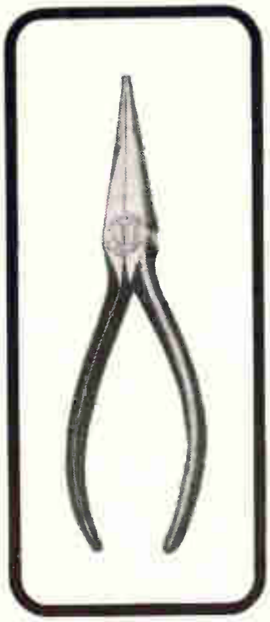


203-5C Long Nose Side Cutting Plier. Available in 5½-, 6½- and 7-in. sizes. Supplied with coil spring.

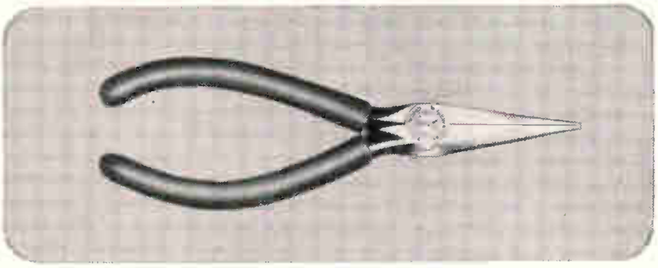
204-6C Transverse End Cutting Plier, 6-in. long. Supplied with coil spring to hold jaws open.



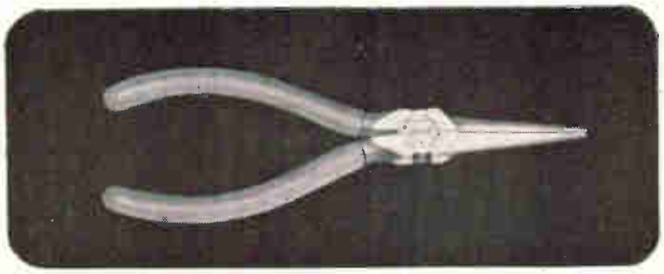
D209-5C Lightweight, Pointed Nose, Flush Cutting Plier. Supplied with coil spring to hold jaws open.



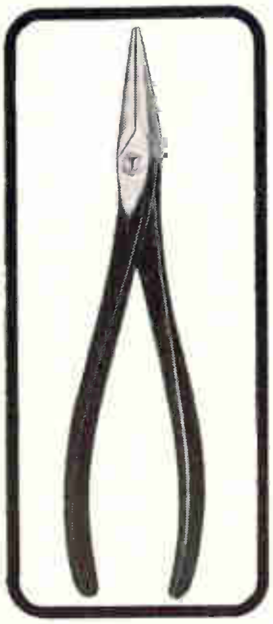
301-5C Long Nose Plier. Available in 5½-, 6½- and 7-in. lengths. Coil spring.



D307-5½C Slim Long Nose Plier for reaching into confined spaces. Yellow plastisol handles. Supplied with coil spring to hold jaws open.



D310-6C Slim Long Nose Plier. Handles are yellow plastisol covered. Supplied with coil spring to keep jaws open.



314-8 8-in. Long Nose Plier. Jaws have knurl.

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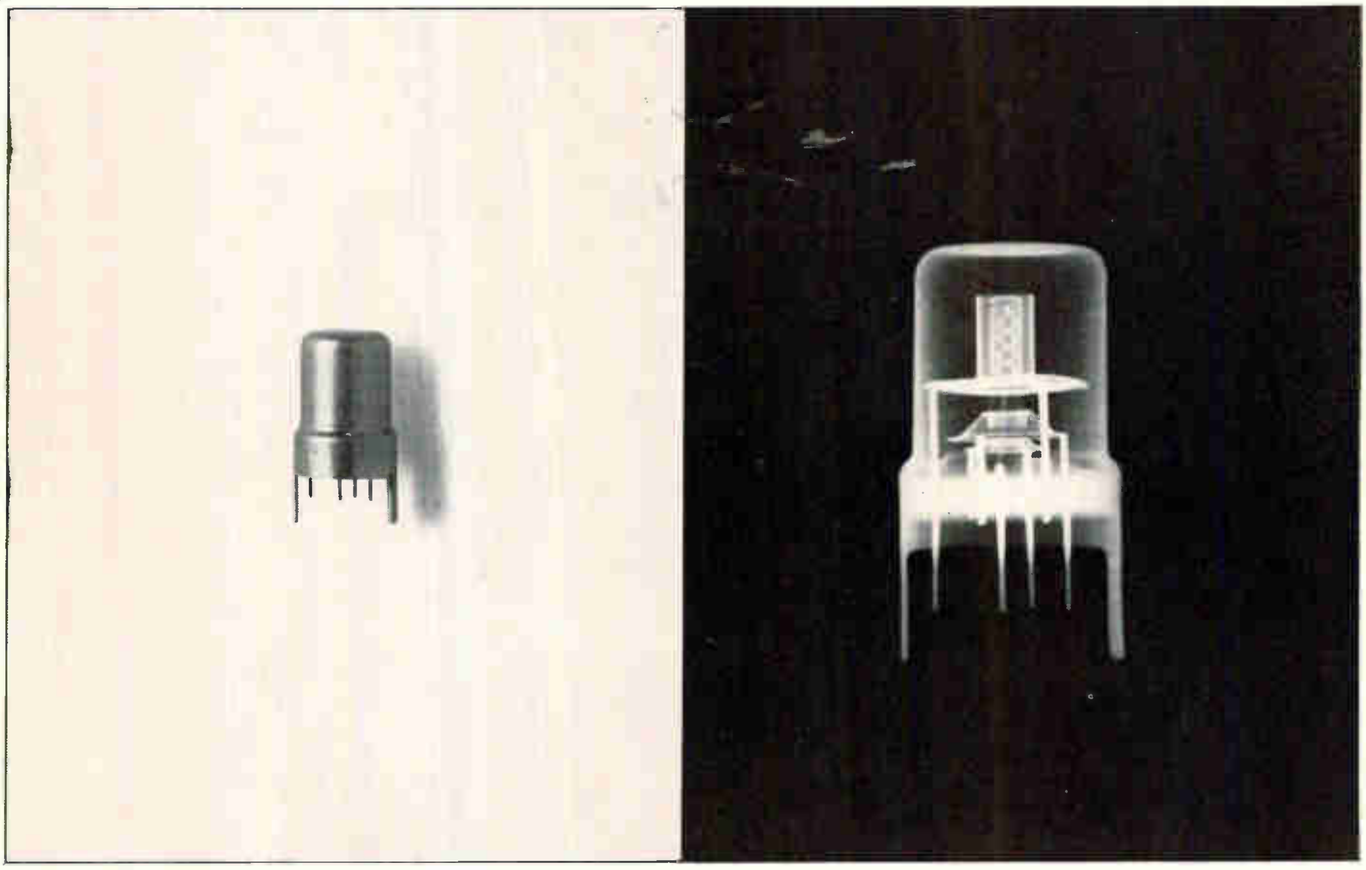

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Often a tiny defect can escape most methods of detection. That's why so many companies depend on Ansco Industrial X-ray films to make the final check on their components.

No method of non-destructive inspection shows up tiny imperfections (especially in tiny components) more clearly or quickly than a radiograph on Ansco Superay® "H-D" X-ray film.

This Class I film is especially designed for high definition radiography. Its ultrafine grain and high contrast provide the ultimate in image quality. Although used primarily with low voltage techniques, Superay "H-D" maintains its high definition characteristics and image quality throughout the full KvP range.

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Circle 41 on reader service card

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All Silicon, 0-20 and 0-40 VDC, Power Supplies Offer Highest Performance AT LOWEST PRICES

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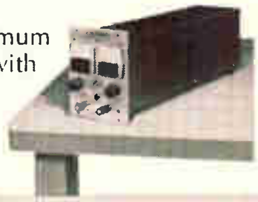

TEMPERATURE COEFFICIENT .015%/°C

LH SERIES
1/4 AND 1/2 RACK MODELS
TO SERVE ALL YOUR NEEDS

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PERFORMANCE-GUARANTEED FOR 5 YEARS

MEETS RFI SPECIFICATIONS-MIL-I-26600, Class 3

WIDE VOLTAGE AND FREQUENCY RANGE— 105-135 VAC, 45-480 cps

CONVECTION-COOLED— no blowers, no external heat sinks

SERIES/PARALLEL OPERATION and ± output to a common reference

REGULATION—Line or Load— .015% or 1 MV whichever is greater

PATENTS PENDING

5 Year Guarantee

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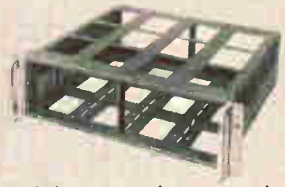

Model RA-1—for ruggedized mounting and use with chassis slides. Features front panel insertion Price $60.00

Model RA-2— for conventional rack mounting. Price $25.00

COMPLETELY PROTECTED

- Short Circuit Proof—Continuously Adjustable Automatic Current Limiting
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- No voltage spikes due to "turn on, turn off" or power failure.

RIPPLE—less than 250 microvolts rms and 1 millivolt P-P

CONDENSED TENTATIVE DATA

DC OUTPUT—VOLTAGE REGULATED FOR LINE AND LOAD

MODEL	VOLTAGE RANGE	CURRENT RANGE AT AMBIENT OF:(1) 30°C	50°C	60°C	71°C	SIZE H W D	CHASSIS (2) MOUNTING	PRICES NON-METERED	METERED (3)
LH 121	0-20V	0-2.5A	0-2.0A	0-1.7A	0-1.5A	5 3/16″ x 4 3/16″ x 15 5/16″	$154	$159	$184
LH 122	0-20V	0-4.5A	0-3.5A	0-3.0A	0-2.5A	5 3/16″ x 8 3/8″ x 15 7/16″	$220	$225	$250
LH 124	0-40V	0-1.25A	0-1.1A	0-1.0A	0-0.75A	5 3/16″ x 4 3/16″ x 15 5/16″	$149	$154	$179
LH 125	0-40V	0-2.5A	0-2.1A	0-1.8A	0-1.5A	5 3/16″ x 8 3/8″ x 15 7/16″	$229	$234	$259

(1) Current rating applies over entire voltage range

(2) Non-metered models with flush panel (add suffix S to model number)
LH 121-S and 124-S: 4-5/16″ × 3-13/16″ × 15-5/16″
LH 122-S and 125-S: 4-5/16″ × 8″ × 15-7/16″

(3) Metered models with front panel controls (add suffix FM to model number)

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Circle 42 on reader service card

Washington Newsletter

April 20, 1964

Checking on the snoopers

Books that whip up public interest are favorite starting points for Congressional investigations. Rachel Carson's "Silent Spring" is now bringing tighter control of the use of pesticides. **Investigators for the House and Senate were hoping for the same kind of reaction to two recent books on electronic snooping,** but so far, they are disappointed.

Thus far Vance Packard's "Naked Society" and Myron Brenton's "Privacy Invaders" haven't sparked enough interest to support the sort of broad inquiry into the use of electronic listening devices the Senate Constitutional Rights Subcommittee made a decade ago.

However, hopes for a broad look at the issue haven't been abandoned. Attention is now focused on a scholarly study being made with Carnegie Corp. funds by Alan F. Westin, an associate professor of public law at Columbia University, for the New York City Bar Association. Westin will hold a symposium in Tuxedo, N. Y., next month, and publish a report later.

He intends to cover the utility of laser beams for eavesdropping, closed-circuit concealed television surveillance, microminiature radio transmitters, lie detectors used without a subject's awareness, subliminal and subaudial message projection, brainwave analysis, and the increased pace of computer processing of information on millions of private individuals. **He will focus on the laws—or lack of them—affecting these developments, and thus will provide fodder for legislators.**

The House Government Operations Committee is currently involved in a critical investigation of government agency use of telephone listening gadgets and lie detectors. It is already satisfied that polygraphy use has gone far beyond national security requirements, and is used in routine personnel work.

Soviet asks to join US satellite setup

The latest bid to participate in the Communication Satellite Corp. system comes from the Soviet Union. Soviet and corporation officials have picked a time and place for hard negotiations: June 15 at Geneva.

The meeting early this month of European countries seeking to participate in the satellite system will be followed by another in May. No firm agreements have been reached, but there has been some progress, corporation officials say.

Meanwhile, the Federal Communications Commission is processing requests from about 210 private companies to buy corporation stock. Stock sales—which were to have been this month—are not expected before May. One reason for the delay is an impending decision by the military to buy services in the commercial system. **This would mean an annual fee of $25 million or more for the company.**

Within the next week or so, contractors for the basic satellite system are scheduled to be selected. Two or more companies will conduct six-month studies before a system is selected.

Proprietary data rules changing

The Defense Department may soon revise the Armed Services Procurement regulations governing acquisition of technical data from military contractors. **The changes would let the military be more selective in the data it seeks,** while still preserving the government's right to any information needed for subsequent competitive procurement. Decisions on data needed will be made early in the contract negotiations. **The concept of proprietary data is expected to be dropped.**

Under present regulations for research and development contracts, if an item is developed wholly at government expense, the contractor must supply all data necessary for reproduction of the item, including proprietary data (manufacturing and other secrets), with unlimited rights. However, in supply contracts the policy is to acquire only data needed for operation and maintenance, plus sufficient descriptive data to permit subsequent procurement from the same source or an adequate substitute from others.

No change is contemplated in the regulations on data developed wholly at government expense. But for both R&D and supply contracts where items are developed at private expense, the distinction between proprietary data (the definition of which has long caused government-industry controversy) and data otherwise readily available to the government would be abolished. Instead, **the government would spell out in the initial contract the data it feels entitled to** and would define the specific purposes for which it is to be used. But the government would not call for the data unless it actually needs it. Prime contractors, in turn, would require their subcontractors to follow the same rules. At present, data wanted by the government is sometimes difficult to get because subcontractors refuse to turn it over to prime contractors.

Conversion aid spelled out

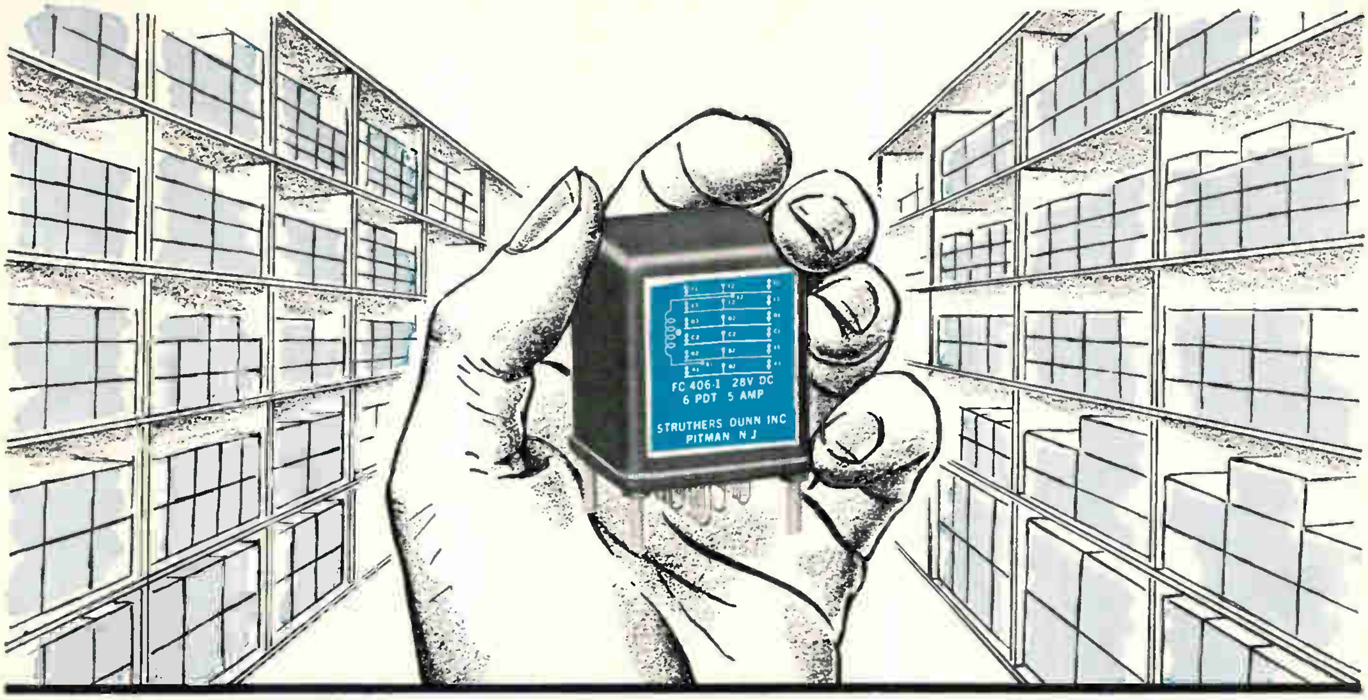
A newly adopted Armed Services Procurement Regulation makes it clear that the Defense Department will help pay for the cost of diversification planning by military contractors facing a substantial loss of defense business. **This aid has been available for some time, but some contractors apparently didn't know it.** The new regulation says plainly that the government can defray the cost of long-range planning for adjusting to the loss or reduction of defense business. The cost may be allocated as an indirect cost under a military contract. The government aid extends only to planning—not to research, development and engineering costs leading to new products for sale to the general public. And the **Defense Department will participate only to the extent that the contractor's business is military in nature.**

Spectrum space referee

James D. O'Connell, who headed the Army Signal Corps from 1951 to 1959, has been given a new White House post. He will be special assistant to the President for telecommunications and director of telecommunications management. **His office will coordinate government communications requirements,** much as the Defense Communications Agency does now for the Pentagon. O'Connell is an assistant director of the Office of Emergency Planning, and has been an electronics consultant to a number of firms. **One of the controversial issues he will face is whether the government preempts more spectrum space than it actually needs while civilian needs are rising.**

Offer to Soviets

NASA may offer to join the Soviets in experiments with Relay I, an active communications satellite. Previous joint tests were with the passive balloon satellite, Echo II.



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Dunco 4 & 6 pole

balanced armature

Air Frame Relays

...to MIL-R-6106C

No waiting.

Your Struthers-Dunn stocking distributor has a complete stock of these Dunco Air Frame Relays.

The FC-400 — a 10-ampere, 4-pole double throw relay.

And the FC-406 — a 5-ampere, 6-pole double throw relay.

He has them both in 28 volt d-c, or 115 volt 400 cycle a-c models. And with plug-in or hook-type solder terminals.

For long life and exceptional reliability, we manufacture with non-gassing materials, clean often as assembly progresses, then hermetically seal each relay before it's permitted to leave the white room.

Standard models — to MS-25269-A1 and -D1; MS-25271-A1 and -D1; MS-25327-A1 and -D1; and MS-25329-A1 and -D1 — are available now.

For relays, see your distributor. For specifications and name of your nearest distributor, write Struthers-Dunn, Inc., Pitman, New Jersey.

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AND CUTS THE HIGH COST OF POTENTIOMETERS

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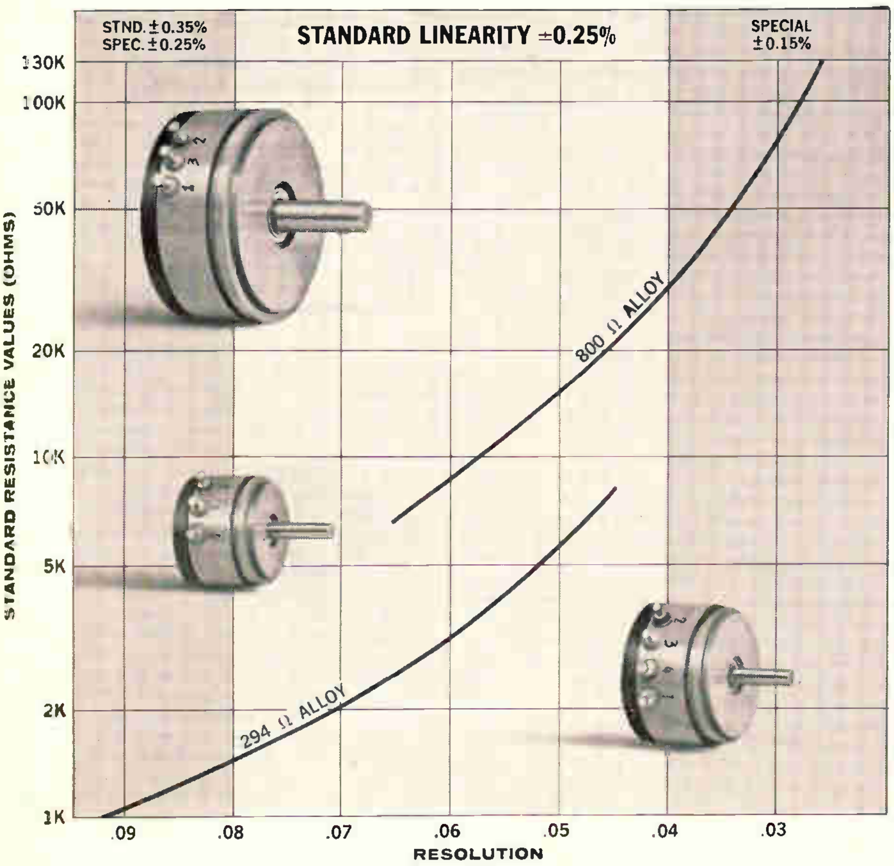

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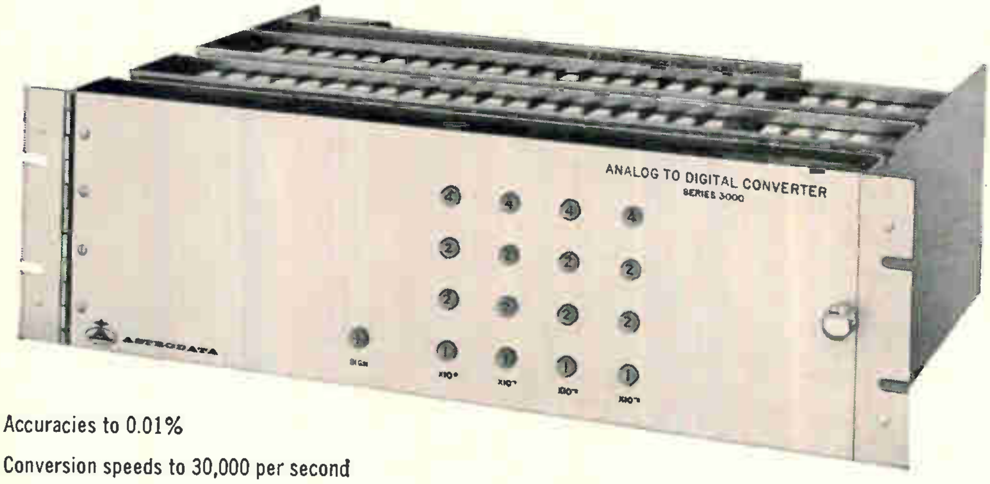

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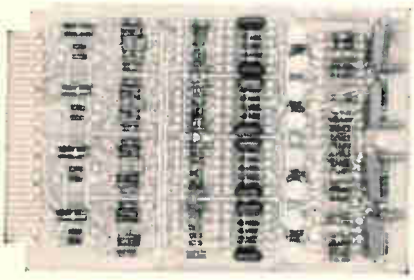

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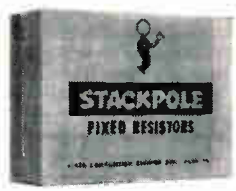

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Depositing active and passive thin-film elements on one chip

A thin-film transistor offers hope of removing the last obstacle to a long-time goal in microcircuitry

By Harold Borkan

RCA Laboratories, Princeton, N.J.

Thin-film transistors offer hope of clearing the last obstacle to attaining a long-time goal of microelectronics. They could allow all-thin-film circuits containing both active and passive components to be deposited on a single substrate in large volume and at low cost. One device being studied is the insulated-gate thin-film transistor (TFT).

Although the device is still in the laboratory stage of development, the life and stability observed in many of the versions have been encouraging. TFTs have operated many months after fabrication, and continuously for many weeks. They have been used experimentally in digital as well as linear circuits, and will eventually provide the circuit designer with the building blocks for integrating many different kinds of circuits.

Development is far enough along so that it is possible to relate electrical characteristics to physical parameters, describe operating characteristics and indicate circuits where the TFT may be particularly useful.

Many advantages

The TFT is well suited as the active element in a completely integrated circuit. It is small, has the desirable electrical characteristics of high input impedance, high transconductance and large gain-bandwidth product, and can be deposited upon an insulating substrate.

Thin-film resistors and capacitors can also be formed easily on the same substrate, with the important advantage that their electrical characteristics are similar to their conventional-component counterparts. In contrast, passive components that are prepared on semiconducting or other noninsulating substrates are not usually equivalent to conventional ones. Diffused resistors have lower tolerances and the capacitors have smaller values because of present limitations in semiconductor technology.

The TFT is a field-effect transistor that consists of a metal gate electrode separated by a thin insulating film from a semiconductor layer that is usually cadmium sulfide. Construction details are given in the panel on p. 54. Current flows through a channel in the semiconductor between two electrodes called the source and drain. Conductivity of this channel is controlled by the voltage applied to the insulated gate.

TFTs can also be used as diodes by connecting the gate and drain. Besides being entirely compatible with passive components, the triodes and diodes can be interconnected into large arrays of complicated circuits, possibly through automated deposition techniques. Thus the TFT should be of great interest to circuit designers.

Operating characteristics

The TFT is characterized by a plot of drain current as a function of drain voltage with the gate voltage as a parameter. Typical drain characteristics are shown in the oscillograms on p. 56 and, like those for conventional field-effect transistors, can be seen to resemble the characteristics of a pentode vacuum tube.

Due to the presence of the insulating layer, the TFT gate may be biased either positively or negatively with respect to the source without drawing appreciable gate current. At zero gate voltage, no appreciable current flows between source and drain. But when the gate voltage is made positive, this small current is enhanced by several orders of magnitude because a conducting channel is formed in the cadmium sulfide just under the insulator. In some units this current may be less than one microampere and increase to 5- or 10-milliamperes with positive bias, limited only by the power-handling capability of the TFT.

This type is called an enhancement TFT. The oscillogram on top is that of an enhancement TFT where the gate voltage required for onset of drain current (V_0) is about one volt. Only negligible current flows for gate voltage less than +1 volt.

The other kind of TFT operation, called the depletion mode, is similar to the mode of operation in a conventional field-effect transistor having a p-n junction at the gate. A depletion TFT has sizable drain current flowing at zero gate bias because of an initial built-in conductivity in the semiconductor. This drain current may be depleted by applying negative gate voltage or enhanced by positive gate voltage. The characteristics on the bottom oscillogram are of a depletion unit with V_0 of about —1 volt and about 1 milliampere drain current flowing at zero gate bias.

Both types desirable

It is especially desirable to have both enhancement and depletion TFTs. Enhancement units are useful for direct-coupled applications since the quiescent d-c voltage of the output of one stage can match the quiescent voltage of the input to the succeeding stage. Depletion-type units are useful for input stages, detector stages and other applications where zero gate bias operation is desirable.

The TFTs whose oscillograms are shown are typical. Both units have transconductances (g_m) of about 4,000 micromhos and have similar character-

Insulated-gate TFT: how it's made, how it works

The insulated-gate thin-film transistor (TFT) is one of a variety of devices being examined by researchers looking for an active component for thin-film integrated circuits.

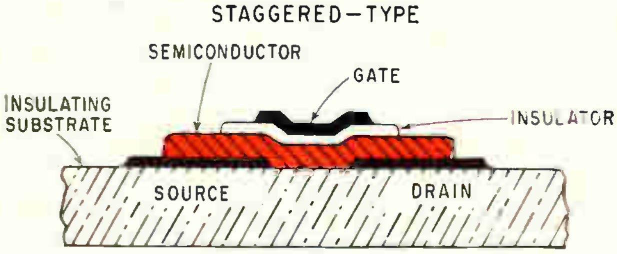
The devices under study fall into two categories—thin-film versions of conventional bipolar transistors, where both electrons and holes enter into the conduction process, and so-called majority-carrier devices where conduction is primarily by means of either hole or electron movement through the material.

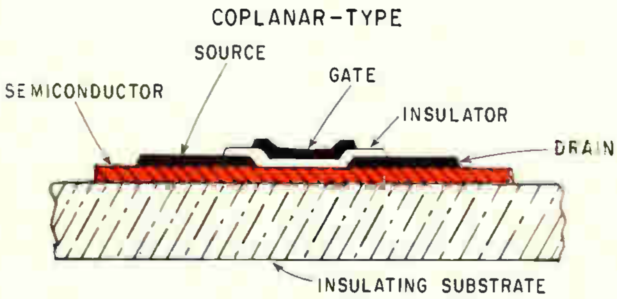
Majority-carrier devices include the TFT and metal-base triodes. In the latter, "hot" carriers having relatively high energies are injected in either of two ways: by emission over a potential barrier that exists at a metal-semiconductor junction, or by tunneling through an extremely thin insulating layer.

All these devices are beset by fabrication problems of varying degrees, but the TFT appears to be furthest ahead in development.

Field effect

The TFT is a field-effect transistor. An early form of the field-effect transistor was described by Julius E. Lilienfeld in 1933.[1] In this device the conductivity between two electrodes was modulated by the potential applied to a third electrode—close to, yet insulated from, a semiconductor layer.





In 1952 Shockley described a "unipolar" field-effect transistor[2] in which the control electrode, the gate, consisted of a reverse-biased p-n junction in a semiconductor substrate. Many such field-effect transistors are now available commercially.

The insulated-gate field-effect transistor was first reported by P. K. Weimer,[3,4] and its characteristics were described by Borkan and Weimer.[5,6] The TFT is deposited upon an insulating substrate, usually glass, and is made entirely by evaporation techniques. Cadmium sulfide is usually used for the semiconductor substrate, but thin films of cadmium selenide have also been successful.[7-9]

S.R. Hofstein and F.P. Heiman [10] have described another insulated-gate field-effect transistor. This device is formed in the surface of a single crystal of silicon. Although some of its physical mechanisms are similar to those in the TFT, differences in the nature of the semiconductor and structure produce some differences in characteristics and their utilization.

Construction technique

Two forms of TFTs that differ in evaporation sequence and electrode materials are shown at the left. The TFT on top shows a staggered-electrode arrangement, with the source and drain on the opposite side of the semiconductor from the gate electrode. The one on the bottom is the more recent coplanar-electrode structure [11] where all three electrodes are on the same side of the semiconductor.

In both structures the semiconductor consists of an evaporated layer of a substrate such as polycrystalline n-type cadmium sulfide less than one micron thick. The two insulator materials used most frequently are silicon monoxide and calcium fluoride. The insulator is quite thin, usually less than 0.1 micron. The gate electrode is deposited through a mask and centered over the source-drain gap. Gold or aluminum is satisfactory for the gate material in either structure.

The source and drain electrodes must make low-impedance, or ohmic, contacts to the cadmium sulfide. Evaporated gold underlying the sulfide and evaporated aluminum overlying the sulfide have been found to be satisfactory for these contacts.

In the typical experimental units the electrodes are 100 mils long. The source and drain electrodes are separated by a gap of 0.4 mil or 10 microns. The thickness of the layers have been exaggerated in the figure; the gap width is about 20 times the thickness of the sulfide.

To obtain the required high-resistivity semiconductor, the sulfide is deposited on a heated substrate and later baked in air. The sulfide is deposited in one vacuum system; and all the other fine-pattern evaporation takes place in another system equipped for precision-masking.

The staggered structure requires a reregistration of the pattern with the masks after the sulfide is deposited. The coplanar structure is easier to fabricate because it does istics except for the value of V_o. TFTs have been made with transconductances as high as 25,000 micromhos, comparable to the best vacuum tube. (Currently available field-effect transistors generally have transconductances under 3,000 micromhos.) As shown in the panel, g_m is a function of drift mobility, capacitance, source-drain spacing and drain current. Once the device is fabricated, g_m can be varied only by changing drain current through variations in gate voltage within the power handling capability of the structure.

The dynamic output resistance, r_d, of each of these units is about 40,000 ohms and the voltage amplification factor, mu, is about 160. The drain characteristics intersect at the origin with negligible voltage offset, indicating that the source and drain contacts are ohmic.

The gate current is very small in both depletion and enhancement TFTs because the gate electrode is insulated from the semiconductor. Typical d-c input resistance is high, usually greater than 10 megohms. The maximum safe drain voltage of the experimental TFTs is about 10 volts and maximum power dissipation is about 20 milliwatts.

Equivalent circuit

The small-signal equivalent circuit of a TFT is shown in (A) on p. 57. The gate, drain and source electrodes are represented as the nodal points G, D and S. The impedances between gate-source and gate-drain electrodes are represented by parallel R-C circuits. The magnitude of these impedances is

not require the realignment procedure and the additional vacuum pumpdown. Another advantage of the coplanar structure is that the heat treatment needed to produce the high resistivity sulfide may be applied without damage to underlying electrodes.

Theoretical analysis

An analysis of the TFT has been made, which predicts the drain characteristic solely from the effect of the electric field produced by the potentials applied to the electrodes.[6] In this analysis it is assumed that the semiconductor layer is thin and homogeneous, and that the source and drain make ohmic contacts to the semiconductor. Only majority carriers are assumed to exist in the semiconductor and it is assumed that their mobility is constant. The drain current, I_d, as a function of gate voltage and drain voltage, V_g and V_d, relative to the source is

$$I_d = \frac{\mu C_g}{L^2}\left[(V_g - V_o)\,V_d - \frac{V_d^2}{2}\right] \qquad (1)$$

where μ is the drift mobility in units of cm²/volt-sec, C_g is the capacitance across the insulator layer in farads, L is the length of gap between the source and drain electrodes in centimeters and V_o is the gate voltage required for the onset of drain current.

Equation 1 is a method of calculating the drain characteristics, I_d and V_d, from the physical device parameters for positive drain voltages up to the knee of the I_d-V_d characteristic. Shockley[8] has shown that an "extrapolated pinch-off point" region occurs above the knee where the drain current is constant, independent of V_d. The normalized drain characteristics predicted by Eq. 1 are shown, where the parameter (V_g-V_o) is the effective gate bias.

As will be shown transconductance (g_m) and the TFT operating points can be obtained from these curves. The area plotted is divided into two regions by the dashed curve, 2, representing the locus of the knees of all the characteristics. In region 1, at low drain voltages well below the onset of current saturation, the output conductivity, G_d, is linear with (V_g-V_o):

$$G_d = (\mu C_g/L^2)\,(V_g - V_o)$$

The drain voltage at the knee, line 2, is equal to (V_g-V_o). In the high-drain-voltage, current-saturation region, 3, there is a square-law dependence of drain current on (V_g-V_o):

$$I_d = (\mu C_g/2L^2)\,(V_g - V_o)^2$$

A consequence of this is that the transconductance, g_m, is proportional to the square root of the drain current:

$$g_m = \frac{1}{L}\sqrt{2\mu C_g I_d}$$

With this square-law dependence, the TFT might become an excellent r-f detector. Voltage V_o represents the gate voltage required for the onset of drain current. If surface states or traps (regions that can capture and immobilize electrons) are present in the semiconductor V_o is positive and TFT is of the enhancement-type. If V_o is negative, the unit has an initial source-drain conductivity at zero gate bias and is termed a depletion TFT.

A figure of merit that characterizes the high-frequency performance of a three-terminal active device is the gain-bandwidth product (GBW). For the TFT it can be shown

$$GBW \approx g_m/2\pi C_g \qquad (2)$$

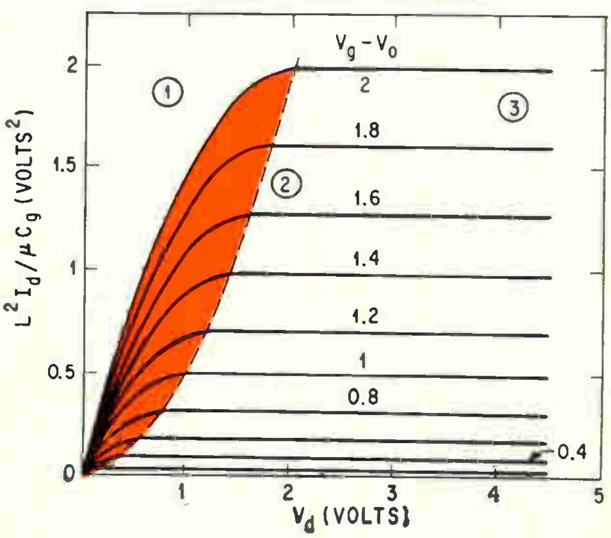
The analysis predicts

$$GBW = \mu\,(V_g - V_o)/2\pi L^2 \qquad (3)$$

Equations 2 and 3 relate the electrical characteristics, transconductance and capacitance, with the physical parameters: mobility, L and V_o. The equations show that gain-bandwidth product can be increased by finding higher-mobility semiconductors and by decreasing the source-drain gap, L. However, the drain current will be limited by the power handling capability of the TFT. Present 100-mil-long TFTs are capable of dissipating approximately 10 to 20 milliwatts, giving GBW up to 25 megacycles.

Experimental measurements of TFT drain characteristics show excellent agreement with the analytically predicted parameters G_d, I_d and g_m. This is convincing evidence that the primary operating mechanism in the TFT is the conductivity modulation of the semiconductor channel by field effect.

DRAIN CHARACTERISTICS

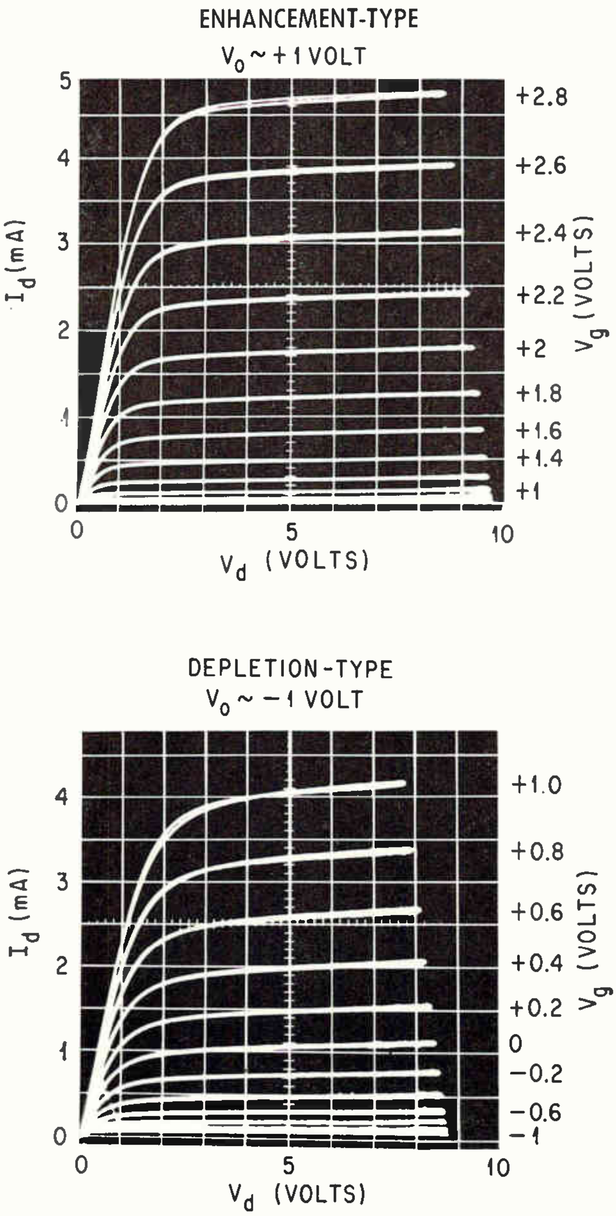


dependent upon the d-c operating point and also upon the frequency. The output circuit consists of the dynamic output resistance, r_d, driven by a current generator, $g_m e_{gs}$. Drain-source capacitance is small and can be neglected.

The impedances between the elements in a TFT have been measured by several different techniques with consistent results. The total gate capacitance, C_g, as measured between the gate and both the source and drain electrodes is shown in (B). The data were obtained from a staggered TFT (see panel) but the variations and magnitudes are typical of coplanar units.

Capacitance C_g is plotted as a function of gate-to-source voltage with drain-to-source voltage as a parameter. The transfer characteristic at the bottom of (B) shows that the unit is of the depletion type.

Approximately one milliampere of drain current flows during the zero-bias condition. With zero drain volts applied, the capacitance increases and tends to level off as the gate voltage increases in the positive direction. This shows that the width of the space-charge region in the semiconductor adjacent to the insulator is being reduced as the gate voltage is increased. The asymptotic value of capacitance approaches the capacitance across the insulator layer.



Oscillographs of drain characteristics are shown for an enhancement TFT and a depletion TFT.

Gate capacitance

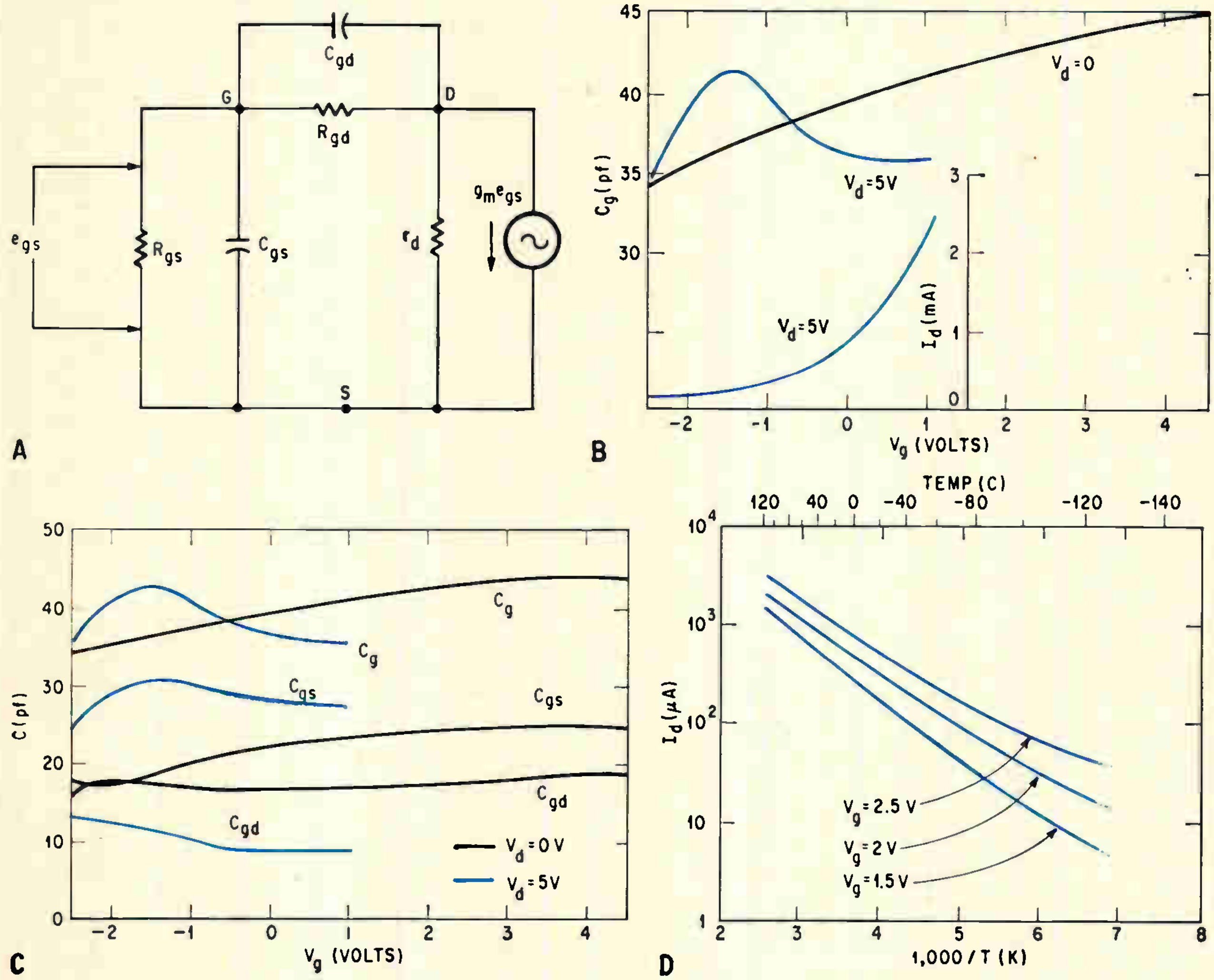
At the higher drain voltages, it is found that the total gate capacitance increases, reaches a maximum, and then decreases with gate voltage. This has been observed in both enhancement and depletion TFTs, the peak in capacitance being shifted toward positive gate biases for the enhancement units. The capacitance data presented were taken at 100 kilocycles using a Boonton Electronics capacitance bridge. Other measurements, taken at frequencies between 2 kc and 200 kc, have shown similar results except that the measured capacitance decreases slightly at the higher frequencies. The percentage change in capacitance is quite small (roughly 20%). However, as described below, the important point about capacitance is that most of it exists in the gate-source circuit.

Three-terminal capacitance measurements have been made to determine the isolated capacitances and shunt resistances that exist between the three terminals of the TFT. The results of such measurements are shown in (C) p 57 where the black curves correspond to zero drain voltage and the colored curves are for five volts applied to the drain.

The total gate capacitance, C_g, is separated into two components: C_{gs}, the capacitance between gate and source, and C_{gd}, the capacitance between gate and drain. It can be seen that C_{gs} can be 25 picofarads, which is comparable to commercially available field-effect transistors having transconductances of about 1,000 micromhos.

With both source and drain electrodes grounded, the total gate capacitance divides about equally between the gate-source and the gate-drain regions. However, at drain voltage in the saturation region, the major portion of gate capacitance exists in the gate-source circuit, and only a relatively small amount is in the gate-drain circuit. It is fortunate that C_{gd} is relatively small since it is magnified by feedback in TFT amplifier circuits, as described later. If C_{gd} were large to begin with, it would be very difficult to use TFTs in cascaded wideband amplifiers.

The shunt resistances from the gate to the source electrode and to the drain electrode also vary with operating voltages. At zero drain voltage, the gate-drain and gate-source resistances are about equal and are not sensitive to gate voltage. But the gate-drain resistance increases and the gate-source resistance decreases as the drain voltage is increased. It has been found that these shunt resistances, measured at 100 kilocycles, are usually greater than about one megohm. In the operating range the gate



Small-signal TFT has an equivalent circuit (A). Total gate capacitances and transfer characteristics of a staggered-electrode depletion TFT (B). The total gate capacitance, C_g, is distributed between gate-source, C_{gs} and gate-drain, C_{gd}, regions (C). Temperature dependence of drain current (D).

is effectively tied to the source through a lower impedance than to the drain, even though the structure is symmetrical.

The measured capacitances and transconductances of experimental TFTs have indicated gain-bandwidth products of up to about 25 megacycles, which is sufficient for many wideband amplifier applications. Some TFTs with a gain of two have operated at 60 megacycles.

The temperature dependence of an experimental TFT is evident from (D). This shows the drain current plotted as a function of the reciprocal of the absolute temperature for a constant drain potential of four volts and various gate voltages. The drain current decreases to about 1/100 of its original value when the temperature is decreased from +120° to −130° centigrade.

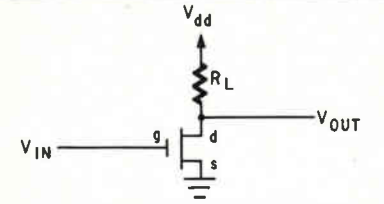
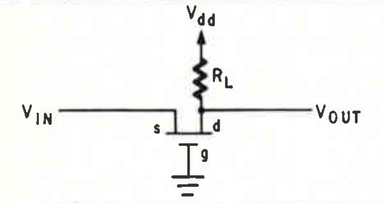
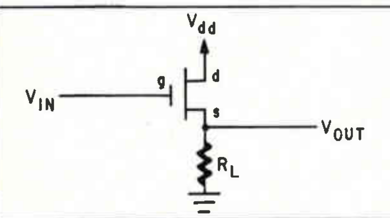
TFT amplifier circuits

An understanding of the electrical characteristics of the thin-film transistor allows this use in designing both conventional and integrated circuits. The design of a single-stage linear amplifier is appropriate for beginning a discussion of circuit design.

As might be expected, a TFT amplifier can be made with either the source, gate or drain grounded. As shown in the table on p. 58, the grounded-source TFT has high input impedance and is capable of voltage gain. The grounded-gate TFT has low impedance and it, too, is capable of voltage gain. The grounded-drain or source-follower amplifier has high input impedance, low output impedance and gain less than unity.

The measured performance on a typical TFT grounded-source amplifier is shown on p. 59 where voltage gain of a low-pass and several band-pass amplifiers are plotted as functions of frequency. The low-pass amplifier produced a voltage gain of 8.5 from d-c up to 2.6 megacycles, and thereafter fell at six decibels per octave. The measured gain-bandwidth product is 22 megacycles.

These measurements were made using a low-impedance signal source while the output was loaded with additional capacitance simulating a subsequent TFT. Of course, in using three-terminal active devices, one may exchange gain for bandwidth if the inherent voltage amplification factor is not exceeded. For the characteristics of the three

	TFT AMPLIFIER	R_{IN}	C_{IN}	VOLTAGE GAIN: A	R_{OUT}
GROUNDED SOURCE		HIGH	$C_{gs}+(1-A)C_{gd}$	$\frac{-\mu R_L}{r_d+R_L}$	$R_L \parallel r_d$
GROUNDED GATE		$\frac{r_d+R_L}{1+\mu}$	C_{gs}	$\frac{(1+\mu)R_L}{r_d+R_L}$	$R_L \parallel r_d$
GROUNDED DRAIN		HIGH	$C_{gd}+(1-A)C_{gs}$	$\frac{\mu R_L}{r_d+(1+\mu)R_L}$	$R_L \parallel \frac{r_d}{1+\mu}$

Impedance and gain characteristics are for the three amplifier connections of a TFT. Mu, g_m and r_d are the TFT amplification factor, transconductance and dynamic output resistance, respectively.

bandpass amplifiers that are shown, the output circuits were resonant at 25, 36, and 60 megacycles. At 60 megacycles the gain was 2.5 and the measured gain-bandwidth product was 17 megacycles.

A photomicrograph of an integrated all-evaporated three-stage amplifier shows the TFTs spaced two mils apart and directly coupled together[12]. The input, output, ground and drain-supply voltage connecting points, as well as the three load resistors, are shown in the photo on p. 59.

This circuit performed as a cascaded three-stage amplifier having a voltage gain of nearly 100. While this is a simple example of a TFT integrated circuit, much more sophisticated integrated circuits have since been built. For example, a completely integrated thin-film scan generator has been built (see photo) that has more than 100 TFTs in an area of 0.15 square inch[13, 14].

The author

Harold Borkan received a degree in electrical engineering from Rutgers University in 1950 and at that time joined the technical staff of RCA Laboratories at Princeton, N.J. He did graduate work at Rutgers on a part-time basis and received the MS degree in Electrical Engineering in 1954. Since 1952 he has been engaged in research on television camera tubes and associated circuits. He is more recently concerned with the measurement, analysis and utilization of developmental thin-film semiconductor devices. Mr. Borkan is a Senior Member of the Institute of Electrical and Electronics Engineers, a member of Eta Kappa Nu and the recipient of two RCA Achievement Awards.

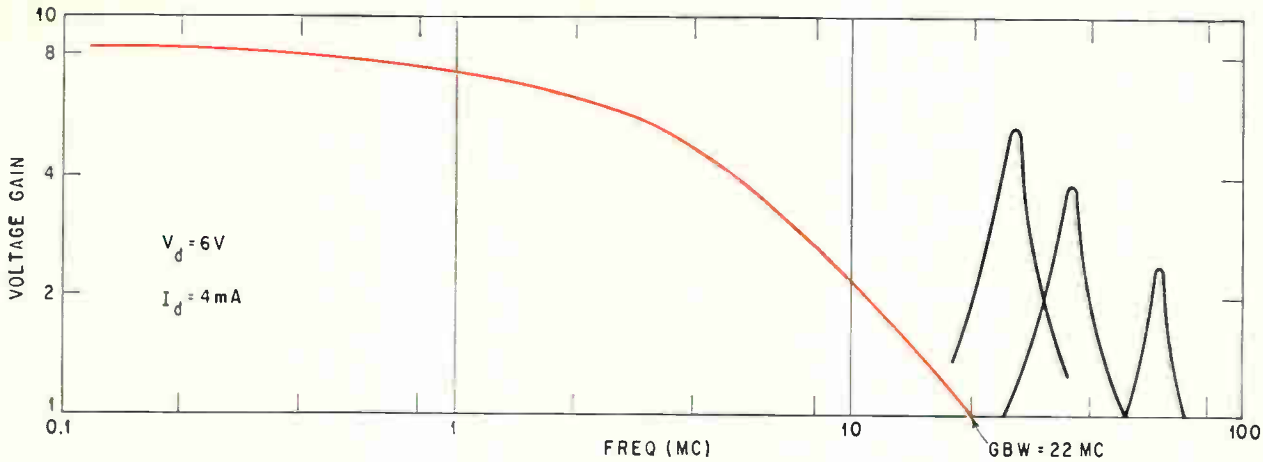
Cascading

In the design of cascaded TFT amplifiers, the gate-drain capacitance restricts the bandwidth even though the capacitance is smaller than the gate-source capacitance. This feedback capacitance is usually about 10 picofarads, but appears to be magnified at the input of a grounded-source amplifier due to the Miller effect, in which an impedance between input and output appears as a reduced impedance at the input. The gain-bandwidth product that was described earlier is an optimum figure that is applied to TFTs unburdened by the Miller capacitance term, $(1-A)C_{gd}$ (see table). Cascaded grounded-source stages yield much poorer over-all performance than is expected from the individual gain-bandwidth products.

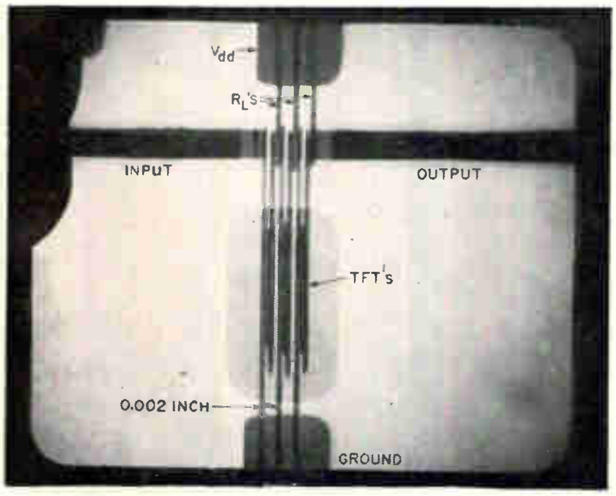
Some solutions

Many solutions to this Miller-effect problem are possible but most have severe limitations. The grounded-gate amplifier, for example, is capable of voltage gain but cannot be cascaded without introducing a poor impedance match that cuts the voltage gain. This situation may be improved by alternating source-follower and grounded-gate stages, a solution adequate for lumped-parameter circuits but very difficult to integrate. Another solution that suffers from the same difficulty is the cascode connection—a grounded-source amplifier driving a grounded-gate stage.

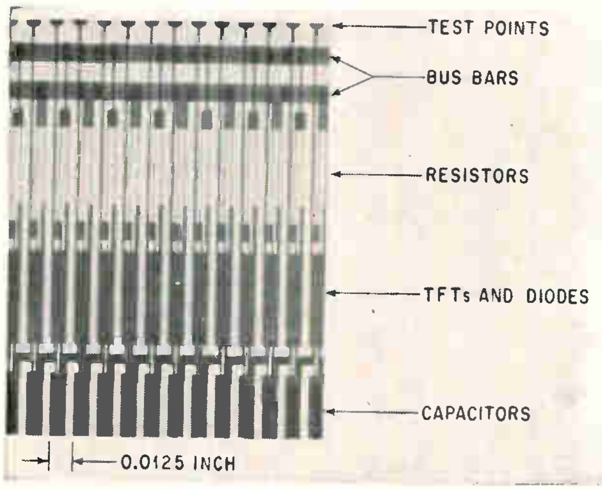
The most promising solution is to use a source-follower amplifier, direct-coupled to a grounded-source stage as shown in (A) on p. 60. The input capacitance is very low, approximately equal to C_{gd}, since degeneration reduces the effect of C_{gs}. At



Gain vs. frequency data are for a low-pass amplifier (in color) and three band-pass amplifiers.



Cascaded three stage direct-coupled amplifier.



Enlarged portion of thin-film scan generator.

the output of the source follower, the large Miller capacitance of the gain stage is driven by the low output impedance of the source follower and, therefore, does not restrict the bandwidth. The output capacitance of this combination is low.

An essential feature of cascaded direct-coupled amplifiers is that the quiescent d-c voltage be the same at the output as at the input of each stage. Otherwise the d-c operating point would progress out of the useful operating range of the drain characteristics.

In the circuit illustrated, the drain supply voltage is 3V volts, with 2V volts existing across the TFT and V volts across the resistor. The TFTs required are enhancement types with bias of V volts on their gates. With this configuration the input and output are both at 2V volts. It is difficult to match input and output voltages with the arrangements mentioned earlier.

A layout for the integrated circuit of each amplifier stage is also shown in (A). The input and output electrodes are in line and the circuit may be cascaded simply by adding on to the array. Only two bus-bars, one for ground and the other for the drain supply voltage, are needed in this arrangement. The resistors can be made of evaporated Nichrome and are aligned with the length of the TFTs to conserve space.

It is possible to fabricate this composite circuit in an area 10 mils by 100 mils, corresponding to a density of 1,000 stages per square inch. The composite electrical characteristics of this stage are much better than those of the individual TFTs. The resultant gain-bandwidth product approximates the optimum figure derived in Eq. 2 of the panel. This composite amplifier stage can also be considered for a building block in switching applications where high speed is important.

Bistable multivibrator

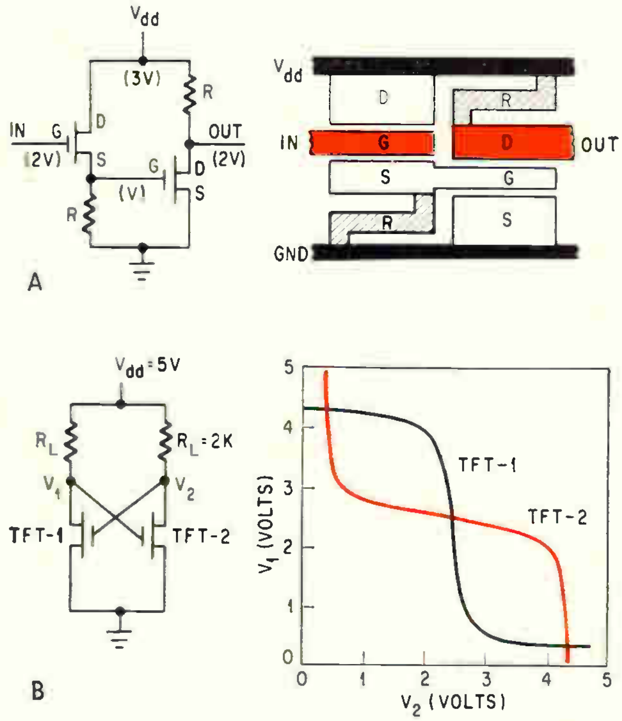
The simple bistable multivibrator (B) on p. 60 uses direct-coupled enhancement TFTs. Only two resistors, two TFTs and the triggering circuit are needed. The graph at the right has been obtained from an actual TFT drain characteristic load line. Voltage V_1, the output voltage of TFT-1 (and also the input voltage of TFT-2), is plotted against voltage V_2, the output of TFT-2 (and also the input of TFT-1).

Since the input voltage of one TFT is the output of the other, the only possible operating points are the three intersections of these curves. The criteria for circuit stability are that the voltage gain of the TFTs be less than unity at the two outer points and greater than unity at the center. The two outer points represent the cutoff and full-on conditions, while the central point is the mid-range of the drain characteristic. These stability criteria are easily satisfied with TFTs.

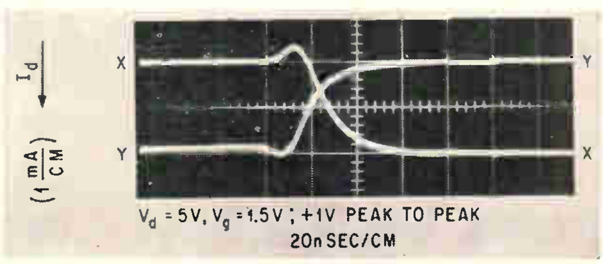
Switching

The TFT is useful in switching applications, since negligible power is consumed in the off state and only moderate power (about a milliwatt) in the on state. The switching waveforms observed for a typical TFT show two 2-milliampere drain-current transitions: X-X is a transition from low to high drain current while Y-Y is the reverse, from high to low drain current. The transient of opposite polarity that is observed on the waveform represents direct feedthrough of signal via the gate-drain capacitance. These results were obtained using a pulsed source having 50 ohms impedance.

TFTs are ideally suited for switching circuits in digital computers; in fact, computer applications offer probably the greatest potential use for TFTs.



Direct-coupled composite amplifier stage consists of a source follower driving a grounded-source stage (A). The layout of the integrated pattern is at right. The possible operating points of multivibrator (B) are indicated by the intersections of the two load lines.



Typical drain current transitions occur in about 30 nsec.

This is because complete logic systems of AND gates, OR gates and inverter circuits can be fabricated in large arrays easily and economically. The circuit design would be the same as for conventional logic circuits—the main point to remember is that parallel logic, where all drains are connected together and all sources are connected together, is a better choice with TFTs than the series system where the drain of each TFT is connected to the source of the next. The reason is that when a TFT is conducting, its source-drain voltage drop is about one volt. In parallel logic these voltages do not add as they do with series logic.

Shift registers can be assembled by directly coupling multivibrators of the type described previously. The necessary triggering would be accomplished with conventional techniques.

The thin-film transistor can be made to function as a diode by connecting the gate and drain electrodes. The best diode characteristics occur when V_o equals zero. An example of a circuit employing diode and triode TFTs is provided by the scan generator referred to previously. This generator, which demonstrates the possibility of using TFTs in X-Y addressing circuits, has 30 clock-driven stages that transfer binary inputs in a manner similar to a shift register. Each stage consists of two TFTs two load resistors and a diode and capacitor.

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The author thanks H. Johnson, P.K. Weimer, W.S. Homa, V.L. Frantz, H.P. Lambert and R.G. Pugliesi.

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Boost for electronic tuning: part 2

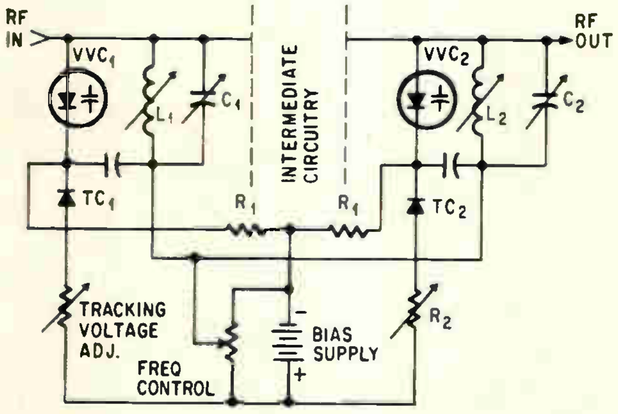
More details on how to use voltage-variable capacitors are given, and a method for detecting tracking errors that crop up in multiple tuning applications

By L.A. Weldon and R.L. Kopski
Philco Corp., Lansdale, Pa.

Why more voltage-variable capacitors than ever are now being put to work to tune communications circuits, and how they do this, was explained in detail in part 1 of this article (Electronics, April 6, 1964, p 49).

Circuit designers are taking a fresh look at cost comparisons, especially for high-quality equipment. Voltage-variable capacitance diodes eliminate the need for mechanical linkages in tuning applications, and systems using them can be tuned faster and more accurately than with a mechanical tuner. In multiple tuning, voltage-variable capacitors allow improved circuit layout.

The diodes can electronically tune two or more circuits to the same frequency, hold the circuits in phase, and multiply frequency with good efficiency at relatively high power levels. Resonant circuits may be tracked or tuned to maintain a constant frequency difference by adjustment of shunt capacitance and adjustment of inductance. Adjustment of a small variable voltage source in series opposition to the bias control voltage provides three-point tracking technique and reduces tracking error.



Tracking voltage is derived from temperature-compensating diodes.

The diagram on this page shows how to obtain tracking voltage from temperature compensating (TC) diodes. The TC diodes are forward biased from a constant-current source of about 100 microamperes (R_1 and the bias supply). The total voltage drop across TC_2 and R_2 should be about 0.75 volt. The drop across TC_1 and the tracking potentiometer should be variable from 0.5 volt to 1 volt.

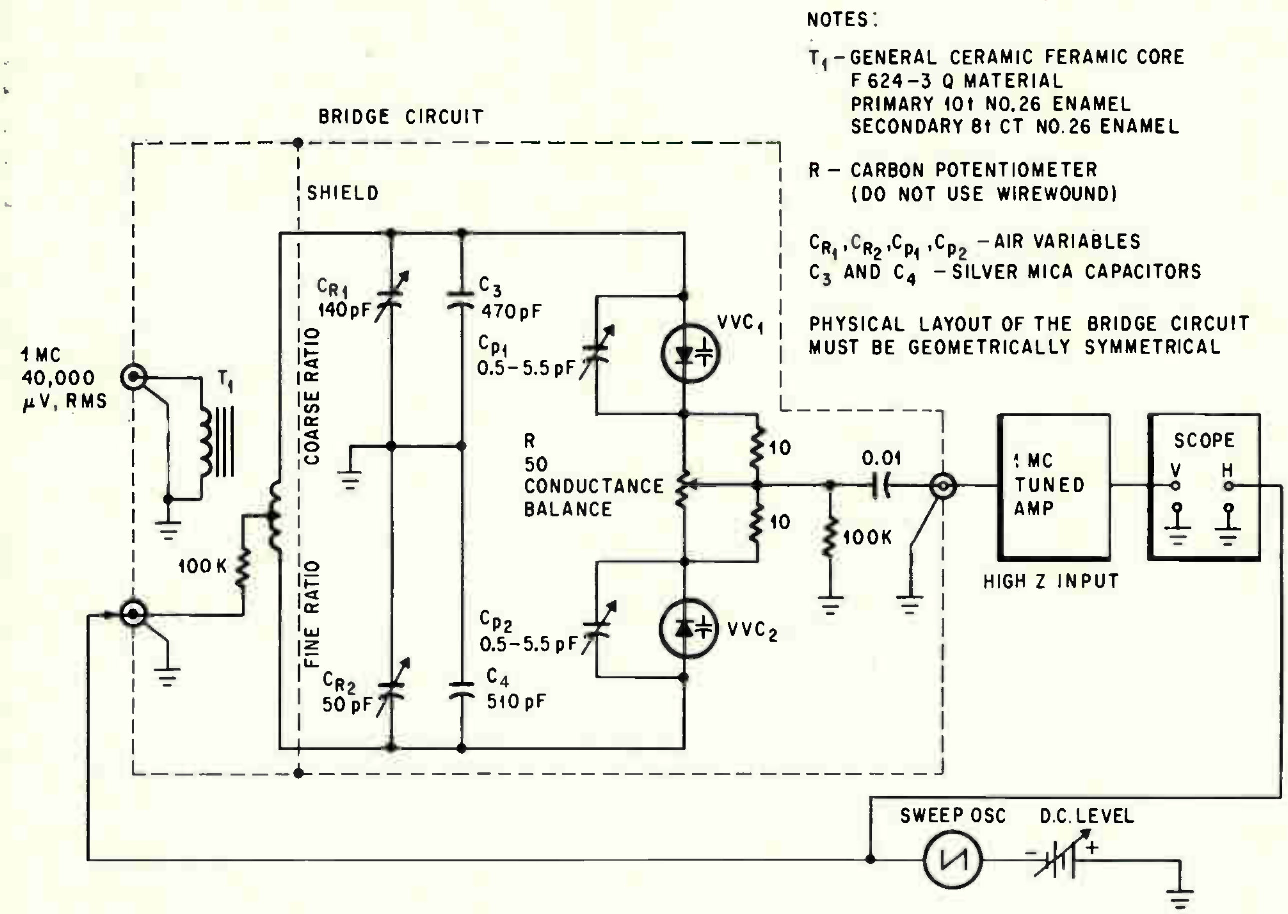
Capacitance tracking

There are various applications—such as in RC filters and capacitance bridge circuits—where the diode capacitance, rather than the frequency of a tuned circuit, must be tracked; diagram A on p. 63 shows a method for two-point tracking of diode capacitances. A proportional difference in bias voltage approximately compensates differences in K and V_o between diodes. Shunt capacitors compensate for variations in n, as in frequency tracking. Constant K cannot be exactly compensated by this method because of the presence of V_o as part of the effective bias for each diode; therefore, the tracking characteristics by this method will differ somewhat from the method shown in circuit B, p. 63.

Series opposing voltages, similar to those described with three-point frequency tracking, may be used to compensate V_o, thereby giving three-point capacitance tracking that is equivalent to three-point frequency tracking.

The major disadvantage of the capacitance tracking methods described is the possible reduction in effective capacitance range of the system. A diode with higher capacitance than other diodes in the system requires a higher proportional tracking voltage; this diode will limit the system range by reaching the limit of its maximum operating voltage before the other diodes do.

In most applications, the circuit designer is concerned with the frequency tracking error that will



Test set-up for measuring capacitance tracking.

result from using a randomly selected set of diodes. However, from the viewpoint of measurement and specification of diode tracking characteristics, it is more desirable to deal with capacitance rather than frequency, since capacitance is a characteristic of the diode itself. A capacitance tracking specification will generally be useful for circuit design regardless of the circuit application.

To make use of the specified or measured capacitance-tracking characteristics in design evaluation, a relationship between percent frequency-tracking error, D_f, and percent capacitance-tracking error, D_c, must be established. Combining expressions for D_f and D_c,

$$D_f = \frac{40{,}000 - 200\sqrt{200^2 - D_c^2}}{D_c} \qquad (4)$$

The expression appears cumbersome at first glance. However, some arithmetic will show that for values of D_c less than 10%, the percentage frequency-tracking error (D_f) is, for all practical purposes, equal to one-half the percentage capacitance-tracking error (D_c). This is a convenient relationship for translating specified and measured performance of a voltage-variable capacitance into circuit performance.

Measurement of tracking error

Capacitance tracking of a voltage-variable capacitance can be measured in test setup above. This capacitance bridge circuit has an output signal voltage proportional to the capacitance unbalance. The signal is preamplified and applied to the vertical input of an oscilloscope. The sweep voltage applied to the horizontal input of the oscilloscope also provides simultaneous slow variation of the bias on the diode. The resultant scope display on p 63 is a picture of diode capacitance-tracking as a function of bias voltage. One-point tracking is shown at the left, two-point tracking at the right. Verical scale is one cm p/p equals 0.1 percent capacitance difference. Horizontal scale is one cm equals 10 volts.

Test set calibration

The test set up above is calibrated by using fixed capacitors of known nominal capacitance and percentage difference, calculated from

$$\frac{2(A - B)}{A + B} \times 100$$

The calibration is accomplished by first substituting fixed capacitors for the two voltage-variable capacitors (VVC_1 and VVC_2) and adjusting the coarse bridge ratio capacitor C_{R1}, the fine bridge ratio capacitor C_{R2} and the conductance balance resistor R to achieve a null balance.

Next, the two fixed capacitors are interchanged and the resultant output is measured by the vertical deflection on the oscilloscope. Capacitors C_{R1} and C_{R2} are readjusted to halve this deflection. The fixed capacitors are then removed and the terminal capacitance is balanced by adjusting C_{p1} and C_{p2} to obtain a null indication. The input signal may be increased to obtain an exact null.

The first and second steps are repeated until the interchanging of the fixed capacitors results in equal bridge output and their removal gives zero output.

The oscilloscope graticule is calibrated as follows: Pairs of fixed capacitors, having nominal capacitances covering the range of values exhibited by the voltage-variable capacitors and having convenient percentage differences, such as 0.5%, 1% and 1.5%, are measured in the test setup. The vertical deflection exhibited by a capacitor pair is marked on the graticule at a point along the scope's horizontal axis (bias voltage) where the voltage-variable capacitor would exhibit nominal capacitance. The result is a field of "tracking-error percentage" lines. The shape of these lines is a function of the capacitance range of the voltage-variable capacitor and of the loading of the bridge circuit by the tuned amplifier.

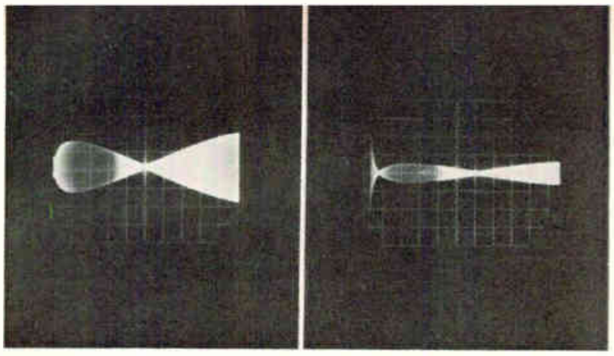
Testing the diodes

Now two voltage-variable capacitances are inserted into the bridge where the fixed capacitors used to be, and the sweep voltage applied. Capacitors C_{R1}, C_{R2} and R are then adjusted for null condition at some bias voltage. This is one-point tracking, usually best achieved at the midpoint of the bias-voltage range.

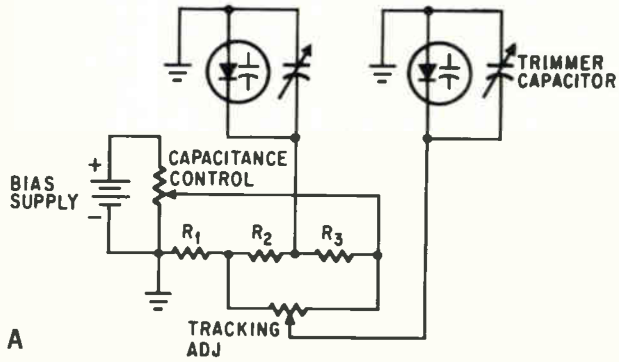
Two-point tracking can be best achieved by performing the above procedure at about 1.5 times the low-bias voltage endpoint and then adjusting C_{P1} and C_{P2} for null condition at about 0.6 times the high-bias voltage endpoint.

In either one-point or two-point tracking, the bridge-signal level must be low enough to prevent affecting the capacitances at low-bias voltage values. This is checked by interchanging the capacitances, readjusting for null, and noting whether the display obtained is identical to that obtained previously. A 20-cps linear-sweep generator, with output adjustable to 100 volts, in series with an adjustable 100-volt d-c bias supply, has been found to work well as a source of sweep voltage.

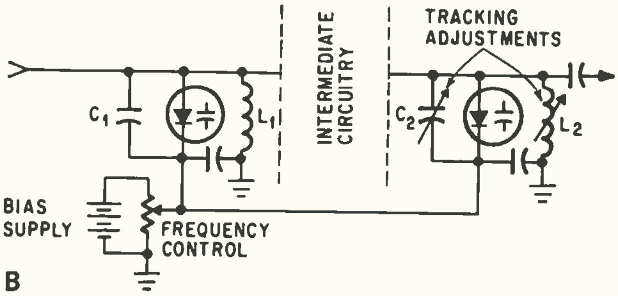
Since the bridge-ratio capacitors C_{R1} and C_{R2} effectively modify the proportionality constant K of the voltage-variable capacitances, this is equivalent to varying the inductance in the tracking method shown in diagram B. Also, the bridge capacitors C_{P1} and C_{P2} are equivalent to the trimmer capacitors C_1 and C_2 of B, so that the capacitance-tracking characteristics measured in the test circuit on p. 62 will be identical to the frequency tracking characteristics obtained in L and C circuit B—remembering, of course, that the capacitance error measured will be twice as great as the frequency error under the same conditions.



Typical one and two-point tracking displays.



Two-point tracking of diode capacitance.

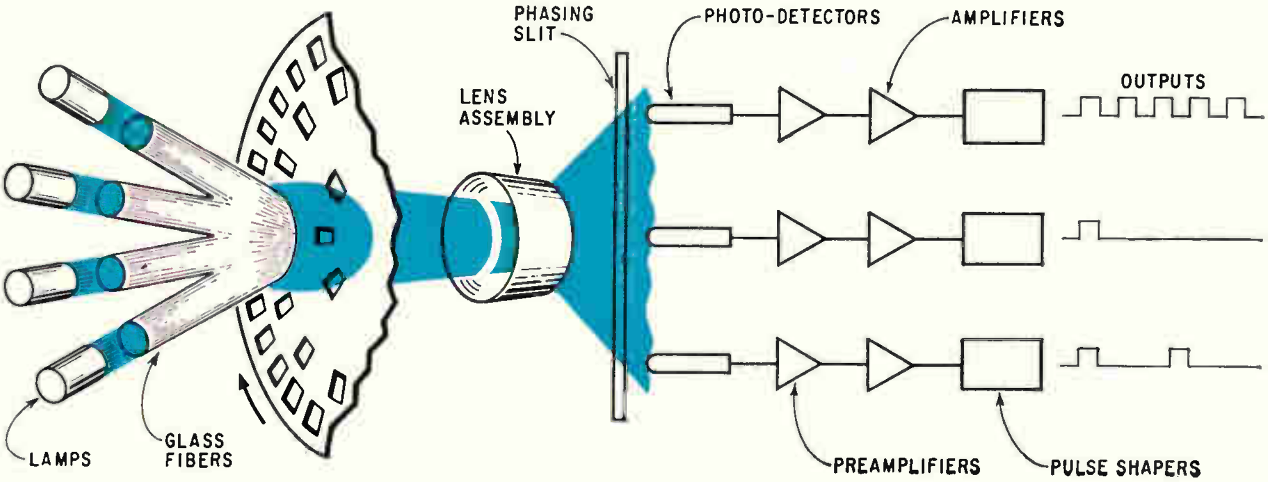


Conventional two-point tracking uses L and C adjustment.

The authors

Lawrence A. Weldon joined the Philco Corp. in 1960 as an applications engineer. He is currently applications supervisor for communications circuits and is responsible for evaluation of semiconductor devices intended for communications applications. He is a 1959 graduate of Drexel Institute of Technology in Philadelphia.

Robert L. Kopski received his B.S.E.E. in 1963 from Lehigh University. He joined the Philco Corp. in 1961. He worked in the transistor application department on switching and communication circuit design, transistor evaluation and the evaluation of voltage-variable capacitor tracking error. He is currently working in the circuit engineering department of the company's special products operation, and is responsible for the design of microwave solid-state switch drivers



Optical memory elements.

Computers

Permanent optical memories for compact systems

Manipulating large amounts of fixed data quickly, they're especially valuable for table look-up and other tasks in systems using only small amounts of temporary storage

By Fred P. DeNegri
Bendix Corp., Eclipse-Pioneer division, Teterboro, N.J.

Optical memory offers an ideal way to store and retrieve permanent data simply, compactly and economically.

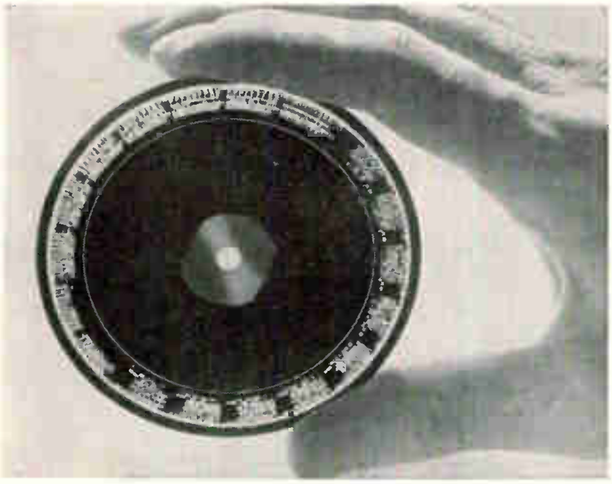
Optical storage permits a capacity of several million bits, average access times of fractions of a millisecond, and bit-transmission speeds in the megacycle range. The resulting devices are especially suitable for table look-up, program storage, function generation, nomographic electronic computation,[1] and operational digital applications.

With optical techniques, permanently stored data remains in its recorded state indefinitely. It cannot be affected by such forces as temperature extremes, power failures, power transients or radioactivity.

Another advantage is that optically stored data is retrieved by nondestructive readout. And when more than one light source is used, with derated lamps and random fiber-optic mixing, the optical reader's reliability is increased well above that of other components in the system.

These characteristics make optical storage especially useful in such airborne applications as in navigational computers, autopilots, monitoring systems, air-data computers, fire-control computers and display systems. Ground-based applications are in digital simulators, special-purpose computers for machine-tool or process control, monitoring systems, and as input devices for general-purpose digital computers.

The disk-type optical memory was designed for



Data disk.

storing permanent data for an airborne digital multi-engine monitoring system [Electronics, Jan. 11, 1963, p. 38].

Previously, a flight engineer would monitor the performance of the plane's engines by using flight manuals containing tables of characteristics, and give the pilot the optimum control settings for a specific airspeed and altitude. In the monitoring system, the tables are on the disk of the optical memory, the table look-up is done electronically, the data is transformed on a digital computer and the information is presented to the pilot by lights or markers on his instruments.

Specifications for the memory device in this multiplexing system could not be filled by existing techniques. Optical techniques were then being developed and their feasibility for the system's specifications was apparent. The problem, briefly, was to store 22,528 RZ (return to zero of the write current after each write pulse) bits in 3½ by 3½ by 6½ inches, to be delivered as eight-volt pulses at a bit rate of 409.6 kilocycles with an average access time of 2.5 milliseconds.

Ingredients of memory

The basic elements of a typical optical memory are: 1. a means of recording or writing permanent data, 2. a permanently stored data structure, 3. a means of illuminating the data structure, 4. a means of reading the stored data, and 5. a means of moving the stored data past the reading point.

To these can be added other features such as: 1. ease of completely changing the stored data, 2. redundant illumination in case of lamp failure, 3. capability for permanently synchronizing the multiple data channels with each other, and 4. self-contained electronics for pulse shaping.

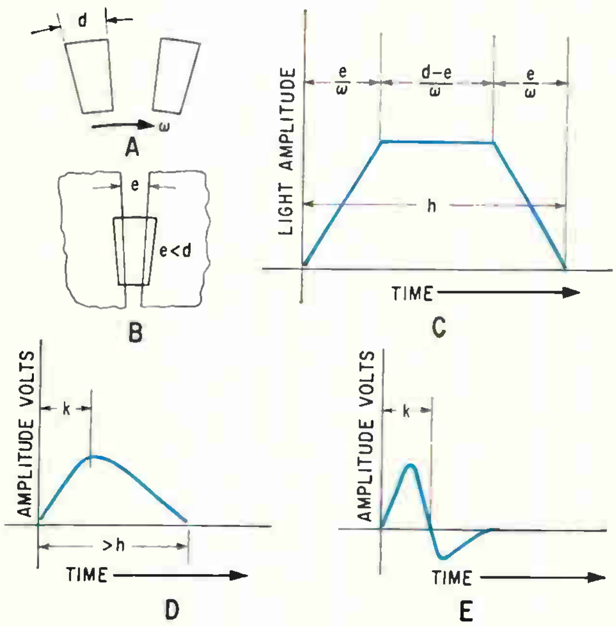
The relationship among these elements is shown on opposite page. For a typical reader channel, the source of illumination starts the data-flow cycle by providing enough light for a usable signal amplitude. This light is then modulated by a rotating track of windows etched in an opaque metallic film on a glass disk. The disk data pattern is then magnified, to simplify mechanical adjustments at the reading point during assembly, and is screened by a phasing slit.

In A below, d is the window width (in radians) and ω is the angular velocity of the data track. The width of the phasing slit, e in B, is also measured in radians, and must be less than the width of the window. The phasing slit, which is a single slit extending over all of the data tracks, is shown as a dashed line in the over-all figure. C shows the resulting forcing function that is presented to the photo-detector. A forcing function, which can be expressed as an equation or a diagram, represents an incoming signal over which a system has no control and is forced to follow.

The photo-detector attempts to follow the forcing function but, due to limitations such as its frequency cutoff point, produces a distorted waveform as in D. The typical detector has a turnoff time somewhat longer than its turn-on time. This characteristic is attributed to the excess carrier current that has been set in motion by light striking the photosensitive junction.[2] This residual current cannot immediately cease flowing. The detector output is then differentiated, as shown in E, and is now ready for pulse manipulation, which involves amplification and shaping.

Success development of the optical memory was predicated on the design of a basic reader channel capable of useful response frequencies beyond 500 kilocycles. Also, because of space limitations, a photo-detector of the miniature solid-state type was favored.

At the start of development, the frequency limits



Forcing function generation: magnified window (A); phasing slit (B); light-forcing function (C). Detector output: photo-junction output (D) and differentiated waveform (E).

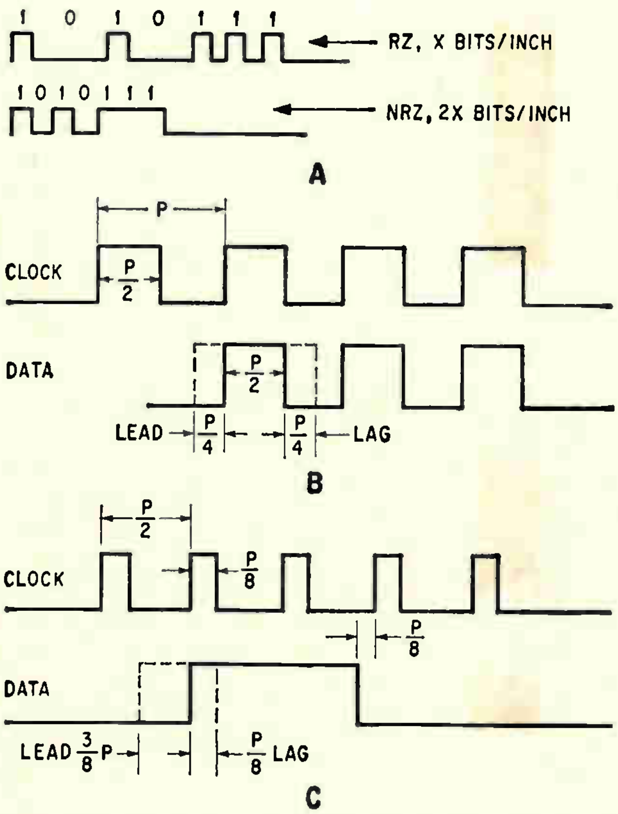
of commercially available photodiodes were rated by their manufacturers at about 50 kilocycles—adequate for the applications for which they were designed, such as reading punched paper tapes or similar perforated media, but only potentially useful in optical memory readers.

Improvements in the relationships between such photodiodes and other elements of the basic reader channel, such as light intensity, bit geometry, lens magnification, circuit design and slit widths, made it possible to read optically up to 500 kilocycles. Later advances in detector technology, such as using exposed transistor junctions, made it possible to read optically beyond a million cycles.

However, the resulting reader channel has practical limitations due to other sources of possible error, such as the geometry of the recorded data, mechanical eccentricities and run-outs, optical distortions, and environmental distortions due to temperature, shock and vibration. Before working tolerances can be assigned to these sources of error, a total tolerable phase error must be determined. To do this, two possible modes of readout can be considered: RZ (return to zero) and NRZ (non-return to zero), as shown in A below.

Phase errors will be considered at the output interface where logical pulse handling begins. By assuming practical pulse-width ratios, the figure shows that maximum phase errors for both RZ and NRZ must be less than $\pm 1/4$ of the RZ clock pitch, P. For RZ (B), this means that the pulse, whose width is P/2, can lead or lag by half of its width, or P/4, before interfering with the correct reading of an adjacent pulse; the total allowable drift is twice P/4, or P/2.

In NRZ recording (C), twice as much data can be recorded per inch, as shown in A, so the NRZ clock pitch, as compared with the RZ clock pitch, is P/2. If the clock-pulse width is P/8, then the maximum allowable drift is 3/8 P leading and P/8 lagging, before impinging on an adjacent pulse slot; the total allowable drift is 3/8 P plus P/8, or P/2, as before. This total error can be assigned as follows: environmental and other sources, 50%; reader channel bandwidth distortions, 25%; and mechanical, optical and geometric errors, 25%.



Recording comparisons: data formats (A); tolerable pulse phase error for RZ (B) and NRZ (C) modes.

Capabilities

This memory, in conjunction with an input-output console, is capable of serial or parallel output of nine-digit data. The encoded format is serial unitary weighted. Each pulse has a value of one, and such functions as X, sin X, 1 − cos X, $\sin^2 X$, ln (X + 1), 1/X, $\sqrt{X} + 1/4 - 1/2$, $2X/\pi$, X^2 and $\sqrt{X}$ can be read out at the nominal design frequency of 409.6 kilocycles as RZ pulse trains. The resolution of each function over its assigned range is one part in 2,048, which is also the number of clock pulses per disk revolution. The 11th channel contains a single reference pulse that starts the data-retrieval cycle; this pulse indicates when to begin reading data.

A motor speed of 12,000 revolutions a minute provides this memory with an average access time of 2.5 milliseconds. The memory unit consumes about 10 watts of power and has been qualified for airborne operation from −54° to 71° C. Its total weight, including all pulse-shaping electronics, is 3.5 pounds; it occupies 80 cubic inches.

The data disk from this memory [p. 65] is a photo-etched copy of an original master disk, which is used to make many such copies. Its three-inch diameter is capable of storing up to 22 channels of data with 4,096 bits per channel, or a total of 90,112 bits. Its nickel-on-glass construction allows the disk to be handled without fear of data contamination from such sources as fingerprints and solvents.

The lens system that magnifies the data structure is a conventional 10-millimeter camera lens providing 5× magnification. Its function is to preserve the track-to-track alignment built into the data structure by the dividing engine used to make it, and to allow the correct track pitch as seen at the detector station. A prism bends the optical image by 90° to accommodate the memory envelope restrictions. After the lens system is properly focused, no further adjustments are required.

Four prefocused incandescent lamps provide the necessary illumination. The light is distributed with about 800 glass fibers, divided into four equal groups, and randomly distributed over one output area; in effect, the light is channeled by four fingers of fibers into a single cylinder of light.

The resulting output beam of light is thus com-

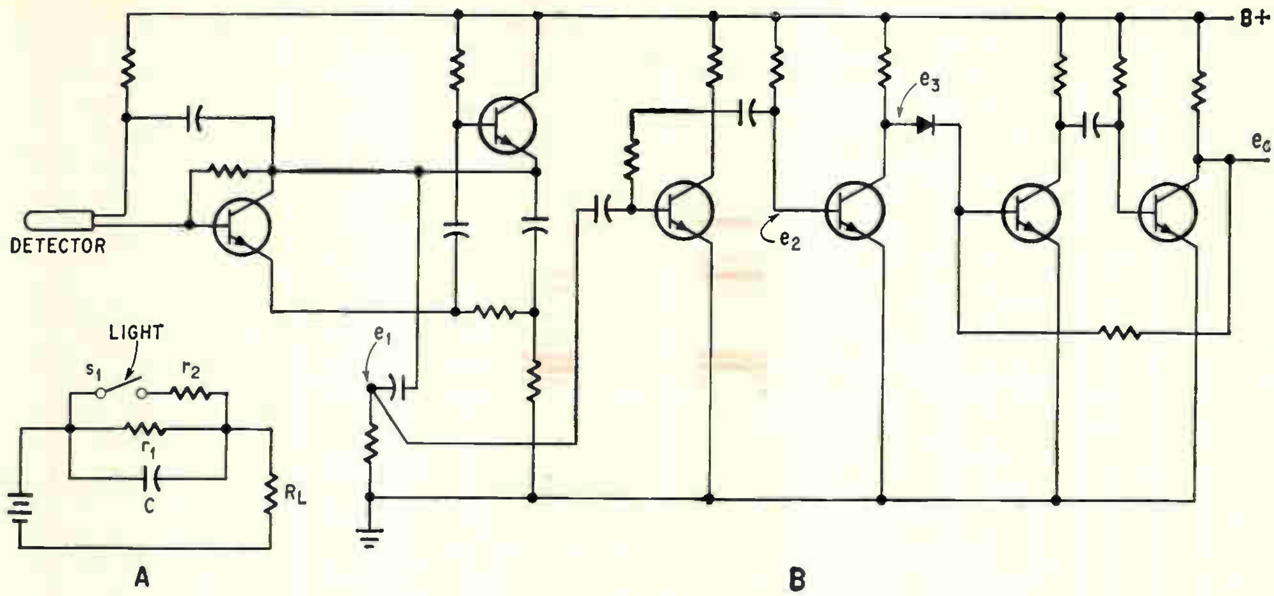


Photo junction equivalent circuit (A); typical reader electronics (B).

posed of hundreds of conically diverging beams that overlap as the distance from the output interface increases. This overlapping helps absorb a lamp failure without adverse effect on the memory. Each lamp has a statistical life of 6,000 hours, based on 20% failures, at 2.5 volts.

Photo-detectors

Two basic types of detectors are used for optical readout. The first is a dual photodiode that functions excellently for frequencies below 500 kilocycles. Because of its frequency limitation, however, it requires a relatively complex circuit.

The second type of detector is actually an exposed transistor junction packaged into a standard diode configuration. This junction is intrinsically much faster than the diode junction and also requires a less complex preamplifier circuit. This type of detector is capable of frequencies exceeding one megacycle. A representative circuit for the photodetector is shown in A above. The modulating light impinging on the junction, is represented by switch S_1, whose closed state corresponds to light "on" and whose open state corresponds to light "off." The r_1 represents the dark resistance of the junction; r_2 in combination with r_1 represents the irradiated junction resistance and C represents the intrinsic capacitance as seen across the junction. The previously mentioned distortion of the forcing function is evident here in the relative magnitudes of the time constants for both the "off" state and the "on" state. Where $t_{off} > t_{on}$,

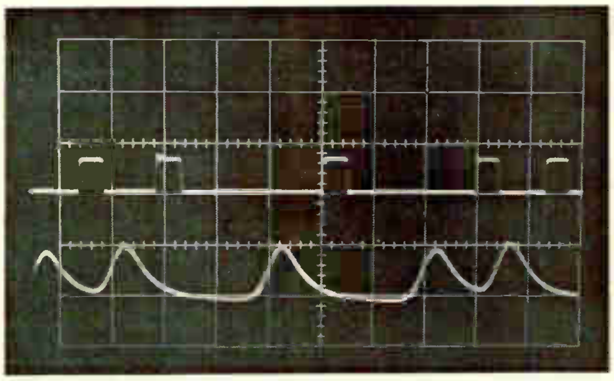
$$t_{off} = \left[\frac{r_1 R_L}{r_1 + R_L}\right] C; \quad t_{on} = \left[\frac{\left(\frac{r_1 r_2}{r_1 + r_2}\right) R_L}{\left(\frac{r_1 r_2}{r_1 + r_2}\right) + R_L}\right] C$$

A typical reader electronic channel, shown in B above, possesses the following waveforms: e_1, the preamplifier output, differentiated waveform, 50 millivolts peak to peak, at 500 kilocycles; e_2, class A amplifier output, 1.5 volts peak to peak; e_3, class B amplifier output, six-volt amplitude, and e_o, multivibrator output, +8 volts amplitude, < 0.1-microsecond rise and decay, one-microsecond pulse width.

The e_o output pulse can be driven directly into a 1000-ohm gating load for further pulse manipulation. The photo below shows actual outputs on a cathode-ray tube display.

Since the photojunction frequency response is inversely proportional to the phasing slit width, and its amplitude response is directly affected by the same slit width, a compromised working width is established at about 75% of a singular magnified window.

The single output is then improved as much as possible by first focusing the lens system for peak signal amplitude and elimination of optical crosstalk. This requires monitoring of the cathode-ray



Typical output waveforms at 650 Kilocycles, RZ readout: pulse shaper (top), with 10 volts per centimeter; preamplifier (bottom), with 1 microsecond per centimeter and 50 millivolts per centimeter.

tube during assembly and calibration, since the detector peaks in the infrared region where human perception is inadequate.

Woven into the focusing adjustment is a separate reader adjustment, which is being monitored during assembly. Both adjustments are performed until peak output results. The remaining detectors are then adjusted to peak while observed in a cathode-ray tube. At this point the two extreme channels (innermost and outputmost tracks) are monitored simultaneously and the phasing slit, which is a single slit common to all tracks, is adjusted so that all data tracks are phased synchronously.

Final phasing is performed while the shaped pulse outputs are being monitored. At this time, final individual reader adjustments and slit adjustments are performed and all hardware is secured. Dimensional tolerances and mechanical adjustment locks assure that no optical cross-talk will occur when the memory is being interrogated.

Recording modes

Assuming identical limitations for all contributing errors, for both RZ and NRZ, on p. 66 shows that when the tolerable pulse phase errors are applied to NRZ data, pulse trains are possible that double bit rates and double capacities. The additional price for using NRZ, however, shows itself as increased complexity and hardware in the associated readout electronics.

For optical RZ data readout, the bit rate and bit frequency are equal. This means that the useful bandwidth of the reader channel for nonlinear data pulses is limited by pulse distortions exceeding $\pm 1/4$ of the pulse pitch, as in B on p. 66.

For optical NRZ data readout, the bit rate is twice the bit frequency. The bandwidth requirements of an NRZ nonlinear data channel are half as severe as in a comparable RZ data channel. This is evident in A on p. 66, where a series of NRZ ones are not required to change state. The result is that the highest frequency encountered on a data channel is only one-half the clock frequency. Therefore, using the same reader channel bandwidth, it is possible to read a double bit rate when using NRZ, providing a double clock frequency is made available, such as by recording a double clock, or by doubling electronic frequency after clock readout. The double clock rate can be read out from the memory because clock pulses are spaced linearly, and are therefore not subject

Optical memory applications

The optical memory, in conjunction with the minimal associated circuits indicated on page 71, is capable of the following uses:

1. Read-out of serial weighted pulse trains
   - a Single disk, or drum revolution
     1. Functions with positive slopes
     2. Functions with negative slopes
     3. Intermixed functions
     4. Two-dimensional nomograms
     5. Functions with scale factors
     6. Functions without scale factors
     7. Families of curves
   - b Multiple disk, or drum, revolutions
     1. Multi-valued functions
     2. Two or more term addition
     3. Two or more term subtraction
     4. Two or more factor multiplication by logarithms
     5. Two or more element division by logarithms
     6. Combinations of one thru five
2. Read-out of serial binary data
   - a All forms of binary codes such as natural binary and binary coded decimal
   - b All types of functions, tables, programs, etc.
3. Read-out of parallel binary data
   - a All forms of binary codes
   - b All types of functions, tables, programs, etc.
4. Miscellaneous
   - a Interrogation and readout for a serial weighted pulse encoded memory can be performed in any practical number base system, or, in any combination of bases, providing the input-output registers are properly connected with the necessary feedback loops.
   - b Conversion from any practical number base to any other base can be accomplished with the clock and reference tracks of the memory in conjunction with suitably wired external registers.

An example of intermixed functions is as follows: Assume an optical memory, possessing serial unitary weighted pulse functions encoded in the RZ format, in conjunction with presetable up-down counting registers. If the memory contains M functions such as f_1, f_2—f_m, than a family of additional functions can be generated by using any function, f_i, to operate the index (or clock) register, and any function, f_j, to operate (or accumulate in) the output register. The result is a family of functions: $N_{y\,ij} = A \pm f_j[f_i^{-1}(N_x)]$, where A = output register preset value, N_y = number of accumulated output pulses, and N_x = clock position, whose maximum value is determined by the limiting range of the two selected functions. $\pm$ indicates the up or down counting mode.

Optical memory specifications

1. MTBF: For the basic memory channel consisting of lamps, fibers, motors, optics, detector, pre-amp and pulse shaper: up to 18,000 hours.
2. Cost per bit (including pulse shapers): 10 cents per bit for low capacities (up to 50,000 bits); 5 cents per bit for medium capacities (up to 250,000 bits); one cent per bit for high capacities, (up to 10 megabits). Actual costs would be a function of the number of readout channels.
3. Capacities: Disk configuration up to one megabit; drum configuration up to 10 megabits.
4. Typical volumetric bit densities (with pulse shaping):
   - For low capacities: 560 bits per cubic inch
   - For medium capacities: 1,000 bits per cubic inch
   - For high capacities: 5,000 bits per cubic inch.
5. Bit rates: RZ, 800 kc
   NRZ, 1.6 Mc.
6. Average access times: As low as 0.625 msec for drums.
   As low as 1.25 msec for disks.
7. Mechanical vibration: MIL-E-5272C Procedure XIII.
8. Temperature Range: −54° to +71°C.
9. Thermal Shock: MIL-E-5272C Procedure I.
10. Power consumption: As low as 10 microwatts per bit for high capacities.
11. Bits per track: up to 16,384.
12. Number of tracks: up to 620 for 10-megabit memory.
13. Disk sizes: up to 8 inches O.D., depending on access time.

to the bandwidth distortions of nonlinear pulse trains, which are pulse trains that do not have pulses in every pulse position. This would be almost any pulse train that is not a train of clock pulses.

Using RZ or NRZ recording, it is possible to encode and retrieve data from the memory in either parallel or serial fashion. The serial data may be coded in binary or as weighted pulse trains, both of which would possess random track access.

To differentiate between these two serial modes, it should be noted that a serial binary train of pulses contains pulses of different weights as determined by the selected code. Their relative position in time determines the weight of each pulse, such as in the series 1, 2, 4, 8, 16, 32. In contrast, a weighted pulse train contains pulses of different weights arranged in groups of identical weights, such as 11122222244. . . . These pulses are counted, or accumulated—rather than being shifted into the output register—by switching them into the appropriate weighted state of the output-counting register.

Assignment of parallel or serial words to corresponding clock positions is identical to the programming schemes used with general-purpose computer memories. Although these schemes are readily adaptable to the optical memory, they do not permit maximum use of the memory as a basic system component. The serial weighted-pulse encoding scheme permits the generation of incremental functions, of functions attained by intermixing of pulse trains, elementary computation by pulse accumulation, and the storage and retrieval of multi-dimensional nomograms. The storage of nomograms permit faster solution rates when solv-

Front cover

The cover photograph shows a disk optical memory, with the cover open for changing the disk, an enlarged portion of which is in the background.

In less than 10 minutes the memory can be opened, the disk changed and the memory restored to operation. A fixed mechanical gauge sets the disk into its correct optical plane. No trimming adjustments are required.

Drum sizes: up to 8 inches O.D., depending on access time.

14. Disk or drum change time: less than 10 minutes.

Solving nomographs with an optical memory

A potentially important application for an optical memory is in storing nomographic data for solving engineering problems. In effect, combining the speed of electronics with the simplicity of graphic techniques permits rapid solution of complex problems such as ordinary or partial differential equations

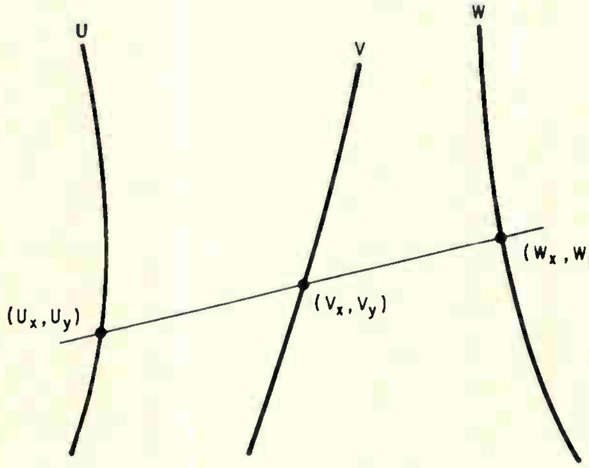
An example illustrates how the technique works: Assume that a point has been selected on curve U and another on curve V, and that a straight line has been drawn through the two points. Where does the line cross curve W?

The angle formed by the straight line and the horizontal axis is the same at all three points of intersection. If the angles are equal, then their tangents are also equal. Therefore, $(U_y - V_y)/(U_x - V_x) = (W_y - V_y)/(W_x - V_x)$. Or, the difference between the Y coordinates of the intersection points on curves U and V, divided by the difference in their X coordinates, is equal to the difference between the Y coordinates of the intersection points on curves W and V, divided by the difference in their X coordinates.

Given the coordinates of the points on curves U and V, a computer can easily find a pair of coordinates for the points on the W curve that will satisfy this linear relationship.

The values of U and V and of their X and Y coordinates, together with a clock track, can be placed on an optical memory as columns of bits, and scanned by photoelectric cells as the memory is moved past them. At any instant the cumulative count of the bits in a given column is taken as the value of that variable in the column at that instant. Knowing the values of U and V, the count can be stopped when the prearranged known value reaches this cumulative count. At this moment the U_x and U_y values are known through their simultaneous cumulative counts.

In a second pass, values of W coordinates are tried out



in the linear relationship, using the known U and V coordinate values; there will come an instant when they satisfy the relation. By stopping the W count at that instant, the cumulative W-count is the value of W that satisfies the relation for the specified U and V values.

Among the more complex nomographs that can be stored and solved with this technique are those for ordinary differential equations. The solution of partial differential equations, or systems of these, is much more difficult but technique shows promise.

A simple nomographic-electronic computer called Noel is in an advanced stage of development at Massachusetts Institute of Technology, where its operation approaches 1,000 solutions a second. Note that this is 1,000 solutions, not computations, per second. The memory used in Noel was built at MIT. Also being investigated is the use of delay lines for temporarily storing the nomographic bit pattern, which would minimize mechanical wear of the permanent optical memory.

Most of the above information is taken from reference 3 ing equations and other relationships and also results in simpler and less costly hardware.[3]

The optical memory is ideally suited for the serial weighted-pulse encoded formats because of its high bit rates, low access and high packing density. Indications are that dimensional reduction incurred in the generating of nomograms will play a significant role in the simplification and cost reduction of special-purpose digital systems. [4,5]

Function encoding

Since parallel and serial binary encoding systems are well known in the computer field, no specific example will be given. However, since the weighted-pulse concept is relatively new, a brief example will show how a specific function can be encoded.[6] In this sample, each pulse is assigned a value of one, resulting in a unitary-valued pulse train.

To encode and store a function (such as $y = f(x)$), it must lie in the first quadrant of an X,Y coordinate system. In addition, it must pass through the origin at its lower range limit and possess a positive slope of less than one in magnitude. Functions that do not possess these characteristics may be transformed prior to encoding.

The same X,Y coordinate system is graphically represented on the storage surface. Here, the clock channel set of windows represents the X axis, any function channel the Y axis, and the singular reference mark defines the origin.

The function $Y = \sin X$ satisfies the above requirements. The range to be encoded will be assumed as 0 to $\pi/2$, which will be divided into 2,048 increments. This number also represents the quantity of clock pulses assigned to this range.

The value of one pulse, ΔX, then, equals $\pi/2$ divided by 2,048, or 1/1,304. The clock position, N_x, corresponding to any value of X, equals X divided by ΔX. Similarly, the number of function pulses, N_y, corresponding to N_x, equals y divided by Δy. However, $\Delta X = \Delta Y$ by the nature of the stored pattern geometry. Therefore, N_y = y divided by Δx. Substituting in the original equation delivers the quantizing equation:

$$y = \sin X$$
$$N_y \Delta X = \sin (N_x \Delta X)$$
$$N_y = (1/\Delta X) \sin (N_x \Delta X)$$
$$N_y = 1304 \sin (N_x/1304)$$

The author

Fred DeNegri received his mechanical engineering degree and his MS in computer engineering from Stevens Institute of Technology in Hoboken, N.J. Since 1948 he has been involved in the development of analog, digital and hybrid instrumentation systems and associated components. His more recent work has been in the development of optical memory and high-resolution electrostatic shaft-encoding systems for airborne use. He holds patents in these fields.

This equation is solved for every value of Nx from 1 to 2,408, and each solution is rounded off to its nearest integral value. If the resulting answer differs from the preceding solution by one, etch a window in that clock location for the function. If the answer does not differ by one from the preceding solution, do not etch a window, and proceed to the next clock position, etc. Such a process is readily programed for quantizing on a general-purpose digital computer. The output format from the computer can be a punched paper tape or typed sheets, either of which will serve to program the encoding engine.

Retrieval of data

Data may be retrieved from the memory in several ways, depending on the encoded data format. The minimal associated equipment required to operate the memory for any mode is shown in the figure on the opposite page.

A typical interrogation cycle for the memory would be as follows:

1. The output register is set into its proper configuration—that is, parallel input or serial input, as a shifting or counting register.
2. The output register is preset to zero or some other value and its up or down counting mode selected.
3. The proper function, or functions, are selected for entry into the output register. The same is done with the index register.
4. The desired clock position is placed into the index register.
5. The REF control switch is closed and the first reference pulse from the memory "sets" the control flip-flop, which in turn open the AND gates. Pulse trains will then flow simultaneously into the index and output registers. Upon the occurrence of the zero state of the index register, the flip-flop is reset and all pulse flows cease. The output register will then contain the desired answer.

The optical memory disk or drum can be provided with magnetic read-write capability for scratch-pad use. Magnetic recording is performed on the edge of the disk or on the surface of the drum-supporting flange. Read-write bit rates are lower than optical bit rates, and are further lowered when data disk or drum interchangeability is involved.

Many system applications are required to manipulate a large proportion of fixed or permanent data using a small amount of temporary storage. One example would be an aircraft performing routine reconnaissance. The pattern is predetermined, so the coordinates for the turns can be stored permanently for each search area. Corrections are needed to compensate for effects of wind, altitude and other variables. These corrections could be made by a flight computer or a flight engineer working continuously with the permanent stored data.

Nomographic computation, combined with high-bit-rate, high-capacity optical memories, can provide faster solutions of special-purpose tasks, and require less hardware.

Fabrication and test

The lamp and fiber assembly first requires the selection of lamps whose area of maximum intensity can be centered on the axis of a supporting sleeve which, in turn, is cemented to the lamp. This assures accurate aiming at the fiber inlets. The fiber assembly requires a fixture into which each fiber is placed individually to achieve the desired random output distribution. The input and output interfaces are then ground and polished.

The data disk is perhaps the most involved subassembly, since it requires a reliable means of converting the original data to the desired window structure. The fabrication cycle is begun by placing a sensitized glass blank into a special camera. This camera is designed to index the blank in predetermined steps, such as 1/2048 or 1/4096. Facing the camera is a set of shutters, each capable of admitting or blocking a "bit" of light intended for the sensitized blank. Each shutter correspond to a radial word on the data disk. Hence at each indexed position a complete word is exposed. This assures pulse phase alignment after the light-forcing function is transformed into the electronic time domain. At this stage, also, the permanent clock "lead" is impressed on the disk.

Input to the shutters, to establish the desired word, is provided by an automatic punched-paper-tape reading system equipped with manual override and feedback monitoring. The entire operation is a closed-loop, self-monitoring cycle that reads words from the paper tape, sets the shutters, monitors their position, flashes the exposing light, indexes the sensitized blank and repeats the cycle.

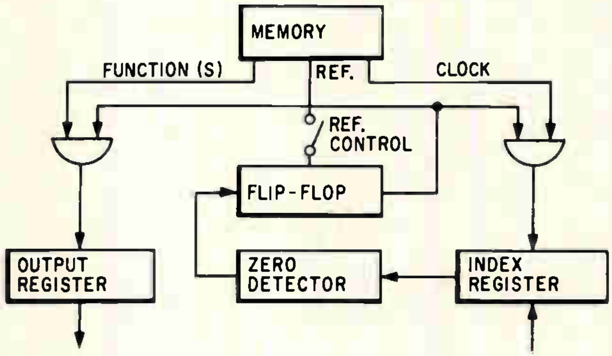
Engine-positioning accuracies limit the resolution of data to be encoded. Since each radial word placed on a disk is self-synchronous on readout, the location of each word is not as critical as it would be if the disk were to be used as a positioning reference. Hence, an engine accuracy of ±30 seconds of arc is adequate to encode a 4,096-word, 22-track disk.

For higher track capacities on both disks and drums using multiple station readout, the engine positioning accuracy must be controlled more stringently. The engine used in this case is positioned by a closed-loop, incremental digital system using a 16-digit Gray code photoelectric encoder as the feedback element. This engine is capable of encoding 16,384 bits per track for both disk and drums.

The completed and phased memory is tested by having the memory generate a punched tape of its own contents. This tape is then automatically compared with the original programing tape, and corrections are made as necessary.

Disk or drum?

The permanently stored data structure on the disk consists of concentric circles of windows



Minimal associated circuits required for optical memory applications.

etched in a thin metallic film bonded to a stable glass base. A vacuum-deposited nickel film, several millionths of an inch thick, has been found to have the best over-all characteristics. The combination of metallic film on glass requires a photo-etching process that causes a loss of line density. However, the ability to fabricate many data disks from a single master reduces disk cost considerably. For high line densities a drum surface is preferred to a disk, with each data drum a separate generated master rather than a photographic copy.

In a drum, line density is not lost, due to the transfer process used with disks. The higher cost of making a drum is compensated for by the increase in storage capacity of the data surface.

Other considerations are involved in selecting either a disk or a drum. These include access time and encoding format.

For low access times, a drum is preferred. For a given amount of data, its smaller diameter is able to tolerate higher speeds. When the desired encoding is in the serial-weighted pulse family (for instance, 11122222244...), such as is used for nomogram storage, the disk may be preferred because its increasing track diameters permit storage of increasing number of bits per track.

Dust particles are no problem, as the data surface is continually in motion and the resulting forced airstream across the surface is enough to "sweep" the disk clean. Also, the entire instrument is hermetically sealed, when specifications permit.

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Circuit Design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Cold-cathode gas tubes switch high voltage fast

By Robert E. Daniels and Arthur D. Cook
Argonne National Laboratory, Argonne, Ill.

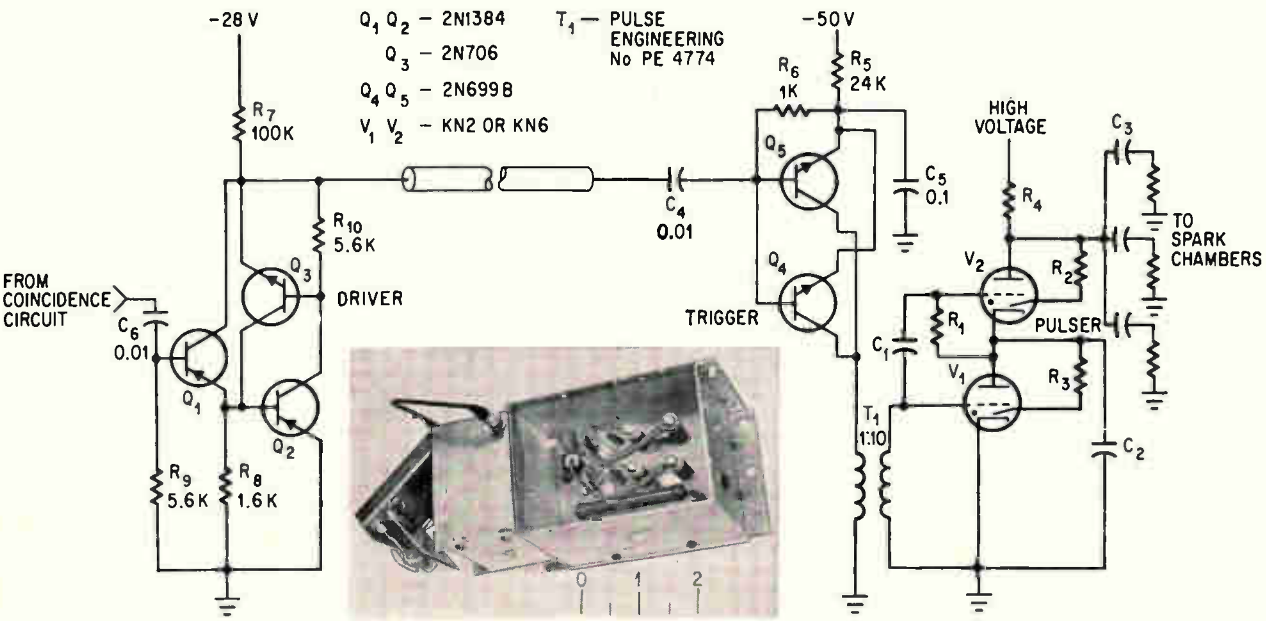
In equipment designed to be carried aloft in a balloon, a reliable, high-voltage switching device having a short delay time and a very fast rise time was required to operate an array of spark chambers. A spark chamber is an instrument used by physicists interested in high-energy phenomena to observe the path of an ionizing particle passing through the chamber.

The average rate anticipated in the experiment was two pulses per second, and a recovery time of 0.15 seconds had to be available after each pulse so that the recording cameras might be advanced. As in all airborne equipment, weight, size and electrical efficiency were important design considerations.

The methods regularly used to switch high voltage were considered for this application, including spark gaps, thyratrons and hard tubes. The device finally selected was a cold cathode krytron gas tube (krypton), type KN2 or KN6, made by Edgerton, Germeshausen and Grier, Inc. The physical size, ruggedness and cold-cathode operation of these tubes make them ideal for airborne equipment. The trigger voltage and trigger current requirements are within the range of transistor trigger circuits, and the tubes are easily shielded for operation in high magnetic fields.

The anode hold-off voltage rating for the krytrons is lower than that required to be switched in this application, and an arrangement for stacking tubes that employed a resistive divider to equalize the voltage drops was developed to allow higher voltages to be switched. When switching 10 kilovolts with this stacking circuit, experimental observations indicate that firing delays of 0.2 microsecond are obtained by increasing the trigger voltage from 300 to 500 volts.

The complete pulser, trigger and driver is shown below. Transistors Q_1 Q_2 and Q_3 form a line driver, allowing this part of the circuit to be located remotely. Cable lengths of 10 feet between the driver and trigger circuits cause no deterioration in performance. The operation of the driver is similar to the action of a thyratron in that a negative pulse input to Q_1 causes transistors Q_2 and Q_3 to go into a regenerative mode, and to rapidly discharge capacitor C_4 into the base-emitter junction of Q_4 and Q_5. This turns on Q_4 and Q_5, discharging C_5 into transformer T_1, which drives the pulser.



High-voltage pulser. Inset shows construction of trigger circuit attached to the side of the spark-chamber pulser. One side of the aluminum box for pulser circuit is made of Rexolite upon which are mounted the pulser components.

Both the line driver and trigger circuits obtain their pulse power from capacitors. This allows the power supply to be isolated by large resistors and prevents it from being shorted in case of circuit failure. The krytrons V_1 and V_2 are stacked in series with charging resistor R_4. Resistors R_2 and R_3 provide the keep-alive current to the tubes and serve to divide the high voltage equally across them.

The over-all delay in this pulser (0.35 μsec) occurs in the rise time of T_1 (approximately 0.2 μsec) and the firing delay of krytrons (about 0.15 μsec). Life tests on the krytrons in this application indicate an average life of 165,000 operations. The pulser and trigger circuits have been tested in magnetic fields as high as 2.5 kilogauss with the use of magnetic shields.

This work was performed under the auspices of the Atomic Energy Commission.

Amplifier improves peak voltmeter response

By Masami Uno

Faculty of Engineering, Shizuoka University, Hamamatsu City, Japan

The conventional method for measuring the peak value of a pulse is to charge a low-leakage capacitor C, through a cathode follower and a diode, with the pulse to be measured. The voltage across C is then read with a vacuum-tube voltmeter.

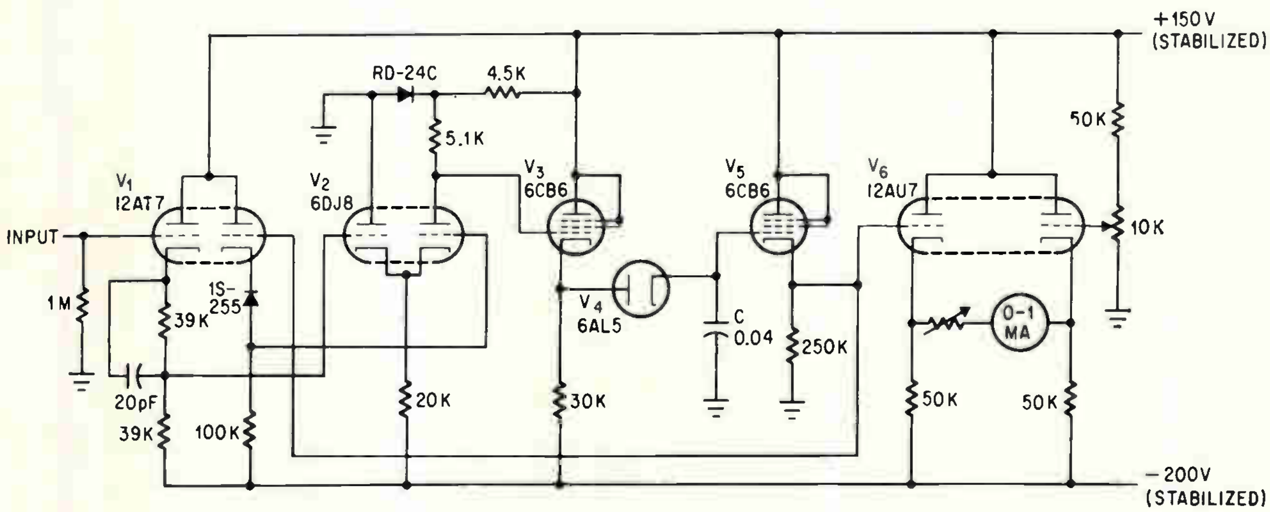
For this method to operate successfully, the charging time constant of the circuit must be small enough so that C is completely charged to the peak pulse value before the pulse begins to fall. On the other hand, the discharging time constant of the capacitor should be large enough so that the charge is maintained long enough for the measurement.

In general, the voltage across C is related to the input voltage by the equation $e_c = e_i\,[1 - \exp(-t/\tau)]$. If the charging time constant is made small, e_c will approach e_1 rapidly, allowing C to charge to the peak value of even very narrow pulses. However, the discharge time constant formed by C, its own leakage resistance and the input of the vtvm also becomes small, and the measurement time becomes too short. If C is made large to increase the measurement time, C will not charge to the peak pulse voltage.

In the new circuit shown above below, an amplifier V_2 is added to the conventional peak voltmeter. The voltage across C is applied as negative feedback to one input of the amplifier, and the pulse to be measured is applied to the other. Assuming that the delay in the amplifier is negligible and that the gain A of the amplifier is much greater than unity, the equation for the capacitor voltage e_c now becomes $e_c = e_i\,[1 - \exp(-tA/\tau)]$. This indicates that negative feedback has reduced the charging time constant to τ/A. It becomes possible to measure the peak value of a pulse with a width narrower by a factor of $1/A$ than is possible by the conventional method with the same value of C. Furthermore, if C is made A times larger, the available measurement time becomes A times longer without affecting the minimum width of the measured pulse.

In the circuit shown, the gain of the second stage of V_2 is about 10. Voltage across the charging capacitor C is fed back to V_2 through cathode followers V_3 and V_1. Readout is accomplished by a 0-1 milliammeter (connected) through cathode-follower V_5 and differential cathode follower V_6.

The author thanks Z. Abe of the General Research Laboratory of Hitachi, Ltd.



This peak voltmeter was tested with a 12.5-volt sawtooth whose base was varied from 15 to 700 microseconds. Response fell off only 3% at low end, whereas conventional voltmeter response falls to about half. Good linearity is obtained up to 40 volts.

The silent war: electronic spying

Electromagnetic reconnaissance is one of the best guarantees against a sneak attack on the U. S. or one of her allies. It's also vital for effective arms control

By John M. Carroll
Managing Editor

Governments don't like to talk about electronic spying—they seldom even acknowledge that it exists. But exist it does, and every time a plane is shot down along the Iron Curtain there's a chance it was engaged in gathering information electronically.

Since 1950, a total of 26 United States planes have been forced down or shot down along these frontiers, and 108 airmen have lost their lives or their freedom.

Major powers conduct electromagnetic reconnaissance, or ferreting, to keep track of a potential enemy's new electronic systems and his deployment of men and materiel. This information is essential in guiding electronics research and development, establishing logistic requirements for perimeter defense, and planning to evade, destroy or jam an enemy's electronic defenses.

Some disarmament experts also see electronic data-gathering as a tool for keeping the peace.

Clues from the news

Electronic intelligence, or the suspicion of it, popped into the news several times recently.

First a North American T-39B Sabreliner with three Air Force officers aboard was shot down over East Germany. This type of jet trainer has been equipped for special radar training missions, but its use specifically for electronic intelligence has never been disclosed.

Next, a Douglas RB-66 Destroyer, a plane often used for electromagnetic reconnaissance, was lost in the same general area. Later there was an announcement that Martin RB-57 Canberras had been used for high-altitude overflights of the Chinese mainland. And then there was President Johnson's disclosure of the existence of the A-11, a high-flying supersonic twin-jet capable of replacing the U-2 for overflights, even of the Soviet heartland.

There are also reports that electronic-intelligence versions of the Samos photographic reconnaissance satellite have been launched in polar orbits.

Soviet restraint

Undoubtedly the Soviet Union also gathers electronic intelligence. A few years ago there were rumors that a Russian electronic reconnaissance plane had crashed off northern Canada.

Why do so few Soviet ferrets become casualties? One reason may be superior restraint by Soviet crews. U. S. forces characteristically operate with everything turned on that can make a radio wave. For that reason, flights 100 miles off shore can be highly productive of electronic intelligence.

But the Soviets typically hold back their electronic transmissions until the last minute, and it may require actual intrusion of their air space to intercept the electronic Orders of Battle—such as tracking radar, fighter-director radar, ground-air missile command signals and ground-air and air-air communications.

Active and passive measures

Electronic countermeasures, of which electromagnetic reconnaissance is only a part, divide neatly into two parts: passive measures, or reconnaissance, and active measures, or jamming.

Jamming attempts to prevent the enemy from using his electronic equipment by either saturating it with noise (barrage jamming) or by deceiving it with intentionally misleading signals (beacons, repeaters, inverse amplifier, gate stealers and track breakers).

Reconnaissance merely establishes the location and electromagnetic characteristics, or "signature" of enemy transmitters.

Electromagnetic reconnaissance plays a major role in strategic and tactical countermeasures.

Action in the North Pacific. Two Soviet Badger reconnaissance bombers that flew over the attack carrier Kitty Hawk (CVA-63) are escorted away by a Navy F-4 Phantom II (not shown) and an F-8 Crusader. The twin-jet Badger is used by both the Soviet Navy and Air Force. Its official name is the Tupolev TU-16. It has a 3,975-mile range.

Electronic spying mission

Every Wednesday at 0700, N. N. Petrov, Captain Third Rank of Naval Aviation, takes off in his twin-jet Tupolev TU-16. He circles the pine-barrens of the Kamchatka Peninsula as he climbs to 13,000 meters, then comes about to a course of 045, true.

Only an observer who has seen a dozen enlisted men climb into the midsection of the bomber would know there is something different about this plane. It is a ferret, one of dozens of Soviet, British and American aircraft that regularly patrol the frontier that separates East from West, playing the serious and dangerous game of electromagnetic reconnaissance.

An hour after takeoff Pavel Ivanov, the senior radio mechanic, comes in on the public-address system to announce an intercept. Ivanov is covering L band from his console. He recognizes the five-times-a-minute beep of AN/FPS-24 search radar.

Minutes later, the radio mechanic at the X-band receiving position picks up the high-pitched squeal of tracking radar. It is time to turn now and follow a dog-legged northward course that will take the big plane east of Gambell on St. Lawrence Island and on toward the polar ice pack.

Hours later, the plane will return with a dozen reels of magnetic videotape and log books bulging with intercept reports of U. S. radars, ionospheric sounders and vhf communications signals, all to be sent to the Signal Intelligence Service in Moscow.

The incident is fictitious, but such events happen daily. Not only off Alaska but on both sides of the Iron Curtain —along the borders of East Germany and Czechoslovakia, the coasts of the Adriatic and Black Seas, the jungles of Southeast Asia, the shoreline of Communist China and the white beaches of Cuba.

Soviet ferreting seldom breaks into the news the way U. S. ferreting does—that is, by having one of their ferrets shot down. The main reason U. S. guns hold their fire when Soviet planes intrude is that many Polish and Czech defectors have escaped in military aircraft.

But there have been at least 90 Soviet intrusions into West Germany during the last two years. Soviet planes have flown over the U. S. Pacific Fleet several times, and regularly patrolled waters off Alaska. On one occasion, two planes flew over parts of Alaska itself.

Soviet trawlers off the U. S. coasts carry an undue amount of electronic equipment for just fishing. There is also a fairly general presumption that the Soviets have launched spy satellites in orbits over the U. S.

In strategic ferreting the object is to locate and identify potentially hostile transmitters including radar, communications, missile guidance and navigational aids. These are purely passive electronic countermeasures. In tactical ferreting, on the other hand, the object is to determine what electronic weapons are being used by an enemy and to determine what countermeasures to employ.

In tactical reconnaissance analysis of data must be carried out while flying over the target area. In strategic uses, analysis may take place in a laboratory many miles from the interception site.

Technically the objectives are the same: capture the signal, determine its frequency, type of modulation (including pulse repetition frequency, pulse width and switching mode, if any), antenna characteristics (including beam width and pattern, rate of rotation, switching mode and polarization), and bearing.

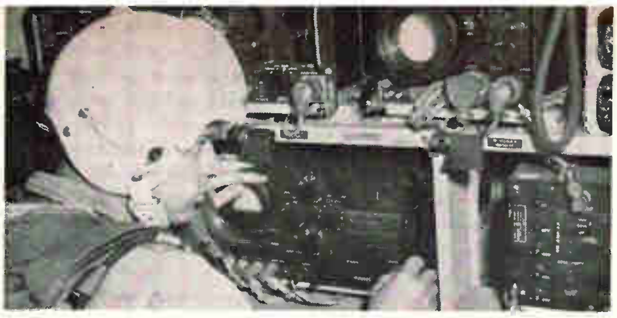
A major controversy in strategic electronic reconnaissance revolves around techniques of signal analysis. Ever since wideband videotape recorders came into being, there has been a tendency to capture all signals indiscriminately and to rely on analysis officers to identify the individual signals and correlate them with positional information. But as the number of potentially hostile radars has multiplied and frequency control has improved, it has become all but impossible to sort out the signals. As a result, many tapes recorded at great risk have been, as far as their actual strategic value is concerned, just so much junk.

Thus there is a movement these days to do more analysis in flight of even strategic information, and planes like the Lockheed RC-130 Hercules have become flying laboratories.

Receiving enemy signals

The first objective electromagnetic research is to receive or intercept enemy signals. There are two approaches to this problem. The first is to scan throughout the frequency band of interest using a relatively narrow-band microwave receiver. The second approach is to use a wide-open receiver that responds to all signals within the band.

In fighter aircraft, ferret receivers are usually



Raven position No. 1 of an RB-66C. The Electronics Warfare Officer is searching for radar signals with an Apr-14 intercept receiver. Next to it is an APR-8B panoramic interecept adapter. Top row of equipment consists of another APR-8B, an ALA-5 pulse analyzer, an ALA-6 direction finder and an aircraft instrument panel. Most of this gear is of late World War II vintage.

Raven position No. 2—there are four. The officer is correcting the altimeter reading on his instrument-panel repeater. The repeater panel, sandwiched neatly between two ALA-6's contains a compass, air-speed indicator, altimeter, cabin-pressure indicator, clock and latitude-longitude indicator. Bottom row contains another APR-14 and APR-8B. Top row holds three ANH-2 wire recorders, the AIC-10 interphone control panel, and an emergency oxygen bottle. Newer gear performs the annotation function automatically.

New uses for old gear

Operational weapons are frequently a generation behind the best materiel available. World War I was fought with Krag rifles and borrowed Lee-Enfields even though the Springfield was officially adopted in 1903.

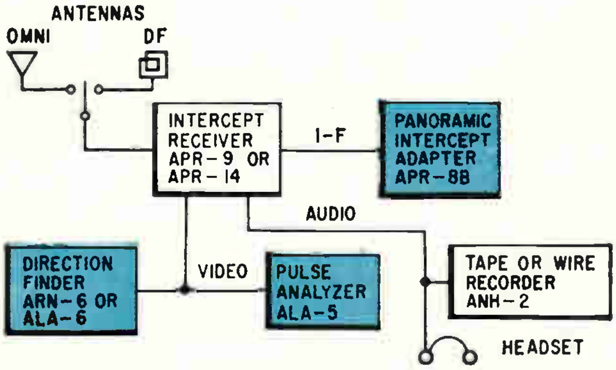
So it is with electromagnetic reconnaissance gear. The workhorse of the tactical Air Command is the RB-66. This plane is slated to be replaced by the mach-2 RF-46 but will be around for a long time.

Right now the RB-66 uses the APR-9 as its receiver for electronic intelligence. This equipment came out in 1945. Although some APR-9's have traveling-wave tube front ends, the operational units use a plain old tuned cavity. However, the APR-9's are being replaced with APD-4's.

The four is a semiautomatic system utilizing wide-open frequency-discriminating receivers. It records everything on 35-millimeter film for later processing and analysis. Each wide-open frequency discriminator receiver covers a certain channel. The receivers do not have search-and-lock-on capability because their function is just to listen in, not to defend the aircraft or provide an electronic countermeasures. The system may also be used for radar direction-finding.

One of the largest ferret systems in use is called the ASD-1. It is flown in RC-135 jet tankers of the Strategic Air Command. It was built by the Air Force's Aeronautical Systems division and has both manned and automatic positions. It is much too big for either the Tactical Air Command or the Navy.

Operational reconnaissance gear lags badly behind the equipment now in research and development. The USD-7 exists only in prototype. YIG-TWT-YIG receivers have been manufactured in only limited quantities. Practically speaking, the U. S. has made little progress in this field since 1945.



Electromagnetic reconnaissance equipment like that used aboard RB-66 bombers of the Tactical Air Command.

Navigator—also on the EMR team. This navigational radar scope helps establish the position of the Air Force RB-66C Destroyer in the air. Above the scope is an N-1 aircraft compass and above the compass are a dial and a clock.

channelized because such receivers can be made small and light. On large bombers, search and lock-on receivers are used. They sweep a band, locate an intercept and lock on.

Until now, most lock-on schemes were analog in nature. They simply located a signal above a certain threshold and used a servo system to tune to it. Newer systems are being digitized—often with microelectronic circuits—and can be programed to lock only onto signals possessing certain predetermined characteristics.

Lock-on capability is important in both strategic and tactical reconnaissance. In the tactical situation the electronic warfare officer must identify

Clues to electronic reconnaissance activity: U.S. planes shot down since 1950

Date	Type plane	No. planes	Result	Where	Comments
4/8/50	PB4Y-2 Privateer (USN)	1	shot down	Baltic Sea	10 lost; patrol/recon plane
6/8/51	F-80 (USAF)	2	forced down	Nuernberg-Fulda area of Germany, landed in Czechoslovakia	planes returned
11/6/51	P2V Neptune (USN)	1	disappeared	near Siberia	10 lost; weather recon
11/19/51	C-47 (USAF)	-	forced down	Hungary	4 returned
6/13/52	RB-29 (USAF)	1	disappeared	Sea of Japan off Hokkaido, left Yokota AB	13 dead; classified recon flight
7/31/52	Mariner PBM (USN)	1	damaged	Yellow Sea	2 killed; 2 injured; patrol/recon plane
10/7/52	RB-29 (USAF)	1	disappeared	Japanese territory	8 lost; routine recon flight
10/8/52	C-47 (USAF)	1	attacked	Koennern, near Berlin	medical evacuation
1/18/53	P2V-5 Neptune (USN)	1	ditched	off Swatow in the Formosa Straits	6 missing, 2 alive
3/10/53	F-84 (USAF)	2	one plane shot down	near Czech border	pilot saved
3/15/53	RB-50 (USAF)	1	attacked	100 mi northeast of Petropavlosk, Siberia	no damage, recon flight
7/29/53	RB-50 (USAF)	1	shot down	off Russian coast	15 lost; recon flight
1/27/54	RB-45 (USAF) F-86 (USAF)	1 16	attacked (escorts)	Yellow Sea	recon flight; 8 Migs attacked; 1 shot down
3/12/54	AD Skyraiders (USN)	2	attacked	from USS Randolph; near Czech. border	......
7/25/54	AD Skyraiders (USN)	2	attacked	from USS Philippine Sea, South China Sea	shot down 2 La-7's
9/4/54	P2V Neptune (USN)	1	shot down	near Siberia	1 dead, 9 survivors; patrol/recon plane
11/7/54	8-29 (USAF)	1	shot down	North Hokkaido, Japan	10 survived, 1 died; photo-mapping recon flight
2/5/55	RB-45 (USAF) F-86 (USAF)	1 12	attacked (escorts)	Yellow Sea	recon flight; 2 Mig 15's shot down
2/9/55	AD Skyraider (USN)	1	shot down	near Tachen Islands	no casualties
5/10/55	F-86 (USAF)	8	attacked	coast of N. Korea	2 Migs shot down; 1 possibly
6/22/55	P2V Neptune (USN)	1	crash landed	St. Lawrence Island, from NAS Kodiak	3 of 11 injured
8/18/55	T-6 (USAF)	1	shot down	near N. Korea	1 killed, 1 injured
8/22/56	P4M Mercator (USN)	1	shot down	near Wenchow in Communist China	16 died; recon flight
1/12/57	Navy plane (USN)	1	attacked by AA fire	Formosa Straits	slight damage
3/6/58	F-86 (USAF)	1	shot down	bet. N. & S. Korea	local training flight
6/27/58	C-118 (USAF)	1	shot down	Soviet Armenia	9 released
9/2/58	C-130 (USAF)	1	shot down	Soviet Armenia	17 died
11/17/58	RB-47 (USAF)	1	attacked	Baltic Sea	recon flight
11/17/58	RB-47 (USAF)	1	attacked	Sea of Japean	recon flight
6/16/59	P4M Mercator (USN)	1	attacked	Sea of Japan, 85 mi. east of Wonsan, Korea	1 injured; infrared recon flight
5/11/60	U-2 (CIA)	1	shot down	USSR, from Adana, Turkey	recon flight, pilot released
7/1/60	RB-47 (USAF)	1	shot down	Barente Sea	4 missing, 2 released
2/14/62	C-124 (USAF)	1	buzzed	Berlin Air Corridor	......
10/27/62	U-2 (USAF)	1	shot down	near Cuba	1 dead; photo recon
5/17/63	H-23 helicopters (USA)	2	forced down	N. Korea	checking markers
1/28/64	T-39B Sabreliner (USAF)	1	shot down	Germany	3 dead; radar training
3/10/64	RB-66 Destroyer (USAF)	1	shot down	Germany	3 released; navigation training

dangerous signals such as tracking radar, and go about jamming them. In the strategic situation, the operator of the electronics equipment frequently wants a longer look at an interesting target to log it properly in his report.

During World War II and the Korean conflict, receivers such as the RDO, SPR-2 and APR-4 operated in the scanning mode, using tuning motors to drive butterfly tank circuits. But the tuning process was slow, spectral coverage was limited and poor selectivity of the tuning circuits led to many spurious responses.

Wide-open receivers

These early intercept receivers had little advantage over a wide-open receiver. A wide-open microwave receiver consists of an antenna, crystal detector and video amplifier (A). It may be possible to pick up signals 50 decibels below one milliwatt with such a receiver. A modern example of a wide-open receiver is the tail-end radar detector.

In addition to having relatively low sensitivity, the wide-open receiver gives no indication of the frequency of the intercepted signal. It is necessary to record the receiver output on magnetic tape, together with some baseband reference signal. Later an analysis officer must laboriously scan short random samples of the tape, using a variable narrowband filter and recorder to isolate each frequency component on the tape—and Heaven help him if there is any intermodulation present!

The wide-open frequency discriminator (B), called the wideband high intercept probability receiver, is sometimes referred to as WOFD or WHIP. This discriminator adds an indication of frequency to the wide-open receiver.

A signal is introduced into the wide-open receiver and split into two branches. Each branch includes a tuned circuit. In one branch the tuned circuit is responsive to the low end of the frequency band being measured, while in the other branch the tuned circuit is responsive to the high end. The outputs of the two branches go to different sets of deflection plates of a cathode-ray oscilloscope, and the angle between the two oscilloscope traces may be interpreted in frequency. This arrangement may be used to indicate phase instead of frequency. When used with two directional antennas, it can indicate the direction of the enemy transmitter.

Tuned front ends

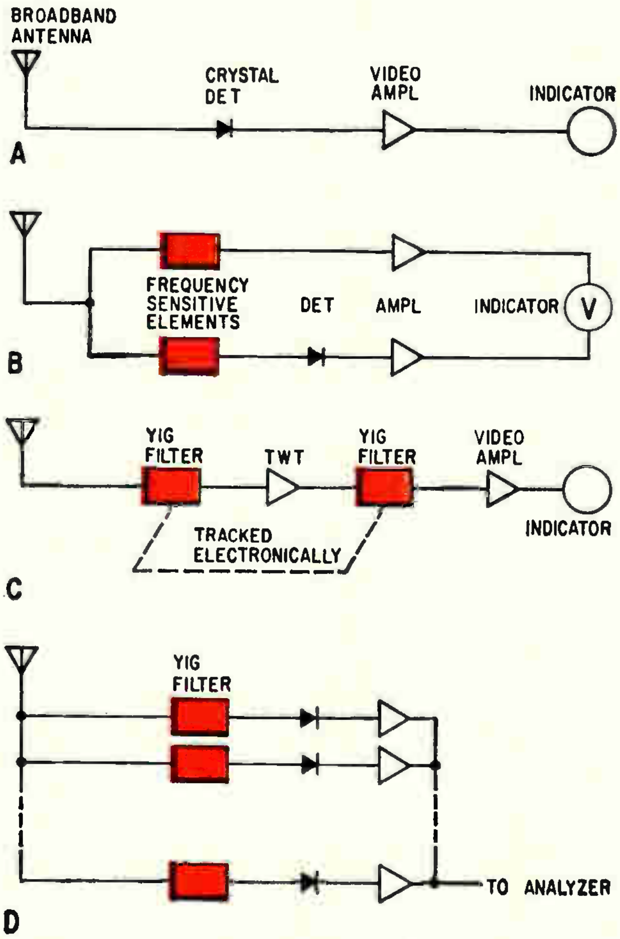
The invention of the traveling-wave tube changed the concept of receiver design. This tube could cover with uniform response an octave of bandwidth. Furthermore, portable video recorders could capture the output of these receivers on magnetic tape.

However, the problems of analysis set a limit on how much of this tape could be processed while the information was still meaningful. Nevertheless, the wide-open receiver and videotape recorder proved useful on missions such as the U-2 flights.

By adding a broadband traveling-wave tube to a wide-open receiver (B), it may be possible to get 20 to 25 decibels of gain. Frequency discrimination can be achieved by placing a traveling-wave tube amplifier ahead of an APR-9 receiver that is mechanically swept from 1.0 to 10.5 gigacycles. These receivers were designed at Stanford University, and prototypes were built at the Airborne Instruments Laboratory division of Cutler-Hammer, Inc., Production models were made by Collins Radio.

Then came the invention of the yttrium iron-garnet (YIG) tuner. Here a polished sphere of yttrium iron garnet is placed inside a magnetic solenoid within a waveguide. Passing current through the solenoid permits varying the frequency of the YIG tuner over an octave bandwidth—roughly 25% above and below center frequency. YIG tuners are available to tune in decade increments from 200 to 18,000 megacycles. Their insertion losses vary from five to eight decibels.

A typical microwave tuned radio-frequency receiver using input and output YIG tuners with a wideband traveling-wave tube between them (C) can tune over an octave in frequency at a scanning rate of 100 cycles per second. Such a receiver is useful in working with modern spectrum analyzers.



Types of intercept receivers: the wide-open receiver (A), the wide-open frequency-discriminator receiver (B), a tuned-radio-frequency receiver using Yig tuners and a traveling-wave tube (C), and the latest multiple-channel receiver (D).

Electronic reconnaissance: state of the art

Equipment	Status: Proposed	Status: Experimental	Prototype	Limited Production	Limited Use	Operational
Receivers						
Mechanically-tuned (APR-9)						■
Mechanically-tuned, twt front end					■	
Electrically-tuned, twt front end				■		
Multiple-channel			■			
Multiple-channel, tunnel diode front end		■				
Paramp front end		■				
Maser front end	■					
Infrared receivers	■					
Recorders						
Audio wire						■
Audio tape						■
Video magnetic tape					■	
Video thermoplastic tape	■					
Camera, manual						■
Camera, automatic	■				■	
Camera, annotated	■					
Analyzers						
Analog meter						■
Graphic, amplitude vs time						■
Amplitude vs frequency, paanoramic adapter (if)						■
Amplitude vs frequency, spectrum analyzer (octave)					■	
Frequency vs time		■				
Integrated display	■					
Direction finders						
Loop type						■
Goniometer type					■	
Polarization indicating		■				

Multiple-channel receiver

The latest in electronic reconnaissance receivers is the multiple-channel system USD-7, a prototype of which was recently completed (D). It is to be manufactured by the Airborne Instruments Laboratory. The receiver increases the frequency intercept capability of reconnaissance equipment to the Ku band from its present X-band capability.

The USD-7 is being miniaturized; it will use only solid-state, and perhaps some microelectronic, components. The receiver covers the entire band of interest using a series of detectors and YIG filters. It can be made to work with an array of directional antennas for direction-finding.

A major problem in the development of multiple-channel receivers was interaction between channels. This required an "ambiguity eliminator" to discriminate between desired signals and spurious responses, and design work on YIG filters.

Developmental reconnaissance receivers have been built using tunnel diodes, parametric amplifiers and even masers. But the more the sensitivity of a receiver is increased, the more difficult become the problems of shielding the receiving installation.

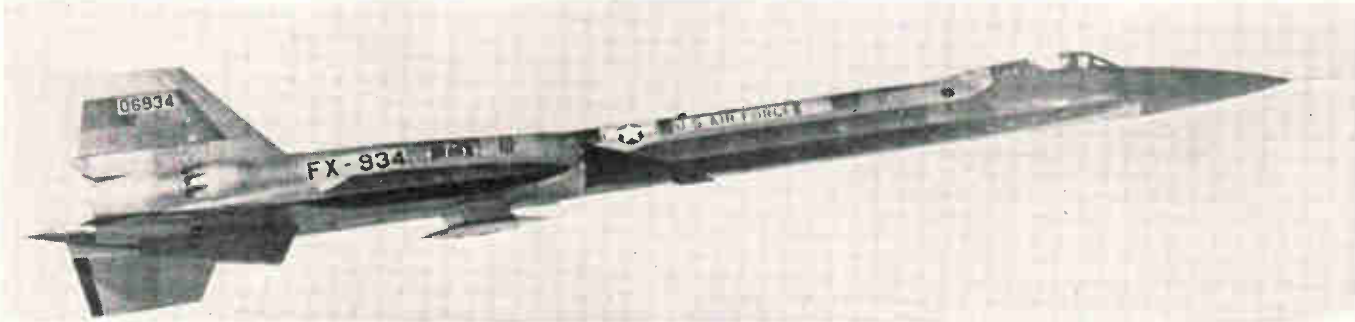
Traveling-wave tubes cannot be swept in frequency, but they do afford an octave or so of bandwidth. Furthermore, it is possible to design a tube to function simultaneously as both an amplifier and mixer. But the tubes do generate spurious signals, and it is hard to make each identical to every other. This is especially bad in direction-finder applications in which two receivers are mounted in pods on opposite wingtips of an aircraft.

Also, operation of traveling-wave tubes always involves a trade-off between noise and gain. For example, a tube with a noise figure of three to six decibels will be saturated by a signal five decibels below one milliwatt, while a tube with a noise figure of 8 to 10 decibels will be saturated by a signal as low as 13 decibels below one milliwatt. This means that if you can tolerate the extra noise you can get twice the radar range.

Some engineers believe that the best electronic reconnaissance system may turn out to be an infrared detector that can pick out a hot radar antenna even when the antenna is not transmitting. Of course, use of infrared receivers would require ferrets to work even closer to the transmitter, with all attendant risks.

Signal analysis

During World War II, operators used pulse analyzers to determine the characteristics of radar intercepts. These instruments used bucket-capacitor



Latest ferrets:

Electronic reconnaissance planes

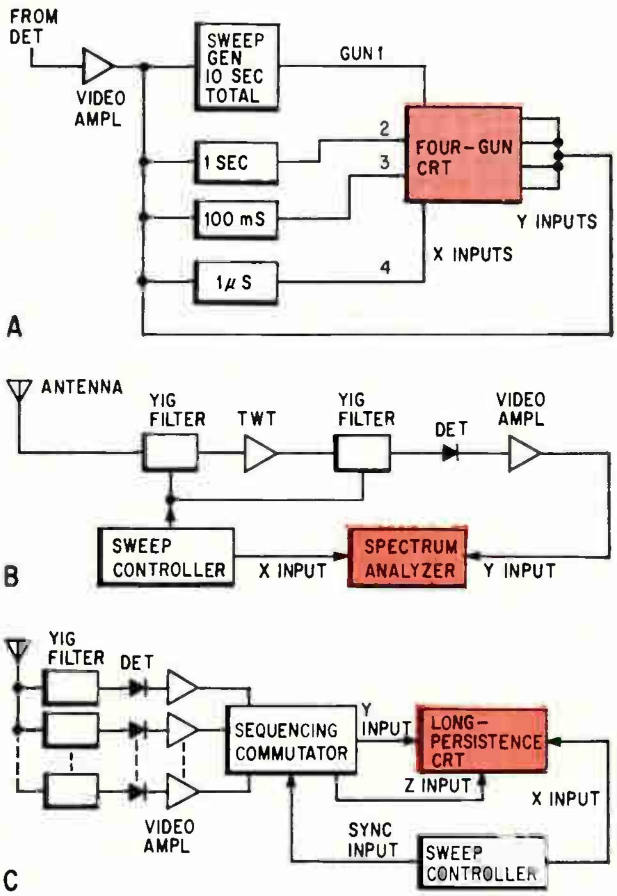
Lockheed A-11 is a 2,000-mph aircraft with a service ceiling of 70,000 feet. It is designed to carry a heavy load of electronic and photo-reconnaissance equipment. Its range is reported to exceed 4,000 miles.

circuits and analog-type panel meters to measure and display pulse width and repetition rate.

In addition, panoramic intercept adaptors were used to display a frequency spectrum equal to the intercept receiver's intermediate-frequency and centered upon the frequency to which the receiver was tuned. Wire recorders, and later tape, were used to capture signals for later analysis.

With the advent of videotape recording it became possible to record signal bandwidths that greatly exceeded the limitation of one kilocycle per inch per second that restricted the range of conventional tape recorders.

An example of a tape recorder that could be used in electronic reconnaissance is the Ampex VRX-1006. This single-channel wide-band recorder has a four-megacycle frequency response and can record up to 90 minutes. It uses two-inch tape on either 12½- or 14-inch reels. Its peak time-displacement error is plus or minus 20 nanoseconds and it can begin recording data two seconds after observation begins.



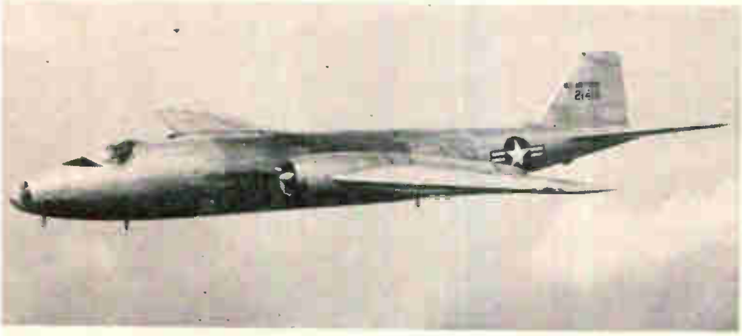
Analysis equipment: amplitude vs. time display using 4-gun cathode-ray tube (A), spectrum analyzer giving an amplitude vs. frequency display of an octave or more (B), and frequency vs. time display.

Doing it with pictures

After World War II, graphic displays have been found to be more informative than the analog meter presentation. For example, a four-gun cathode-ray oscilloscope triggered by the intercepted pulse (or operating with an astable sweep generator) can provide a display of time vs. amplitude (A). Such a display clearly illustrates the lobe pattern of a radar beam as the beam rotates past the receiving antenna, and is useful in analyzing pulse-time multiplexed signals. The calibrated horizontal sweep ranges of the four guns extend from 0.1 microsecond per centimeter to one second per centimeter.

Also, the current waveform applied to the YIG filter of an electronically tuned intercept receiver may be slaved to the horizontal sweep of a cathode-ray oscilloscope to provide a frequency-vs.-amplitude display of the whole frequency band of interest. Such a display is not affected by the receiver intermediate-frequency bandpass characteristics, as is the conventional panoramic adapter display (B).

The excellent bandpass characteristics of modern intercept receivers and spectrum analyzers permit displaying the intermediate frequency of the intercepted signal directly on the scope face of the spectrum analyzer. In this way, unique spectral signatures of individual items of hostile equipment can be obtained and identified. The technique permits following closely the redeployment of electronic material. The operator can even tell when the enemy changes his magnetrons!



Martin RB-57D Night Intruder is a U. S. Air Force version of the English Electric Canberra. Basic aircraft is a single-place twin jet; the version used in overflights of Red China is a larger airplane.

McDonnell RF-4C Phantom II will become a major electronic reconnaissance plane for the Air Force. Its top speed exceeds 1,400 miles an hour. Later on, the Navy will probably go to the Grumman EA-6A Intruder.

The outputs of a multiple-channel receiver can be applied to video filters with slightly overlapping response characteristics to provide a time-vs.-frequency display (C). This display can, in turn, be intensity-modulated to add amplitude information. Such a three-dimensional intercept display can be very useful.

Graphical intercept outputs are photographed to provide a permanent record for later analysis. A back-printing fiber-optic display device can be employed to continuous annotate the intercept record with positional information derived from the aircraft's latitude-longitude computer. Modern cathode-ray tubes permit simultaneous photography of the scope display and viewing by the intercept operator.

Director finding

The final chore of the operator is to get a DF fix on the hostile transmitter. Formerly, two antennas were used for reconnaissance, both housed in a radome beneath the ferret plane. One was a discone for omni-directional reception. The other consisted of two microwave-horn antennas back to back, one polarized vertically, the other horizontally. The antenna rotated in synchronism with a PPI oscilloscope trace to present a twin-leaf pattern pointing at signal maximum.

This was unsatisfactory because of the effects of the radome on the aircraft's aerodynamic configuration and because of the time required to get a bearing. Furthermore, the oscilloscope presentation of a signal maximum is never as precisely defined as the visual presentation of a signal minimum or null indication.

Modern systems use flush-mounted broadband antennas located in different parts of the plane. Polarity of the receiving antenna system can be switched easily and quickly from horizontal to vertical to circular. Use of log periodic antennas permits covering a 10-to-1 bandwidth while a goniometer presentation provides an instantaneous display fixing on the signal null. The speed of modern ferret aircraft, as well as provisions for automatic positional annotation, permit a lone plane to triangulate hostile stations quickly.

Integrated reconnaissance

A trend in ferreting will be an integrated servo system combining aerial photography, electromagnetic reconnaissance, infrared and ultraviolet devices.

One such system was the Little Snooper, a Boeing C-45 outfitted with aerial cameras by Chicago Aerial Industries, Inc., electronic reconnaissance gear by Ling-Temco-Vought, Inc., videotape recorders by the Ampex Corp., infrared surveillance equipment by HRB-Singer, Inc., and a General Electric low-light-level television camera. The aircraft flew in May, 1963.

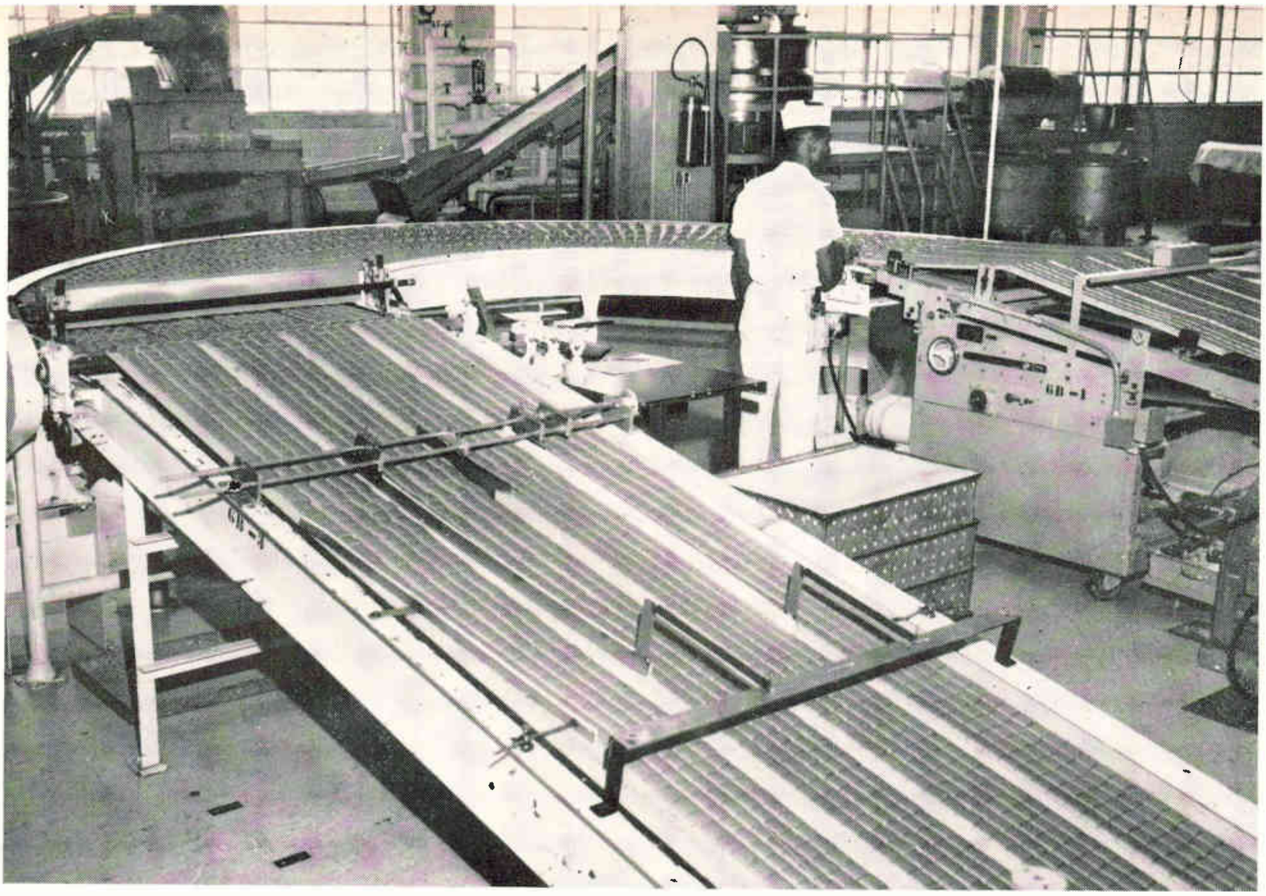
And the future

Even if general disarmament were agreed to by the major nations of the world, either the signers of such a treaty or some supernational agency would have to carry on ferreting operations to guard against violations of the treaty. In fact, the U. S. Arms Control and Disarmament Agency is vitally interested in such reconnaissance.

Peace can flourish only when nations are secure in the knowledge that no sneak attack is imminent, and electronic reconnaissance can help to grant that assurance. Yet every ferret flight risks not only the lives of the airmen involved but the peace of the world.

However, there may be a better way. A day may come when U. S. ferret planes with light blue noses, wing tips and tail surfaces will patrol one side of the East-West border with Russian pilots at the controls and Russian navigators plotting the course, while similarly equipped Bears and Badgers with Americans in command patrol the Eastern side of the frontier. And Irish, Swedish and Burmese operations analysis officers may probe the logbooks and scan the magnetic tapes, looking for—but hopefully never finding—evidence of treaty violations.

The author thanks John F. Mason, Senior Associate Editor, and Laurence D. Shergalis, Regional Editor, San Francisco, and Herbert Cheshire, McGraw-Hill World News, Washington, for their help in gathering material for this article.



Stacked end to end, these Fig Newton cakes would reach from New York to Philadelphia. More than one million pounds are baked daily, using a process computer to direct batching of the ingredients.

Industrial electronics

Take two tons of flour . . .

Nabisco's batching system, the first in the baking industry to be controlled by a computer, keeps cookie quality and taste consistent

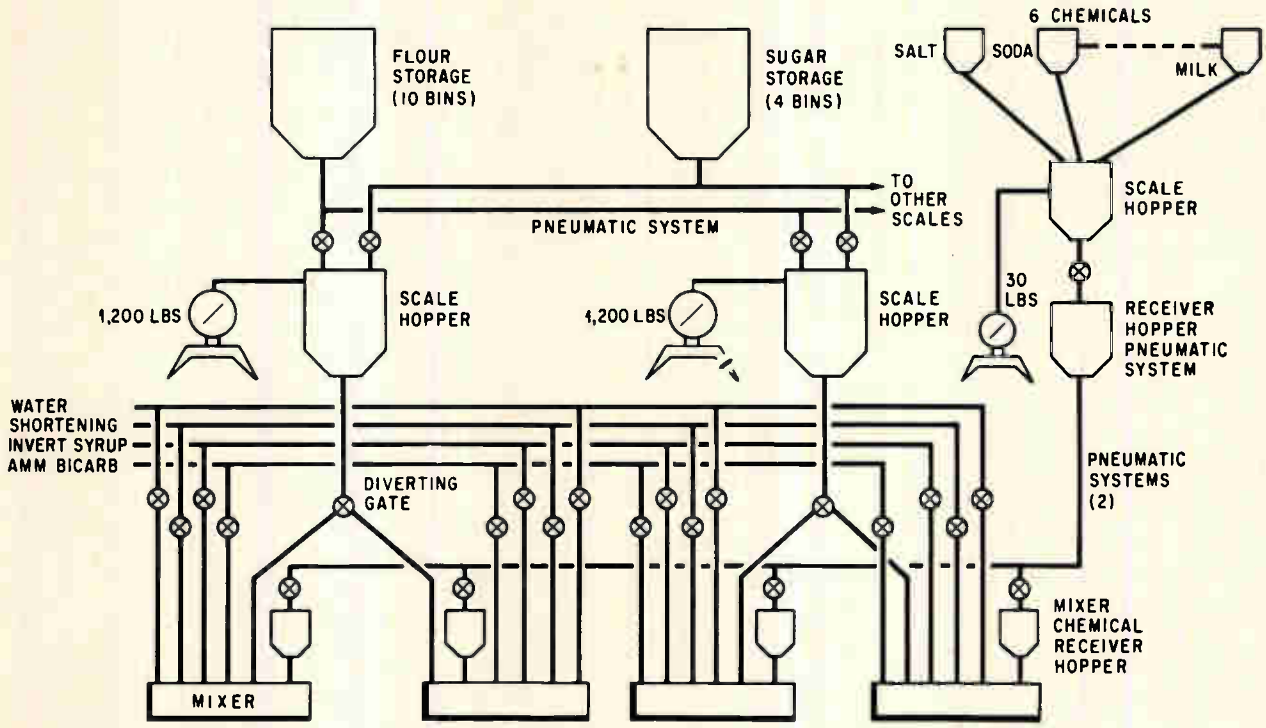
By Louis S. Gomolak

Industrial Electronics Editor

Every day the world's biggest biscuit baker, the National Biscuit Co., turns out nearly 400 miles of Premium Saltine crackers, using a digital computer to control batching. Batching is a process which brings together, in correct sequence, the near-ton of ingredients required for each batch. (Although computer-controlled batching is widely used in the cement and petroleum industries, its use in baking is new.

In early 1962 when Nabisco received bids for a control system for a new addition to its Chicago bakery, one stood out like a chocolate cookie in a bag of marshmallows. Instead of quoting on an analog system, the Systems Design division of the Foxboro Company, Foxboro, Mass., proposed digital computer control.

Computers are new in the highly competitive food processing industry, which is governed by taste whims and impulse buying. Nabisco planks down over three-and-a-half million dollars a year for research on the cookie and cracker with the new taste, the different appeal.



Tons of ingredients are delivered from the storage bins to the scale-hoppers, weighed, and then dumped by gravity flow into mixing machines. All pneumatic systems are computer controlled.

The black specter haunting every baker is that today's cookie may not taste like yesterday's. Taste variation can kill a line faster than my three-year old can gulp down an Oreo. Nabisco sees computer-controlled batching as a giant step toward uniform quality—identical taste in each variety of the 17 million cookies and crackers coming out of the ovens daily.

The process computer also controls batching of all the ingredients used to bake over a million and a half pounds of Fig Newtons—enough to stretch from New York to Philadelphia, if no one nibbles—every sixteen working hours. Ingredient delivery is computer-controlled, too, in the daily production of 70 thousand pounds of Oreo cream sandwiches, 55 thousand pounds of Ritz crackers, and a veritable mountain of Cheeze Nips, Triangle Thins and snack varieties.

A Saltine, as an example, goes through five major processing steps before it can be shipped: batching the dry and liquid ingredients; mixing; shaping the dough; baking and packaging. Nabisco's computer system, at the present time, controls the batching process—a sticky web of timings and sequences demanding strict quality control.

Flour flows

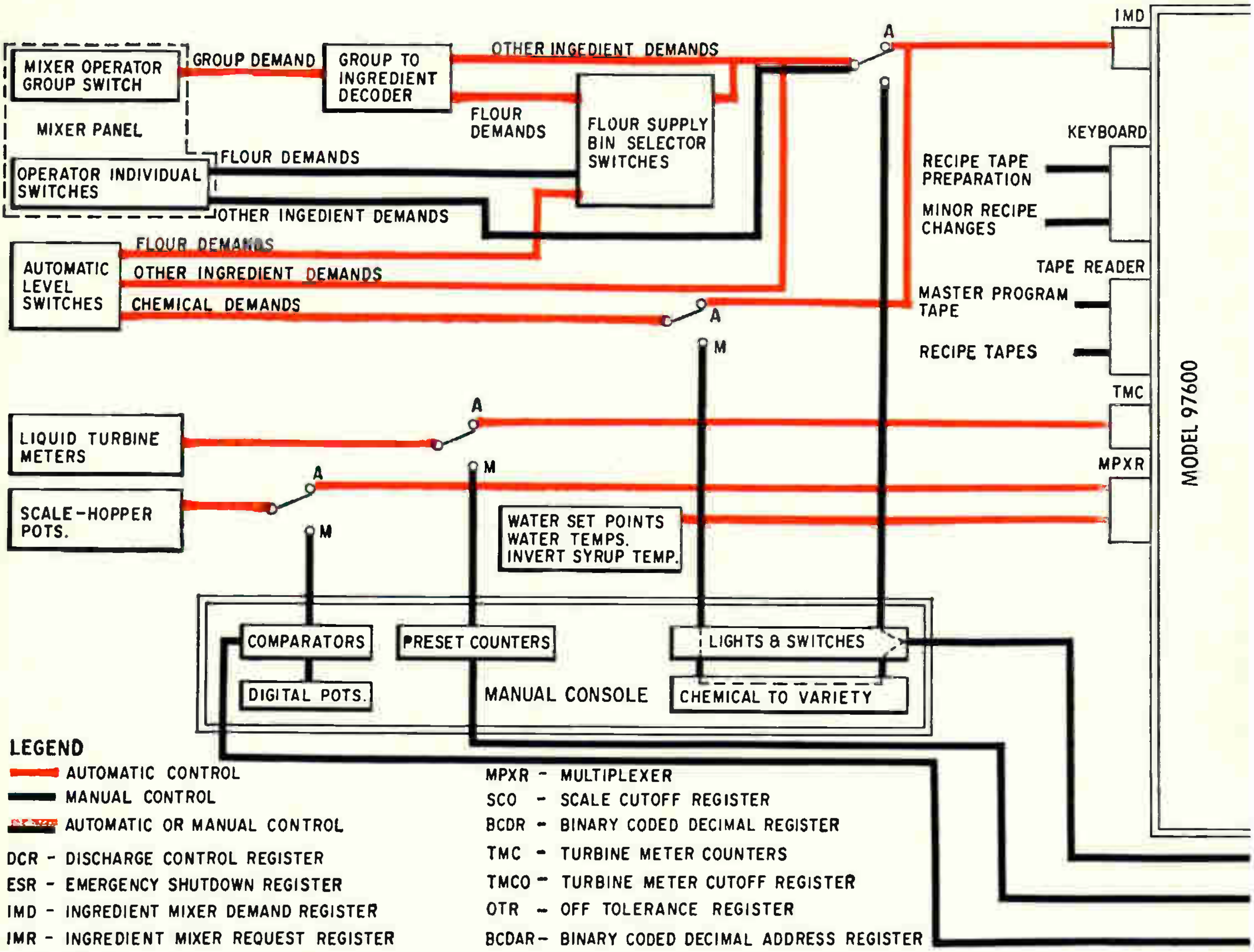
The constant in baking is the recipe. To achieve consistent results—the housewife in a closet-sized kitchen or the master baker in a mile-long facility must follow a recipe for amount of ingredient, sequence of batching, mixing and baking time.

There are twenty dry and chemical ingredient storage bins at the Chicago bakery. These hold tons of three types of flour, granulated sugar, 4X (confectioners) sugar, and chemicals such as milk powder, salt, soda and the like. These main bins are filled by the carload, pneumatically. They are not under computer control.

The process computer enters the picture by selecting, metering and controlling the weight of large quantities of ingredients, a thousand pounds or more at a time—at an accuracy of one pound in twelve-hundred—delivering them from the bins to scale-hoppers, 1,200 pound capacity receptacles containing a weight-scale. As shown in the diagram above, dry ingredients are conveyed pneumatically, but while the scale-hoppers are common to each bin, they can be fed from only one bin, one ingredient at a time. This allows accurate weight control and, in case of a valve failure, prevents ruining a number of batching processes by massive over-delivery of an ingredient.

Probably the toughest systems design problem was sequencing—operating the nine dry and liquid ingredient delivery systems to a 0.1% accuracy. There is a total of 16 steps for just one system actuation. These include actuating and getting feedback signals from valves, motors, blowers, electro-pneumatic and electrical mechanical devices.

The normal sequence is to weigh an ingredient, compare its value to one stored in the computer memory, then discharge it from the fourth floor



Automatic delivery begins when a mixer-operator selects a switch position for ingredient group signals. These are decoded into specific ingredient demands and treated by the computer on either a chronological or priority basis. Demands are satisfied by output signals to ingredient-selecting

bin, using gravity flow, into a third floor mixing machine. While only one ingredient can be delivered to one scale-hopper at a time, two types of flour and two types of sugar, can be, and are, moved simultaneously, to four different scale-hoppers. As the computer sees demands for the various dry ingredients, it starts and stops the four systems, and delivers the required ingredient to one of seven scale-hoppers which are fed by each system.

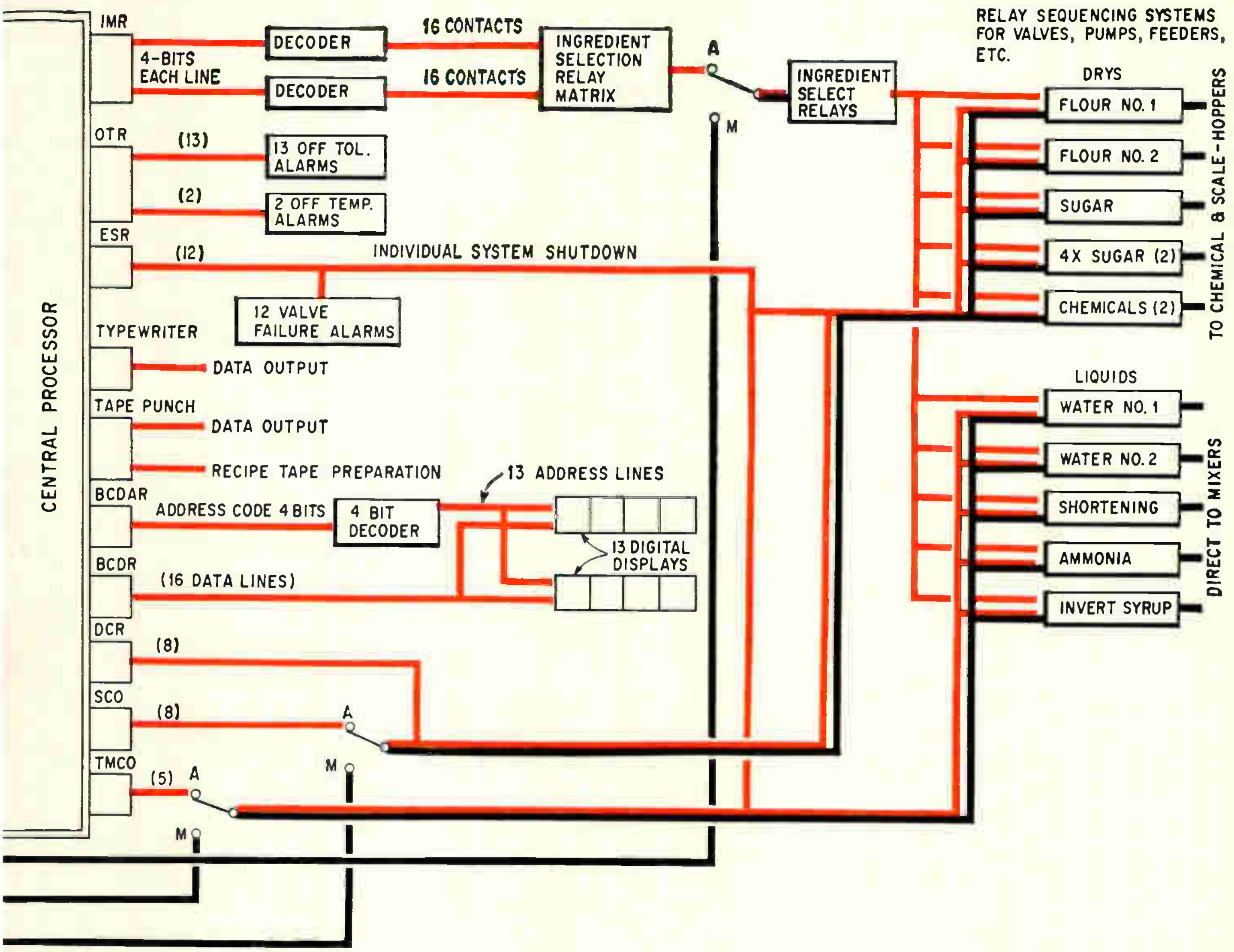
The chemicals have a system of their own because they are weighed in small quantities—as bakeries go—of up to 30 pounds, versus 1,200 pounds for the flours or sugars. The chemicals are also delivered as a sub-batch to the individual mixer chemical receiver hopper, located just above each mixing machine.

The liquids used—water, shortening, invert syrup (a viscous sweetener) and ammonia bicarbonate—are each delivered directly from their source to the mixing machines. They can be delivered to a mixer one at a time or three or four simultaneously; the sequence of mixing might call for, say, water to be mixed with flour, then add shortening and ammonia bicarbonate, mix, add granulated sugar, mix and so on.

Nabisco does not want to rely completely on computer control yet, so mixing time is still under control of the mixer operator. Although the semi-automatic portion of the control system has been in use since May of 1963, and the computer system has been on-line since January 1, 1964, Nabisco feels the system is still experimental. If it works to their expectations, there are thoughts of extending computer control to include mixing time, the multi-temperature 300-foot long ovens, and possibly even to packaging.

The all-knowing computer

The Ingredient Metering Control System includes both computer- and operator-actuated networks as illustrated in the diagram at the top of this page. There is no manual back-up system; the operator-initiated process and the computer



relays. The computer continuously monitors the dry or liquid ingredients, shutting the systems down when the correct weight has been delivered, and dumping the dry ingredients into the mixing machines. The liquids go directly into the mixers, channeled from their sources by the computer.

system use the same bank of ingredient select relays.

The computer is Foxboro's model 97600 Central Processor, which is an integral unit of its 97000 Digital Industrial Process Control System. The Central Processor is functionally equivalent to Digital Equipment Corp.'s PDP-4. The 97600 was custom designed by Digital to specs drawn up by Foxboro's Digital Systems division at Natick, Mass.

By the ton

Mixer ingredient control divides into three major operations—dry ingredients, chemicals, and liquids.

Mixing a batch of cookie or cracker dough means blending almost a ton of various dry and liquid ingredients for specified periods—sixteen different times a day. Early each morning, the mixer superintendent programs pinboards, located at the back of each mixer-operator control panel. The panels are attached to each of the eleven giant mixing machines. On the face of the panel is a selector switch marked group one, two, three and four, plus a reset position. Each group number specifies certain ingredients, both dry and liquid. For example, group one could be flour and water, group two shortening and granulated sugar, etc. The four groups represent the sequence of various ingredients into the mixing process; totaled they are the recipe for, say, Saltine crackers.

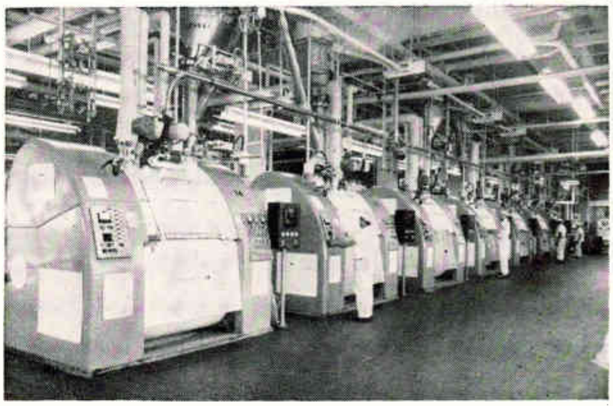
As the bell for work rings, each mixer-operator starts a batching sequence by turning the selector switch to group one. The outputs of the pinboard energize relays. A contact of the relay supplies the specific ingredient demand signals to the computer. These demands go, in the case of flour, to the Flour Supply Bin and Pneumatic System Selector Switches which further decode the flour signal to select a specific bin for use that day. The other group-one ingredient demand, for water, goes directly to the Ingredient Mixer Demand register. All demands are processed on either a chronological or priority basis by the computer, being determined by both the master and recipe programs stored in a 4,000 word, 8-microsecond cycle, 18-bits per word memory. The master program calls for the 88 ingredient-demand input channels to be scanned once every ten seconds; the weight measurement channels are scanned once every four seconds during a measurement sequence.

The computer stores these demands and satisfies them (as soon as all previous demands for a specific ingredient system have been cleared from the output registers) by sending coded signals through the Ingredient Mixer Request register.

The output of this register is an eight-bit binary signal, which is divided and sent to two four-bit reed-relay decoders. Relay logic is used throughout the system, except for the computer which is solid-state. Relays were used principally because of the high price of high-power-rated semiconductors. The output of each four-bit decoder is sixteen discrete signals (using all possible combinations of four-bits). These signals are applied to the horizontal and vertical lines of a 16 x 16 matrix called the Ingredient Selection Relay Matrix which selects one of up to 256 ingredient-mixer combinations.

Working with the Ingredient Mixer Request register is a single-bit register, not shown in the control diagram, called the GO flip-flop. This register powers the relay decoder contacts, after a delay of five to ten milliseconds. The delay allows the contacts to settle down after the relays are energized. These relays handle all ingredient selection for the eleven mixers; false signals could select ingredients for one mixer through contacts that had been set for another mixer. After the delay, power is applied to the decoder contacts via the GO flip-flop, by the computer. This actuates the desired relay in a bank of latching-type Ingredient Select Relays which provide power to start up the required pneumatic delivery system.

The pneumatic system moves, say, flour from a storage bin to a scale-hopper. On the mixer-operator's control panel a green "In Operation" light is illuminated. The computer monitors the weight once every four seconds if all pneumatic systems are in operation—more often if system load decreases to one or two systems. It compares the signal (zero-to-ten volt range) from a potentiometer on the scale to a weight value stored in its memory. When the scale-hopper potentiometer signal, which comes through a multiplexer, reaches a preprogramed value, the computer sends out an inlet valve-closing signal through the Scale Cutoff register. By the time the valve actually closes, the exact amount of flour, plus or minus a pound will have been delivered to the scale-hopper. After thirty-seconds delay during which the flour particles suspended in air settle out, the computer again takes a look at the in-scale weight, compares it to the in-memory value and displays the actual weight on a binary-coded-decimal input digital display on the control room panel. If the flour weight in the scale-hopper is within the stored value, the computer sends a scale discharge signal through the discharge register automatically discharging the flour into the mixing machine.



Batches of ingredients, weighing a ton, are mixed in eleven giant mixing machines, pictured here. Just above each is a chemical receiver-hopper for salt, soda or milk-powder.

Recollections of a process engineer

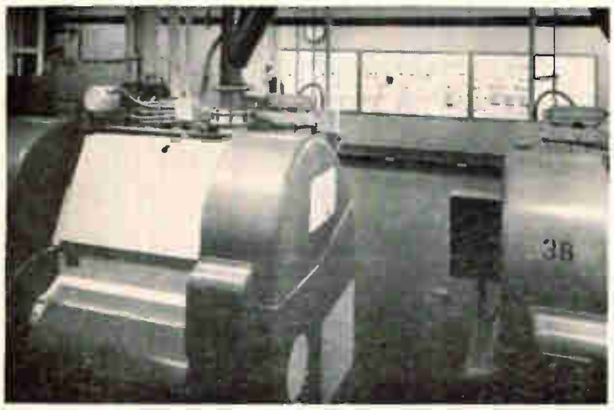
■ **The case of the white avalanche**

To discover exactly how much the pneumatic systems, under computer control, were delivering, Nabisco conducted pre-start-up tests of different types of scale-hoppers. A huge cart called a dough trough was rolled under one scale-hopper. The hood of this scale-hopper fitted tightly over the top of the dough trough and it was impossible to tell what, if anything, was going into the cart. Once, somebody forgot that 1,200 pounds of flour were already in the trough and commanded the computer to deliver another 1,200 pounds of flour. It did. When the trough was rolled away, a fine white avalanche roared down. It was like trying to fit ten pounds of jello into a six-ounce glass.

The over-weight problem

Before an Ingredient Select Relay is energized, the computer checks the scale-hopper for an off-tare condition—any unaccounted for weight. This might be ingredients left from a previous load or, as has happened, of monkey-wrenches left by workmen after a repair job. If the scale is off-tare, the value is printed out and also displayed on a digital readout. A supervisor, after having cleared up the trouble, pushes a Scale Advance button, ordering the computer to override the off-tare signal and energize the ingredient select relay.

If the scale-hopper inlet valve does not close within a stored time delay, a feedback signal is routed to the computer. The signal activates the Inlet Valve Failure Alarm through the emergency shutdown register. The appropriate pneumatic system is shut down and this information is printed out for the panel operator. The operator, having notified maintenance, then resets the off-tolerance register via the Advance button and clears the emergency shutdown register via an entry to the



White-room precautions are taken to keep ever-present dust out of control panel and computer rooms. This is the forty-foot control room panel, as viewed from between two mixing machines.

computer on the teletypewriter.

Add ten pounds of salt

The chemicals are controlled in the same manner as the flour ingredients. The differences in chemical selection and delivery are that chemicals are delivered as a sub-batch to the chemical mixer receiver hopper, and that the computer gets only a demand for chemicals for, as an example, mixer number one.

Stored in the computer, when the recipe punched tapes are run at the beginning of the day, are the various types of chemicals and combinations of types for each mixing machine. The chemicals —salt, soda, milk powder, meal, and others—are weighed (and compared to memory value) one at a time and discharged by computer signal into the large pneumatic system receiver-hopper. When all ingredients for mixer number-one are in this receiver-hopper, a computer generated signal activates the pneumatic system, sending the sub-batch to the mixer chemical-receiver hopper. At the specified time in the recipe mixing sequence the mixer operator presses a Chemicals Discharge button on the mixer control panel, dumping the chemical sub-batch into the mixer.

In the chemical delivery system the computer controls vibratory feeders which carry the chemicals from their individual supply bins to the pneumatic system receiver scale-hopper. Thus, there is no need for an inlet valve failure check as in the flour and sugar systems. There are both off-tolerance and off-weight sequences. The mixer operator can accept the off-tolerance or off-weight condition by later reapportioning the other ingredients. This is done by going into the memory through the teletypewriter keyboard and changing the ingredient values for this particular batch—the same is true for flour and sugar.

Liquid systems

The liquids—water, shortening, ammonia bicarbonate and invert syrup—are piped directly from storage, or city water lines to the mixing machines, at specified times in the recipe mixing procedure.

In each of the five liquid systems, two for water because of the large amounts used, there is a turbine meter. This is a device with a propeller located in the pipe. As the liquid sweeps by the propeller turns. Using magnetic pick-up, the turbine meter sends a series of pulses—16 equal a tenth-of-a-pound—directly into the computer Turbine Meter Counter.

When the pulses total the cutoff weight stored in memory, the computer generates a shutdown signal through the Turbine Meter Cutoff register closing the inlet valve. After a delay the computer checks back to see that the valve has closed. Then the computer compares the actual metered liquid weight with the desired weight stored in memory. The actual weight is always displayed at the end of each metering cycle on a digital display on the control room panel.

The liquid shortening and ammonia bicarbonate systems are straightforward operations; the water and invert syrup systems are not.

In the invert system, the amount of weight delivered per unit volume depends upon temperature. When temperature rises, syrup viscosity increases. Stored in the computer memory is an invert correction table. The computer monitors the invert temperature, using resistance bulbs, about once every second and, using the table, corrects the weight for the number of pulses coming from the turbine meter.

In the water system the story is more complicated. Every recipe specifies one of three water temperatures—some cookies need hot water, some ice cold, others normal tap water. When the computer receives a demand for water, it selects one of three set point water temperature generators located on the control room panel. (There is about a three or four percent difference in water weight over a temperature range of 35° to 180° F.)

The computer selects the right set point and starts the water flowing, continuously comparing

■ **The case of the cavitating chemicals**

One of the pre-start-up problems involved measuring the chemicals in the high production hoppers. The measurement devices are merely level switches. When covered with material, a torque is developed to hold the level switch contact open. However, this rotating switch (a paddle-wheel type of device) causes cavitation with some types of chemicals. When this happens, the paddle encounters no torque and causes the switch contact to close (as it does on low-level when the level of material drops below the paddle).

When cavitation occurred in the mixer chemical receiver hopper, a new chemical demand signal was sent to the computer. Since the computer can't detect between a genuine low-level signal and one caused by cavitation, it supplied a second batch of chemicals.

The solution was to add new circuitry which allows only one chemical demand signal per batch to be created.

the actual water temperature to the set point. Until water temperature and set point coincide, all water goes to drain.

The water is handled by two three-way valves, under control of an analog temperature controller attached to a resistance bulb near the valves.

There is about one-hundred and fifty feet of piping from the three-way valves to the mixer inlet valves. By the time water travels this far it can change temperature. This could be disastrous in a tightly specified recipe. To avert wastage of batch, there is, near the mixer inlet valves, an interlock analog temperature controller. Signals from resistance bulbs come to the controller from the mixer-inlet valve area and also from the three-way valve area.

The computer activates the three-way valves but does not begin counting turbine meter pulses right away. The computer first monitors the temperature at the three-way valves and also the action of the interlock controller. When the temperature is right at the three-way valves, the computer sends a signal to close the drain valve. This signal will not take effect until the interlock controller also signals the valve that the temperature is the same throughout the system. The computer then closes the drain valve, opens the mixer-inlet valve and counts turbine meter pulses.

If the actual metered weight is out-of-tolerance when compared to the memory value, an off-weight alarm is actuated. The off-weight is typed out and the computer blocks further use of that particular water system. Pushing the liquid system Advance button on the control room panel will reset all registers and release the system for new demands.

If the mixer inlet valve does not close, after the computer checks back, an inlet valve failure alarm is sounded, the system is shut down, and the condition is printed out. The panel room operator must then push the Advance button and clear the emergency register via a keyboard entry.

When all ingredient groups have been loaded into the mixer at their proper time, each ingredient in its proper sequence, the operator switches the group selector to reset. This tells the computer the batch is completed. Batch data can now be printed out if desired.

Right now Nabisco has almost more data than cookies. The company is now examining the data to find out if it can optimize the control process.

Nabisco is presently installing another pair of the giant mixing machines to feed a new three-hundred-foot-long oven. Batching process control is more complicated than either Nabisco or Foxboro anticipated; as has been the case with every process newly placed under computer control. Nabisco is studying ways to optimize control and gain memory space.

If they can't, they say the memory system may have to be expanded to accommodate increased control functions.

No hands

There is one more system which is connected to the process computer. At the present time, Nabisco is running a number of high production mixing machines. When the scale-hoppers for these mixers signal the computer that ingredient level is low, the computer searches its memory for ingredient type and delivery sequence, then activates the right pneumatic system, on a priority basis. The high production mixers must be satisfied before any non-priority system demands are met. It is more important to keep high production going than to fill the demands for those products made in batches.

The computer also controls the liquids and chemicals for a continuous Oreo cookie system. These demands are automatically generated by level switches. These ingredients are supplied on a batch basis to large hoppers which furnish a continuous supply to the Oreo system. When the new batch has been delivered, the bakery management can, if desired, have a print out of that particular batch, or any batch for that matter.

Almost no hands

If for some reason the computer is not functioning, system operation is initiated by an operator in the control room. Under semi-automatic control the mixer-operator still uses the selector switch to initiate the batching process. When the group

■ **The case of the dusty contacts**

Dust is a real problem in a bakery. Sugar dust, flour dust, chemical dust, dust dust and more dust. In the pulverizer room where Nabisco refines granulated sugar to make its own 4X confectioners' sugar, the dust is so fine that drawing even the smallest arc would produce a sizable explosion. Electrical equipment, motors, etc. must be explosion-proof.

The potentiometers, switches, relays and other kinds of equipment are so-called dust-proof but, because they require periodic adjustment, they are not hermetically sealed. The flour, sugar, and other kinds of dust build up into some extremely effective insulation.

During the initial phases of system start-up, the computer occasionally failed to cutoff the feeding operation to a scale at its cutoff value. Upon investigation it became apparent that not enough current was drawn by the measuring system to break down the dust film formed on the potentiometer winding. (Good systems design requires low currents through voltage devices such as potentiometers if high accuracy is to be maintained.)

The solution was to use a capacitor between the wiper and one end of the scale potentiometer. The capacitor was the energy source for a reversing current during scale discharge. This current reversal broke down the film formed on the potentiometer.

Since many field logic conditions must be fed back into the computer and since all computer inputs are low-voltage d-c, the most straightforward scheme would be to use low-voltage d-c on the field relay contacts. However, to counteract the dust problem, 110v a-c is used for these contacts, with buffer-relays supplying the low-voltage d-c feedback into the computer.

ingredient signals are decoded by the pinboard relays, the individual dry ingredient demand signals come into the control room panel and light various ingredient lights. The panel operator pushes an ingredient Start button which energizes the same Ingredient Select Relay equipment that a computer signal would have actuated.

For the desired weight of the dry ingredients the operator adjusts a manual potentiometer, with digital readout. Then the pneumatic system automatically delivers the ingredient to the mixer specified and when the desired value is reached a comparator amplifier on the panel sends a systems shutdown signal to the pneumatic system. The operator can then take a look at a vacuum-tube voltmeter calibrated in pounds—zero to 1,200—and if the weight is within specification push a scale discharge button.

For liquids, the panel operator adjusts the pre-set knobs on the system's Veeder-Root counters for the desired liquid weight. When the pre-set and turbine meter counts reach coincidence, the counter generates a shutdown signal.

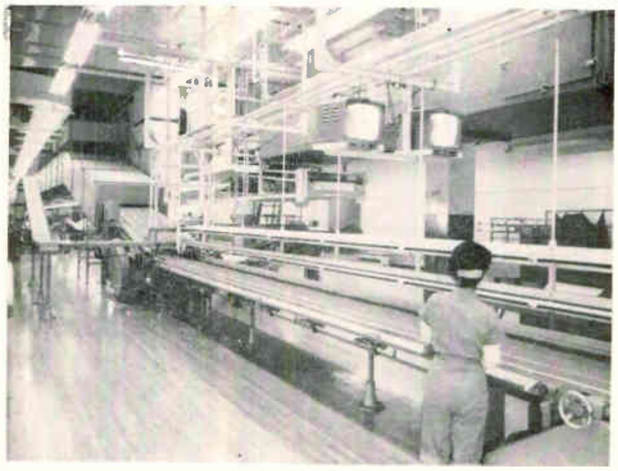
For the chemicals, the operator must go through two steps. He sets up manual potentiometers for the different chemicals and switches a selector to the specific mixing machine. Next he watches the indicators and when they light up for the various chemicals, he pushes a Chemical Start button. When the last chemical of the chemical sub-batch is in the pneumatic system receiver hopper, the pneumatic system will automatically deliver the sub-batch in the manner already described.

One option the mixer-operator has, during either computer or semi-automatic control, is that of demanding any dry ingredient in advance. By turning a mixer-panel hold-discharge switch to hold, and then switching the selector to the next group, the operator commands the computer to deliver the ingredient whose demand is first recognized, and weigh it. But the automatic discharge signal is blocked by the mixer-operator's hold. When switched to discharge, the scale-hopper will dump into the mixer. This is one way in which the operator can have ingredients waiting, until a mixing operation is completed. It is also the way the operators schedule their coffee and smoke breaks.

For some time to come

Many problems have yet to be ironed out before complete bakery computerization becomes a reality. Nabisco's installation is now running, on-line, throughout two 8-hour shifts per day. Over a sixteen-hour period the control system produces, with uniform quality from a batching standpoint, millions of cookies and crackers daily. While there are other bakery computer systems—see box at right—Nabisco's computer-controlled batching is the first major advance in the baking industry toward absolute quality control by computer direction.

The author thanks Ralph Guimond, Bob Benson, and Wendell Young, of Foxboro and George Quinn and John Gude of Nabisco, for their assistance.

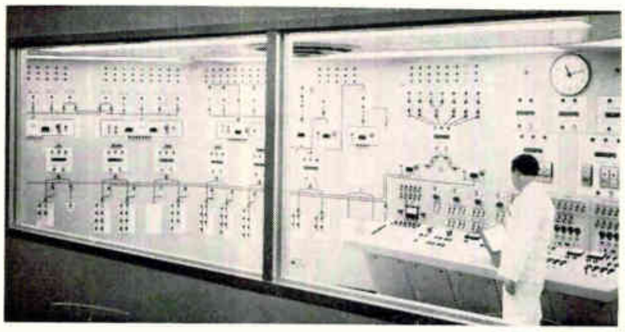


Cooling tunnels, at left, have closed-circuit tv cameras strategically placed throughout. Operator watches potential trouble areas during cooling of cookies.

Computers in bakeries

There soon will be three computers in the baking industry. Nabisco's has been operating on-line since January 1. A GE-225 data processor calculating formulation, including nutritional values and farm purchasing prices, has been in operation since late '63 for recipes at Pillsbury Company's Minneapolis bakery.

The third will be the system now being installed in the Kitchens of Sara Lee. According to E.E. Kuphal, Director of Facilities Planning for the bakery, the Honeywell 610 computer will be delivered sometime this month and on-line operation of the mixing and batching sequences should start in late July at the earliest. Closed-loop control of the 150-foot-long ovens will begin after sufficient data has been logged to determine exactly how to control the eight different temperature zones. Warehousing freezer operations should begin this month.



Checking the daily baking schedule during the period last year when Nabisco used only the semi-automatic control system. Although the processes may be actuated from the panel, delivery of the ingredients is still automatic.

Low-cost oscillator transistors revamp uhf tuner design

Government mandate for all-channel television receivers steps up uhf tuner design. Engineers are replacing vacuum tubes with transistor-diode circuits

By Leon H. Dulberger
Staff Writer

The television industry's need for reliable, efficient, low-cost ultrahigh-frequency tuners has revised tuner design. The hot, costly vacuum tube is being replaced by the cool, inexpensive transistor. Semi-conductor diodes have already overtaken the vacuum tube as mixer elements.

Over $50 million will be spent on uhf tuners this year as television receiver manufacturers comply with the government's requirement that all new sets be equipped, by April 30, for both uhf and vhf reception.

There are nearly 60 million tv receivers in this country but less than ten percent of them can get uhf broadcasts. About 120 uhf television transmitting stations were in operation at the beginning of this year. In the 470 to 890 megacycle range used for ultrahigh-frequency transmission there are 70 channels. The use of these high frequencies and the large number of channels required, as well as price considerations, has led to new tuner designs.

The design of vhf tuners has become routine; tuning circuits are formed by multiturn coils, fixed capacitors and adjustable metal core coils—using lumped parameters. By comparison, tuned coaxial lines a fraction of a wavelength long, stray capacitance and tiny variable capacitors or stamped inductance rings may be used at uhf—combining lumped and distributed parameter techniques.

Manufacturers are faced with the problem of deciding whether the public will insist on detent tuning—the familiar click-stop arrangement in vhf tuners. Two major methods are being used now by uhf tuner manufacturers; capacitance tuning with continuous geared devices, and inductance tuning with mechanical detenting. The large number of channels on the uhf band makes station selection difficult and detent tuning is seen as a probable solution.

The most important problem is that of providing effective and reliable uhf tuner performance at economical prices. The customer is being asked to buy uhf capability in his all-channel receiver, though broadcasting service of interest to him may not yet exist in his area. A new receiver will cost about $20 more than the straight vhf receiver.

Transistor vs. vacuum tube

Design engineers at most of the uhf tuner manufacturing companies have turned to the transistor. They say that it is more reliable than the vacuum tube. This is important from a product marketing point of view.

Perhaps an even more cogent reason for the increased use of the transistor is its lower cost. A transistor sells for less than a first-rate tube. Manufacturers of black and white tv sets are having to scramble for nickels and it's easy to understand why the transistor became everyone's first choice when its priced dropped to 70 cents, undercutting the nuvistor vacuum tube which sells for $1.05. A tube requires other components; a socket for the tube runs about five to ten cents, including labor. Transistors don't require sockets, are soldered directly into the circuit. The heater circuit for a vacuum tube demands a feedthrough capacitor at the cost of about five cents with labor, plus a heater choke for another five cents, roughly.

Another requirement of vacuum tubes, which makes them less popular with designers, is the need to specify one of two filament types—in the case of nuvistors, a 6DV4 or a 3 DV4—depending on whether the uhf tuner will be used with a transformer-powered receiver, or a line-powered, series heater string receiver. With a transistor no filament power is required.

Several transistor types are available including the silicon planar epitaxial SE3002, by Fairchild Semiconductor, the first firm to break the price barrier and bring the devices into competitive stance with vacuum tubes. The semiconductor division of Sylvania Electronic Products, Inc. is also producing an oscillator transistor that tuner builders report is available in limited quantities. Texas Instruments Inc. makes a germanium transistor which is a pnp type, but by reversing only the collector supply wiring of the tuner, it may readily be used. The company guarantees a junction temperature rating of 125° C that is compatible with uhf tuner design.

Another problem arising from the use of vacuum tubes in uhf tuners is the frequency drift of sensitive components caused by heat generated by the tube's filament. A transistor produces no heat.

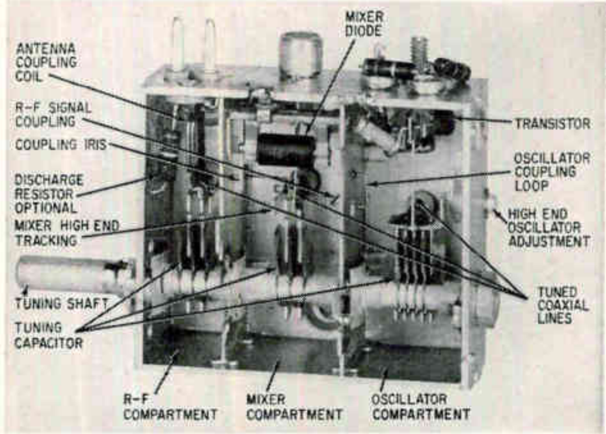
Capacitance tuning most prevalent

The majority of the half a dozen major uhf tuner manufacturers are producing variable-capacitance tuners. The technique calls for a three-gang capacitor with each section tuning a coaxial line. Representative of the capacitance-tuned designs is the uhf tuner built by the F. W. Sickles division of General Instrument Corp. It uses a diode mixer, and a transistor oscillator, the latter being a silicon planar epitaxial type.

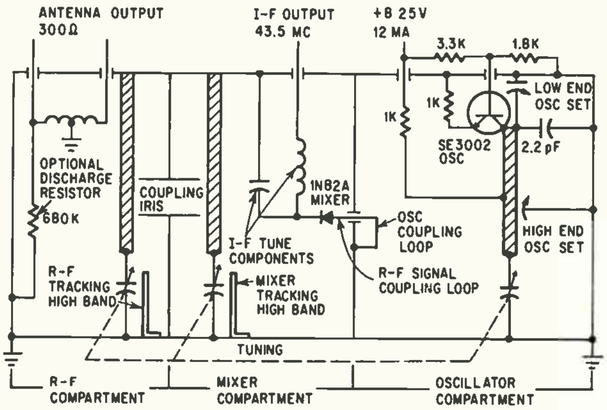
An antenna coupling loop transfers r-f energy into the quarter-wavelength, capacitively tuned, coaxial line. A small amount of the energy is then magnetically coupled to the mixer through an iris, also called a coupling window, cut into the coaxial wall. The mixer compartment consists of another capacitively tuned coaxial line, electrically a quarter-wavelength long, but physically much shorter. The desired quarter-wave electrical length is achieved by allowing for stray capacitances, and controlling the inductance per unit wavelength by adjusting the wire (or line) diameter of the coax, in different models.

To adjust tracking of the r-f section over the entire band, the plates of the variable capacitor in the r-f section are bent to allow it to track with the oscillator, as a step during calibration of the tuner. Metal tab capacitors are used to trim the r-f response of the tuning capacitor. This is done essentially to control reception of channel 83, at the high end of the uhf band.

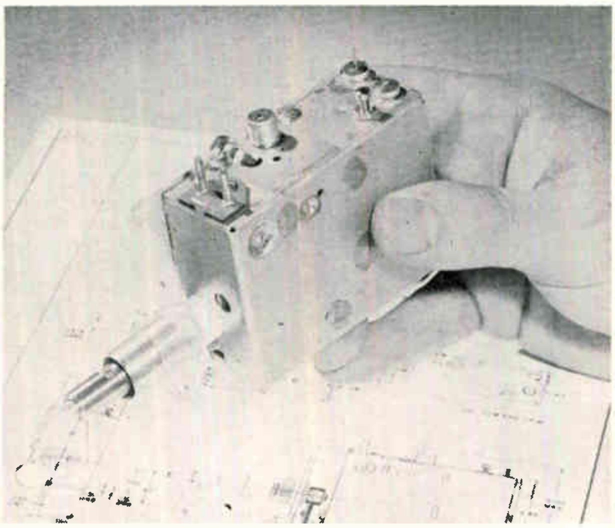
The mixer element is a point contact diode chosen for efficient heterodyning action at the operating frequencies. In the Sickles tuner it is a silicon type 1N82A. This diode exhibits a low conversion loss resulting in minimum over-all system noise figure. Poor conversion efficiency causes snow in the received picture, though there is little effect on the sound channel. The diodes are manufactured and selected for low noise, and obtained both from General Instrument's own semiconductor division



Compact transistor uhf tuner by the Sickles Division of General Instrument Corp. uses capacitance tuning to select stations. Coaxial lines form tuned circuits.



A silicon, point-contact diode mixer and a silicon planar epitaxial transistor oscillator are used in this uhf tuner developed by the Sickles Division.



To get channel selection and fine tuning with a single knob, Standard Kollsman Industries, Inc. designed their tuner with a two-speed planetary drive in conjunction with a coaxial shaft. The outer shaft carries the channel indicator dial, and the inner shaft, keyed to the outer by a pin-in-slot, provides station selection and fine tuning.

and from the Semiconductor division of Sylvania Electric Products, Inc., a unit of General Telephone and Electronics.

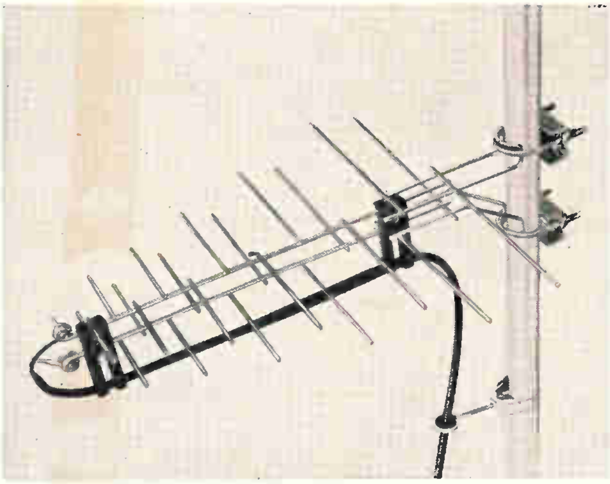
The oscillator compartment is made up of a half-wave long capacitively tuned coaxial line. The selection of a half-wavelength permits end feeding of the coaxial line by the oscillator transistor. A combination of voltage and current feed is used. Both high and low-frequency trimmers set the ends of the tuning spectrum in the oscillator circuit. The oscillator circuit might be considered as a modified Colpitts circuit, with tapped capacitance feedback, though some inductive feedback exists. The coaxial nature of the circuit physically places the components inside the tuned circuit. The two capacitors for oscillator feedback consist of the internal capacitance of the transistor, and the combination of the trimmer and compensating capacitors.

The compensating capacitor has a coefficient opposite to the inherent temperature coefficients of the transistor and other hardware such as the coaxial line, ganged capacitor and trimmer.

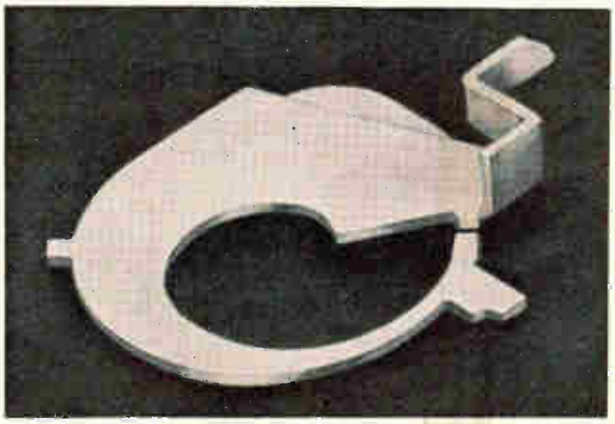
The oscillator transistor used is Fairchild Semiconductor's type SE3002. It exhibits good oscillator action and has adequate power to drive the mixer diode. The collector load may be either a choke or resistor, with the resistor most often used.

Coupling from the oscillator to the mixer compartment is by a pickup loop in the oscillator compartment. The loop wire passes through the wall of the oscillator-mixer common wall, and then becomes an r-f pickup loop which couples to the mixer diode, located in the mixer compartment. The diode feeds the resulting i-f signal to the i-f tuned circuit components, tuned to 43.5 Mc center frequency. The i-f output is fed into the channel 1 position of the vhf tuner in the tv receiver with which it is designed to operate. By agreement within the industry, channel 1 is connected so that both the r-f amplifier tube, and the mixer tube in the vhf tuner may be used to provide an i-f gain of roughly 40 db, measured at the 43.5-Mc center frequency.

Final values of the inductance and capacitance in the i-f circuit of the uhf tuner are chosen to give maximum over-all receiver performance with the particular vhf tuner used, and the connecting cable employed with it.



Log periodic uhf receiving antenna by Blonder-Tongue Laboratories, Inc. provides high gain, broadband, pickup.



Inductive element in Oak Manufacturing Co.'s uhf tuner.

Integral tuner

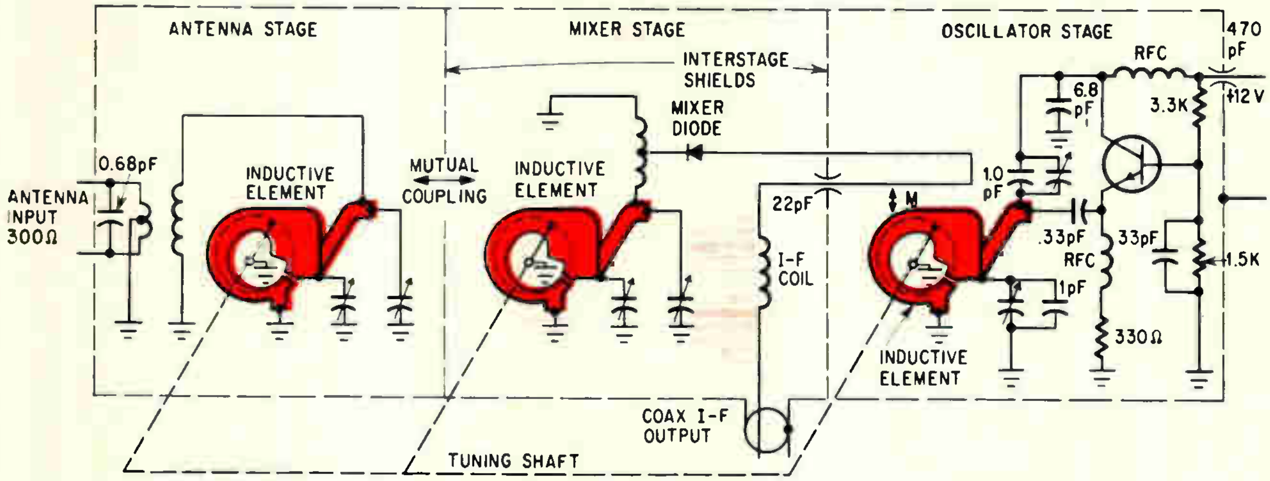
According to Alfred Sfreddo, Jr., chief engineer, tv tuners, for the Sickles Division of General Instrument Corp., building an integral uhf-vhf tuner presents problems which place realization of such a design at least a year away. One reason is the price differential between transistor and vacuum tubes. When transistors and tubes for vhf are priced equally, one barrier will be overcome.

A more pressing reason for building vhf and uhf tuners in separate mechanical packages is that uhf uses transmission line type tuning, and vhf uses lumped constant tuning. The integration of the two tuning methods will certainly compromise the performance of a tuner in one of the spectrums, or possibly both. Actually, some form of mechanical or electrical switching would be needed, and even then performance would be compromised. Sfreddo doesn't believe that the industry wants to settle for a compromise, but he notes that every tuner house is trying to solve the problem.

Inductive tuning permits detenting

Most industry experts remember that tv set buyers insisted on click-stop tuning, rejecting continuously tuned, front ends for vhf though only 12 channels were involved. Uhf covers 70 channels which are generally harder to tune. At uhf a form of "memory tuning" has evolved for receivers, providing a mechanical means of setting stations without repeated fine tuning. Detent tuning requires linearity of dial coverage. This is readily achieved with inductance tuned, frequency determining circuits.

The Oak Manufacturing Co. has developed an inductance tuned uhf tuner which uses a transistor oscillator and diode mixer. The company points out that all its new uhf tuners are transistor operated. Oak uses an inductive element, or ring,



Inductive tuning used in Oak Manufacturing Co.'s tuner permits detented design. Precious metals coat the inductive elements to control surface conductivity and achieve wear resistance.

made of steel for rigidity. It is a flat metallic stamping in the form of a circle, with an electrical gap. To control the electrical surface conductivity, and the wear and life-determining characteristics, the inductive elements are coated with precious metals including gold and silver. The wiper element is formed in a "U" shaped cross-section made of silver.

One inductance element is used in each of the uhf tuner stages, including the antenna, mixer and oscillator. The inductive tuning format used by Oak permits a 270° active dial spread, which gives roughly a 4° detent channel stop-width. An advantage claimed for inductive tuning is that only one element need be stamped out for each stage. With a variable capacitor, several must be stamped and then assembled and careful attention to radial and axial tolerances, both mechanical and electrical, must be provided.

As to potential contact trouble using inductive tuning, it should be remembered that wiper contacts are used on variable capacitors as well as inductive tuning systems. The velocity rate, a prime cause of wear, is lower on variable capacitors. Oak has tested the inductive uhf tuning system and found its wear resistance far exceeds anticipated consumer use. Additionally, the system remains free of wiper noise. The Oak tuner permits rotation in either direction and can be provided to continuously pass through 360°.

Edward D. Chalmers, vice president Engineering at Oak, points out that development of an inexpensive uhf amplifier transistor would permit a better distribution of gain in all tuner designs. Right now, the industry has to achieve all the gain at i-f frequencies which can lead to operating instabilities. R-f transistors must be priced at under $1.00 for tuner use.

Antenna developments pace uhf

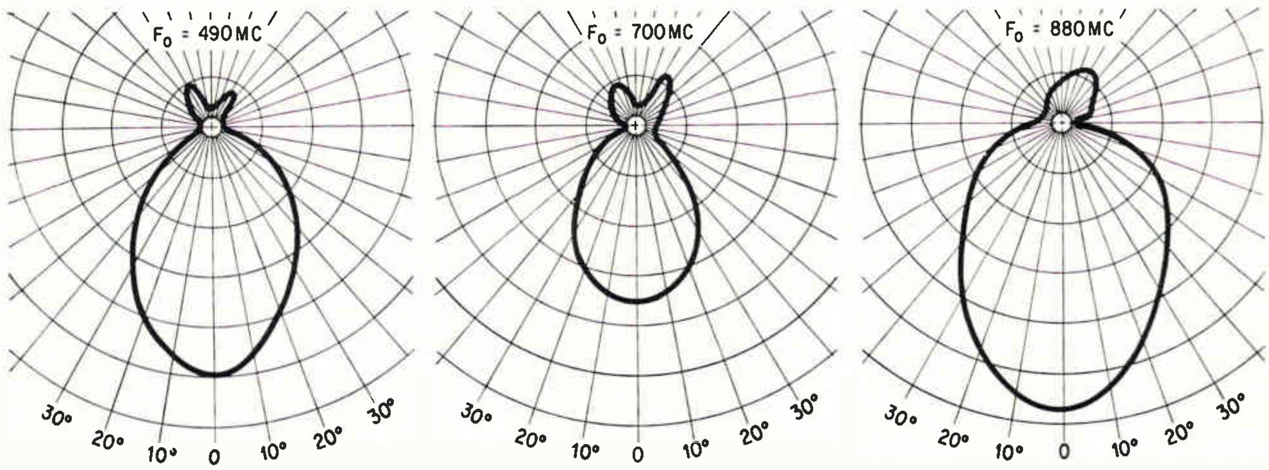
Development of high performance receiving antennas for uhf operation is getting increased attention. One manufacturer produces a small loop antenna built right into the receiver and this works reasonably well. But antenna manufacturers have found that high gain antennas are required in many cases at uhf frequencies, even in cities. The problem in cities is elimination of ghosts and the solution is often achieved by the better directivity afforded by a high gain antenna.

The outdoor bow tie antenna has long been popular for uhf use. It is actually a form of dipole that is a section of a broad-band conical antenna. A conical antenna may be thought of as two ice cream cones set end to end. For uhf, flat pieces of aluminum are used to form the bow ties which approximate sections of the conical, and a flat wire grid sheet is used as a reflector, which helps to boost gain at some frequencies. Also popular is the corner reflector antenna and the parabolic antenna, two high efficiency designs for uhf reception.

A wideband, high-gain antenna with great promise at uhf frequencies, is the log periodic, so-called because the spacing and length of its elements are periodically related on a logarithmic basis. It can be thought of as a section of transmission line, along which several stubs have been placed, whose relationship to each other in terms of length and separation is the same as that used in the calibration of a slide rule (as on the C scale).

The log periodic antenna operates like a traveling Yagi. One may think of the stub arrangement as moving up and down the transmission line progressively with frequency. Thus, the only elements active for a particular uhf channel are the ones that are resonant at that channel frequency.

The Blonder-Tongue Laboratories, Inc. have built a log periodic antenna designed for uhf receiver use, engineered to achieve the maximum gain possible with the log periodic principle, at minimum cost. In Blonder-Tongue's design usually no less than five of the log periodic elements are active for reception of any one channel. A simplified but essentially accurate explanation of this antenna's operation during reception of a single channel in the uhf band is that one stub acts as

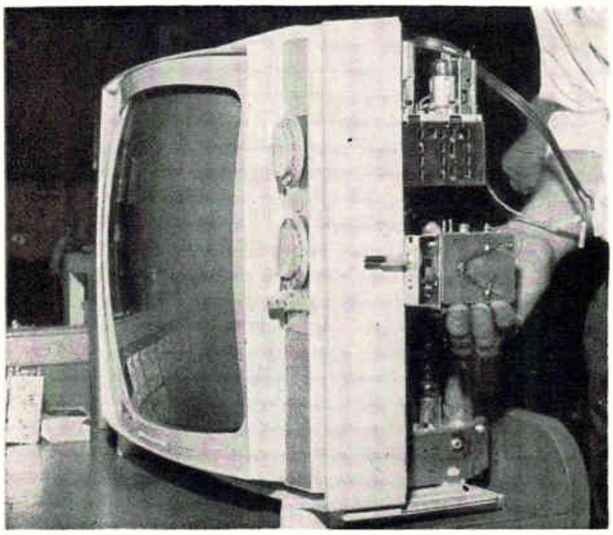


Horizontal receiving pattern of uhf log periodic antenna built by Blonder-Tongue Laboratories, Inc. The gain over a tuned dipole is 9.2 db at 490 Mc and 10.5 db at 880 Mc. Front-to-back reception ratio is at least 20 db.

the equivalent of a driven element in a Yagi, while two of the shorter ones in front act as directors and two of the rear elements act as reflectors. The elements in front and in back of the element that tunes to the channel being received, may alternately be thought of as intercepting elements, or cells, adding energy to the signal picked up by the main element.

The receiving pattern of the Blonder-Tongue antenna is characterized by the cleanliness of the broadband and high gain response in the desired forward lobe, over the frequency range of 470 Mc to 890 Mc. Careful spacing of the transmission line is observed in design to raise the antenna impedance and achieve the closest possible match to a 300 ohm television tuner input.

The firm choose an all-welded steel design, with a heavy zinc coating to maintain antenna efficiency. Heavy connector terminals are employed to avoid signal loss due to skin resistance at uhf frequencies.



Uhf tuner by Sickles Division of General Instrument Corp. is held by technician. Vhf tuner is mounted on tv receiver. The combination provides coverage from channels 2 through 83, comprising an all-channel receiver.

Future uhf tuner components

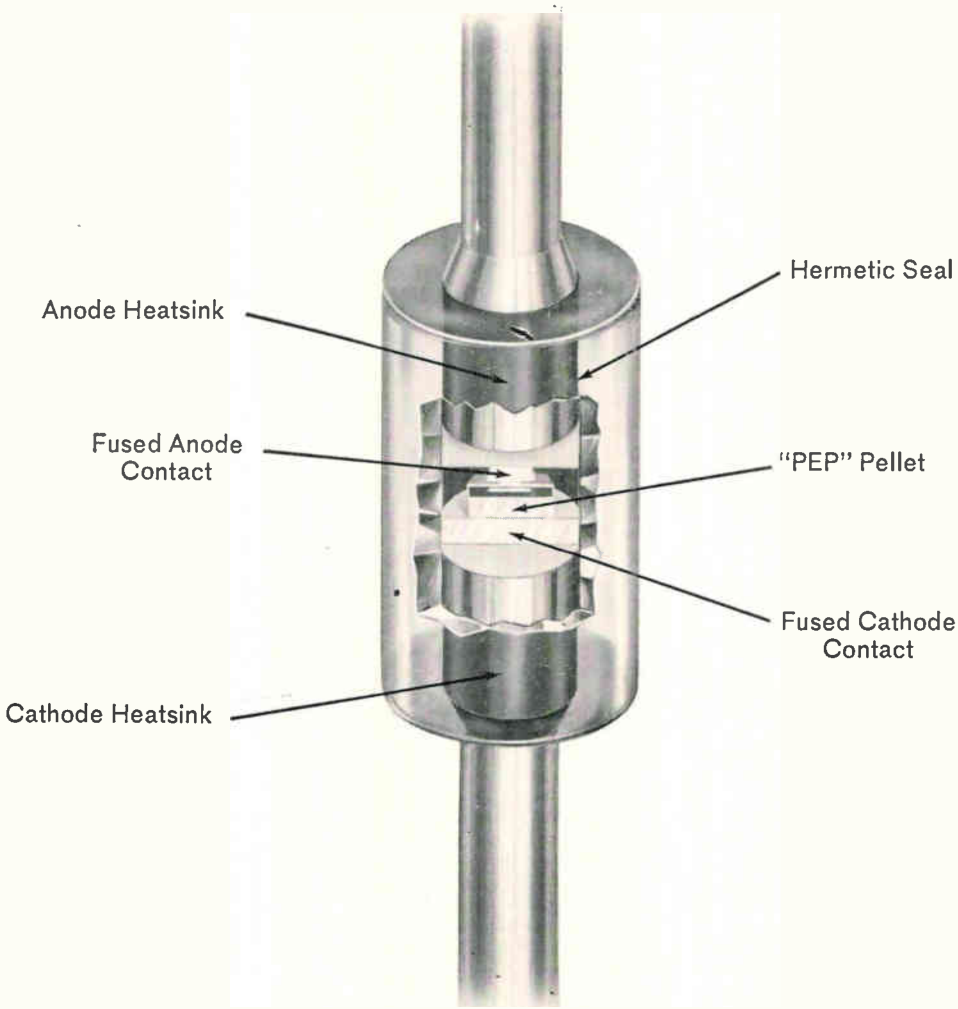
The mixer diode is considered to be one of the most troublesome components in the entire tuner, and subject to what one chief tuner engineer describes as "black magic". Unbonded point contact diodes are generally used. They are susceptible to physical as well as electrical shock. The latter may be caused by static electricity discharge, or by electrically leaky soldering irons which inject a voltage into the diode during the wiring steps.

Therefore, research is now being carried out on back-diodes, a variation of the tunnel diode, for mixer service. To date, however, both performance and price do not allow its use in uhf tuners.

Thin film techniques are under study for uhf tuners but for economic reasons use of thin film is impractical now and may be for several years to come. One television receiver engineer observes that since picture tubes now take up considerable space, the advantages of thin film circuits in reducing tuner size may not be a practical goal.

Use of a transistor to replace the mixer diode for future uhf tuner designs is also being considered. The autodyne system of local oscillator-conversion circuitry, where a single transistor is used simultaneously as the oscillator and mixer is also under consideration. But this system is subject to signal overloading and other troubles. Based on the experience of European vacuum tube autodyne circuit makers the system seems to hold little promise.

Continuing experiments with airborne uhf television transmission, may be important. One theory holds that six tv transmitting planes constantly in flight over the country could provide complete coverage at uhf frequencies. The possibility of using satellites like the Syncom or other systems for commercial uhf transmission has been advanced. However, higher power transmitters would be required than are presently available in satellites. An alternate to higher transmitter power might be high gain receiving antennas, though experts hold that practical designs of moderate size could not be readily achieved.



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Capacitance C @ 0 volts C @ −10 volts	2-4	2-4	3	2.5	6	30 15	pico-farads pico-farads
Recovery Time t_{rr} ($I_R = I_F =$ 10ma, recovery to 1 ma	4	5	100	4	10	20	nano-seconds
Conductance typical I_F @ $V_F = 1$ volt, 25°C	100	150	100	250	400	800	ma

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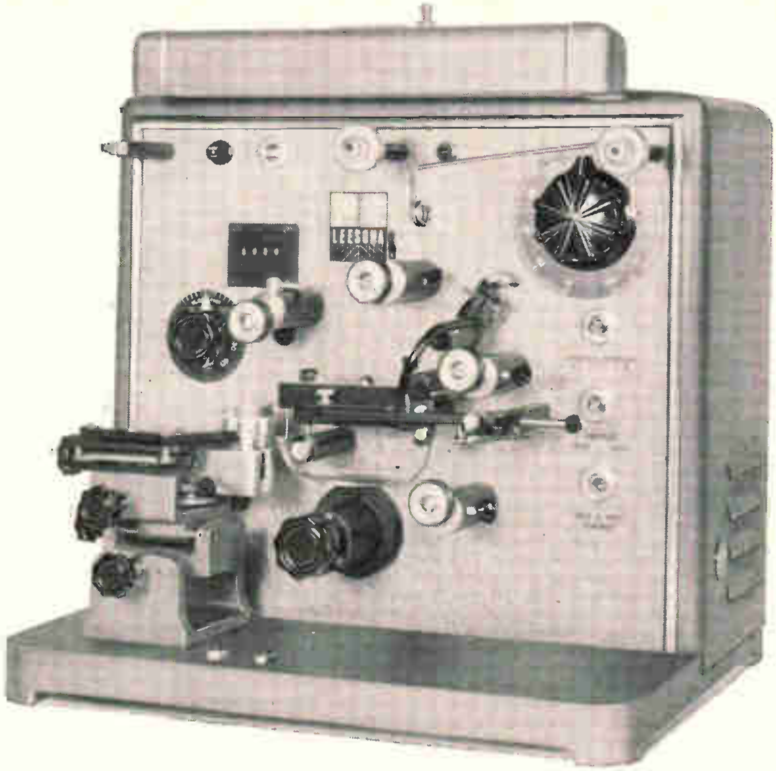

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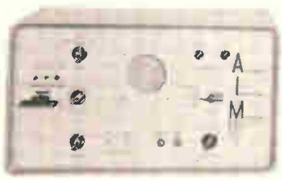

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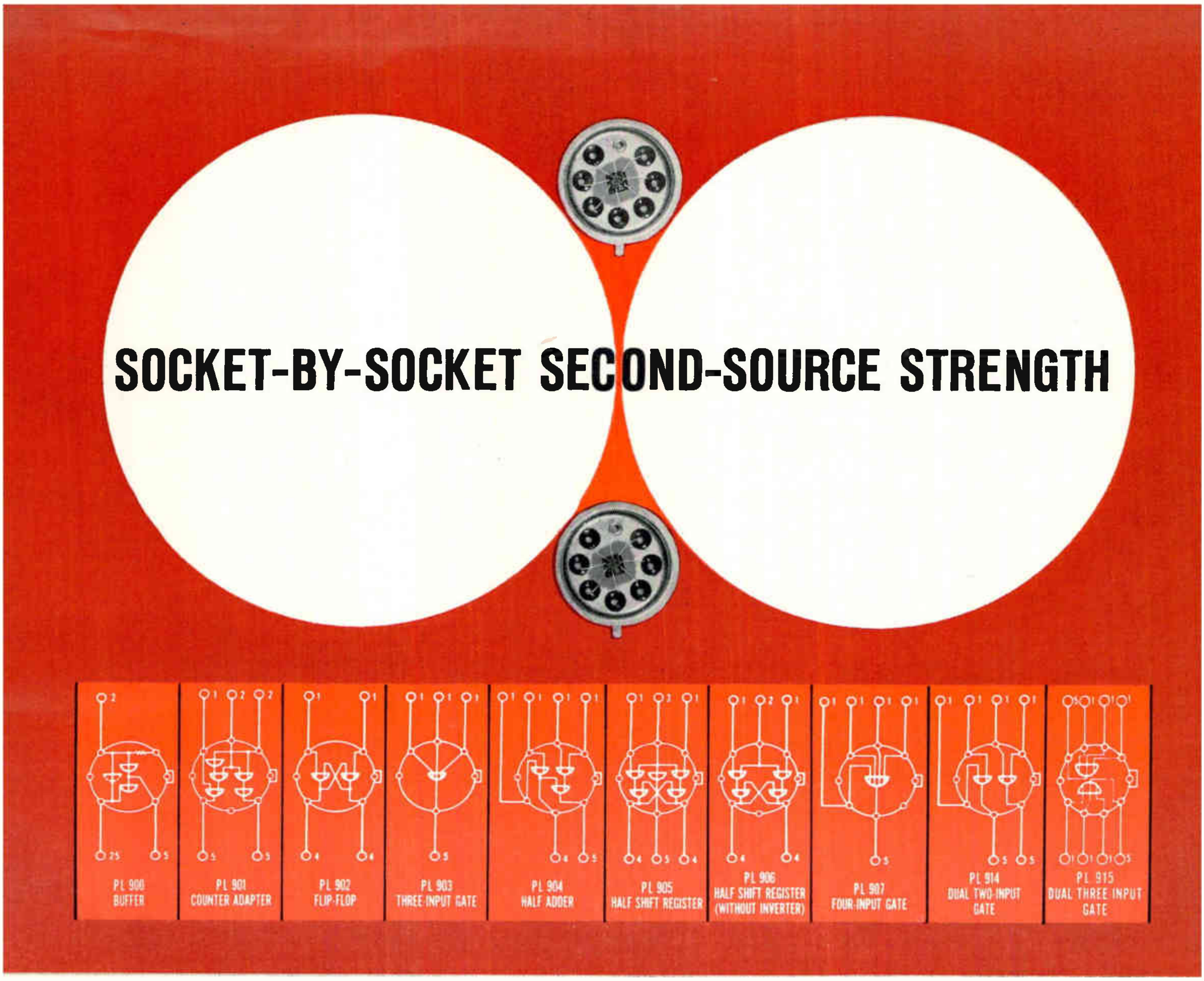

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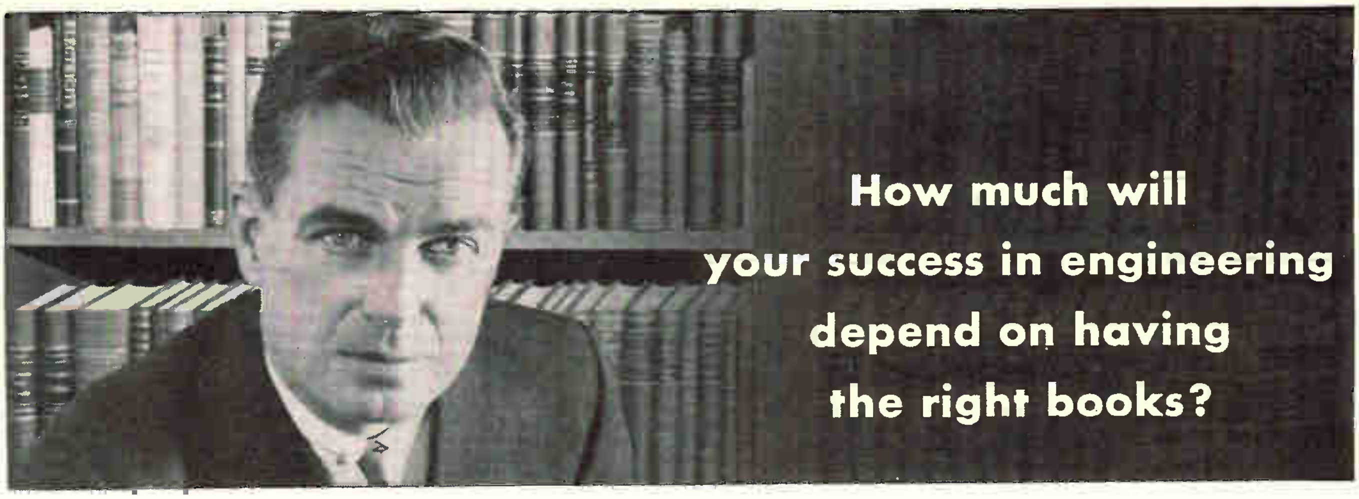

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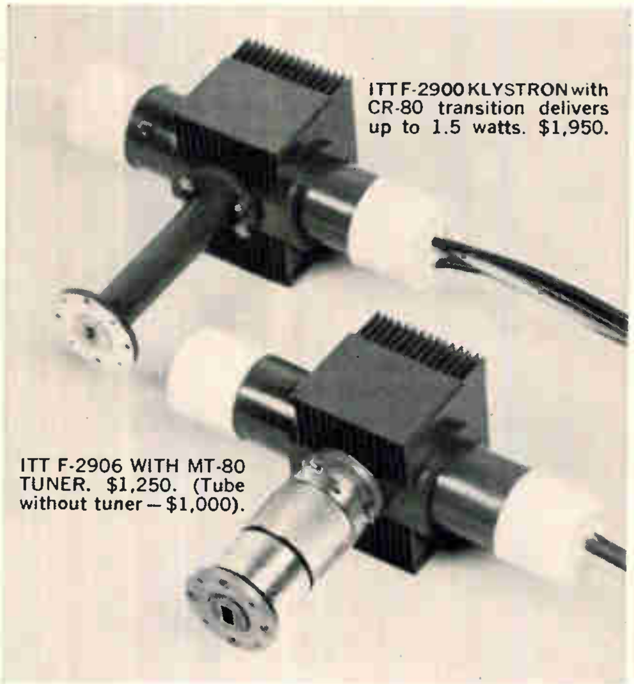

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F-2905	33-38 Gc	500 mW	2000	40	−50	−600	6.3	1.2
F-2906	28-33 Gc	500 mW	2000	40	−50	−600	6.3	1.2

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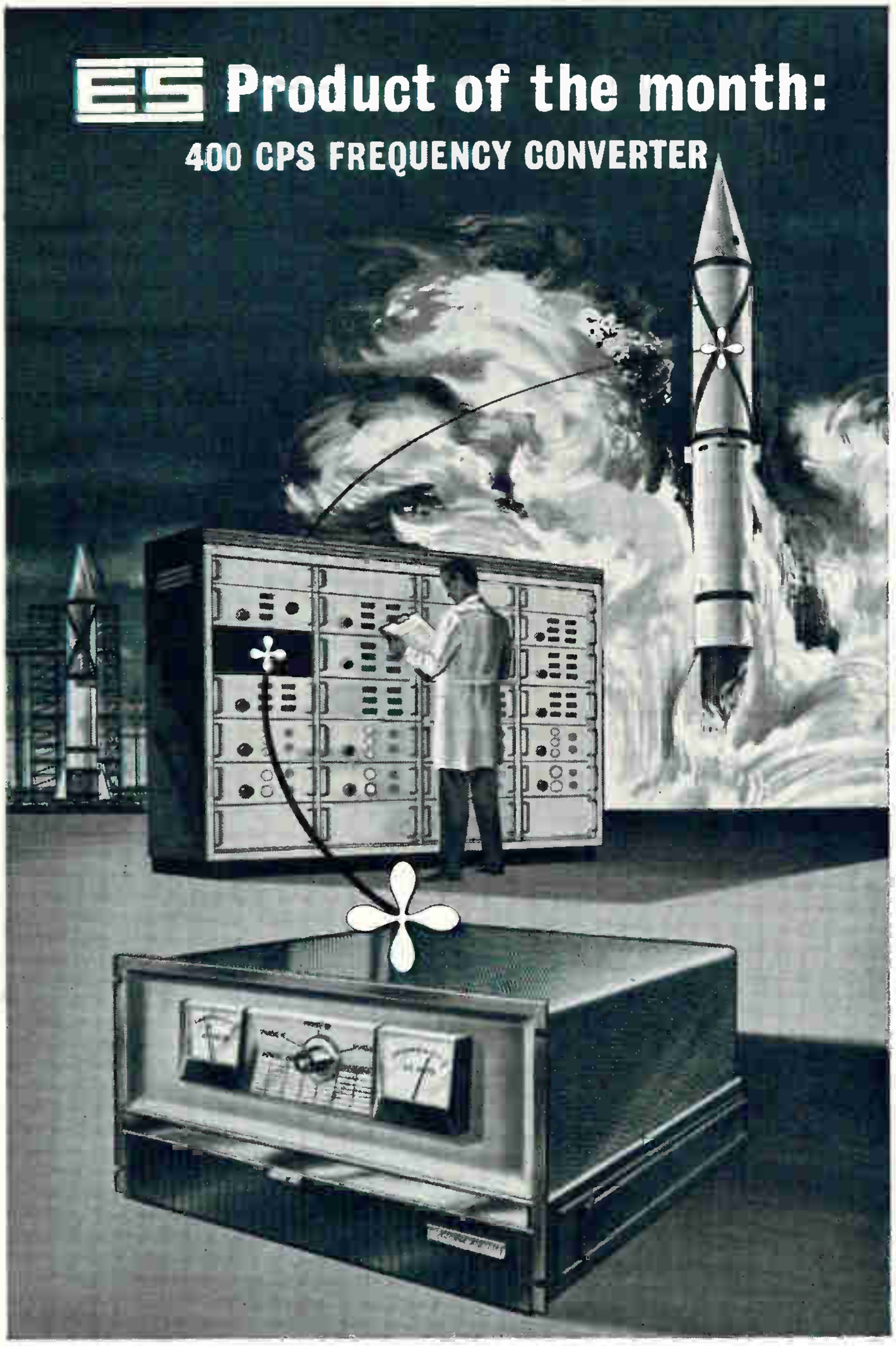

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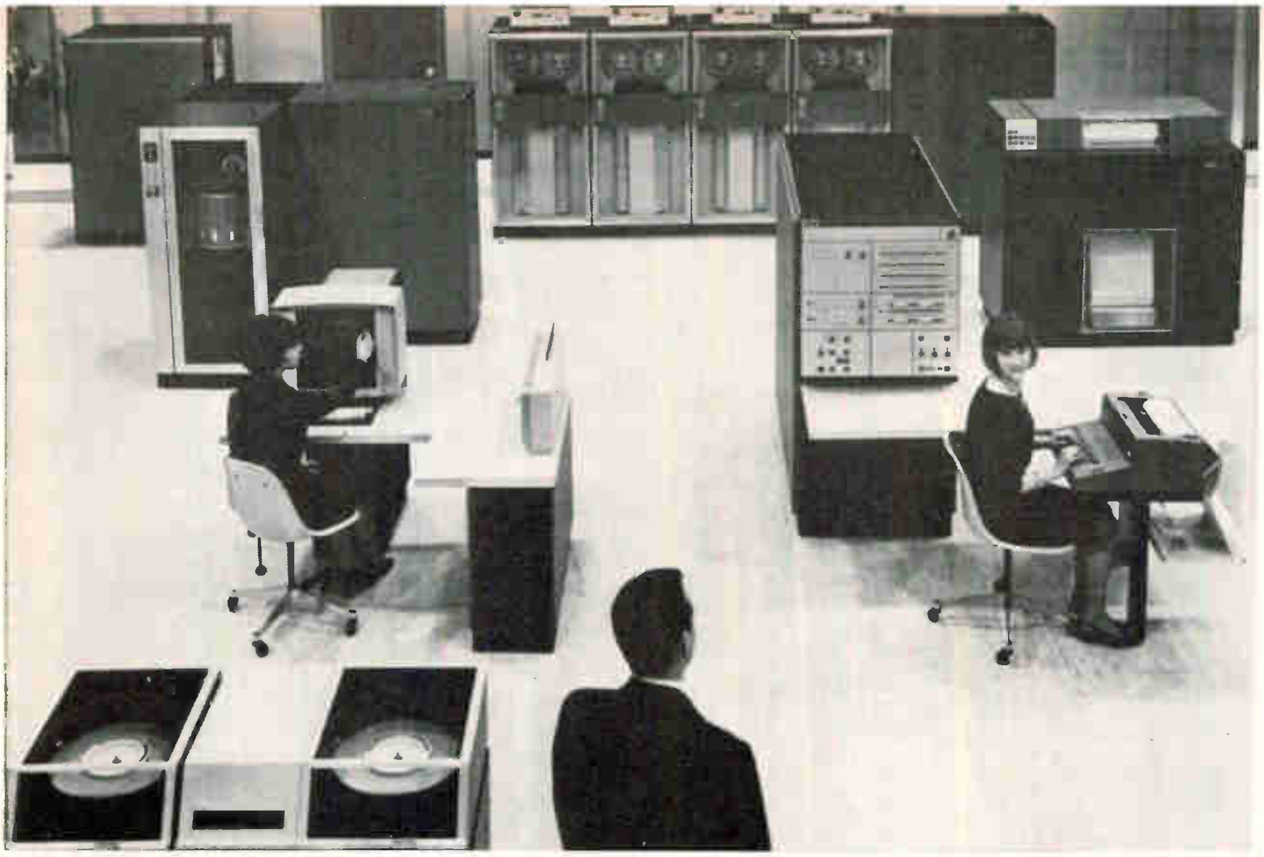


Giant IBM system/360 occupies one third the floor area of former computers of the same power.

Computers

IBM burns its bridges

System/360 spans all segments of the market. It's compatible, modular, and built with microelectronics. IBM has made its own commercial computers obsolete

By Lewis H. Young

Editor

Thomas J. Watson Jr., chairman of International Business Machines Corp., faced a closed-circuit television audience of 100,000 businessmen in mid-April. "This is the most important product announcement we have ever made," he told them.

The company had gone to extraordinary lengths to introduce its new IBM system/360. And engineers could understand why. With a single new system, IBM had made every one of its commercial computers obsolete.

First with microelectronics. Enthusiastically, Watson called the new system a new generation of computing machines. The same system is available in machines that are as small as the current IBM 1400 series or bigger than the IBM 7000 series machines. All—big or small—can use the same programs. And a user can increase the power or capability of his installation by adding modules of memory and logic.

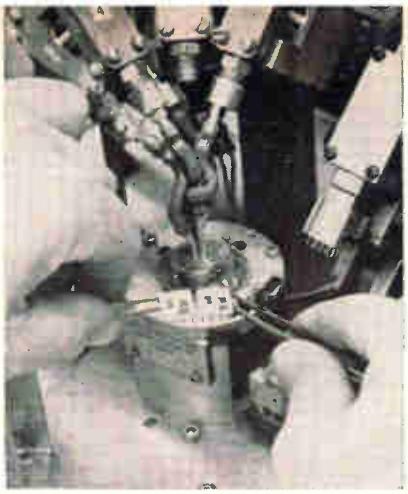
It is the first commercial computer equipment to be built with microelectronic components. The tiny devices make logic circuits faster and cheaper.

The same system can be used to solve scientific problems or process paperwork in commercial data applications. In fact, the same computer can do both jobs equally well. Warren C. Hume, president of IBM's Data Processing division, predicted: "The system/360 will allow a company to integrate all its computer functions in a single machine."

Faster and cheaper. IBM claims its new system will mean faster, less expensive and smaller computers. Comparing a small system/360 to an equivalent IBM 1401 computer, one company executive said, "It is four times faster than the 1401 even though its cost will be about the same." The machine is equivalent to a 1410 computer and will cost far less.

Another executive, Bob O. Evans, vice president, Development Data Systems division, compared a large

Passive elements are screened on ceramic wafers and baked.



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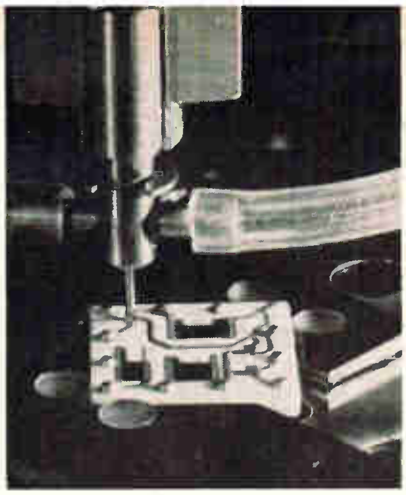


Semiconductor devices, the size of a grain of salt, are positioned

system/360 machine to the Stretch computer. Te said, "The new machine will be 50% faster than Stretch and will occupy only 30% as much floor area."

I. New computer organization

When IBM announced the system/360, it unveiled 350 separate items. They included six different models, from the smallest, model 30 through models 40, 50, 60 and 62 to the biggest, model 70; also 19 different memories and 44 input and output devices, 26 brand new.

Development of the central processors and peripheral equipment was carried out in IBM laboratories around the world. The control memory, for example, was designed at the company's Hursley, England, facility, along with the model 30 central processor. IBM's Italian facility designed paper tape equipment.

Compatible and modular. Although each model has its own unique logic structure, every machine has the same general-purpose organization. The biggest innovation is the addition of many general registers and floating point registers (see figure below) to work with the arithmetic units. With such an organization, even the smallest sized computer can run input and output operations (up to 248 different devices) while it is performing arithmetic or data processing operations.

The three-part arithmetic unit allows the computer to perform arithmetic, data processing and communication control operations.

Memories in levels. A hierarchy of memories stores data. Fast transistorized memories perform local storage; core memories are available at two speeds; giant core memories, one-seventh the size of conventional core memory units, have capacities of up to 8 million characters, all directly addressable; and magnetic strip memory cells can store up to 400 million characters.

The giant core memories allow the system to store programs for many jobs and to run the computer nonstop on different problems.

Because the machine has such capabilities, supervisory programs are required to run it. Even the smallest unit has a microprogram to direct data flow. It is a "read only" capacitive memory, made by etching a pattern of copper on an epoxy glass plate.

Tinier cores. IBM's fastest core memory, with a one-microsec cycle time, uses smaller cores—0.013 inch inner diameter and 0.021 inch outer diameter instead of 0.019 inch inner and 0.030 inch outer diameters.

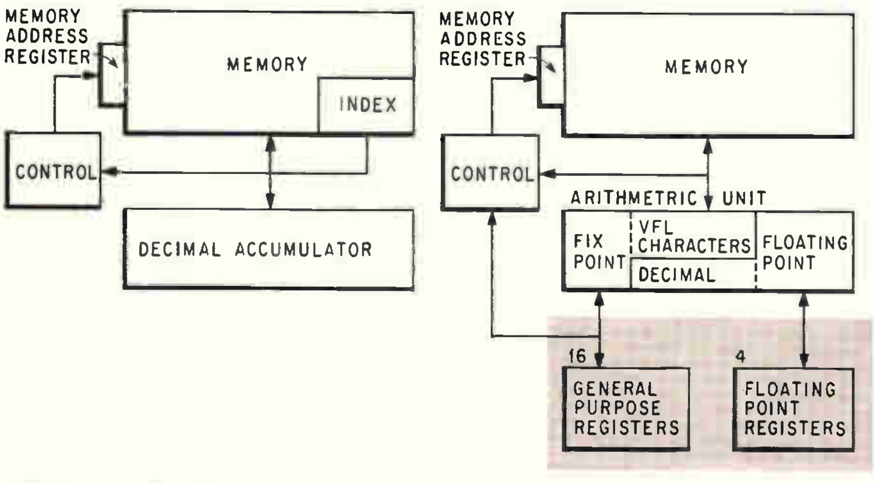
Cycle time is further reduced by the use of microelectronic circuitry that runs the logic portion of the memory system. IBM was able to locate its core modules around the smaller circuitry, cutting the length of circuit paths and shortening cycle times even more.

Automation of core memory production will reduce the cost of these units sharply. IBM estimates per-bit costs in large memories will be only one tenth the cost of former memories.

II. Shrinking logic

IBM's microcircuit building block is an unsophisticated circuit compared to the integrated circuits of many military applications. But it is practical for commercial manufacture. The company calls it "solid logic technique."

The company chose this method because it thought production yields would be far higher than those of integrated monolithic cir-



Architecture of new computer system shows the big innovation: the addition of a three-part arithmetic unit connected to general and floating point registers, compared to a former IBM computer.

cuits. So far the gamble has paid off. Yields have averaged between 50% and 60% though they have dropped as low as 20% on bad production days.

Something old. Circuit design was carried out just as if conventional discrete components were to be used. In fact, circuit diagrams of the new modules are quite similar to those drawn for IBM's earlier computers. The approach: tried and tested diode transistor logic.

When IBM decided to design a microelectronic system, designers suggested 400 to 500 digital circuits. Engineers modified them to 35 basic designs—including such circuits as and-or inverters, inverting drivers, exclusive-or blocks, and indicator drivers to light bulbs—which could build any equipment in the system/360.

The limited number of circuits helps make the system look attractive economically. IBM has shrunk the cost per wafer by reducing the types of modules and increasing the volume of each type.

Even though full-scale production has not yet started, the economics look so good Andrew H. Eschenfelder, general manager, Components division, says, "We can build a basic digital module so it will cost no more than a transistor."

Nanosecond switching. Another attractive feature of IBM's new microcircuit design is its ultra high speed operation. Classified according to speed, there are three families of circuits: one group operates at speeds of 5 to 6 nanoseconds (billionths of a second), another at 15 to 30 nanoseconds and a third at 300 nanoseconds.

Eliminating the long wiring normally found in most computers is partially responsible for the faster operation. But not completely. The semiconductors and resistors of IBM's solid logic technique are held to closer tolerances so designers get the exact electrical characteristic they want.

At very high speeds, IBM gets additional speed by holding transistors out of saturation with a feedback circuit. In addition, the production technique turns out semiconductor devices with junctions equivalent to junctions in the best grade of transistors.

Impact on components. Ever since microelectronic circuits were first built, component suppliers have wondered how far a systems builder might go with them. IBM has supplied an answer a lot of companies won't like. It has gone all the way back to the raw materials.

Although IBM will use its solid logic technique only for computer logic units in arithmetic units and control units at the start, its future plans seem clear. Peripheral equipment will be redesigned soon.

IBM is shrinking rapidly as a customer for discrete components.

How IBM makes microcircuits

To fabricate its computers, IBM developed a microelectronic technique it is calling Solid Logic. The end products are hybrid circuits: passive elements silk-screened on a ceramic wafer and active elements —transistors and diodes—made separately and soldered to the wafer.

IBM chose an established circuit design, diode transistor logic, because it appeared flexible, economical and suited to automatic production. The extensive use of diodes keeps costs down since diodes are cheaper than transistors.

Each silicon diode chip, the size of a grain of salt, contains two diodes with a common anode connection. The transistor, the same size silicon chip, is a single sided device. All electrodes are on the same side for automatic connection.

Active elements. IBM goes back to the basic material to start its active elements. It grows its own silicon crystals and slices them into wafers. In four etching and vacuum diffusion steps, the emitter, collector and base are laid down and junctions built. Photographic techniques lay out 1,100 transistors on each wafer.

Then the half dollar of silicon is coated (or passivated) with a 60-millionths-of-an-inch layer of glass. Over connection points, three to a device, a hole is etched through the glass with acid and lined with chrome-copper alloy and lead.

Gold plated copper pellets are shaken over the wafer until they drop into the etched holes. Heating the wafer melts the lead linings in the holes, soldering the pellets to the silicon chip. The pellets become electrical and mechanical contacts.

The wafer is then cut into individual devices. Each device is tested automatically for 28 electrical characteristics, and transistors are graded into types. IBM is building two classes of transistor and two types of diode.

Passive elements. The ceramic substrate is about ⅝ inch square, with 12 tiny holes positioned around its edge. Wiring patterns and resistors are silk screened on it, an old and established technique.

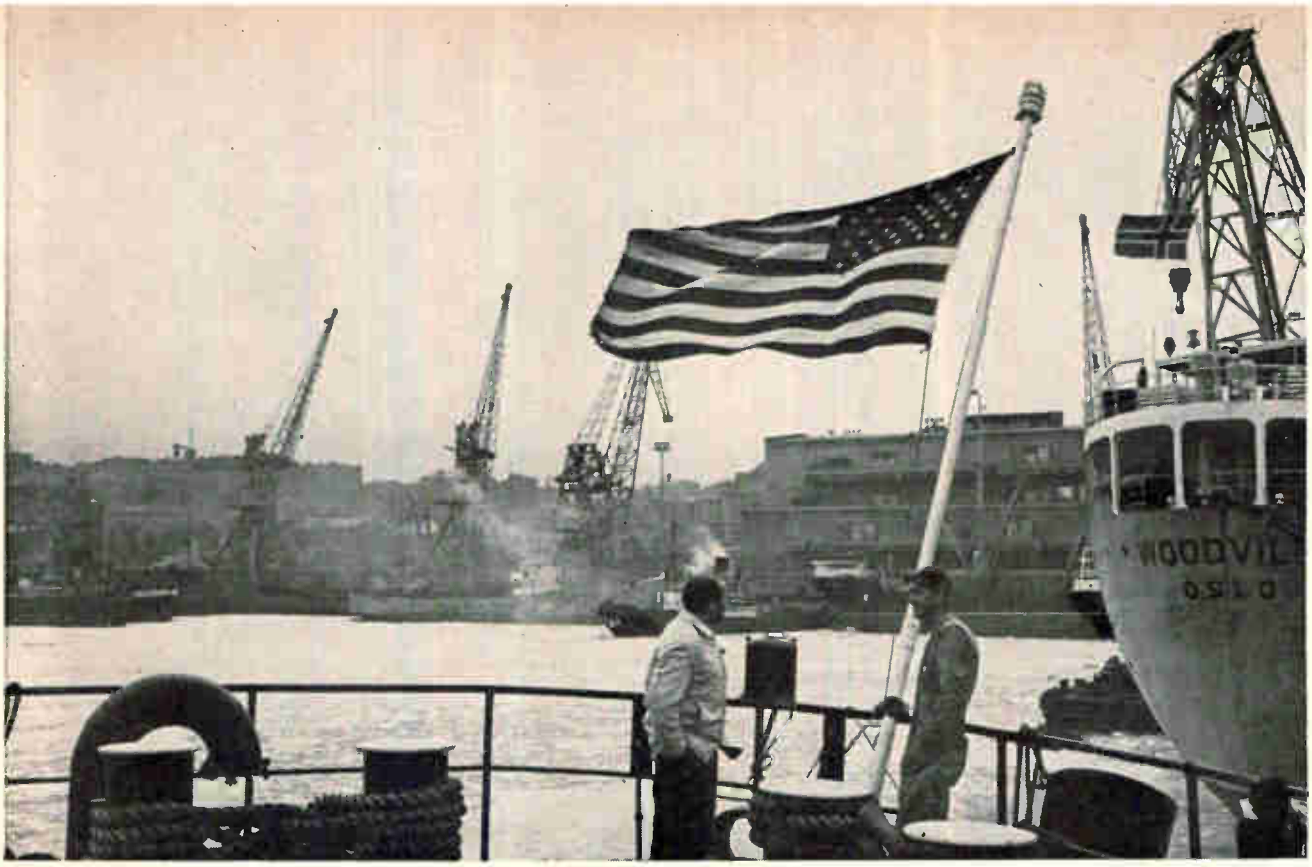
The resistor material is really a semiconductor: palladium oxide and silver in a glass binder. Resistor shapes are maintained close to squares because long thin shapes would slow down the speed of operating circuits.

After the resistors are baked onto the ceramic, the square wafer is dipped in solder to make connections to the resistors. Copper pins are then fed into the 12 peripheral holes and swaged into place.

Specially designed equipment then automatically measures the resistance and trims it by sand blasting to within one percent of specified value, at a rate of one per second.

Finally, the semiconductor devices are placed automatically on the ceramic wafer, pellet side down. The wafer is then encapsulated in plastic.

IBM currently has 100,000 square feet of floor space at its Fishkill plant devoted to building its solid logic technique units. By the fall of 1965, when production of the system/360 computers reaches a peak, the company will have one million square feet of production space for the circuits.



Russia's Black Sea port, Odessa, sees rare sight, the American flag. It flies from stern of the Washington Trader, one of the ships unloading U.S. wheat last month. Quarter-billion-dollar wheat deal with Russia set the stage for the current debate on U.S.-Soviet trade.

Industrial Electronics

Should we sell to the Russians?

Communist countries want to buy electronic equipment. They're already getting it from our allies. Should the U. S. relax its export ban?

On the wall of a Commerce Department office in Washington is a chart depicting the rise and fall of applications from American companies for licenses to export products to the Communist bloc.

"That," says a department official pointing to a steep rise in 1959, "is Camp David," where President Eisenhower and Premier Khrushchev reached agreements that eased international tensions.

Then skipping a few years of ups and downs on the chart, he comes to an almost perpendicular plunge. "That is the Bay of Pigs," the unsuccessful invasion of Cuba in 1961.

United States trade with the Soviet Union, and the attitude of business to that trade, reflects the headlines. The headlines now speak of relaxing tensions. The urge to do business with the Communists is on the rise again. As a result, the U. S. is beginning its first major reevaluation of East-West trade policy since the cold war began.

Whether the U. S. should, like its allies, reduce restrictions on sales of electronic and other technical products to the Communist bloc poses such a tangle of strategic, psychological, financial and political questions that the problem will probably not be resolved until after the fall elections.

The Johnson Administration has implied that it would accept some relaxation of restrictions. But before it makes any drastic changes it wants a mandate from Congress.

U. S. restrictions. U. S. law prohibits exports that substantially contribute to the Soviet-bloc economy. This definition stretches wider than our allies' bans on selling militarily useful equipment.

The U. S. permits some electronic sales to the Red bloc, but these total only about $1 million a year. The U. S. bans all sales to Communist China and other Asian Communist countries, but other Western nations do business with Peking.

The embargo list. The U. S. and 14 other Western nations prohibit sales of military and space equipment to Communist countries. The embargo list, kept up to date by a coordinating committee, includes

An Electronic's staff report, compiled from dispatches by Electronics regional editors and McGraw-Hill World News Bureaus in the U.S., Moscow, London, Paris, Tokyo and Bonn.

practically all electronic equipment relevant to the production or use of military and space systems.

In 1958, much industrial electronic equipment was removed from the list. In 1962, the latest revision, several items, including electron-beam welders, were added and some of the transistors were removed.

U. S. restrictions, however, are more stringent than those of some European countries. Besides the coordinating panel's list, the Commerce Department has a "positive list" of products that cannot be exported without licenses. It includes practically every type of electronic equipment, components and materials worth selling, even radio and tv. This is what most of the argument is about. License applications are carefully screened and frequently refused.

To sell or not to sell?

There is no clear-cut consensus in the electronics industry on the wisdom of trading with the East.

"We believe in peace through trade," says Michel Bergerac, director of overseas operations, ITT Cannon Electric, Inc., a subsidiary of the International Telephone & Telegraph Corp., but "with the East it's a very complicated matter.

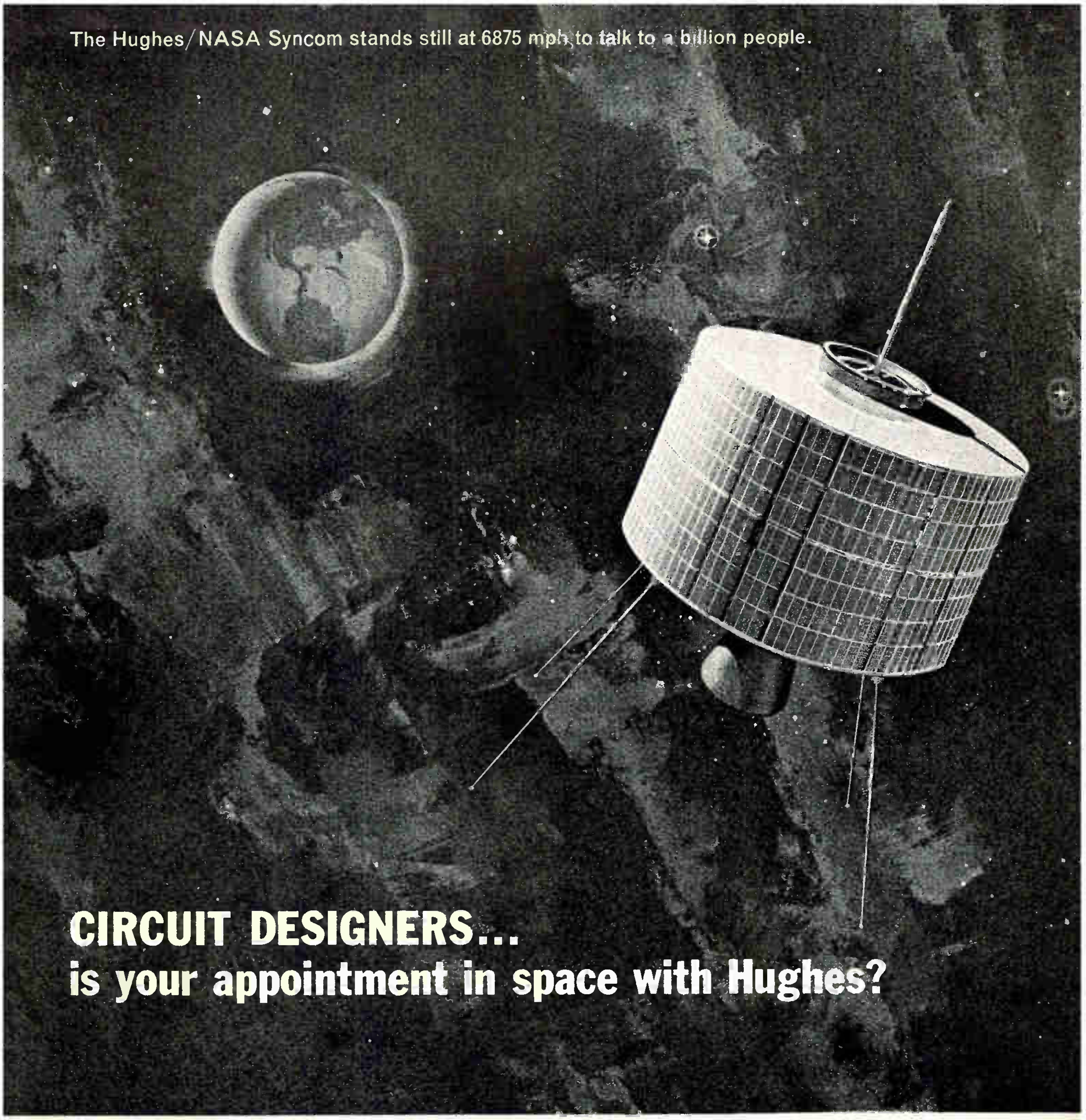
"As long as we don't sell products of an advanced state-of-the-art nature, there is no reason not to sell," he continues. "There are no bad moral connotations as long as the goods sold aren't strategic.

"A real objection is in the placement of sampling orders where the company is buying just one or two of a product in order to copy it. In this case, we charge a higher price."

A contrary view comes from Ray Gilmer vice president of marketing for Varo, Inc., in Garland, Tex. "I say let's don't sell them anything. I definitely oppose any trade with Communist countries," he declares. Varo is not trading with the Red bloc and doesn't intend to.

"Morally wrong." Adds the president of another Southwest firm: "It is ethically and morally wrong to trade with Communist nations . . . Regardless of how some attempt to justify such trade, we think there is more than dollars involved here."

Other companies, with a stake in the European market, are



Today, Hughes is one of the nation's most active aerospace/electronics firms. Projects include: F-111B PHOENIX Guided Missile System, TOW Anti-Tank Missile, SURVEYOR Lunar Spacecraft, SYNCOM, VATE, ARPAT, POLARIS, Hard Point Defense and others.

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. . . "Why not let us compete?" . . .

rankled by the advantage their competitors gain through sales to the Soviet bloc.

B. A. Olerich, general manager of the international division of the Ampex Corp., thinks it "certainly does not represent anything constructive if U. S. firms are barred from selling behind the Iron Curtain when other Western countries are free to sell."

B.A. Olerich, Ampex Corp.: Restrictions on exports "certainly does not represent anything constructive. . when other countries are free to sell."

"Why not let us compete," asks another Ampex official, "and have Russia pay for her equipment with dollars, contributing to our economy?"

Scope is criticized. U. S. trade restrictions "go far beyond the objective of keeping military equipment out of (Russian) hands," says James H. Binger, president of Honeywell Inc.

"The U. S. should broaden the list of items we can trade," he maintains. "We're not going to starve them out and we're not making it tough on them by keeping our products out. If they don't get these items from us, they will get them somewhere else."

"I know the French are selling (nuclear analyzers) to Russia," complains the sales manager of a Chicago company. "The French have even sold instruments they learned to make while working under license agreements from U. S. manufacturers. I am sure the British are selling nuclear instruments to Russia. Why shouldn't we have a piece of this business?" He says his company could sell 5% to 10% of its output to the Soviets. "If we had some super-secret technique of making these instruments, maybe there would be some excuse for dragging our feet," he argues.

Gertsch Products, Inc., in Los Angeles, doesn't trade with the Eastern bloc, but says it would if the United States Government okayed it.

"I know other countries do it, but we do not," says Elmer Gertsch, president. "I have an inquiry now on my desk from Yugoslavia about the newest state-of-the-art equipment, but we won't answer it."

London wants more

The British government is developing a favorable climate for expanded East-West trade except in strategic products. Moreover, it wants the strategic list revised to take into account communist scientific achievements. It is foolish, the British insist, to embargo equipment the Russians are now producing.

Britain's economy depends on overseas sales. In addition the government believes that trade will ease tensions and raise the standards of living in the East.

"A fat man is less likely to become a Communist than a thin one," says Prime Minister Home.

Just a few million. United Kingdom exports of electrical machinery total about $200 million a year. Of this, Russia in 1962 and 1963 took $4.5 million and $4.2 million, or only 2%. Telecommunications exports to the Soviets rose from $153,000 in 1962 to $750,000 last year. Exports of scientific electrical instruments to Russia are around $2 million a year.

Major British exports to the East are civil radars, marine communications, direction finders, broadcast gear, plus some computers.

Most makers of electronic instruments here see more business coming in large plant contracts. Instrumentation and controls comprise as much as 10% of a chemical plant's cost. At least five such contracts are being negotiated with the Russians, Czechs and Communist Chinese, including a $111 million synthetic fiber plant for the Soviet Union.

The Soviets have just contracted for a $6-million plant to assemble cathode-ray tubes.

Trade with China. About $600,000 worth of scientific instruments including photographic and optical goods, was sold to Communist China in 1963. But there are signs that trade is expanding.

The Chinese need analytical instruments. This month, more than $1.5 million worth of British scientific equipment was shown in Peking. The items displayed had been on a Chinese shopping list. The Chinese are expected to buy most of them at the end of the show.

In November there will be another British industrial exhibition in Peking. It will include telecommunications and electronic equipment and scientific instruments.

French say "oui". France, too, has relatively few restrictions except for strategic electronic equipment. But trade is hardly booming.

Ray Gilmer, of Varo, Inc.: "I say let's don't sell them anything." He's just returned from a trip that included Saigon (above) and Berlin, and doesn't think coexistence is possible.

In 1962 France exported $1,738,367 worth of electronics gear to Rumania, $1,584,489 to Russia and only minor amounts to other Soviet satellites. For Rumania and Russia, the big categories were radio and television transmitters.

... Computers for the Red Chinese? ...

and receivers, various kinds of measuring instruments and cathode-ray tubes.

Nonetheless, Paris seems to want French industry to maintain a warm relationship with the Russians. This is why French companies participate in Russian trade shows.

Recently established diplomatic relations with Communist China have not yet resulted in any substantial trade in electronic equipment. In September, the French will exhibit measuring equipment in Peking.

Japan is doing business

Japan has trade agreements with Russia, and unofficially promotes private trade with Red China. Japan is a converter nation with few raw materials. China has the raw materials, but little manufacturing.

Red China wants large digital computers, which could be used to develop nuclear weapons, power resources, oil refining and other industry. One rumor is that the Mitsubishi Electric Co. may produce the Gamma 60 computer for sale to China. Mitsubishi has a tie-in with Compagnie des Machines Bull, which makes the computer in France.

A group promoting Chinese-Japanese trade listed as other needs radio communications and broadcast equipment as well as other wireless equipment, including radar, loran and navigation aids. Test equipment is also needed, but much of it is on the embargo list.

Trouble in Taiwan

Nationalist China—a big Japanese customer—is unhappy about the trade with Peking. There have been serious repercussions in Taiwan over last September's agreement to sell China a chemical fiber plant. About 4% of the plant's $20 million cost is for control and measurement apparatus. Though the plant has not yet been shipped, there is talk of a second sale.

Under private agreements, Japanese shows were held last year in Peking and Shanghai. This year the Chinese will display their products in Tokyo and Osaka. China doesn't want to sell; it wants to show the technical level that Japanese equipment should surpass for sale to China.

During 1963, Japan exported more electronic equipment to Red China than to Russia: about $1,004,000 compared with $637,000. Best sellers were industrial controls and measuring equipment.

This year, Japan will sell Russia about $9 million worth of electronic products directly, plus the controls for fertilizer and chemical plants that Russia is expected to buy. Before long, Japan expects to be able to export numerically controlled metalworking tools too. Japan is a convenient source of products needed in Siberia.

View from the Kremlin

The Western electronics equipment that Russia most wants is advanced instrumentation and control systems.

The Soviets are striving for a 225% increase in their chemical industry, and will need from the West somewhere between $1 billion to $10 billion in plant equipment. Instrumentation will be a considerable portion of that.

They will also buy refineries, complete with controls, and will probably want computers for new power stations and high-voltage transmission networks.

The Soviets could also turn to the West for automatic production lines. Installation of 400 such lines was planned for last year, but only about half were completed. Western observers believe the Soviets are weak in sensors and servomechanisms, though their computing capability is good.

Because components are largely swallowed up in military electronics—more than 90% of Russia's electronics industry is engaged in military and space programs—components trade will probably never extend beyond spare parts and modules for imported control systems. Nor will consumer electronics be a substantial market for many years. Russia won't spend its gold reserves for tv sets.

Figures on foreign electronics trade are difficult to get. Practically all of Russia's electronics purchases ride piggyback on larger items and don't always show up in

. . . East strives to catch up . . .

the trade figures. For instance, when England sold the Soviets a textile mill recently, the controls weren't listed under electronics.

But there is no doubt that trade is up sharply. For instance, between 1961 and 1962 (the last year for which figures are available in Moscow), instrument imports rose from about $45 million to nearly $60 million. Most of the instruments were bought from Soviet-bloc countries. England and West Germany together sold some $4 million worth to Russia during the Cuban crisis year of 1962, while U. S. sales were less than $250,000 in 1961 and about $90,000 in 1962.

Within the Soviet bloc

The annual Leipzig Fair in East Germany, with exhibits from all over Eastern Europe, is a good indicator of technical developments and policies within the Soviet bloc.

At the 1964 show last month, it was clear that efforts to catch up are being made.

While Russia still supplies most military requirements, other Communist countries are planning to push development of such equipment as solid-state devices, microelectronics gear and lasers.

Most bloc members, like Russia, are stressing chemical-industry and automation buildups, forcing a revamping of economic planning. After years of downgrading the electronics industry in favor of heavy machinery and other durables planners find they can't build modern industry without electronics.

Hardest push in Germany. Of all the bloc nations, East Germany is giving electronics the most attention. Communist Party boss Walter Ulbricht has ordered that all industries rely on electronic data processing by 1970 to save manpower. He is giving top priority to solid-state devices and microelectronics—still in the laboratories in East Germany—and he wants automated production for use in computers and communications.

Plans are to introduce micromodules into computers by 1965 and to transistorize telephone and radio systems by 1966. In 1965, the state-owned VEB Electromat, in Dresden, is to have an automatic line able to produce a million transistors a year. A similar line is being prepared for Czechoslovakia. In 18 months, the state plant in Hermsdorf is supposed to produce 500 micromodules an hour. A plant in Frankfurt with 2,500 employees, is exporting power transistors to other bloc nations.

Look-alikes. That East Germany is copying American equipment was obvious from a couple of electronic equipments on display at the fair, one a comparator and another a recorder. Prices were competitive too.

East Germany is well along in lasers and has displayed several models. It expects to export about 100 next year. Neodymium-doped glass, ruby crystal and gas-type lasers for research, welding and other industrial applications are made. About 100 East German engineers are now developing lasers.

East German exports of electronics spurted 180% between 1962 and 1963. But exports are tied to political strategy. Communications equipment, for example, is exported to Africa and Asia and is also bought from Western Europe.

Poorer Cousins. Poland and Hungary are advancing rapidly in fields such as lasers and building-block electronic elements. The Czechs appear to be making strides in computers. Bulgaria and Rumania are still the poor cousins in electronics technology.

Want more details?

Exports to Communist countries are regulated under two primary laws: the Battle Act (Mutual Defense Assistance Control Act of 1951), for the strategic embargo list, and the Export Control Act of 1949, for the "positive list."

The Government Printing Office, Washington, D.C. 20402, sells reports on these acts, with the texts, actions taken to enforce the acts, lists of embargoed or to-be-licensed products, and statistics on East-West trade. Recommended are:

Export Control, 66th Quarterly Report, by the Secretary of Commerce, 1964. Price: 20 cents.

The 1958 Revision of East-West Trade Controls, the State Department report on the Battle Act. Price: 25 cents.

The Battle Act Report 1963, a Department of State Publication 7406. Price: 30 cents.

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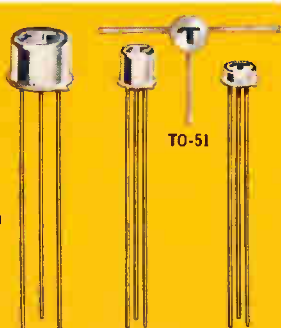

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Analog multiplier develops 2.8-v output

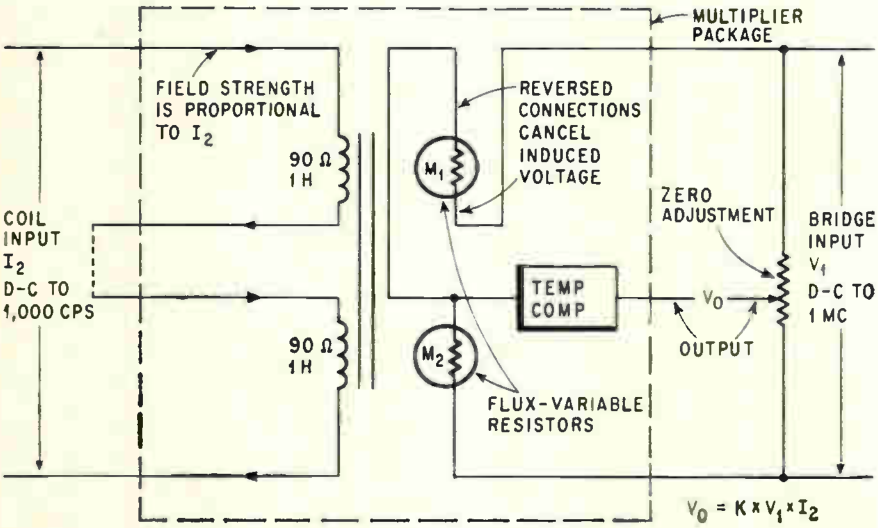
New design idea uses thin-film magneto-resistors. Multipliers have applications in power measurement, control systems and computers

Conventional bridge-type analog multipliers use servo-controlled potentiometers to unbalance the bridge. A new solid-state device uses thin-film flux-sensitive resistors, called magneto-resistors, as variable bridge arms, shown in the accompanying schematic diagram. The bridge is then unbalanced by applying a magnetic field to the magneto-resistors.

Two 1,000-ohm thin-film magneto-resistors are mounted in 0.006-inch-wide air gaps in the multiplier's magnetic core. An input, applied to the coil wound on the multiplier's core, produces push-pull resistance swings and unbalances the bridge.

Besides measuring power, the multipliers are used in control systems and analog computers, where they provide such functions as division and square-rooting, as well as multiplying and squaring. Other uses for the multiplying action are in wide-range wattmeters, modulators, mixers, choppers, discriminators, detectors and spectrum analyzers for audio frequencies.

The magneto-resistance multiplier has several advantages over Hall-effect multipliers. They include higher output voltage, lower drive current, wider temperature range, smaller size and automatic cancellation of induced "noise" voltages. Narrow air gaps permitted by the use of thin-film magneto-resistors also minimize magnetizing current.



Magnetic circuit is arranged so that coil input I_2 produces differential (push-pull) changes in M_1 and M_2 resistance

Maximum dissipation in the magneto-resistance elements is 0.3 watt, permitting 24-volt maximum input. Drive current for full output is then only 12 milliamperes. Outputs exceeding 2.8 volts can be achieved in short-duty-cycle applications where higher input voltages may be applied to the bridge terminals. The resistance and inductance of each half of the multiplier's split coil are 90 ohms and one henry, respectively. Coil input frequencies cover d-c to 1,000 cycles per second; the magneto-resistance bridge, being a resistive load, may be operated from d-c to one megacycle.

The series 3000 MistoR multiplier weighs six ounces and fits into a can 1$\frac{7}{16}$ inches high by 1$\frac{5}{8}$ inches square. Without the can it can be fitted into the case of a conventional moving-coil meter, converting the meter into a wattmeter, root-mean-square voltmeter or rms current meter for use in the audio range.

The price for single quantities is $98.50; delivery is in six to eight weeks.

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MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. [302]

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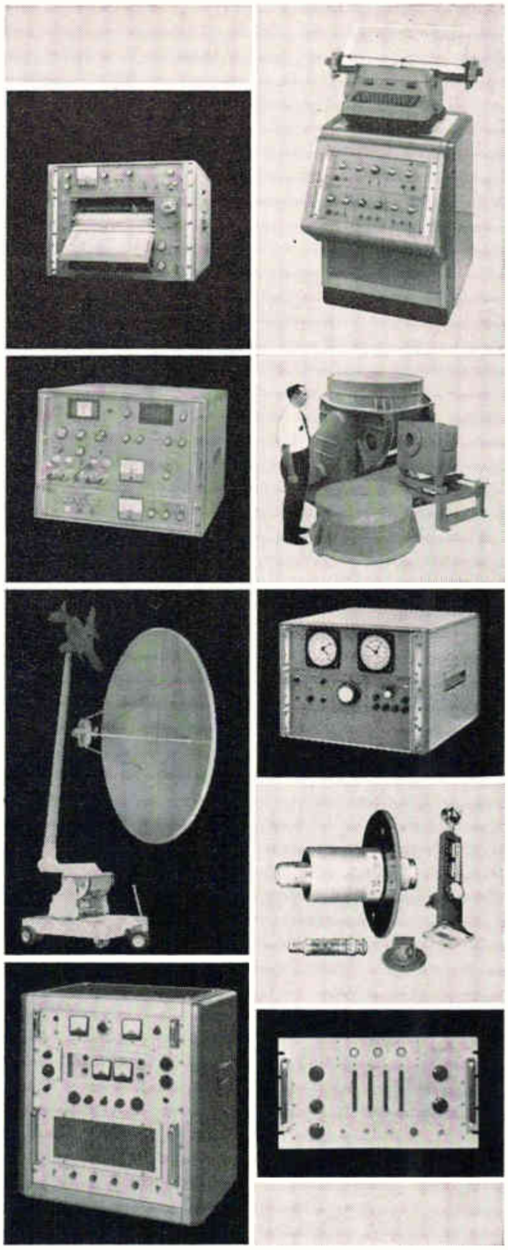

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Pure sintered oxides
Vacuum-tight ceramic-metal assemblies

In the field of pure sintered oxides produced by C.G.E.C. two ceramics are specially adapted to electronic applications :
Alucer 97 and Berycer

ALUCER 97

97 % pure alumina sintered at high temperature, specially well adapted to refractory metallizing for ceramic-metal seals.

BERYCER

pure beryllia (BeO content higher than 99,9 %) sintered at high temperature. Berycer provides a very good thermal conductivity and a great electrical resistivity.

Both oxides are vacuum-tight, non porous (therefore immediatly degassed), very refractory. They have a high mechanical strength, a good resistance to thermal shocks, low losses under high frequency, good dielectric properties. They can be machined to accurate dimensions and offer an excellent surface finish.

C.G.E.C. can produce components in Alucer 97 or Berycer, according to your specifications.

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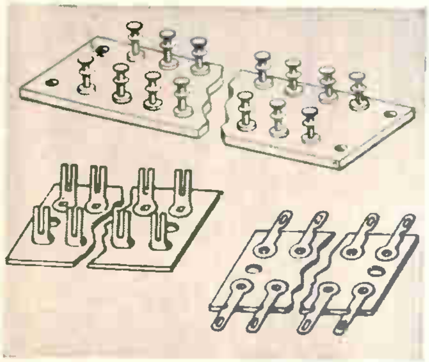
TEL: 93-32-91 TARBES

Circle 203 on reader service card



Terminal boards eliminate tooling

Standardized terminal boards cut production costs by eliminating the tooling and set-up charges usually applied to nonstandardized boards. Boards are available in a variety of the most popular terminals spaced ¼ inch, $\frac{7}{32}$ inch and ⅜ inch apart. Insulation and materials conform to MIL specs. Terminals are securely riveted and hot tinned finished, providing easy solderability and a shelf life described by the manufacturer as indefinite.
Keystone Electronics Corp., 49 Bleecker St., New York, N.Y. [311]

Driver transformer is compact and light

A transistor driver transformer, engineered for compactness and high voltage capabilities, is suitable for driving high impedance loads such as oscillator tubes 15,000 v d-c above ground. It is manufactured and guaranteed to MIL-T-27B, grade 4, class R, life X. Input is 24 v and output 480 v, peak-to-peak triangular wave. Maximum size is 2¾ by 2¾ by $2\frac{1}{16}$ in. high. Ceramic seal terminals 2⅞ in. high are placed opposite mountings.
United Transformer Corp., 150 Varick St., New York 13, N.Y. [312]

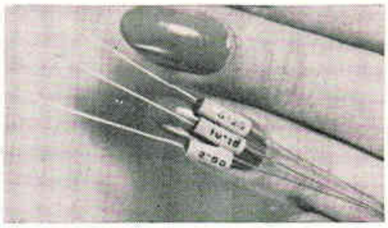
Ferrite cores enhance high-speed memories

New ferrite core planes and stacks make possible 1-μsec cycle times for coincident current memory systems. The units feature 20-mil diameter cores with 180-nsec switching times and are available in various bit and winding configurations. Tentative electrical specifications for the planes and stacks include a read and write drive current requirement of 750 ma, which produces an output of 35 mv average. The zero output voltage is 7 mv average. These parameters are measured with a driving pulse rise time of 50 nsec and a 450-nsec pulse width. Core dimensions are 20 mil o-d and 13 mil i-d.
Ferroxcube Corp. of America, Saugerties, N.Y. [313]

Wedge-lock connector pressurized to 50 psi

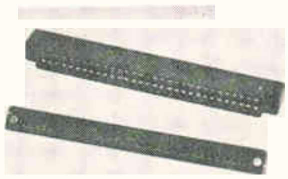
An all-purpose captive-contact wedge-lock cable clamping type connector has been developed. Fully weather-proofed and pressurized to 50 psi for cables with

unperforated jackets, the ease with which its three components (nut assembly, contact-wedge assembly, body assembly) may be put together cuts assembly time by more than 50 percent. No special tools are required. Shorting inside the connector is eliminated as no combining or trimming of braid is required. There is no indentation of cable dielectric, resulting in low vswr.
Automatic Metal Products Corp., 323 Berry St., Brooklyn 11, N.Y. [314]



Electrolytic capacitor features low leakage

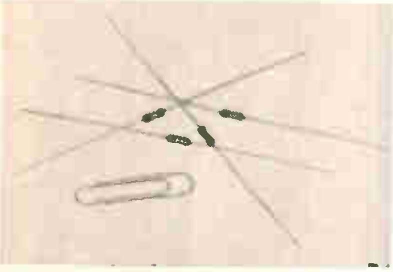
Ultraminiature electrolytic capacitor type TTC features excellent electrical characteristics, low leakage, low equivalent series resistance, and high reliability—all packaged in a microminiature case. It has an operating temperature range of —30° C to +65° C. Capacitance tolerance is —10 percent to +100 percent of rated capacitance. The low-cost capacitors are also subjected to extensive life and shelf tests.
Aerovox Corp., 740 Belleville Ave., New Bedford, Mass. [315]



P-C connectors have bellows contacts

Three printed-circuit connectors—22, 31 and 41 contact configurations having beryllium copper bellows contacts with two taper pin receptacles per contact—have been an-

nounced. The bellows contact principle results in low card insertion and extraction forces.
Viking Industries, Inc., 21343 Roscoe Blvd., Canoga Park, Calif. 91304. [316]

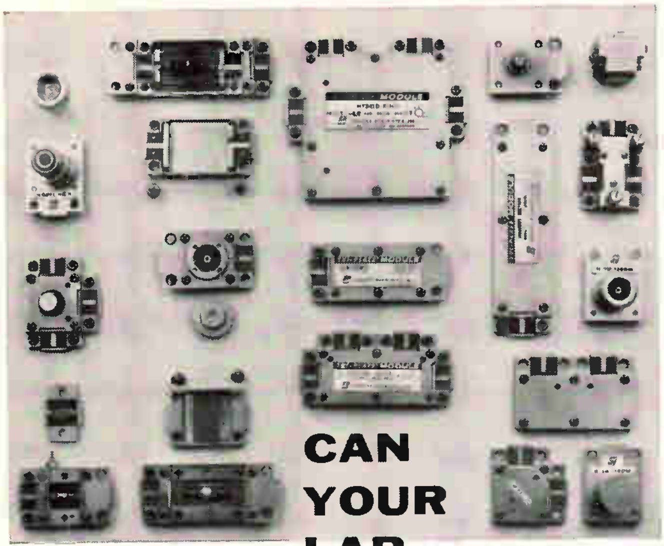


Metal film resistors rated ¼ watt at 100 C

Miniature metal film resistor, the RE-¼, rated ¼ w at 100 C with weldable or solderable leads is constructed with expansion fitted cap and lead assemblies. Conformal coating withstands severe mechanical and environmental stress. Resistances from 10 ohms to 200,000 ohms in tolerances from ±0.1 percent to ±5 percent (±1 percent standard), and temperature coefficients of ±100 ppm/deg C (C-1), ±50 ppm/deg C (C-2), or ±25 ppm/deg C (C-3) are available.
American Components, Inc., 8th Ave. and Harry St., Conshohocken, Pa. [317]

Midget chopper weighs 12 grams

Tiny but tough electromechanical chopper is ideal for printed circuits. Specifications are: size, 0.4 in. in diameter, 0.8 in. long; weight, 12 grams; noise, less than 1μv into 100,000-ohm load; vibration, 10 g to 2,000 cps. It has all welded construction. No solder flux eliminates contact contamination, assuring at least 5,000 hours of operation.
Cambridge Scientific Industries, Inc., 527 Poplar St., Cambridge, Md. [318]



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It can with TRI-PLATE® modules. TRI-PLATE modules offer you the fastest, most economical technique for testing and proving strip transmission line microwave circuits. In minutes you can assemble the TRI-PLATE modules that correspond to your schematic, lock in signal paths by tightening integral connectors, apply power and test the authentic circuit . . . in high-performance strip transmission line.

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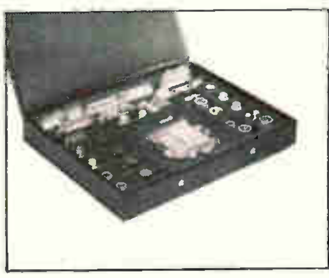

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OFHC COPPER
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*Reg. Amer. Mtl. Climax, Inc.

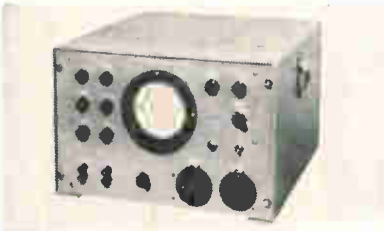
Circle 204 on reader service card

Scr regulators have low distortion

High-efficiency a-c regulators that are about half the size and weight of comparable units are announced. The ACR series silicon-controlled-rectifier a-c regulators, offered in 500, 1000, 2000, 3000, and 5000 VA models, are designed for controlling rms voltage to a variety of loads requiring precision regulation, low distortion, and fast response time. Units can be programmed and sensed remotely. Regulation is ±0.1 percent rms. Time constant is 30 millisec. Distortion is less than 3 percent. Series operates at up to 95-percent efficiency. Temperature coefficient for all models is 0.015 percent per deg C. Prices start at $290.
Sorensen, a unit of Raytheon Co., Richards Ave., South Norwalk, Conn. [351]

Operations monitor records multiple events

A new 150-channel operations monitor has been developed for recording on-off, go/no-go or other two-state operations in order of occurrence, duration and time relationship. Model 14 3615 00 can record on all 150 channels simultaneously with time accuracies of 1.25 millisec. Resolution of pulses as short as 2.5 millisec is easily achieved. The sequence recording system contains a pulse power supply and an interchangeable switching logic by which a variety of inputs can be accommodated. The entire unit is packaged in a shielded, mounted enclosure which meets MIL-I-26600, Class I specifications for rfi emanation.
Brush Instruments, division of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio [352]



Ultrasonic phasemeter serves as standard

An ultrasonic primary phase standard/meter, model 718-B, measures phase shift to ±0.1 deg absolute, by comparing its precision internal reference with a signal return from a component under test. The instrument also generates two voltages having a previously adjustable phase relationship which may be used to calibrate phase meters. Phase shift is read in a continuous range of 0 to 360 deg on two precision calibrated dials, one coarse and the other of which reads through a range of +3 deg to −3 deg with widely spaced 0.1-deg calibrations.
Acton Laboratories, Inc., 533 Main St., Acton, Mass. [353]

Digital voltmeters offer high sensitivity

Low-cost, 4-digit, all-electronic digital voltmeters, series 4300, are announced. Available in 18 models,

they offer high common mode rejection (60 db at 60 cps), 1000-v ground isolation, and 100 μv sensitivity. They feature automatic, manual or programed range selection, and automatic polarity changing. Ranges of the series 4300 are $\pm$0.9999/9.999/99.99/999.9 v d-c. Maximum speed is two readings/sec plus 0.5 sec for automatic ranging. Accuracy is $\pm$ (0.05 percent of reading +1 digit). Prices range from $875 to $1,235.
Non-Linear Systems, Inc., P.O. Box 728, DelMar, Calif. [354]

Synthesizer-exciter has digital readout

Type 263 synthesizer-exciter has a 1-w maximum output and a continuously variable frequency range of 100 kc to 30 Mc. A resolution of +0.05 cps at any frequency, digital readout, a-m and f-m modulation facilities and a built-in 1-Mc frequency standard accurate to 5 parts in 10^9 are featured.
Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J. [355]

Digital meters read voltage and frequency

Series 990 digital instruments are designed to offer an extra measure of versatility and reliability for industrial usage. Providing the choice of both frequency and d-c voltage measurements in one instrument, the four models of series 990 make full use of electronic techniques and dispense with electromechanical switching. Measurement ranges extend from zero to 750 v d-c and from 2 cps to 1 Mc for frequency measurements. Provisions are also included for directly driving a digital printer. Priced from $1,095.
Electro Instruments, Inc., 8611 Balboa Ave., San Diego 12, Calif. [356]

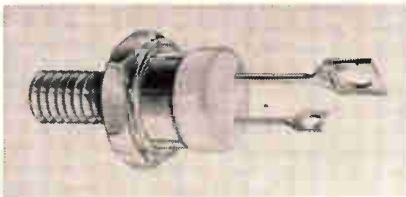
Pressure transducer kit offers high accuracy

On the market is a pressure transducer kit that offers accuracy of 1 percent of reading from 1 to 500 psi, differential or gage. Intended for general test laboratory use, the model KP15 kit includes a P15 pressure transducer rated at 2000 psi maximum line pressure, five bi-directional interchangeable diaphragms with ranges of ±1, ±5, ±25, ±100 and ±500 psi, wrenches and accessory fittings.
Pace Engineering Co., 13035 Saticoy St., North Hollywood, Calif. [357]

Voltage standard has modular design

Model 146AG5 a-c absolute voltage standard has an output voltage range of 0 to 511.110 v rms and a resolution of 1 mv with six full switching decades. Standard output frequencies are 50, 60, 400, 800, 1000, 2400, and 4800 cps; absolute accuracy is 0.035 percent. The all-transistor unit is modular, uses convection cooling only. Input power is 105 to 125 or 210 or 250 v, 47 to 440 cps, 200 w.
Rotek Instrument Corp., 11 Galen St., Watertown, Mass. [358]

New Semiconductors



All-diffused scr's feature reliability

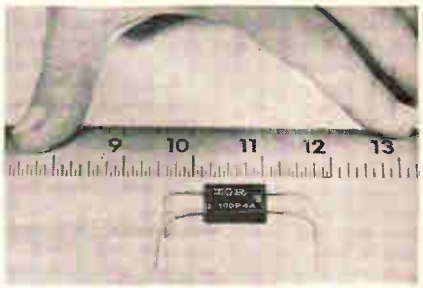
Series 2N681 through 2N689 silicon-controlled rectifiers in the TO-48 packages are designed for regulated power supplies, power inverters and motor-control circuit-design requirements. The all-diffused units feature rigid post-and-clip construction with the posts that connect the terminals to the pellet anchored at both ends. This produces an element of reliability and mechanical capability said to be unequalled in the scr field. The devices have a positive temperature coefficient for the forward breakover voltage (V_{bo}) characteristic, with the minimum V_{bo} guaranteed at $T_c = -55$ C.

Silicon Transistor Corp., Carle Place, N.Y. [331]

Capacitor diodes have high Q

Silicon high capacitance Varactron diodes feature an all-epitaxial construction with an abrupt junction design to permit maximum change in capacitive reactance. Working voltage is 100 v d-c with low reverse current leakage specified. The diode has a minimum Q of 200 at —8 v and 25 Mc with a series resistance of 0.125 ohm max. Capacitance values of the VA-520 series is 250 pf at —8 v (330 pf at —4 v). The diodes find important applications as circuit tuning elements for amplifier, oscillators, automatic frequency control loops, frequency tracking filters, remote control tuning, frequency connectors and modulators, and self-balancing bridge circuits.

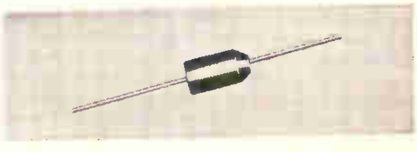
Crystalonics, Inc., 147 Sherman Ct., Cambridge 40, Mass. [332]



Rectifier assembly replaces four diodes

A series of extremely compact silicon rectifier assemblies with large output capabilities is being produced to replace bulky circuitry made up of individual semiconductor devices. The new assemblies will perform the functions that formerly required four individual diodes. Designated the 10B series, the assemblies are single-phase, full wave bridge rectifiers rated from 200 to 1,000 v peak reverse voltage. Output is up to 1.8 amp average dc and transient capability is from 350 to 1,250 v. Other circuit configurations are available in this miniaturized rectifier line including the center tap, doubler, tripler and quadrupler circuits. Price is $2.50 to $4.50.

International Rectifier Corp., 233 Kansas St., El Segundo, Calif. [333]



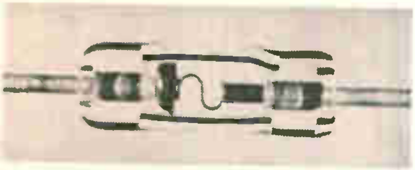
Axial rectifiers deliver 2 amp d-c

Miniature axial rectifiers provide an average d-c output up to 2 amperes half-wave at voltages ranging from 15 to 1,200 piv. The 2A series of insulated body silicon rectifiers op-

erate at full rated current up to 50 C and withstand an 8-millisecond 200-ampere surge. They have a maximum reverse current of 25 μa at rated voltage, a maximum d-c forward drop of 1.2 v at rated current, and meet all environmental specs of MIL-S-19500 C.
Solitron Devices, Inc., 500 Livingston St., Norwood, N.J. [334]

Silicon rectifier rated at 1,500 v

A top-hat, axial-lead silicon rectifier rated at 1,500 v, 1 amp is announced. The single-junction 1N4374 offers space savings, improved circuit efficiency, and increased reliability for applications such as high-voltage radar power supplies, h-v cathode-tube circuits, and microwave power supplies. In addition to a working peak reverse voltage rating of 1,500 v, it features a high surge current capability of 15 amperes (one cycle at 50 C), a low forward voltage drop of 1.5 v at $I_F = 500$ ma, and a leakage current of only 300 μa at 1,500 v and 150 C. Price is $5.36 (100 to 999 quantities).
Texas Instruments, Inc., 13500 North Central Expressway, Dallas, Tex. [335]



Four-layer diodes encased in glass

Silicon four-layer subminiature glass diodes are two-terminal devices that exhibit many of the characteristics of the more complex multiterminal devices. In the ON state the device has a dynamic resistance of less than 2 ohms and a a voltage drop of approximately 1 v; in the OFF condition it has a forward leakage of less than 5 μa. Switching is accomplished by varying the voltage across the device. Switching time is in the fractional microsecond region. Dissipation is 150 mw.
National Transistor, 500 Broadway, Lawrence, Mass. [336]

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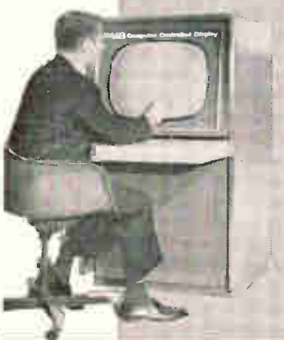

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Distortion-free optics, brilliant imagery. Ideal for quality control, inspection and assembly of miniature parts and circuits. Magnification: 8X to 40X. A complete range of coated achromatic optics is available. For details, write Elgeet Optical Co., Inc., 303 Child Street, Rochester, New York 14611.

Elgeet

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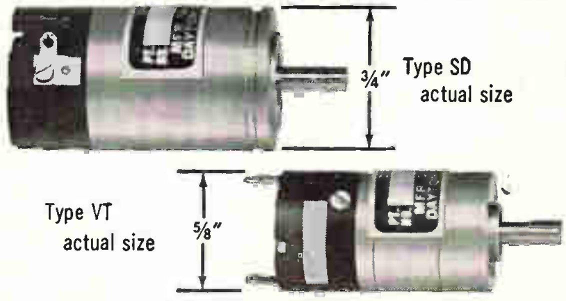

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yes, smaller!

We believe the new Globe SD and VT motors are the smallest and lightest permanent magnet precision d.c. motors available. Typical continuous duty output for these motors is 0.3 oz. in. and 0.25 oz. in. at 10,000 rpm. respectively. A variety of windings is offered to produce the characteristics required. Standard windings for 27 v.d.c. produce no-load speeds from 5,000 to 22,000 rpm; 3 to 50 volts standard, higher voltages available. Special units can include speed governors, gearheads, brakes, and radio noise filters. Unusual efficiency and output torque are obtained with high reliability, designed to meet MIL specs. Write for Bulletin VTD to Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE

GLOBE INDUSTRIES, INC.

New Subassemblies and Systems

Power supplies are silicon regulated

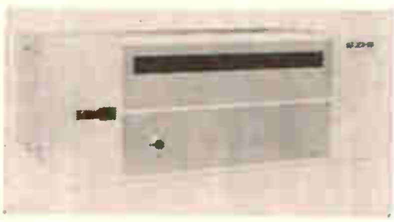
All-silicon, regulated, continuously variable power supplies have voltages up to 40 v d-c and currents up to 4 amps. The LH series is available in ¼ rack and ½ rack sizes. They feature uniform temperature coefficients from 0 to 50 C. Integrated silicon circuit maintains 0.015%/deg C temperature coefficient for any incremental change over the operating temperature range of the supply. Units are completely protected against short circuit and electrical overload and excessive ambient temperature. Line regulation is 0.015% or 1 mv, whichever is greater, for a-c input of 105-135 v a-c. Load regulation is 0.015% or 1 mv, whichever is greater, for no load to full load.
Lambda Electronics Corp., 515 Broad Hollow Road, Melville, L.I. [371]

Small gear motors for automated systems

A complete line of small gear motors is capable of being used in an extremely wide variety of applications in numerically controlled machines and automated systems. Designated Mina-Gear, the right-angle design gear motor with the Spiroid face-type gearing is available in models ranging from 1/100 to ½ h-p with output speeds from 15 to 350 rpm. Reduction ratios are available from 10:1 up to 102:1. Gear housing will combine with eight different motor frames, is available with a built-in clutch, and can be built as a separate reducer. The line comes in virtually all motor types: a-c, d-c and a-c/d-c.
General Electric Co., Schenectady 5, N.Y. [372]

Foam-potted package contains 100 dry reeds

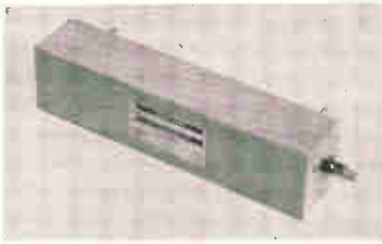
One hundred dry reeds are incorporated into a single package for a new missile ground control computer. A new method of encapsulation, involving polyurethane foam, affords lighter weight and repairability not possible with solid potting materials. All 100 reeds operate from a single coil with 5-millisec response at nominal coil voltage. Outside dimensions are approximately 4½ by 6¼ by 2¾ in.
Wintronics Div./Michigan Magnetics, Inc., 1132 S. Prairie Ave., Hawthorne, Calif. [373]



A/d converters rated to 30,000 bits/sec

Series AD 20 analog-to-digital converters have conversion rates up to 30,000 bits per sec, with accuracies up to ±0.01%. The all-silicon converters have an operating

temperature range from 0° C to 100° C. Transformer coupling from control and output signals minimizes grounding problems. Four models are available with binary or BCD output. Price for model AD 20-14, 13 binary bits plus sign, 13,300 conversions per sec, is $3,700.
Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif. [374]

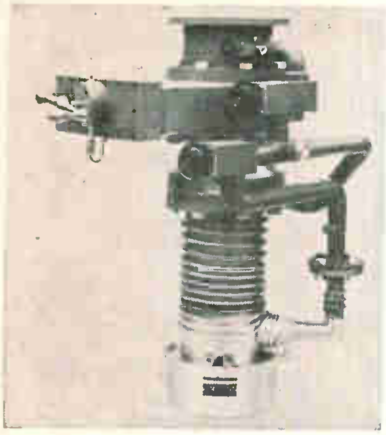


Delay line provides high resolution

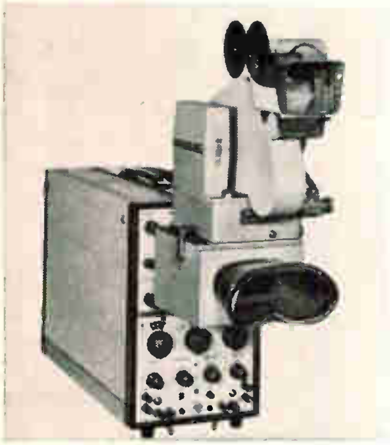
Variable delay line for use as a phase shifter in the frequency range from 50 cps to 200 kc has been developed. The V649 has a delay range of 0 to 10 μsec which is continuously adjustable by 10 turns of a ¼-in. control shaft, providing a resolution of 5 nsec or 0.2 deg phase shift at 100 kc. Delay linearity with frequency is constant within 1 percent over the frequency range. Vswr is within 2 db up to 150 kc and within 3 db up to 200 kc. Temperature coefficient of delay is 25 parts per million and impedance is 100 ohms. Unit is ideal for use as a phase shifter for c-w signals; however, it can delay pulse information, when so used it has a rise time 1.8 μsec; ripple is 5% and attenuation is 5.5 db.
Computer Devices Corp., 6 W. 18th St., Huntington Station, N.Y. [375]

Pumping modules produce high vacuum

High-vacuum pumping modules, the SB series, are available in 4, 6 and 10-in. sizes. They can be quickly mounted on chambers used for research and testing in metallurgy, materials, electronics, and space simulation. Each module consists of a diffusion pump, slide



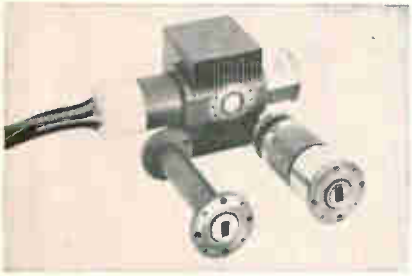
valve, baffle and manifold assembly. Net pumping speeds are 300 liters per sec for the 4-in., 600 liters per sec for the 6-in. and 1,500 liters per sec for the 10-in. units. Ultimate pressure capability is in the 10^{-8} torr range with guaranteed performance in the 10^{-7} torr range.
NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass. [376]



Pulse advance magazine for crt cameras

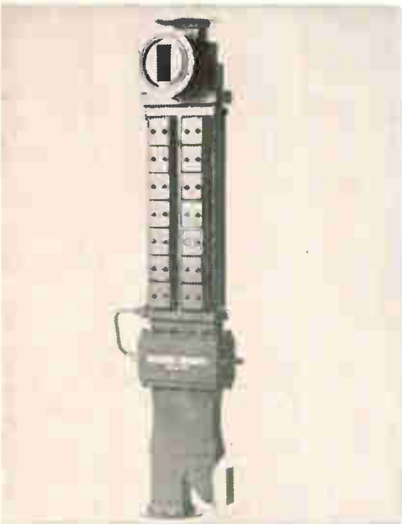
Model 3800P pulse advance Rapromatic magazine for film-processing oscilloscope camera systems, records data, processes film, and views results in 85 seconds. Its integrated design enables the user to convert the pulse type unit to a continuous film system by means of a new gear train conversion kit—model 3804. Model 3800P will completely develop and affix the film. It operates at a max speed of 12 frames per minute so that it is easily adjustable for ¾ in. or 1½-in. frame. Price is $2,200.
Analab Instrument Corp., 30 Canfield Road, Cedar Grove, N. J. [377]

New Microwave



Small and rugged reflex klystrons

Type F-2900 millimeter-wavelength reflex klystrons cover the 28-to-38-Gc range; they are fixed-tuned and deliver a minimum of 1 watt power output at the design frequency specified by the user. A 2% tuning range is available when the MT-80 mechanical tuner is acquired as an optional accessory. The electronic tuning range is 0.1%. The small size and rugged construction of these tubes make them suitable as test equipment primary signal sources, receiver local oscillators, parametric amplifier pumps, and low-power transmitters.
International Telephone and Telegraph Corp., 320 Park Ave., N.Y.C., N.Y. [391]



S-band duplexer achieves low losses

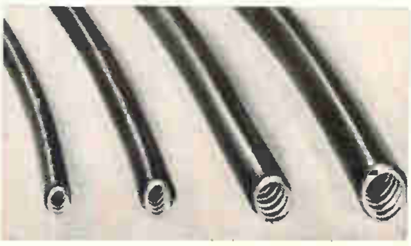
A compact circuit utilizing ferrite and gas tube technology to provide efficient duplexing at 6 Mw peak, 30 kw average in S band has been developed. The new circuit provides transmitter and receiver isolation with minimum losses and fast recovery time. The gas tube elements are replaceable in the field. The MA-3234 package is well-suited for the ultra-high powers being generated at S-band, and also in systems employing parametric amplifiers in the receiver. When used with low-loss, long-life gas-tube parametric amplifier protectors, the device offers complete duplexer reliability. Receiver isolation is 20 db at all times regardless of the antenna mismatch. Transmittal losses of 0.5 db and receiver losses of 0.2 db have been achieved over a 10% bandwidth.
Microwave Associates, Inc., Northwest Industrial Park, Burlington, Mass. [392]

Two-cavity oscillator operates at 13.3 Gc

Designed for doppler radar applications, the X1111 two-cavity oscillator operates at 13.3 Gc with a minimum output of 2 w. Its inherent amplitude stability and high-power output make it ideal for parametric amplifier pumping applications. Unit also has excellent temperature stability, low noise characteristics, and is built for use in severe environmental conditions.
Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, Calif. [393]

Flexible waveguides are pressure-tight

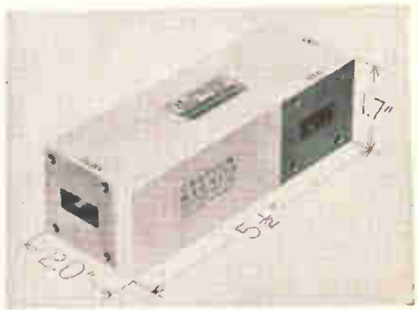
Flexible waveguides with elliptical cross section for the 4.4- to 8.6-Gc range are produced in long continuous lengths. Construction is high-conductivity copper, corrugated



New Microwave

and covered with a polyethylene jacket. The waveguides are pressure-tight and feature performance comparable with rigid rectangular systems. They simplify site layout and reduce installation costs for fixed or transportable systems. A selection of end fittings is available to adapt elliptical waveguide to standard rectangular waveguide flanges.

Andrew Corp., P.O. Box 807, Chicago, Ill. 60642. [394]



Compact duplexers operate in X band

Model X201LTI duplexer provides 60 db minimum isolation from antenna to receiver over the range of 8.5 to 9.6 Gc, has an 0.25 db max insertion loss from antenna to receiver and a max vswr of the transmitter port of 1.10. Unit measures 1.625 in. by 2.0 in. by 5.5 in. and weighs less than 2 lb.

E&M Laboratories, 7419 Greenbush Ave., N. Hollywood, Calif. [395]

Traveling-wave tube designed for 1.7 to 2.3 Gc

Type 7642 traveling-wave tube incorporates periodic-permanent-magnet focusing. It delivers 18 watts c-w power output in the 1.7 to 2.3-Gc communications band. This twt may be used as a driver tube for ground-based satellite telemetry transmitters and for tv studio-to-transmitter links. Variants of the 7642 are available for operation in the new 2.5 to 2.69-Gc educational tv band.

Radio Corporation of America, Harrison, N. J. [396]

New Production Equipment

Compact kit provides easy-to-build circuits

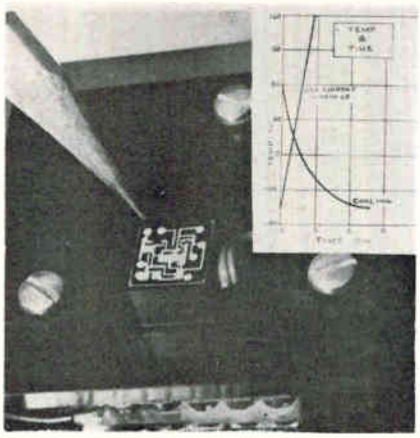
A new method of preparing prototype breadboard circuits for lab testing or for limited production circuitry has been developed. Called Proto Boards, the units are available in kit form and consist of (1) a silicon rubber base, soft to receive wire ends of components, impervious to solder, gridded for easy layout; (2) a plastic frame with either side or end (or no connectors) connectors which fit over the base after preliminary circuit is assembled; (3) a Proto-Poxy kit consisting of catalyst and resin in separate cans, a mixing paper cup and wooden stir rods; (4) Proto-Sketch sheets in pad form for preliminary layout of the circuit on gridded paper. The ease with which circuits are built with so few components is the significant design breakthrough. By eliminating the hundreds of tiny hardware parts, Proto Boards offer not only speed but labor saving costs.

The Vicon Instrument Co., 1353 Mesita Rd., Colorado Springs, Colo. [421]

Bonder mounts multiple components

A new precision machine rapidly bonds up to six different semiconductor components to headers or substrates under steady state conditions. The assembly equipment features six individual component trays; a single, thermostatically controlled heat column; a lazy-susan arrangement that speeds selection and transfer of components to the substrate; a high-accuracy micropositioner/optical train for natural, tension-free "feel" to component positioning; a dual gas system, one for tinning, one for bonding; a variable amplitude oscillator that imparts a horizontal scrubbing motion to the tool during bonding to speed eutectic formation. It is claimed that improved reliability of devices manufactured with this machine is assured because of the uniformity of control of all bonding conditions.

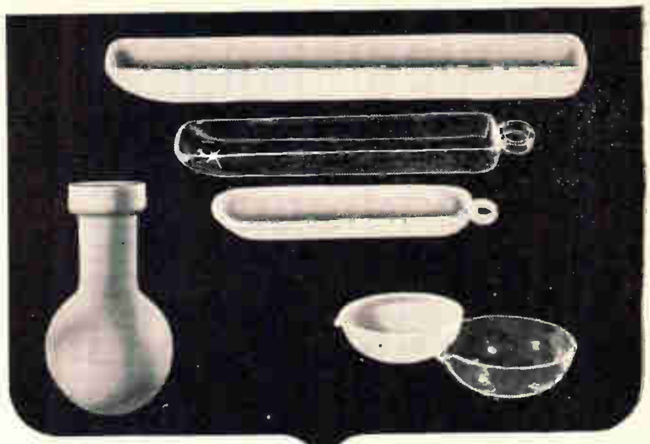
Kulicke and Soffa Mfg. Co., 135 Commerce Drive, Fort Washington, Pa. [422]



Thermal test block checks microcircuits

A new thermal test block for microcircuits is cooled and heated thermoelectrically. It can be adapted to small transistors, crystals and resistors. Unit will pull down to —70° F in less than 5 minutes, —80° F under slight vacuum-Bell Jar. By reversing polarity the unit heats to 225° F in less than 2 minutes. Block requires water cooling. Fin-fan cooling is available. Dimensions are 3½ by 3½ by 1 in., insulated. Model 600 can be used for thermal-life cycling, circuit parameter measurement as a function of temperature, and to check temperature coefficient of resistance.

Frigitronics, Inc., 525 Broad St., Bridgeport, Conn. 06604. [423]



New Materials

Metal strip makes cryogenic magnets

Cryotape, a material for making superconducting magnets, is composed of a niobium-tin core encased in a niobium sheath. It may be wound, unwound, and then rewound without damage to the material. It is ⅝ in. wide and 2½ mil thick, available in continuous lengths up to 1,000 ft. Cryotape is guaranteed to carry a minimum of 250 amp at zero field; 100 amp at 70 kilogauss field. It has been pulsed to 1 million gauss. Price is $3 per ft in quantities in excess of 1,000 ft; $4 per ft, less than 1,000 ft. Minimum order is $250.

Materials Research Corp., Orangeburg, N.Y. 10962. **[411]**

Epoxy resin retards flame

Dolphon CW-1070 is a flame retardant Class H epoxy supplied in a one-package, semi-solid form. Designed for use at elevated temperature (180 C), it has been developed for casting, potting and impregnating electrical equipment operating at high temperatures. CW-1070 meets all the requirements of MIL-T-27A, Grades T&U, provides superior high temperature resistance, excellent electrical properties, good mechanical strength, low shrinkage, and extreme flexibility. At 70° F, it has a pot life of at least six months.

John C. Dolph Co., Monmouth Junction, N.J. **[412]**

Chemical stripper removes wire coatings

Developed to aid electronic assembly work, a new chemical stripper, designated NY-OFF485, represents a one-step system for the removal of various nylon coatings from wire. Nylon-coated wire ends can be dipped in NY-OFF485 to easily wipe away unwanted coating prior to soldering or welding. Wire can be prepared rapidly without fear of damage to the base metal. The material packaged in ready-to-use form, sells for $5 a pint and $8 a quart.

Chemclean Corp., 128-07 Eighteenth Ave., College Point 56, N.Y. **[413]**

Silver tapes supply conductivity

Conductive silver transfer tapes introduce a new way to produce conductive lands, connections, or circuits on different substrates. This new dry process replaces the present wet application of silver paints and eliminates disadvantages such as irregular thickness, smearing, overflow of the silver layer and waste of expensive silver material. Conductive leads in any pattern or shape can be placed with great accuracy on a desired surface without the necessity of masking the surface not to be coated. The tapes, supplied in rolls, are available in any thickness value (generally between 0.0005 and 0.005 in.) and in any requested width up to $\frac{1}{32}$ to 8 in.)

Vitta Corp., 382 Danbury Park, Wilton, Conn. **[414]**

Molding compound for semiconductors

A thermosetting material, type 305 silicone molding compound, provides maximum electrical and environmental protection for diodes, transistors and power rectifiers. Semiconductor devices encapsulated in the transfer molding compound operate at a temperature range of −65° to 275° C for a minimum of 10,000 hours. The high flow material permits a high-speed molding cycle and low molding pressures of 150 to 1,000 psi. Even at 200° C, the material shows a dissipation factor of only 0.006 or less at a frequency of 10^5 cps, a low value compared with conventional molding compounds. Also, the compound protects device functions from severe mechanical shock, vibration and high g forces.

Dow Corning Corp., Midland, Michigan. **[415]**

New Literature

Converters and multiplexers Texas Instruments Inc., 3609 Buffalo Speedway, Houston, Texas, has announced a 12-page catalog on the series 8000 analog-to-digital converters and multiplexers.
Circle 451 reader service card

Components Cambridge Thermionic Corp., Cambridge, Mass. 02138, offers a completely revised full-time engineering design catalog of its more than 15,000 types of guaranteed Cambion electronic components. **[452]**

Precision instruments Rohde & Schwarz Sales Co., Inc., 111 Lexington Ave., Passaic, N. J. Catalog describes a precision capacitance meter, inductance meter and limit bridge. **[453]**

Pin and socket connectors AMP Inc., Harrisburg, Pa. offers a 48-page catalog on the complete line of AMP-Incert series M crimp, snap-in type pin and socket connectors. **[454]**

Stepping drum programmer Tenor Co., 13460 W. Silver Spring Drive, Butler, Wisc. Bulletin 0164 illustrates and describes a stepping drum programmer that provides a basic method for controlling load circuits in an interlocked predetermined sequence. **[455]**

Insulating products 3M Co., 2501 Hudson Road, St. Paul, Minn. 55119, offers a brochure containing data and samples of nine of its Class F insulating products. **[456]**

Scope accessories Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005, has prepared a 36-page booklet covering a family of accessories now available for oscilloscopes. Request copies on business letterhead.

Fluid amplifiers Electronic Devices Dept., Corning Glass Works, Bradford, Pa. Bulletin describes fluid amplifier applications, the usefulness and properties of photosensitive glass in making the devices, design and fabrication techniques, and details of several operating devices. **[457]**

Adjustable stop switches Daven Division of McGraw-Edison Co., Livingston, N. J. A 4-page brochure provides complete specifications and prices on 87 adjustable stop switches that now replace 2,001 standard types. **[458]**

Precision potentiometers Helipot Div. of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., has published data sheet 63560 for models 6103, 6213, and 6603 single-turn rotary cermet precision pots. **[459]**

Magnetic tape transport Digital Equipment Corp., 146 Main St., Maynard, Mass. Bulletin describes tape transport type 570, an electro-pneumatic device that is compatible with IBM 7291-VI format and has a maximum transfer rate of 62,000 six-bit characters per second. **[460]**

Communications technology Comtek Inc., 435 Main St., Woburn, Mass. Brochure discusses the company interest in, and facilities for undertaking development of a wide variety of electronic and electromechanical devices oriented to microwave concepts and indigenous to the field of communications technology. **[461]**

Semiconductor testing Semiconductor Specialists, Inc., 5700 W. North Ave., Chicago, Ill. 60639. Bulletin covers the transistor, capacitor, diode, Zener reliability testing and encapsulation services being offered. **[462]**

Miniature trimmer CTS Corp., 1142 W. Beardsley Ave., Elkhart, Ind. Data sheet 1201 covers the series 201 low-cost miniature knob-operated carbon trimmer variable resistor with wide resistance range. **[463]**

Telemetry ground station Defense Electronics, Inc., Rockville, Md. Bulletin UPTS-1 describes a self-sufficient telemetry ground station for reception and recording of satellite signals in the 398 to 402-Mc range. **[464]**

Voltage-current calibrators Computer Test Corp., Route 38 Longwood Ave., Cherry Hill, N.J. Bulletin No. 63-I presents data on models 1082/1085 voltage-current calibrators, instruments for amplitude analysis of a-c, pulse, or d-c signals from 1 mv to 200 v. **[465]**

R-f coaxial connectors General RF Fittings, Inc., 702 Beacon St., Boston, Mass. 02115, has issued an 8-page catalog describing series GM microminiature r-f coaxial connectors. **[466]**

Telemetry filters Kenyon Transformer Co., Inc., 1057 Summit Ave., Jersey City 7, N.J., has published an engineering monograph entitled "Optimizing Subminiature Subcarrier Telemetry Filters." **[467]**

Electronic components National Tel-Tronics Corp., 52 St. Casimir Ave., Yonkers, N.Y. Data contained in a 44 page catalog of electronic component parts are designed for use as a ready reference in purchasing and engineering. **[468]**

Facilities brochure Intellux Inc., 30 S. Salsipuedes St., Santa Barbara, Calif. Brochure illustrates and describes the company's products and facilities in the areas of: thin-film circuitry; flush, inlaid and multilayer printed circuitry; and electronic components. **[469]**

Color-coded lever switch The Capitol Machine and Switch Co., 36 Balmforth Ave., Danbury, Conn. Single-page bulletin describes and illustrates the HLL 3-position lever switch with color coded positions. **[470]**

Semiconductor test equipment Fairchild Semiconductor Instrumentation, 844 Charleston Road, Palo Alto, Calif. A brochure describes eight high-speed, high-volume testers designed to serve both semiconductor users and manufacturers. **[471]**

New Books

Pulse Circuits

Basic Pulse Circuits, by Richard Blitzer, McGraw-Hill Book Co., New York, 436 p, $11.75.

This book has two noteworthy features: it gives both vacuum-tube and transistor circuits for almost every type of pulse circuit covered, and describes the operation of both in minute detail.

Although written for the technician who wants to upgrade himself, the book is a useful reference for an engineer unfamiliar with pulse circuits, or who needs occasional brushing up.

The topics covered are mostly those included in the senior term of the electronic technician course taught at RCA Institutes, where the author has been an instructor for the past 16 years: networks, pulse amplifiers, linear and non-linear waveshaping, multivibrators, timebase oscillators and generators, binary and octal systems and electronic counters, gates, pulse-circuit applications, and transient analysis.

Stephen B. Gray

Lasers

Masers and lasers: How they work, what they do, by M. Brotherton, McGraw-Hill Book Company, New York, 1964, 207 p, $8.50.

An addition to the small but growing number of books on lasers, Dr. Brotherton's volume is written for the nonspecialist. It explains the basic principles of masers and lasers, gives the necessary technical background in nontechnical language, and tells the story of how these devices were discovered, developed and built, and what they may be used for.

The book develops the concept of energy levels and level transitions, then goes on to show how the first maser was built and why it could not have been built any other way. Successive chapters describe the next development—the ruby laser, the semiconductor junction laser, and finally the real and projected applications, with stress on communications.

This is not a book for the physicist, but it will give the engineer who is working in a more conventional field the necessary perspective for understanding and evaluating new laser and maser developments. The technical executive can derive from it the basic knowledge he will need when lasers and laser applications become commercial items. To the reader who has no professional interest whatsoever in lasers or in masers, Dr. Brotherton's well written book will tell a fascinating story of one of our time's most amazing inventions.

George V. Novotny

Space electronics

Appointment In The Sky: The Story of Project Gemini, by Sol Levine, with foreword by President Lyndon B. Johnson, Walker and Company, New York, 1964, 214 p, $5.

Although basically not a technical work, Sol Levine's book is useful in placing the U. S. and Soviet space programs in perspective. Billed as "the story of Project Gemini," the book does more to describe the motivation and mission profiles of the Mercury, Gemini and Apollo programs with pertinent details on the Vostok series added. The book is a result of the efforts of Martin Company's deputy technical director for Gemini to interpret the manned space program for the general public. While the purpose is to be commended, one cannot help but notice the large number of Martin Co. mentions throughout the book.

For the engineer who follows U. S. and Soviet developments, the author does quote Drew Pearson in giving names of three Soviet cosmonauts said to have perished in the early Soviet space efforts. He cites the cases of Cosmonauts Alexis Ledovsky and Terenty Shiborn who, in separate flights in 1957, were reportedly sent 200 miles into space and never recovered. In January, 1959, Andrei Mitkov's launch vehicle reportedly blew up on the launch pad 20 seconds after lift-off. It wasn't until April, 1961 that the Russians succeeding in sending Yuri Gagarin into orbit and recovering him.

The U. S. has had its moments,

too, the author points out. He illustrates this by describing the fish that got away—the Snark missile that ended up in the jungles of Brazil. Then there's the story of the V-2 fired from White Sands, New Mexico that got out of control and plowed into a cemetery just outside of Juarez, Mexico. Also discussed is the controversy over Astronaut Gordon Cooper's ability to see houses and railroad trains from his high orbital altitude. The question is raised as to whether he was seeing things or his vision was improved in orbit.

Appendices at the end of the book tabulate U.S. and Soviet space firsts, Gemini prime and subcontractors, results of manned flights and planetary data, and a glossary lists the latest in space technology and jargon. Two sections of photographs and artist's concepts complete the story in pictures.

Joel Strasser

Computers

Advances in Computers, Volume 4, edited by Franz L. Alt and Morris Rubinoff, Academic Press, New York and London, 312 p, $12.

Fourth in a series that covers computer advances from programing to microelectronics, this particular volume contains articles on formulation of data-processing problems for computers, all-magnetic circuits, computer education, digital fluid logic elements, and multiple computer systems. Although few readers would be interested in all the topics, this volume, like those which preceded it, is well suited to a company library.

The article on All-Magnetic Circuit Techniques, by David R. Bennion and Hewitt D. Crane of Stanford Research Institute, and on Digital Fluid Logic Elements, by H. H. Glaettli of International Business Machines Research Laboratory, Zurich, are probably of greatest interest to readers of this magazine. The article on computer education, by Howard E. Tompkins of the National Institutes of Health (now at the University of Maryland) makes interesting reading for anyone even remotely involved in the subject, and includes an extensive annotated bibliography.

Stephen B. Gray

Technical Abstracts

Alphanumeric display

The Matricon, an Alpha-Numeric Target Cathode Ray Symbol Tube,* R. Winfield, Sperry Gyroscope Co., Great Neck, L.I.

The Matricon is an electrical-output cathode-ray tube for generating alphanumeric symbol signals for television-type presentation in which they are combined with video-intensity modulation signals for simultaneous display.

Symbols are generated in the Matricon by an alphanumeric matric target that controls the incident electron beam from an electrostatic electron gun to a signal-collector element. The metallic elements comprising the target are individually controlled and selected for each symbol, permitting digital techniques for symbol selection. The entire target is used for each display and thus there is no magnification of beam position error between tube and display.

The resulting signals can be accurately timed and automatically controlled by standard computer techniques. They also have wide bandwidths for compatibility with nonstandard, high-resolution television displays.

Scan conversion

Scan Conversion as Applied to Manual Multichannel Tracking, John Cole and Ray Winfield, Sperry Gyroscope Co., Great Neck, L.I.

This paper describes a system that allows a single operator to keep several radar target displays continuously updated.

Each tracking channel has its own cathode-ray storage-tube scan converter to store the new scan information. The stored information is fed sequentially from each scan converter to a common television monitor displaying the radar return picture; each channel is fed in upon completion of data entry from the previous channel.

The system uses a one-gun magnetic storage tube with electrical output to minimize read-write registration errors, and has enough storage-time capacity to retain the written information even for the slowest practical antenna-scan periods. Old information is automatically erased when an operator enters the target-position error, which is done by a joy-stick-controlled target-hook marker.

Among the system's advantages are the nonfading, high-brightness, constant-intensity video and automatic target sequencing on a single display, leading to less operator fatigue and more efficient operation.

Presented at the Third National Symposium of the Society for Information Display, Feb. 24-28, San Diego, Calif.

Particle counter

Junction counters produced by ion implantation doping, F.W. Martin, W.J. King, S. Harrison, Ion Physics Corp., Burlington, Mass.

A solid-state silicon radiation counter has been developed for detecting and analyzing low-energy charged particles. Although nuclear spectroscopists have a choice of three other counters (diffused-junction, lithium-drift and surface barrier) for special purposes, the new counter covers the main characteristics of the three others and serves as a multipurpose device.

Implanting impurity-doping ions near the surface of a semiconductor offers a means of permanently creating a surface region of a given type of conductivity. This technique has been used to insert acceptor ions in a silicon lattice and to produce a surface region in a junction counter similar to that in a thin-diffused counter.

However, the concentration of acceptors as a function of depth below the surface can be altered from the usual profile obtained by diffusion. Dead layers can be thinner than in most diffused counters. The surface region may be regarded as one intermediate between that in a surface-barrier and a diffused-junction counter, in which the charge responsible for the formation of a junction has been implanted so close to the surface that many characteristics of a barrier are retained, but conduction in a direction parallel to the surface is by holes and electrons in a p-region below the surface oxide layer.

Using the implantation technique, large-area (122 mm^2) counters have been produced in 10,000 ohm-cm of silicon with resolutions as good as 50,000 electron volts at 40-volt bias. Dead layers and resolution of these counters are better than in typical diffused-junctions counters, and the resolution of these counters is better than typical barrier counters of the same size.

Present designs cannot compete with lithium-drift devices in depletion depth, but are useful for high-resolution spectroscopy.

Presented at ninth scintillation and semiconductor counter symposium sponsored by the IEEE, AEC and NBS, Feb. 26, 1964, Washington, D. C.

Decimal memory

Polycrystalline Ferroelectric Multiremanence Memory Elements,*
C.E. Land, G.W. Smith and I.D. McKinney, Sandia Laboratory, Albuquerque, New Mexico.

A new computer memory element stores data directly in decimal form. Memory devices used in nearly all modern computers now store information in binary form, using devices with only two stable states, such as magnetic cores. Thus, they can remember only two digits. In contrast, the new element can be made to have ten or stable states, thus allowing a computer using this memory to make its calculations directly in the more convenient decimal system.

The new memory element is made possible by the development of a technique for hot pressing piezo-electric ceramics. Several types of elements have been constructed using lead-zirconate-titanate ceramic materials. Information is stored in the element by applying a fixed number of voltage pulses of sufficient magnitude and duration to change the effective polarization of the material in small increments. The resulting stable polarization state may be detected by measuring the small-signal response of the element. One simple method of doing this is to switch the element into the tuned circuit of an oscillator. The resulting oscillator frequency corresponds to the information state of the element.

In addition to having many levels

of storage capacity, the new element is said to have three other important characteristics; the data can be read out nondestructively, little energy is required to switch from one state to another and little time is required to switch from one state to another.

In addition to computer applications, the new element is claimed to have important potential for use in f-m discriminators, tunable filters, voltage variable coupling transducers, ceramic transformers and stress or strain sensors.

Sealing components

New Composite Materials for Packaging Semiconductor Devices,* A.M. Huntress, Texas Instrument Incorporated, Attleboro, Mass.

Advances made in materials for packaging semiconductor devices are described. One new composite material for sealing metal-to-glass in the manufacture of eyelets and headers allows transistors to operate at three times the normal power level with no increase in junction temperature. The material consists of a layer of copper, clad on both sides with F-15 Alloy (iron-nickel-cobalt). Addition of the copper layer increases thermal conductivity to roughly 15 times that of solid F-15 Alloy, does not detract from basic requirements for a glass sealing material.

Another new material is a composite foil for weldable printed circuits. This weldable foil has high peel strength between the foil and epoxy-filled fiberglass substrate. In addition, with the composite material, the weld nugget is confined to the upper layers of the foil and helps prevent damage to the substrate. The three-layer foil has a thin top layer of nickel, an intermediate layer of steel and a thin bottom layer of aluminum. Each material has a specific function. The nickel provides a weldable surface, and has a low electrical resistivity which helps keep the welding current confined to the upper layer of the foil. It also alloys easily with conventional lead materials. The steel layer provides a thermal barrier. The aluminum layer provides high bond strength to an epoxy glass substrate. This particular setup is intended primarily for integrated circuits which have flat,

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gold-plated F-15 Alloy leads.

Frame parts of F-15 Alloy contain a stripe of aluminum metallurgically-bonded on each side, for integrated circuit packages. This composite material suggests the possibility of bonding the leads directly to the semiconductor device. The lead frame parts are turned out in continuous lengths. They are separated to serve as the integral connection from the semiconductor device to the external circuit in flat packaged circuits. Tips of the leads are clad in aluminum.

Sampling system

Simple Submicrosecond Transient Sampling Techniques,* D.N. Bray and H.J. Jensen, Sandia Corp., Livermore Laboratory, Livermore, Calif.

This technique is useful where the event to be observed occurs only once, or where reduction to a form for digital computer processing is required.

This sampling system is built about a transmission line that has 30 memory units, each consisting of 120 tunnel diodes in series, attached at intervals along the line. The unknown signal is applied and propagates down the line, where it is detected at one of the early memory units and a trigger pulse is generated or is supplied externally. The trigger pulse, which must have more amplitude than the maximum of the unknown signal, is applied at the opposite end of the line just before the unknown signal arrives and propagates in a direction opposite to the input. The memory stores the maximum negative potential seen during propagation of the two pulses. Thus, the peak value sensed is the amplitude of the trigger pulse minus the amplitude of the unknown pulse at the memory gate when the trigger pulse arrives, and the voltage recorded is the complement of the input.

The technique allows the reconstruction of an unknown pulse up to about one microsecond along from a series of samples taken as often as every 10 nanoseconds, with sample apertures of about 2 to 15 nanoseconds.

* Paper presented at International Convention of the IEEE, held in New York City, March 23-26, 1964.

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* These Advertisements appeared in the April 6, issue.

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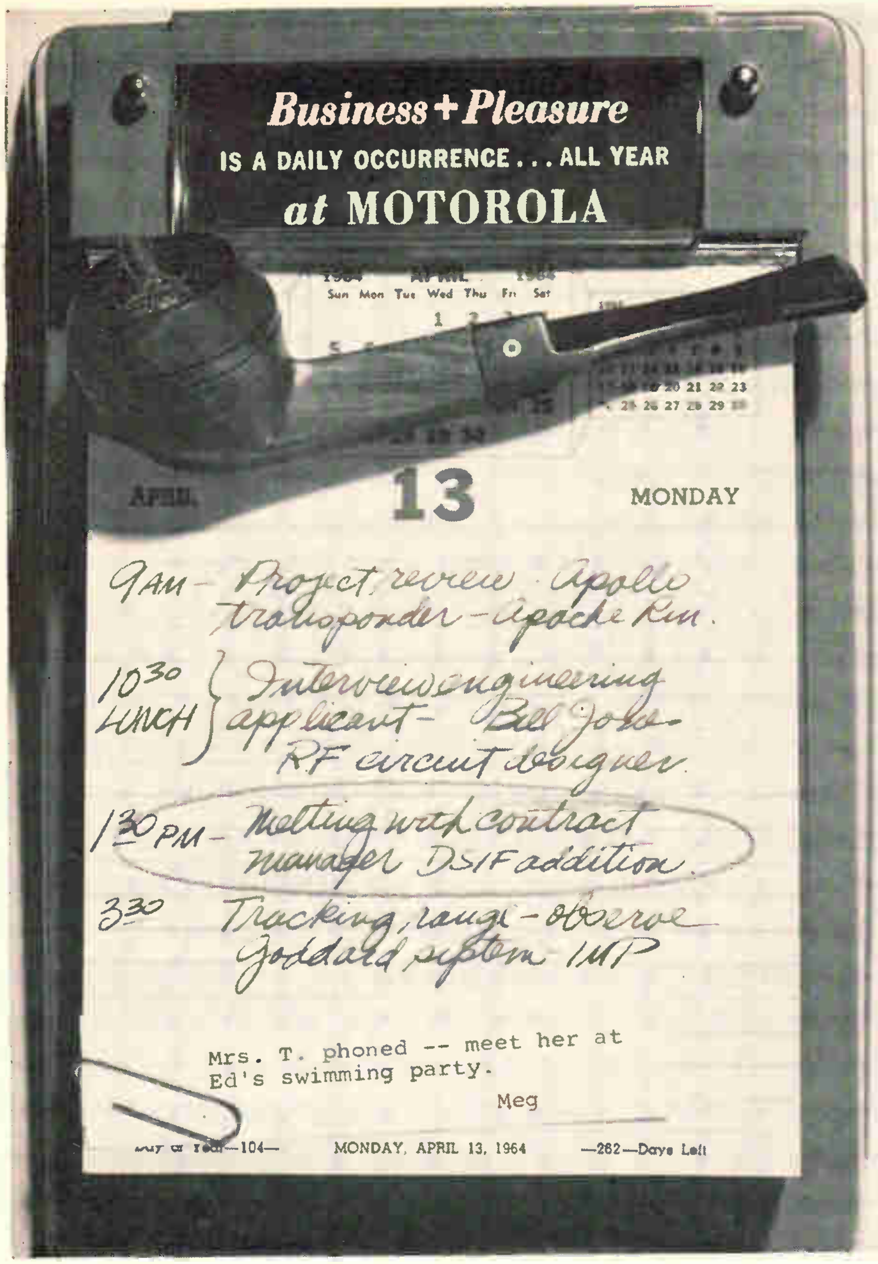

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