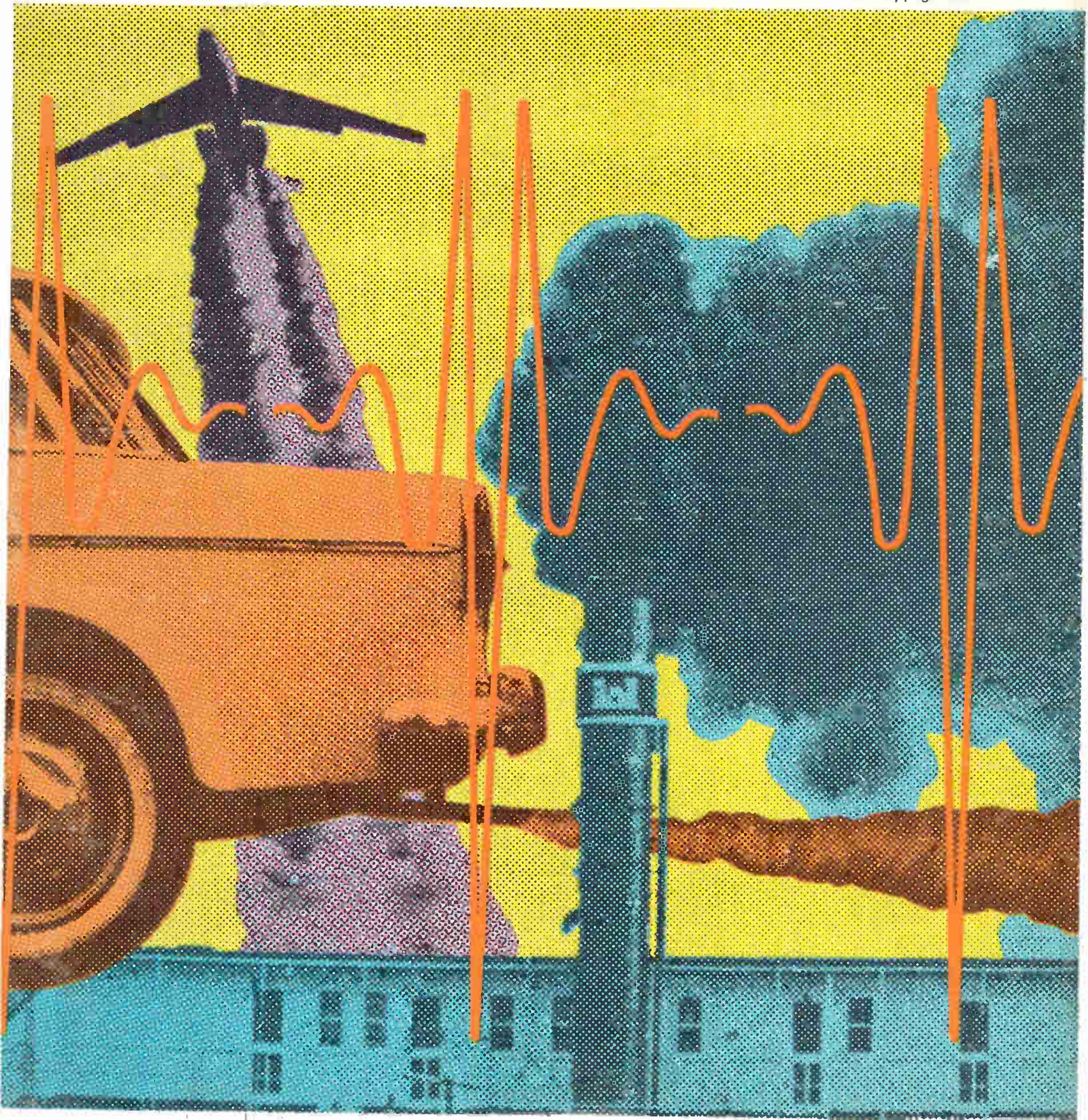
Electronics

Outlook for cylindrical film memories: page 124
Cutting costs in color tv cameras: page 134
Multiplexing with MOS switches: page 152

November 11, 1968
$1.00
A McGraw-Hill Publication

Below: Pollution analyzer scans the air, page 112



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UTC has over 500 audio types in stock, ready for immediate delivery. And UTC engineers are constantly adding to the line. Microwatts to kilowatts. Less than ¼ Hz to greater than 1 MHz. MIL-T-27 or industrial. Metal-encased or open frame. Input, output, mixing, matching, modulating, phase shifting, hybrid, baluns, ring modulators. All in continuous production for sample or high-volume requirements.

If the specific unit you need isn't on our shelf, we'll tailor a standard unit to your special requirements—saving the time and costs of starting from scratch. Check your local distributor for immediate off-the-shelf delivery. For catalog, write: United Transformer Company, Division of TRW INC., 150 Varick Street, New York, N.Y. 10013.

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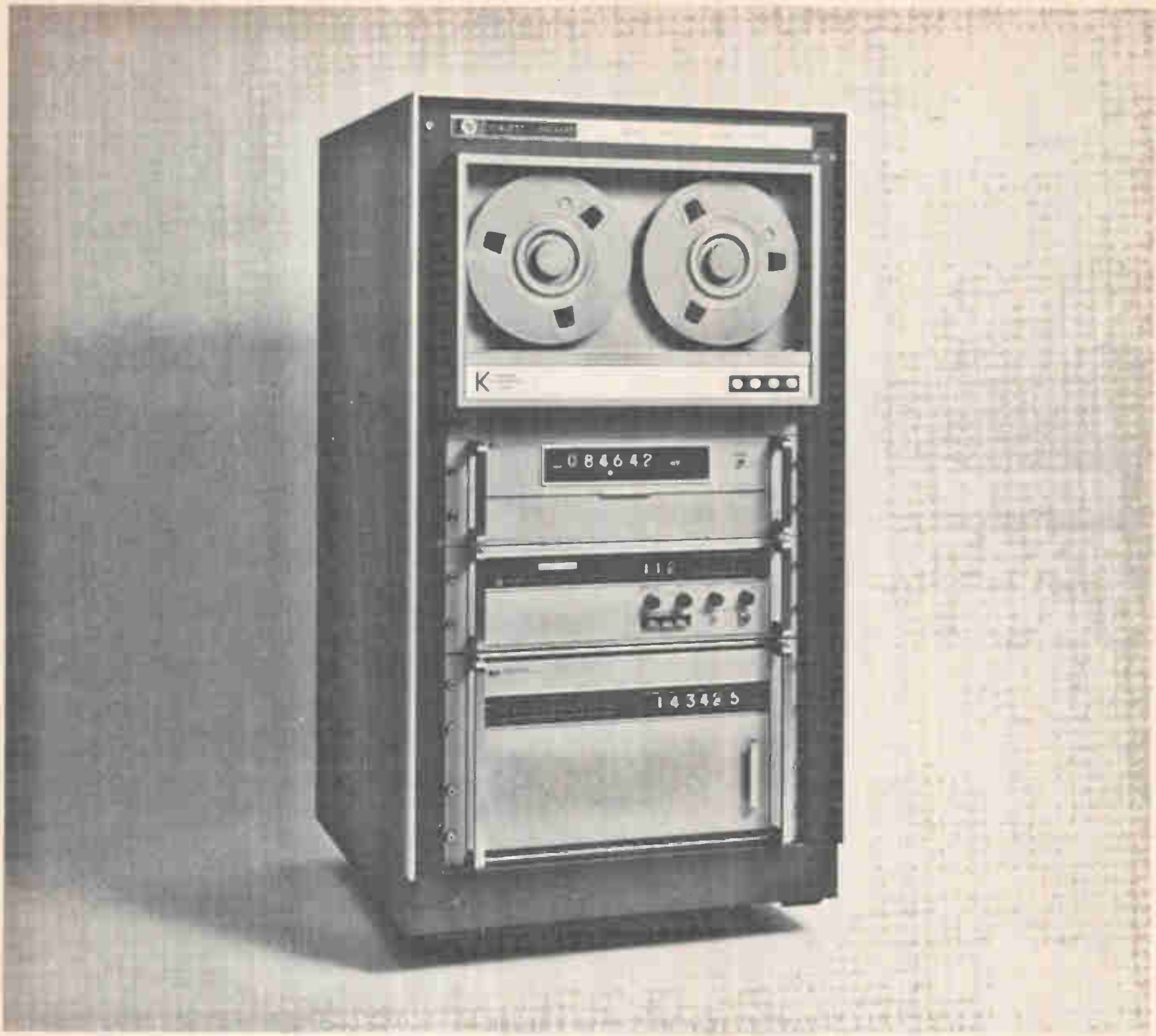
Circle 900 on reader service card



Speed Reader

HP's new 2012 series—the only data acquisition systems that can accurately measure noisy low-level signals at speeds to 40 channels per second. Quickly and easily expandable in input channel capacity, measurement capability and output recording devices with plug-in cards.

They're built around the 2402A Integrating Digital Voltmeter—a speedy quarterback that calls the signals—expands with plug-in cards from basic dc measurements to accept ac voltage, resistance, and frequency. The new 2912A—a reed scanner with built-in programming capability—expands from 10 to 1000 input channels in 10-channel increments. The 2547A—a new, versatile coupler that mates with a wide variety of output recorders—has clock and manual data-entry plug-in options.

Ask your HP field engineer about the versatility that comes with the fast HP 2012 Data Acquisition Systems. Or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

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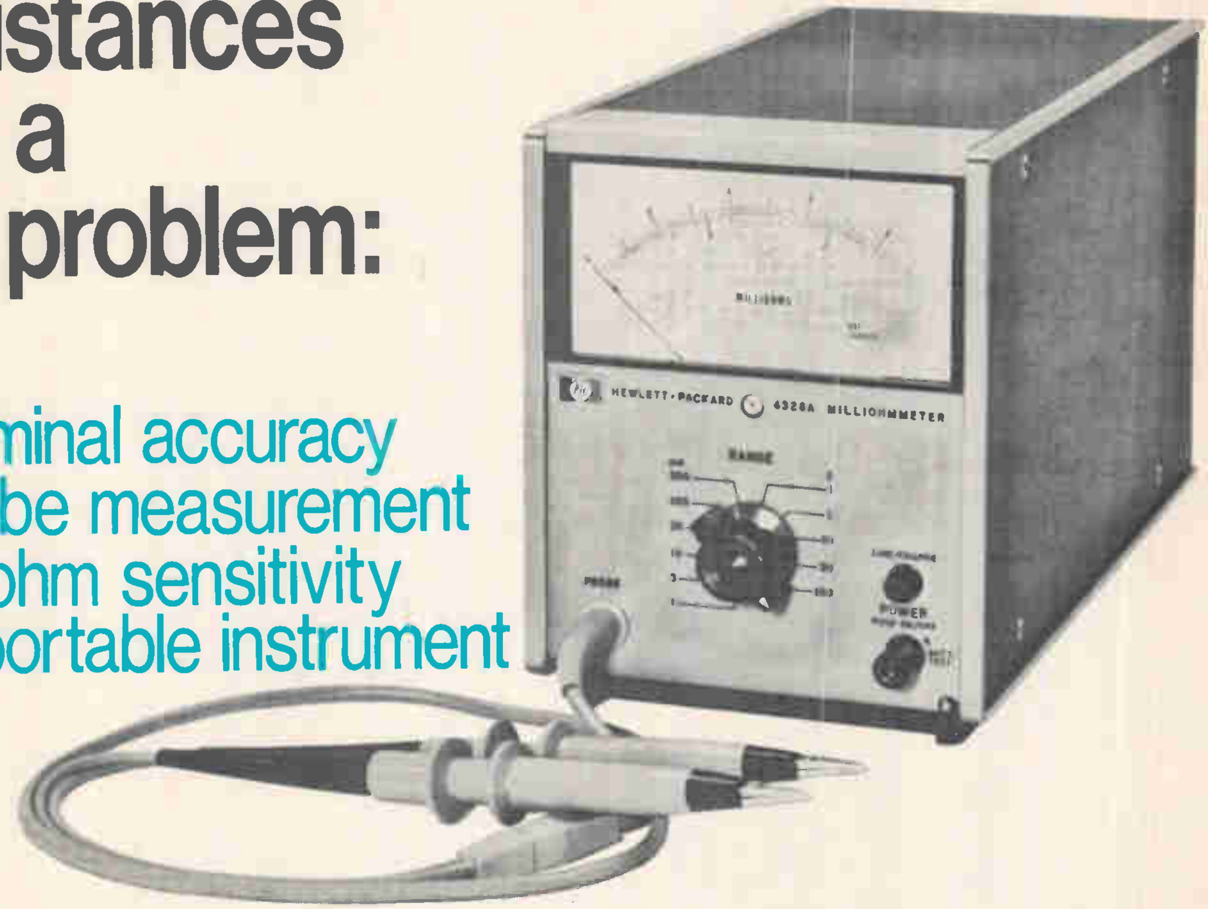
DATA ACQUISITION SYSTEMS

03813

Circle 1 on reader service card

Where small resistances are a big problem:

4 terminal accuracy
2 probe measurement
50 μohm sensitivity
in a portable instrument



The new Hewlett-Packard 4328A Milliohmmeter, with 50 μohm sensitivity, improves on 4-probe resistance measurements by incorporating both current and voltage drive in one probe. It provides this great sensitivity by using a Kelvin Bridge technique, combining an oscillator and a phase-sensitive voltmeter to offer today's most convenient measurement of extremely small resistances.

The 50 μohm sensitivity is excellent for measuring contact resistance of relays, switches and connectors; in trouble shooting to test the quality of grounds and other short-circuit phenomena; for making lead and end wire resistance measurements on pots.

Range of the 4328A is 100 ohms to 1 milliohm full scale in a 1, 3, 10 sequence. A built-in phase discriminator lets you make precise resistance measurements on samples with a series reactance up to *twice* full-scale resistance, a feature that makes the meter useful for magnetic core material measurments.

Applied voltage is limited to 20 millivolts RMS by special sensing circuits, regardless of the measurement range, and extra protection for sensitive devices is afforded by having the oscillator function *only* when a resistance is connected to the probes.

The 4328A Milliohmmeter, in addition to its 2-probe convenience, is fully portable . . . weighs only 7 lbs., is offered with an optional rechargeable battery. Price: $450 ($25 more for the battery option; fitted leatherette field case $15).

For more information call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

18712

Electronics

Volume 41, Number 23 November 11, 1968

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Electronics International

New Products

Technical Articles

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Readers Comment

Image makers

To the Editor:

With reference to Toshiba's ultrasonic acoustic image converter [Sept. 2, p. 169], I disagree with the statement that "Toshiba . . . will probably be the first to put one on the market."

James Electronics has produced and marketed an ultrasonic image converter since 1964. Our system was the first to be available commercially in a practical form for industrial nondestructive testing or laboratory research. It offers a 2-inch aperture at any frequency between 1 and 10 Mhz, compared to the Toshiba limitation of 1 inch.

The James system can also be supplied with acoustic phase sensitivity, presenting the phase information in color on a standard broadcast color television monitor. The color form of the image converter is sensitive to changes in acoustic impedance as small as 1 part in 10^8.

One of the most important applications for the ultrasonic image converter, apparently overlooked by Toshiba, is in acoustic holography, which offers the promise of removing many of the limitations inherent in use of the image converter to produce ultrasonic shadowgrams.

John DuBois
Director of engineering
Instrument Division
James Electronics Inc.
Chicago

Earlier work . . .

To the Editor:

In reference to your story on lasing plastic [Sept. 16, p. 55], our client, the Korad department of Union Carbide, reported the same thing more than a year ago. Korad physicist B.H. Soffer and B.B. McFarland, in the "Applied Physics Letters" of May 15, 1967, specifically reported lasing a solid sample of Rhodamine 6G in polymethylmethacrylate (i.e., plastic), as well as alcoholic solutions of Rhodamine 6G.

Related articles appeared in

Add Sprague Series 7400A to your prints for Series 74N TTL circuits. They're pin-for-pin identical.

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SN7402N	Quad 2-Input NOR	USN-7402A
SN7410N	Triple 3-Input NAND	USN-7410A
SN7420N	Dual 4-Input NAND	USN-7420A
SN7430N	Single 8-Input NAND	USN-7430A
SN7440N	Dual 4-Input NAND Buffer	USN-7440A
SN7450N	2-Wide 2-Input Expandable AND-OR-INVERT	USN-7450A
SN7451N	2-Wide 2-Input AND-OR-INVERT	USN-7451A
SN7453N	4-Wide 2-Input Expandable AND-OR-INVERT	USN-7453A
SN7454N	4-Wide 2-Input AND-OR-INVERT	USN-7454A
SN7460N	Dual 4-Input Expander	USN-7460A
SN7470N	D-C Clocked J-K Flip Flop	USN-7470A
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SN7473N	Single chip, pin 11 GND	USN-7473A
—	Single chip, pin 7 GND	USN-74107A
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SN7475N	Quadruple Bistable Latch	USN-7475B
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SN7482N	2-Bit Binary Adder	USN-7482A
SN7483N	4-Bit Binary Adder	USN-7483B
SN7490N	Decade Counter	USN-7490A
SN7491AN	8-Bit Shift Register	USN-7491A
SN7492N	Divide-By-Twelve Counter	USN-7492A
SN7493N	4-Bit Binary Counter	USN-7493A

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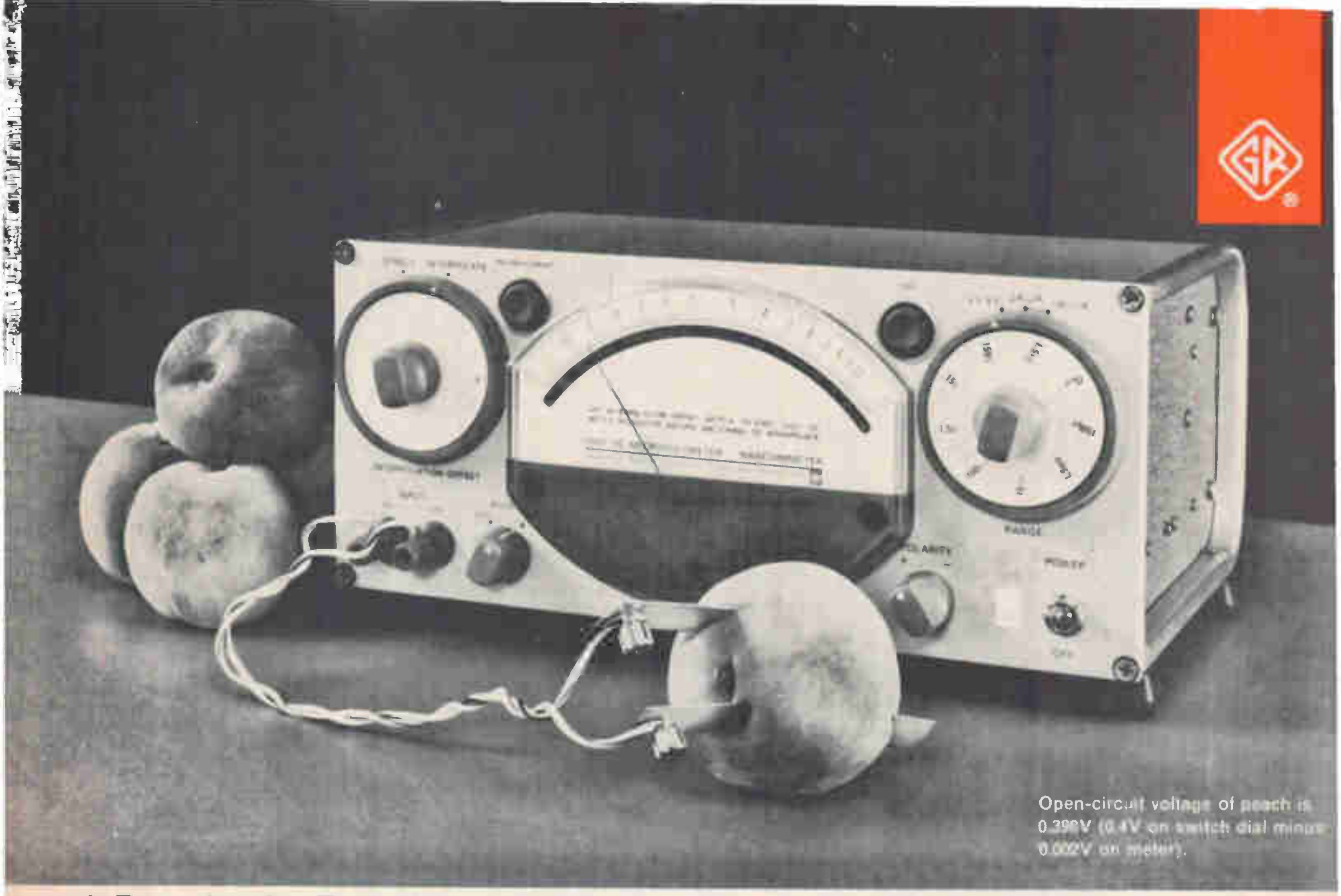


Open-circuit voltage of peach is 0.398V (0.4V on switch dial minus 0.002V on meter).

A Peach of a Reading, ±0.2%, at a Peach of a Price, $665.

Is a low-level dc voltmeter essential to your measurements work? You'd probably like one as accurate as the economies of your measurement allow. How about one that's ±0.2% accurate, measures below 1μV and costs only $665?

Need more than just a voltmeter? Besides being a microvoltmeter, the GR 1807 also is a nanoammeter, null detector, and differential voltmeter at the same ±0.2% accuracy . . . as a microvoltmeter the 1807 offers nine decade ranges from 15μV full scale to 1500V . . . as a nanoammeter, currents can be measured from 15 pA full-scale to 10 mA . . . as a null detector the 1807 has a common mode rejection of greater than 160 dB plus a 3-second recovery speed for overloads up to 1,000,000:1; and, used as a differential voltmeter, this 1807 offers accuracies 10 times better than conventional voltmeters You might say that the GR 1807 fills in the accuracy gap that's been created between analog and digital voltmeters.

What's the secret? Nothing really. By using differential techniques, the first one or two digits can be moved off the meter and put on a switch. This allows the meter to do just the fine work — the interpolating. You can do this by setting the interpolation-offset switch to subtract from the input a calibrated voltage equal to the most significant figure of the unknown, and then read the difference directly from a meter. Thus, the 1807 achieves digital accuracies but still preserves the versatility of an analog device.

Other features . . .

High input impedance, greater than 500MΩ on most ranges, eliminates practically all loading errors . . . The use of a photochopper modulator minimizes noise, drift, and offset problems . . . Excellent common-mode rejection is achieved by using Teflon throughout the 1807 to isolate high and low terminals from ground. The meter readout is also unique — it is logarithmic above 10% of full scale and linear below 10% of full scale. The meter zero is offset upscale by about 20° to permit easy reading around zero . . . D-C amplified output is provided to drive chart recorders . . . Problems arising from thermoelectric voltages generated by junctions of dissimilar metals have been eliminated by copper-to-copper junctions at all points in the input circuitry . . . a built-in switchable RC low-pass filter with a 1.5-Hz cut-off is provided to eliminate any ac hash that might be superimposed on the input dc signal . . . And, you have a choice of either battery or line-voltage operation.

For complete information, write General Radio Company, West Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH8034 Zurich 34, Switzerland.

GENERAL RADIO

Circle 6 on reader service card

Readers Comment

"Chemical & Engineering News" (June 19, 1967) and in "Laser Focus" (July 1967). The news stories included references to the lasing of a dime-store plastic triangle. (Actually, both the original Korad achievement and Bass and Deutsch's repetition involved lasing of the dye in the plastic, not the plastic itself.)

It is true, though, that the Electronics story emphasized the economy of plastic as a laser material, whereas Korad's emphasized the continuous tunability of organic dye lasers.

James B. Marine
Public relations director
Bowes Co.
Los Angeles

. . . on lasing plastic

To the Editor:

Concerning your description of the work of two Raytheon scientists on the laser properties of acrylic plastics containing Dayglow pigments [Sept. 16, p. 55], these pigments are dyes related to fluorescein.

In an Office of Naval Research project at the Polytechnic Institute of Brooklyn, A. Baczynski (now of the University of Torun, Poland) and I demonstrated in 1965 stimulated emission from polymethylmethacrylate rods containing fluorescein. The work was reported at an international symposium in Paris in June 1966 and is described by me (in English) in the January 1967 issue of the Journal de Chimie Physique.

We showed that the acrylic plastic must be produced in such a way as to remove strains. This apparently explains why the Raytheon workers failed with commercial plastic rods but had success with plastic sheets, the latter being of better quality because of their method of manufacture.

Gerald Oster
Department of Biochemistry
Mount Sinai School of Medicine
New York

Information please

To the Editor:

I would be interested in hearing from any of your readers who can supply historical or technical data about the mechanical-scanning tv receivers built by the Western Television Corp. of Chicago (circa 1930).

I am restoring one of these receivers and would also like to locate a "kino lamp" and other components used in these sets.

Ed Bukstein
Northwestern Electronics Institute
Minneapolis
Minn.

Readers' letters should be addressed:
To the Editor,
Electronics,
330 West 42nd Street, New York,
N.Y. 10036

Samelson

The growth of single crystals of II-VI compounds and the study of thin optical and electrical properties were Harold Samelson's primary interests up to 1961. Since then his field has been liquid lasers. Samelson, author of the article on liquid lasers on page 142, participated in the discovery and subsequent development of chelate lasers, and since 1966 has been engaged in research on inorganic liquid lasers based on aprotic solvents. He has been with the General Telephone & Electronics labs since 1956.

Copenhagen to Canada to California has been the itinerary of Per Mogensen's professional career. Coauthor of the article on metal oxide semiconductor multiplexer switches on page 152, Mogensen is a 1962 MSEE graduate of the Danish Technical University. He worked in Toronto before joining Fairchild in 1965. For Wallace Chan, the state of the art has been California. He holds a BSEE from the University of California at Berkeley and is working for an MSEE at San Jose State College. Chan, who joined Fairchild in 1967, is working on a six-channel multiplexed analog-to-digital converter on a single MOS chip.

Mogensen

Chan

Haines

Almost from the day he graduated from Syracuse University 15 years ago, Frederick J. Haines has been involved in the development of television cameras and studio systems for closed-circuit or broadcast applications. He credits General Electric, where he spent 10 year designing cameras and other tv broadcast equipment, for most of his training in the field.

Before joining International Video in 1967 as a project engineer, Haines, the author of the article on page 134, was engineering manager for video products at Granger Associates in Palo Alto, Calif. Before that, he was a project engineer at Sylvania Electric Products.

The successful meeting of East and West at Marquette University is evidenced by the article on Gunn devices on page 148. Japan's T. Koryu Ishii, a professor at Marquette, is currently working on millimeter-wave and microwave solid state systems. Stanley V. Jaskolski, another professor, is now conducting research on the high-field effect in various semiconductors. And Mohammed Al-Moufti, from Iraq, did research for his master's thesis on r-f transmission lines using bulk-effect devices.

Meier

Inventor and developer of the magnetic rod elements used in NCR's 315 RMC computer, Donal A. Meier, author of the article on page 128, holds nine U.S. patents and heads a research section at NCR that's working on LSI memories.

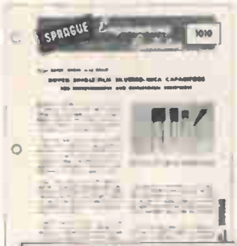
The author of the plated-wire survey on page 124, George Fedde heads Univac's data processing technology group. He has been at the firm for 12 years and holds an MSEE degree from MIT.

Joining Librascope in 1960, Richard Flores is now manager of the plated-wire memory department there. He's the author of the article on woven-wire memories on page 131.

A systems engineer by experience, Alan Bessen has been involved during the past few years in the expanding field of electro-optics. He has developed the infrared contamination detection system described on page 112, as well as an optical miss-distance indicator, and has major experience in inertial navigation and fire-control systems.

Bessen holds a BEE degree from Cooper Union, where he subsequently taught courses in physics, and an MSEE degree from Columbia. He joined the Ford Instrument division of Sperry Rand 15 years ago and is now an engineering project supervisor in the special-purpose computers department. He is a member of Tau Beta Pi and the IEEE.

Do you have this new capacitor data?



DIPPED MICAS . . . for entertainment and commercial equipment

Single-film silvered-mica capacitors cost less than stacked mica or ceramic types. These capacitors are rated at 300 WVDC and have good stability and retrace characteristics over their operating temperature range of -55C to +85C. Capacitance values from 10 to 360 pF, ±5% are available. Put this quality and performance into your next design. Ask for Engineering Bulletin 1010.

CIRCLE READER SERVICE NUMBER 220

SPARK GAPS . . . for TV tube protection

Sprague spark gaps suppress transient voltage surges and protect your expensive picture tube and allied circuitry. They are available in 1.5 kV and 2.5 kV ratings, and have a maximum capacitance of 0.75pF, providing an economical means of safely bypassing transient overvoltages. All Sprague spark gaps are 100% tested to insure your circuitry. Use them to protect your picture tube warranty. Ask for Engineering Bulletin 6145A.

CIRCLE READER SERVICE NUMBER 221

DISC CERAMICS . . . for general, temperature-compensating, and low-voltage applications in industrial, commercial, and consumer equipment

Cera-mite® general application discs for bypass and coupling at low cost. Nine disc sizes from .300 to .875 inches have 100, 250, 500, and 1000 WVDC ratings, in standard or temperature-stable formulations. Dual-section discs have up to .022μF @ 1000 V. Ask for Engineering Bulletin 6101D.

CIRCLE READER SERVICE NUMBER 222

Cera-mite temperature-compensating discs for controlled capacitance change with temperature in R-F oscillators, precision amplifiers, timing circuits, other critical applications. Select from ten linear temperature coefficients from NPO to N2200. Capacitance values from 1 to 2200 pF with 1000 WVDC ratings are available, plus popular values at 3000, 4000, and 5000 WVDC for TV yoke circuits. Minified units in 250 WVDC ratings may be obtained with capacitance values ranging from 22 to 990 pF. Ask for Engineering Bulletin 6102B.

CIRCLE READER SERVICE NUMBER 223

Hypercon® ultra-high capacitance discs for low-voltage circuits. Replace electrolytics with non-polar Hypercon capacitors only a fraction as large. The 2.2μF, 3 volt disc has a diameter of .875 inches; the 0.1μF, 25 volt unit measures .750 inches. Ask for Engineering Bulletin 6141F.

CIRCLE READER SERVICE NUMBER 224

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COMPONENT CAPSULES

New 3 amp hermetic A15 replaces costlier rectifier diodes

GE now offers a higher rated companion to its field-proved, 1 amp A14 rectifier at a significantly lower cost than other stud or lead mounted units (depending upon configuration). The A15 is rated 3 amps at 70°C and the 200 to 800 volt models are transient voltage protected up to 1000 W for 20 μS in reverse direction.

A15's dual heat sink design means low thermal impedance. Easy adaptation of axial leads to PC boards reduces installation cost below stud mounted units.

Both the A15/A14 are hermetically sealed in an all-diffused, glass passivated junction structure. No internal cavity means more resistance to environmental stresses . . . thus increased reliability.

High-power A15 is now available through GE distributors for applications including power supplies, battery chargers, TV damper diodes, communication equipment and small portable appliances. Circle **Number 231.**

Microwave Circuit Modules reduce design cycles and improve system performance

While producing lower overall costs, these design benefits result from:

- Optimum integration of active devices in package form
- Over two decades of microwave circuit development
- The industry's most advanced tube technology

MCM's used as: oscillators, amplifiers, multipliers, detectors, mixers, etc. Available in a variety of individually designed configurations.

Compare MCM features:

- Stable frequency performance in severe adverse environments
- Small size and lightweights—as low as 1 cubic inch and 2 ounces with high power to volume ratio
- Fast warm-up—3 seconds or less capability
- High performance from a single active device

GE is your one source for full R&D backup, critical testing experience and facilities and an unequalled output of highest performance active components including coaxial and planar gridded tubes. Circle **Number 232.**

New benefits from GE's hermetically sealed reed relays

Glass to metal seals and steel housing now provide true hermetic enclosure for reed relays. The GE 3SBN reed relay has:

- Increased sensitivity
- Immunity to magnetic interference effect
- Very low thermal emf's in contact circuits
- Protection of contact capsules and coils, because of rugged construction
- A lower weight than plastic encapsulation

This new relay comes in Form A, 1–6 poles and Form C, 1–5 poles and is only 0.350 inches high. The relay is available in a wide range of system voltages and is ideally suited for printed circuit board applications.

For more information Circle **Number 233.**

New low-cost miniature indicating lights ideal for limited space applications

GE's new, low-cost CR-103HE indicating lights are only $1\frac{11}{16}$ inches long and mount with a speed nut in a ¾ inch diameter hole — perfect for applications where space is at a premium.

Flush and cylindrical lens types are available. The cylindrical lens protrudes only ¼ inch, and is ultrasonically welded for maximum strength. Both are available in four lens colors: clear, amber, red and white. Four body colors are available: gray, white, beige and black.

The standard light has a 6 inch lead stripped ½ inch, but special lengths are available. Leads are staked into the body of the unit to insure that no movement takes place inside the light.

The CR103HE is UL listed for 120V, 240V, and 460V, and is ideally suited for applications where visual display and appearance is important. For more information Circle **Number 234.**

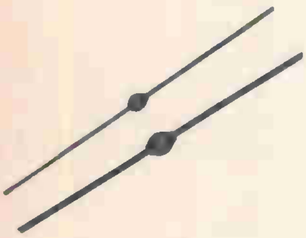
GE computer-grade capacitors offer over ½ farad at 5 volts

New GE 86F500 High-Capacitance computer-grade capacitors now provide up to 540,000 μf at five volts (34,000 μf at 100 volts) in a single case.

These enlarged-capacity units are excellent choices where large blocks of capacitance are required—as in power supply filters, for example. 86F500 units are rated for continuous operation at 65C or at 85C with proper voltage derating.

GE's new computer-grade capacitors provide highest capacitance per case size, high ripple current capability, low ESR, long shelf and operating life.

Units are available in nine case sizes—diameters $1\frac{3}{8}$" to 3", with lengths up to $8\frac{5}{8}$"—for operation up to 100 VDC. Circle Number 235 on your reader service card.



Microwave Circuit Modules (MCM)

New 3S BN

CR103HE

86F500's

A TECHNICAL DIGEST FOR INNOVATORS OF ELECTRONIC EQUIPMENT

Versatile GE meter relays are ideal for hundreds of applications

Including: temperature control, equipment overload protection, "go—no go" production line testing, and alarm sounding for a pre-selected value.

Accurate, repeatable control action over the entire scale is possible because there are no contacts on the unit's indicating pointer to cause mechanical interference. All units feature automatic ON-OFF reset control action. They easily adopt to manual reset.

No amplifier necessary. The unit's solid-state switch is connected in series with the coil of the load relay which operates it directly. Standard 120-volt a-c operation means no special power supply is needed.

The unit's "piggyback" control plug-in module design saves installation time, and eliminates the need for separate mounting.

For complete information about this meter relay and GE's full line of panel meters Circle **Number 236.**

Big Look® Meter Relay

Computer tape reel drives—one of many applications for these motors

The excellent commutating ability, fast response, and long insulation life of GE $3\frac{13}{16}$, $4\frac{5}{8}$, and $6\frac{5}{16}$ diameter fhp motors meet computer tape reel demands for continuous duty, low maintenance, and reliability. And, applications don't end here.

Stall torque ratings from 3 to 120 ounce-feet and higher and various motor voltages span many application needs. This means these d-c motors can be custom tailored for almost all peripheral equipment needs.

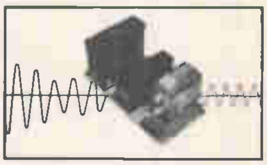
Special mounting flanges, brake mounting arrangements on the commutator end, and shaft extensions can be furnished to your requirements. Also available: cooling air duct inlets at convenient locations. For more data, Circle **Number 237.**

D-C Reel Drive Motor

Here's your key to low cost voltage stabilization

Every GE voltage stabilizer supplies constant output voltage to within ±1%, even with input fluctuations up to 15%. For special economy, core-and-coil units provide the lowest cost voltage regulation obtainable. They help meet tight space requirements, make wiring connections easier, and provide all the mounting flexibility you can ask for.

Voltage stabilizers are available in rating from 15 to 15000 volt-amperes in both standard and custom-designed models. Ask your GE sales engineer for publication GEA-7376 or circle magazine inquiry card **Number 238** for details.



AC Voltage Stabilizer

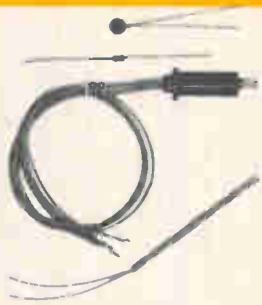
Fill your needs for sensitive temperature control with GE thermistors

Want extreme sensitivity to relatively minute temperature changes? You get it with GE thermistors (temperature-sensitive resistors). These devices also have temperature-compensating capability.

High sensitivity and small size make GE thermistors ideal sensors for SCR and transistorized controllers.

Operation over a wide temperature range permits thermistors to compensate the combined effects of copper windings and temperature-sensitive electromagnetic core materials.

GE thermistors are available as elements or in a wide variety of probe assemblies to suit your applications. Circle **Number 239** for more facts.

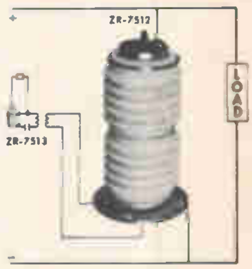


New circuitry combines TVG's in pairs for easy HV crowbarring

New developments in firing circuitry now make it convenient to crowbar high-voltage power supplies by utilizing GE's companion Triggered Vacuum Gaps in tandem.

And what's more—attaché-case size sensing and firing circuitry is now possible. A unique pulse transformer allows fault sensing at ground potential, even where the TVG trigger is at high negative voltage.

Use General Electric's ZR-7512/13 TVG combination shown in the sketch for protection at 45-KV, or other combinations covering from 300 volts to over 75 KV. For more information Circle **Number 240.**



FOR THE NEW IDEAS IN ELECTRONICS, look to General Electric—your best single source for electronic components.

ELECTRONIC COMPONENTS SALES OPERATION

GENERAL ELECTRIC

285-44

I'm Edson deCastro, President of Data General. Seven months ago we started the richest new small computer company in history.

This month we're announcing our first product: the best small computer in the world.

Data General wasn't started on a shoestring.

My associates and I had been with a company where we developed the most successful line of small computers in the business. And we knew the only way to go was big. Right from the beginning.

So we got the financing to be big. To build a plant that'll knock out these computers by the hundreds. To develop a large enough technical service organization to really support our customers.

And we designed a revolutionary computer. The NOVA.

Other small general purpose computers are built around an obsolete architecture based on an old technology. NOVA is built around medium scale integration. It's the first with multi-accumulator/index register organization. The first with read-only memory you can program the same way you do core. The first low cost machine that allows you to expand memory or build interfaces within the basic configuration.

One more thing. The price with a 4096 16-bit word memory and Teletype interface is only $7950. And we're offering the best discounts in the business.

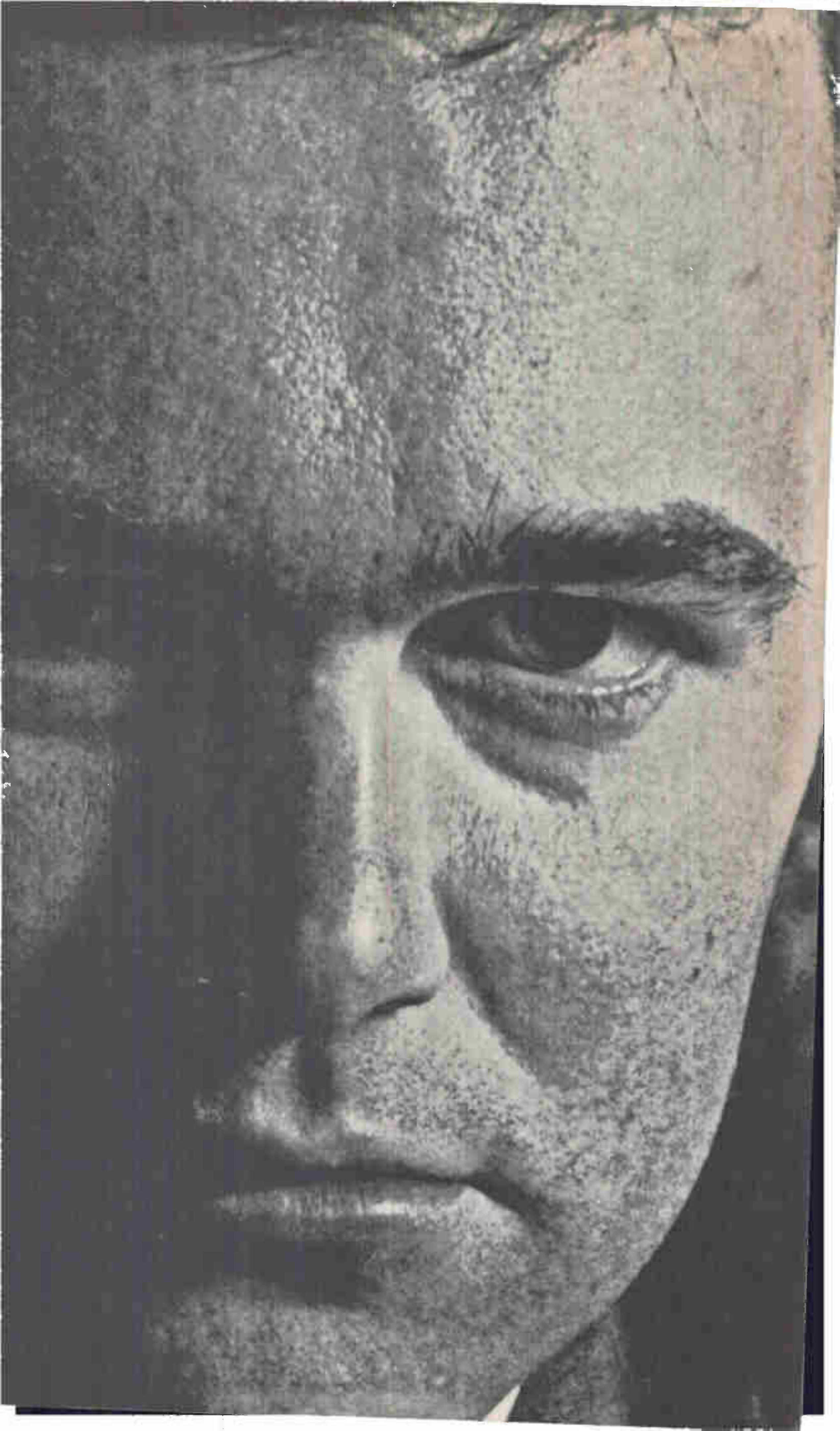
Because if you make a small inexpensive computer, you have to sell a lot to make a lot of money. And we intend to make a lot of money.

DATA GENERAL CORPORATION

275 Cox Street, Hudson, Mass. 01749

Specifications: NOVA is a 16-bit word general purpose computer. It has four accumulators, two of which may be used as index registers. It offers a choice of core or read-only memory of 1K, 2K, 4K, 8K, and up to 32K 16-bit words (or twice that many 8-bit bytes). NOVA comes in the desk top console shown here or a 5¼" tall standard rack mount package. Both the desk and rack versions can hold up to 20K 16-bit words of memory or interface for a large number of peripheral devices. NOVA has the most flexible I/O facility ever built into a machine of its class. It will include a high-speed Data Channel and automatic interrupt source identification as standard equipment. Write for more information today. Or see us at the Fall Joint Computer Conference on Wednesday.

Circle 12 on reader service card



Cox

The appointment of Marshall G. Cox as marketing director of the Components division of the Raytheon Co. signals an entirely new direction for the division's Semiconductor operation. Cox, 33, comes to Raytheon from Fairchild Semiconductor, where he was in charge of computer marketing, Fairchild's biggest sales target. Raytheon has been known as a "hi-rel" military house, specializing in low-quantity, high-price, and high-reliability orders. No more.

Electronic data processing, Cox says, will account for 45% of integrated-circuit sales by 1971. If Raytheon is to grow, it will have to enter the volume fields; the hiring of Cox was one step of division manager Nevin Kather's plan for such entry. "The plan in 1968 was to add to our revenue by concentrating on existing markets," Kather says. "Now we have to diversify our customer base." Adds Cox: "By the end of 1969 we will have penetrated the commercial market with both proprietary and second-source products."

Faster TTL. The specific areas where Raytheon wants to compete are transistor-transistor logic, semiconductor memories, linear circuits, and—somewhat downstream—sub-nanosecond emitter-coupled logic in complex medium-scale integration.

Raytheon already second-so
Sylvania in both SUHL 1 and
2, the brand of TTL with the
est performance ratings. But i
also offer, by the end of the
eight complex circuits in the p
lar Texas Instruments series
74, and will introduce a whole
(25 elements) of its own TTL
This proprietary TTL, now g
under the house name of R
will have propagation times o
der 4 nanoseconds—less than
thirds the typical rating of SU
It will be pin-compatible and
trically compatible with SUHL
really super-SUHL," Cox says
a grin.), but with a single ma
change it can be made compa
with the series 54/74 as
Moreover, the power dissip
will be the same as SUHL's.

"We have made a formal ma
ing study and found many ma
of small- and medium-sized
puters who want superfast
for the central processing
peripheral equipment, and
terminals," Cox says. The new
will be out early next year.

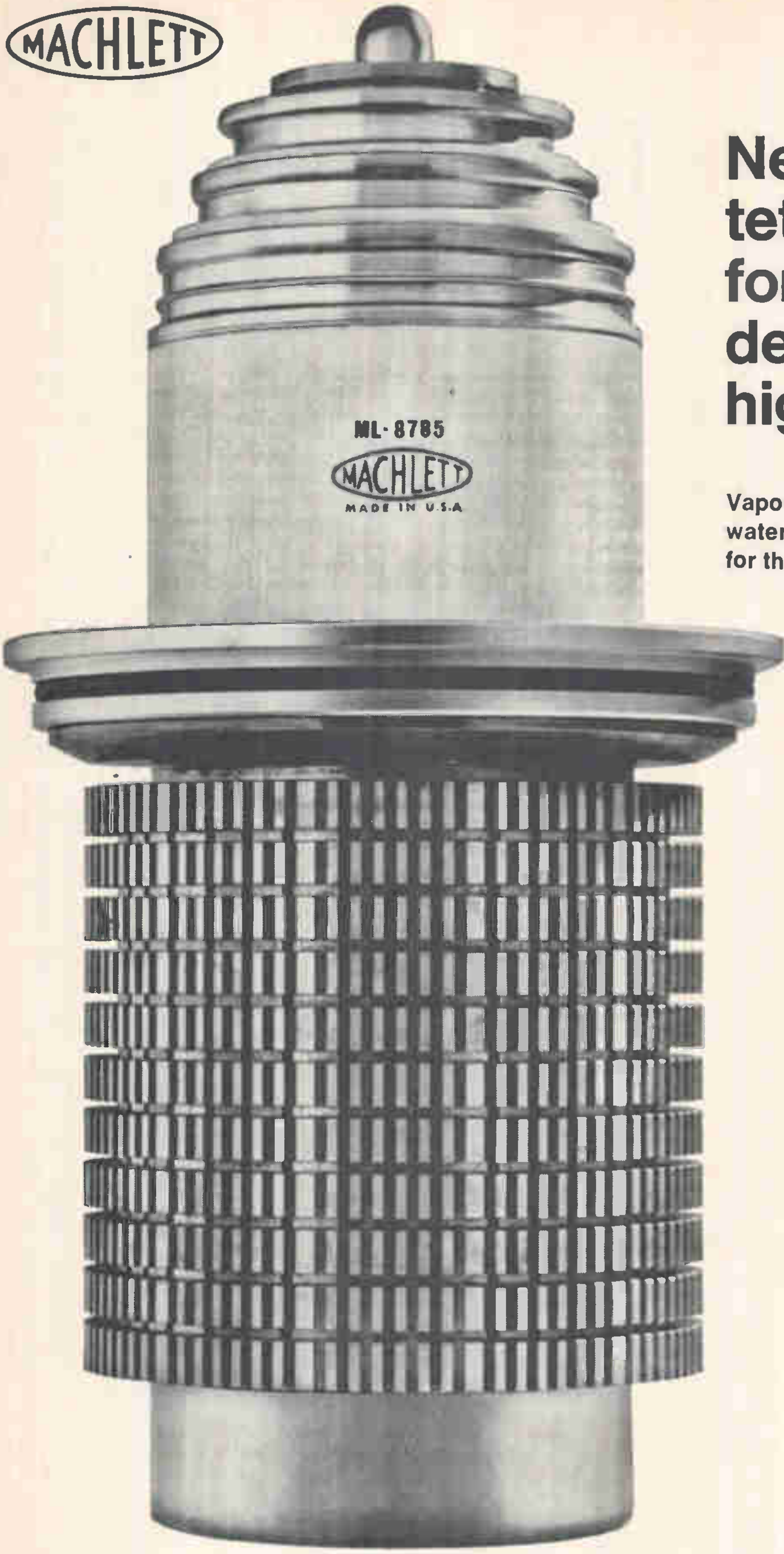
All in plastic. In memories,
theon will first aim at the scr
pad market. The company ha
ready announced a 16-bit scr
pad, and it will have a 6
device in the first quarter of
year and a 256-bit beam-le
chip in the second quarter. C
plans are for hybrid packages
from four to eight beam-lead c

It will be hard to compete in
mories in the future without a n
oxide semiconductor line,
Raytheon sold its MOS operatio
Hughes last year. But, says Ka
"we will be back in MOS by 1
or whenever it's necessary."

In linears, Raytheon now sec
sources Fairchild's 709 and
operational amplifiers and
tional Semiconductor's LM101
amp, and makes its own fully c
pensated version of the 101
plans to introduce an impr
version of the 741, a fully com
sated circuit.

To underline the complete
of Raytheon's change, Cox n
that the company will offer e
circuit in a plastic package by

MACHLETT



New Machlett tetrode... for single tube design at high power levels

Vapor-cooled ML-8785 (or ML-8786, water-cooled) is particularly suitable for these applications:

High Power Communications

Class C Telegraphy...to 350 kW

Linear RF Power Amplification

Class AB—Suppressed Carrier Service to 260 kW PEP

Pulse Modulation or Amplification

40 kV	DC Plate Voltage
50 kv	Peak Plate Voltage
500 a	Pulse Cathode Current
1000 μs	Pulse Duration
.01	Duty

Pulse Power to 15 Mw

Write today for details on these versatile "single-tube-design" tetrodes. The Machlett Laboratories, Inc., 1063 Hope Street, Stamford, Conn. 06907.

RAYTHEON

THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

Circle 15 on reader service card

end of the first quarter of 1969.

All of these plans, of course, will require increased production capacity, and the Semiconductor operation is now investigating foreign assembly facilities; its present plants are in Paso Robles, Calif., and Mexicali, Mexico.

If ever there existed an organization that depended on digital data—in fact, whose very lifeblood is real-time, transaction-oriented information—it's the New York Stock Exchange. In the single-minded world at the southern tip of Manhattan that is the financial district, anything that promises to increase the efficiency with which that data is delivered gets as warm a welcome as the latest hot issue.

The exchange now has a new man in charge of promoting efficiency: Robert B. Grant, vice president and director of the Electronic System Center. The 46-year-old Grant, who came to Wall Street in August from the Celanese Corp., is responsible for the exchange's computer activities and for devising new data-handling methods.

Over the horizon. It's in the latter area that the cigar-smoking Grant has his work cut out for him. "We have more to do in the long-range planning area. We have to plan for tomorrow and, equally important, beyond tomorrow—so that when we get to tomorrow we know where we're going from there."

But Grant hasn't turned his back on hardware problems. He can't, because the exchange's problems are unique. Not only does it have an unusually large number of real-time requirements, but its computers must have a level of data integrity that off-the-shelf hardware simply doesn't provide. Custom modifications must be made.

"We also must have multiprocess redundancy," explains Grant, "in which one machine monitors the other, spots degradation, and calls in other equipment or itself—a kind of shoulder-tapping operation. The hard truth is that we simply cannot tolerate more than 15 seconds of down time."

new 4 WAY INDUSTRIAL CERMETS

MODEL 3059

...*with* BOURNS *Reliability Sealed in!*

"4-way" means our new industrial Model 3059 is available in two printed circuit pin configurations of MIL-R-22097 (RJ-11 and RJ-12), as well as solder lugs and stranded insulated leads.

It was designed that way because as the newest member of the growing line of Bourns cermet potentiometers, it must — like every Bourns product — offer more by design and deliver more by performance.

The Model 3059 has a maximum temperature coefficient of 150 ppm/°C for all resistances; a power rating of 1.0 watt at 70°C, and an operating temperature range of −55 to +150°C. In addition, each unit is individually inspected for performance to guaranteed electrical and physical charcteristics.

Complete technical data on the new industrial cermet Model 3059 potentiometer is available from the factory or your local Bourns field representative.


Actual Size

SPECIFICATION TABLE

Standard Resistance Range	10 ohms to 1 megohm
Resistance Tolerance	±10%
Power Rating	1.0 watt
Operating Temperature Range	−55 to +150°C
Temperature Coefficient	±150 ppm/°C maximum*
Seal	Mil-Spec immersion
Terminals	RJ-11 and RJ-12 Printed Circuit Pins, also Solder Lugs and Stranded Insulated Wires.

*100 ppm/°C available

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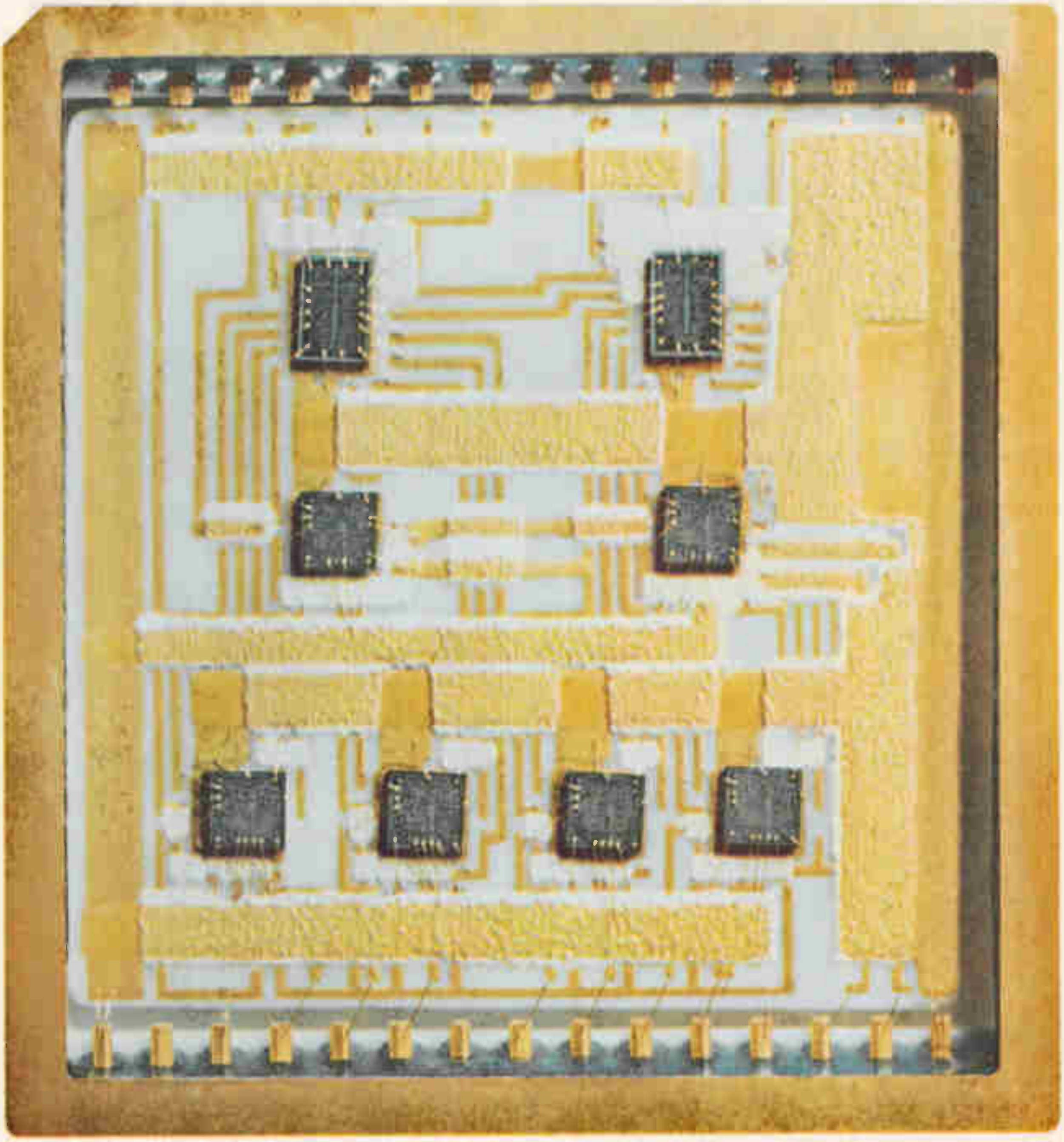
Fairchild can make more hybrids in



an hour than you can use in a month.

We can make any hybrid, in any quantity, using any method: Thick film. Thin film. Thin film on silicon.

We can make them faster than anyone in the industry. And deliver them quicker to anyone in the world.

We'll take any functions you need and package them any way you want. Our list of hybrid components has everything from a simple diode to a complex LSI array.

For your less complex applications, we have a line of off-the-shelf standard hybrids priced like discretes.

If this commitment makes sense in general, we'd like to send you the whole story in detail. Our brochure is called Fairchild Hybrid Microcircuits. It can give you more ideas in an hour than you could use in a year. Write for it.

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Circle 19 on reader service card

MAGNETICS

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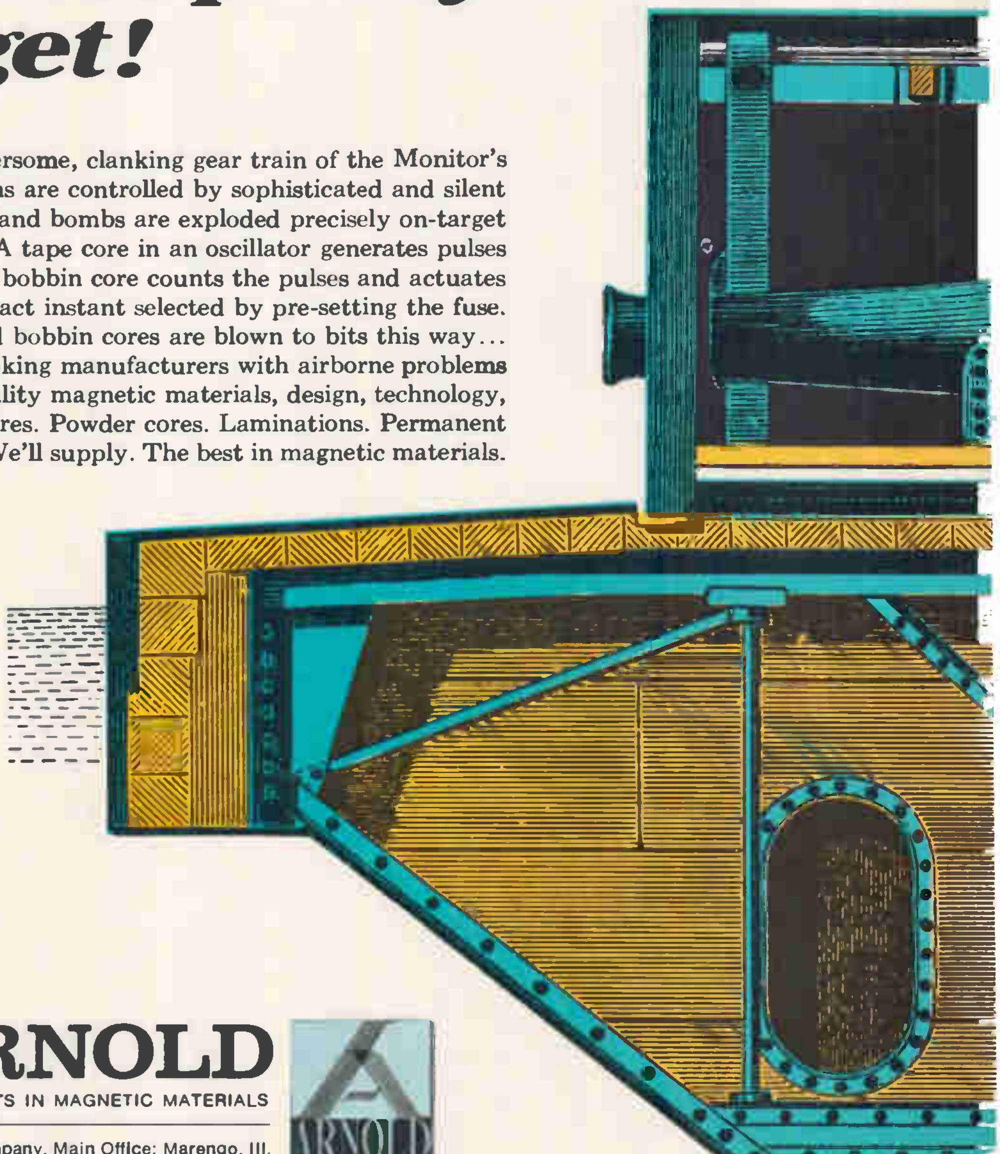
Unlike the cumbersome, clanking gear train of the Monitor's cannon, today's weapons are controlled by sophisticated and silent means. Artillery shells and bombs are exploded precisely on-target by delayed action fuses. A tape core in an oscillator generates pulses for a timing circuit. A bobbin core counts the pulses and actuates the explosive device at the exact instant selected by pre-setting the fuse. Some of our best tape and bobbin cores are blown to bits this way... but they do their job. Forward-looking manufacturers with airborne problems look to Arnold for high-quality magnetic materials, design, technology, components. Magnetic cores. Powder cores. Laminations. Permanent magnets. You ask. We'll supply. The best in magnetic materials.



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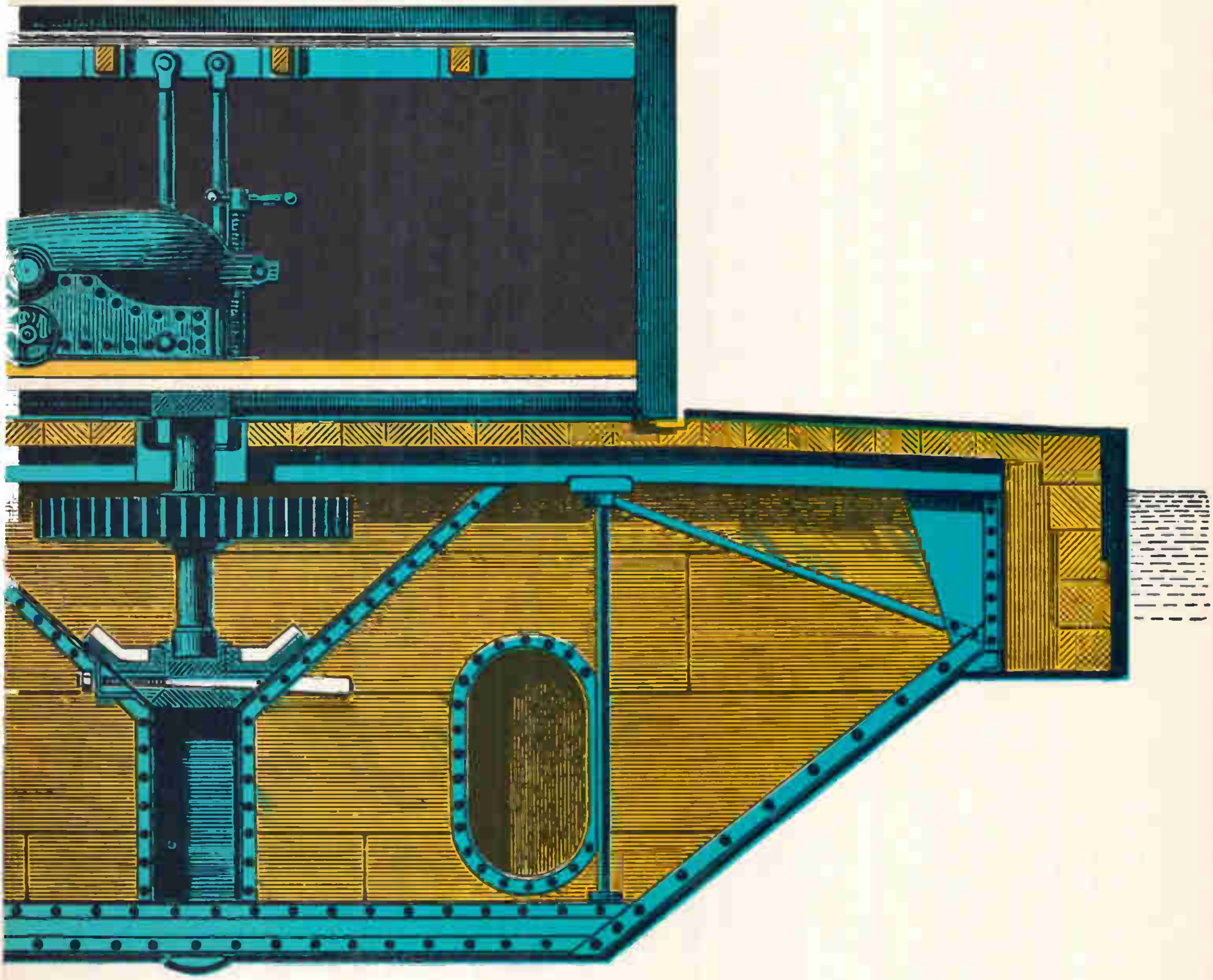
BY ARNOLD



Meetings

Reliability physics: problems of connection

Connecting elements in an integrated circuit presents a continuing problem: the combination of properties demanded of the interconnection material is hard to get. And the problem is worse for large-scale and medium-scale integration, because two or more layers of interconnections are needed. So serious is the difficulty that it's to be the focus of attention at this year's Symposium on Reliability Physics (formerly Physics of Failure in Electronics) in Washington Dec. 2 to 4.

An entire session, for example, will be devoted to electromigration of interconnections in IC's. This effect, which causes openings in the aluminum interconnection paths, was originally thought to be a result of evaporation due to internal heating. It is now known that the aluminum atoms in the interconnection migrate as a result of momentum transferred by impinging electrons.

J. R. Black, an engineer with Motorola, will lead off the session with a survey of present knowledge of the effect and a report of his work on a prediction model that incorporates the effects of temperature, current, and composition on electromigration.

M.J. Attardo, A.H. Landzberg, W.E. Reese, and G.T. Wenning, researchers at IBM's Components division, will give the results of their study of the precise nature of the effect in long interconnection paths. And electromigration is not limited to aluminum, as T.E. Hartman and J.C. Blair of Texas Instruments report in their paper on electromigration in gold film conductors.

Surface studies. Some of the problems of multilayer LSI interconnections (and the corollary dielectric layers) are discussed in papers by G.L. Schnable and R.S. Keen on failure mechanisms, and by Schnable and E.S. Schlegel on test structures for studying surface effects. All are with Philco-Ford.

One of the sessions will be devoted to scanning electron microscopes and electron-beam microprobes—among the most powerful and popular analytic tools to become available to the semiconductor industry. P.R. Thornton of the University College of North Wales will survey applications in an invited paper. The use of electron-beam techniques to study IC metalization problems will also receive attention in this session.

For more information, write Joseph Vaccaro, Rome Air Development Center, Griffiss Air Force Base, N.Y. 13440.

Calendar

Automatic Support Systems Symposium for Advanced Maintainability, IEEE; Sheraton-Jefferson Hotel, St. Louis, **Nov. 12-14.**

Conference on Thermal Conductivity, Department of Commerce; National Bureau of Standards, Gaithersburg, Md., **Nov. 13-15.**

Analytical Symposium Advanced Technical Program, American Chemical Society, Society for Applied Spectroscopy, American Microchemical Society; Statler Hilton Hotel, New York, **Nov. 13-15.**

Meeting of the Anti-Missile Research Advisory Council, Advanced Research Projects Agency and the U.S. Naval Postgraduate School; Monterey, Calif., **Nov. 14-16.**

Symposium on the Applications of Lasers to Photography & Information Handling, Society of Photographic Scientists and Engineers; Airport Marina Hotel, Los Angeles, **Nov. 14-15.**

Conference on Engineering in Medicine & Biology, Biomedical Engineering Society; Shamrock-Hilton Hotel, Houston, **Nov. 17-20.**

Conference on Magnetism and Magnetic Materials, IEEE and the American Institute of Physics; Hilton Hotel, New York, **Nov. 17-21.**

(Continued on p. 24)

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Not when we have more than 80,000 non-American readers.

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Manufacturers of electronic components & equipment	78.5%
Manufacturers using electronic equipment	81.1
Government & military	82.1
Independent research & development	88.8
Operators of communications equipment	90.0
Service & installation	77.3
Educational institutions	93.5
Distribution	not asked

Proof of its importance to non-American readers can be found in their loyalty. More than 88% read 3 out of every 4 issues.

	% who purchase or specify
Manufacturers of electronic components & equipment	91.3%
Manufacturers using electronic equipment	94.9
Government & military	94.6
Independent research & development	93.0
Operators of communications equipment	90.7
Service & installation	92.6
Educational institutions	88.9
Distribution	94.4

If you're in the international electronics market, ELECTRONICS INTERNATIONAL wants YOU!

Meetings

(Continued from p. 22)

Photovoltaic Specialists Conference, IEEE; Jet Propulsion Laboratory, Pasadena, Calif., **Nov. 19-21.**

Microelectronics Packaging and Interconnection Conference, Society of Automotive Engineers; Rickey Hyatt's House Hotel, Palo Alto, Calif., **Nov. 20-22.**

Winter Annual Meeting & Energy Systems Exposition, American Society of Mechanical Engineers, Hilton Park Sheraton, New York, **Dec. 1-5.**

Conference on Applications of Simulation, Association for Computing Machinery, IEEE; Hotel Roosevelt, New York, **Dec. 2-3.**

Reliability Physics Symposium, IEEE; Hilton Hotel, Washington, **Dec. 2-4.**

Vehicular Technology Conference, IEEE; Hilton Hotel, San Francisco, **Dec. 3-4.**

Entry Vehicle Systems and Technology Meeting, American Institute of Aeronautics and Astronautics; Williamsburg, Va., **Dec. 3-5.**

Circuit Theory Symposium, IEEE; Hilton Plaza Hotel, Miami Beach, Fla., **Dec. 4-6.**

Symposium on Theory & Measurement of Atmospheric Turbulence & Diffusion in the Planetary Boundary Layer, Sandia Corp. and the Atmospheric Sciences Laboratory of the Army Electronics Command; Albuquerque, N.M., **Dec. 5-7.**

Vehicular Technical Group Conference, IEEE; Hilton Hotel, New York, **Dec. 6-8.**

Electrical Insulation Conference, IEEE; Biltmore Hotel, Los Angeles, **Dec. 8-12.**

National Electronics Conference, IEEE; Conrad Hilton Hotel, Chicago, **Dec. 9-11.**

Fall Joint Computer Conference, IEEE; Hilton Hotel and Civic Center, San Francisco, **Dec. 9-11.**

Consumer Electronics Symposium, Conrad Hilton Hotel, Chicago, **Dec. 9-10.**

Symposium on Adaptive Processes, IEEE and UCLA; University of California at Los Angeles, **Dec. 16-18.**

Winter Institute in Computer and Information Sciences, University of Florida; Gainseville, **Dec. 17-21.**

American Association for the

(Continued on p. 26)

Meetings

(Continued from p. 24)

Advancement of Sciences; Dalla
Dec. 26-31.

Reliability Symposium, IEEE;
Palmer House, Chicago, Jan.

Second Hawaii International Co
Department of Electrical Engine
University of Hawaii, Honolulu,
22-24.

Winter Power Meeting, IEEE; Ne
Jan. 26-31.

International Symposium on
Information Theory, IEEE;
Nevele Country Club, Ellenvill
Jan. 28-31.

PMA Metrology Conference, Pre
Measurements Association; The
Ambassador, Los Angeles, Feb.

Winter Convention on Aerospac
Electronics Systems, IEEE; Biltr
Hotel, Los Angeles, Feb. 11-13.

International Solid State Circu
Conference, IEEE; University c
Pennsylvania and the Sherato
Philadelphia, Feb. 19-21.

International Convention & E
IEEE; Coliseum and Hilton H
New York, March 24-27.

Conference on Lasers & Optoele
IEEE; Southampton, England, M
25-27.

Semiconductor Device Resear
Conference, IEEE; Munich,
West Germany, April 11-14.

Joint Railroad Conference, IEE
Queen Elizabeth Hotel, Montr
April 15-16.

International Magnetics Conf
(Intermag), IEEE; RAI Buildin
Amsterdam, Holland, April 1

Geoscience Electronics Sympo
IEEE; Marriott Twin Bridges M
Hotel, Washington, April 16-1

Conference on Switching Tec
for Telecommunications Netw
IEEE; London, April 21-25.

Electrical & Electronic Measure
and Test Instrument Conferenc
Instrumentation & Measureme
Symposium, IEEE; Skyline Hote
Ottawa, Canada, May 5-7.

Frequency Control Symposium,
Components Laboratory, U.S. A
Electronics, Shelburne Hotel, A
City, N.J., May 6-8.

(Continued on p. 286)

A REAL WINNER

2N5452 @ $14.95 EA.

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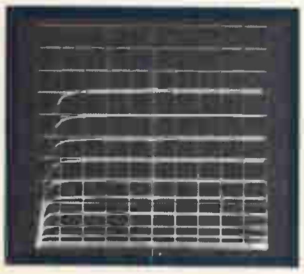

Definition	2N5452
Offset Voltage	5 mV Max
Offset Voltage Drift −55° to +125°	5 μV/°C Max
Output Admittance at f = 1 kHz	0.35 μmho Typ 1.0 μmho Max
Output Admittance Match at f = 1 kHz	0.05 μmho Typ. 0.25 μmho Max

All Parameters measured at V_{DS} = 20V, I_D = 200 μA

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WINNERS

Most people never dreamt we'd go this low. Here are 10 that did. A dream of a device at $14.95. For the 82% of you who guessed too high you'll find the greatest reward is in using the 2N5452.

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Moosup, Conn.

J. Prager
Burlington, Mass.

Ernie Sanchez
Concord, Calif.

R. E. Williamson
Patrick AFB, Florida

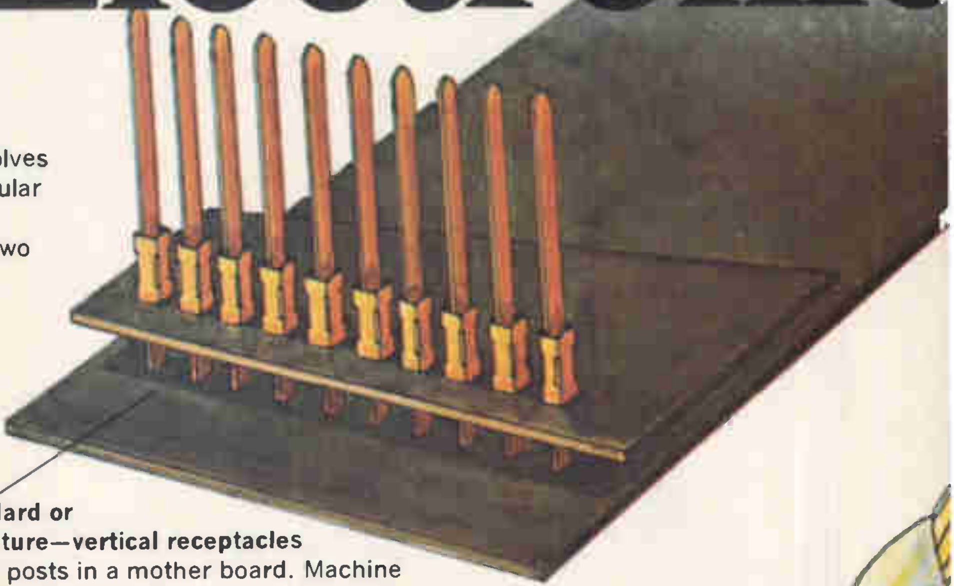
George Yakoubianir
Cos Cob, Conn.

Laszlo F. Zala
Cleveland, Ohio

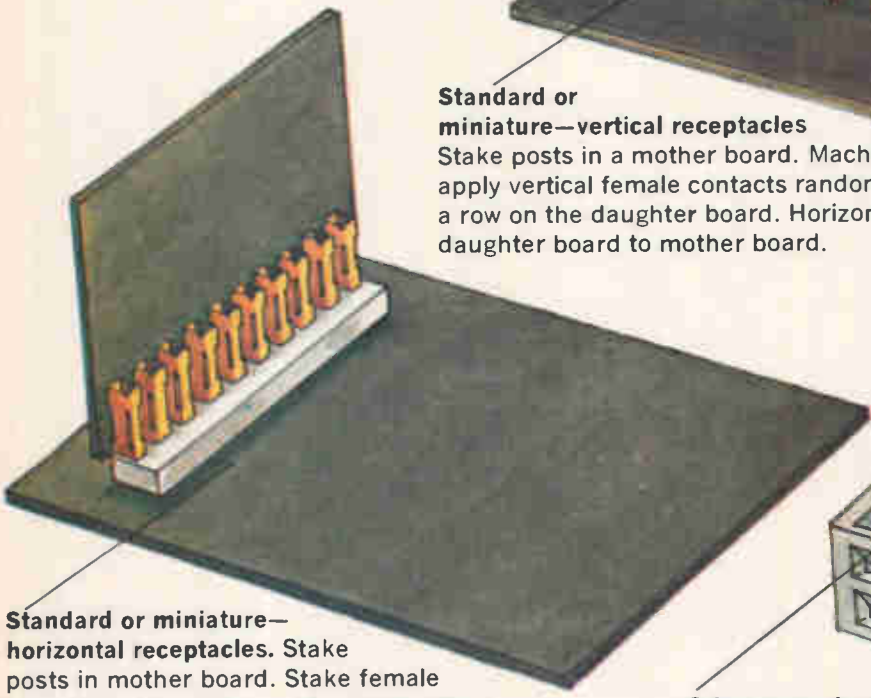
Circle 27 on reader service card

The Electronic

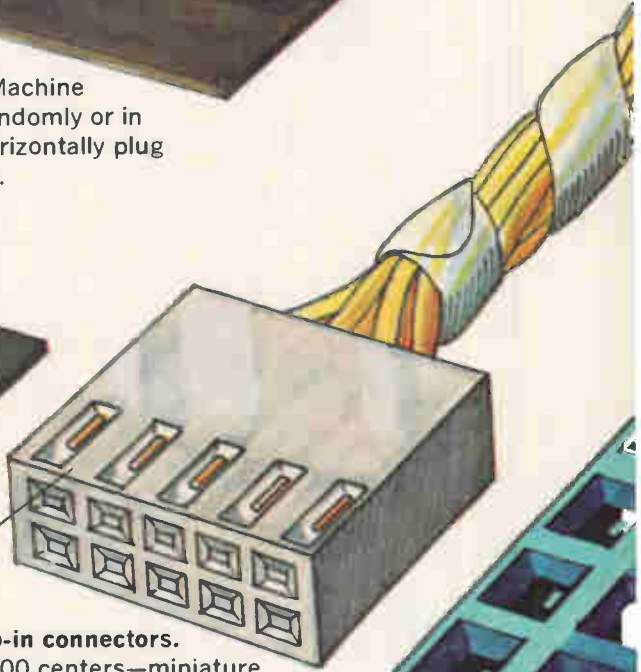
For the modular man, the do-it-yourself AMPMODU★ Interconnection System solves your interconnection problems for modular packaging. You start with a post and a receptacle—and you build from there. Two sizes: Standard which uses .031 x .062 posts and Miniature which uses .025 x .025 posts.



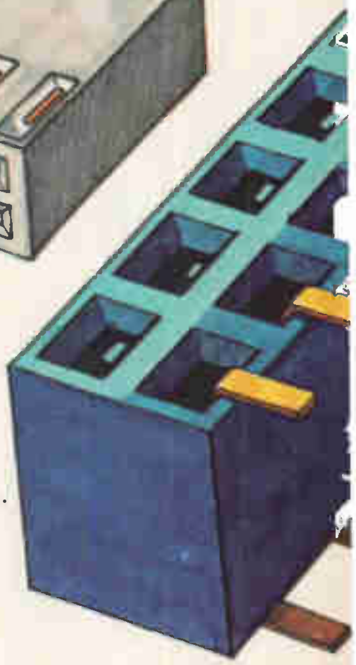
Standard or miniature—vertical receptacles Stake posts in a mother board. Machine apply vertical female contacts randomly or in a row on the daughter board. Horizontally plug daughter board to mother board.

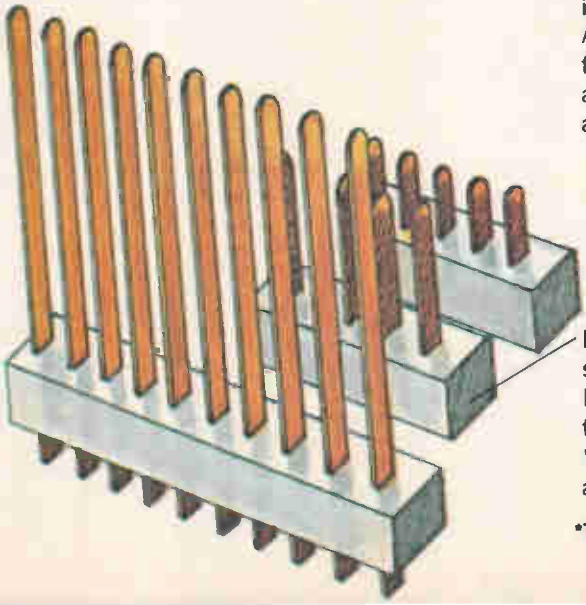


Standard or miniature—horizontal receptacles. Stake posts in mother board. Stake female contacts horizontally on edge of daughter board and plug daughter board vertically into mother board. Posts can be placed randomly or in even patterns in both horizontal or vertical approach.



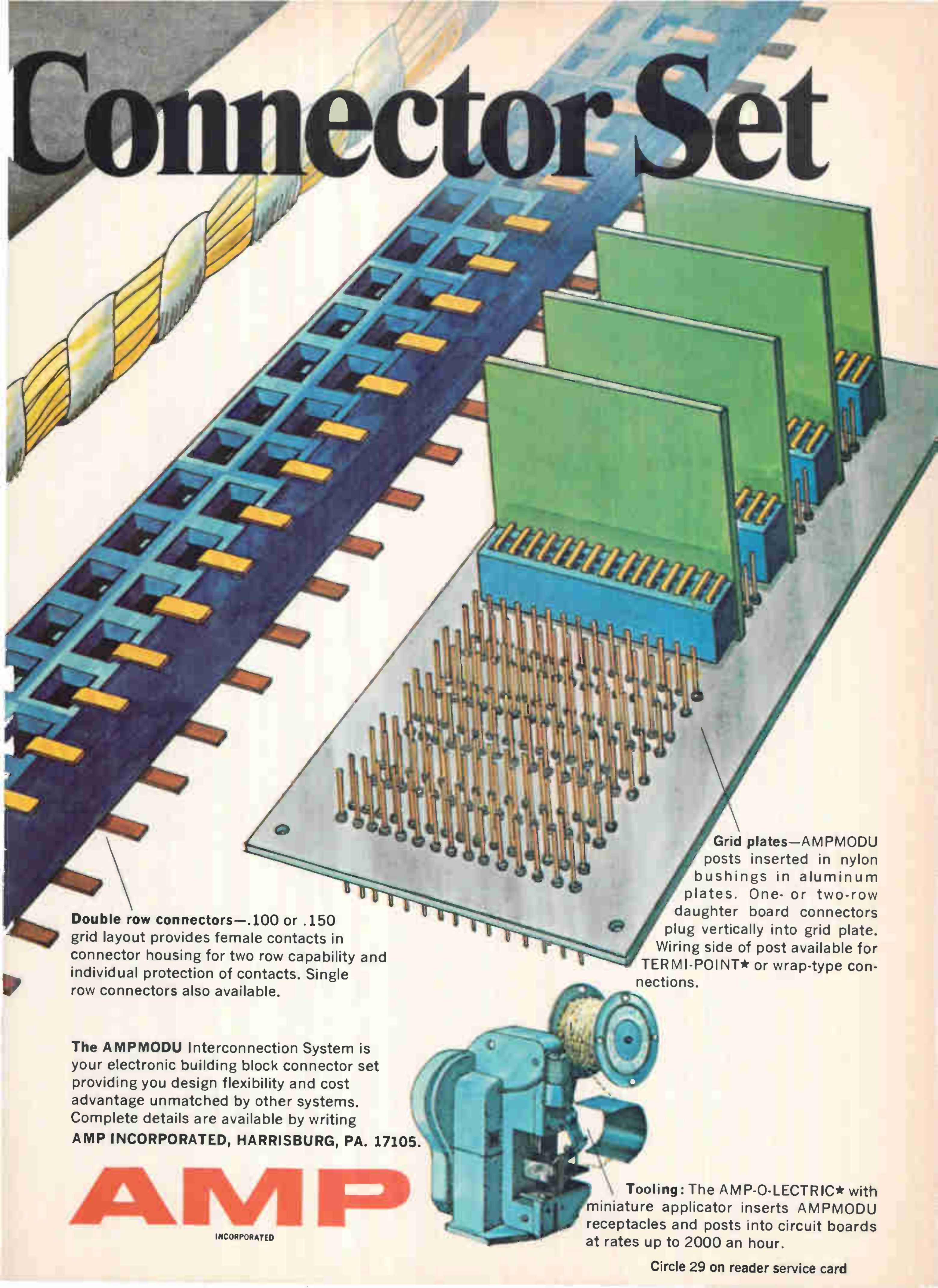
Crimp-snap-in connectors. .150 and .100 centers—miniature size only. Crimp female contacts on wire. Snap them into connector housing. Mates with posts installed on printed circuit board. Also for input/output jumpers for grid plates. When not used in a housing, similar contacts can also be crimped to flat flexible cable.





Incremental nylon connectors provide standard size posts in three different lengths. Permits one, two or three daughter boards to be stacked horizontally to mother boards. Where metallic chassis are required, posts are available in snap-in nylon blocks.

*Trademark of AMP Incorporated


Connector Set
Double row connectors—.100 or .150 grid layout provides female contacts in connector housing for two row capability and individual protection of contacts. Single row connectors also available.
Grid plates—AMPMODU posts inserted in nylon bushings in aluminum plates. One- or two-row daughter board connectors plug vertically into grid plate. Wiring side of post available for TERMI-POINT★ or wrap-type connections.
The AMPMODU Interconnection System is your electronic building block connector set providing you design flexibility and cost advantage unmatched by other systems. Complete details are available by writing
AMP INCORPORATED, HARRISBURG, PA. 17105.
AMP
INCORPORATED
Tooling: The AMP-O-LECTRIC★ with miniature applicator inserts AMPMODU receptacles and posts into circuit boards at rates up to 2000 an hour.
Circle 29 on reader service card

Editorial comment

A challenge from the power industry

Foolproof delivery and round-the-clock availability are the minimum specifications the electric power industry demands for its only product—kilowatts. Can the electronics industry—actually the offspring of the power industry—help achieve these goals? If programs undertaken by the Los Angeles Department of Water and Power and the Houston Lighting & Power Co. are indicative, the answer is yes. Both utilities will use a real-time computer system for load switching and dispatching.

But there are skeptics in the power industry. Some doubt the adequacy of the programing, others the accuracy of the monitoring and peripheral equipment [Electronics, Sept. 30, p. 125].

The skeptics notwithstanding, it seems inevitable that closed-loop systems will be developed with an infallibility assured by redundancy and the use of high-reliability components. There appears to be no better way to meet the demanding requirements of power systems already too complex for men to handle. As we see it, the power industry needs electronic gear in these areas:

- communications
- sensing and switching
- processing (conversion and inversion).

At the International Electron Devices Meeting in Washington last month, Leonard Linde, an engineering consultant with nearly 40 years of experience in the power field, challenged engineers to develop a vast computer-based system of "protective intelligence" that would continuously monitor all sections of a power system and jettison parts of it when necessary to protect the remainder. Today's relay systems protect only assigned and relatively small zones.

Because speed is all-important in isolating parts of a system or diverting power, a reliable system will have to be exceedingly fast. Furthermore, because the measuring of systems trends (changes in frequency, voltage, or power factor) consumes precious time, trend prediction will be increasingly critical.

The electromechanical relays used to protect today's power systems are likely to be replaced by solid state devices. Relays are subject to the fallibility of mechanical devices and require significant power. The transition will not be without hitches, Linde notes. Problems of compatibility between old and new systems must be resolved, and speed, accuracy, and power requirements will have to be set for the new systems.

Public utilities will probably bypass the common carriers in meeting their special data transmission needs. Instead they'll look to the electronics companies to develop microwave telemetry gear capable of transmitting lots of data reliably and at very high speed.

The potential market involves more than just monitoring and supervisory equipment. Linde, in discussing consumer needs, suggests that the development of a reliable and economical fuel cell could revolutionize the power field. Customers using such cells for direct current would need more electronics to provide multiple frequencies and voltages.

The transmission of d-c power at high voltage will also create a demand for electronic gear. The first U.S. application of hvdc will be to transmit power from the Columbia River to Los Angeles. In such a system, conversion and inversion of power could be accomplished with grid control mercury rectifiers that are cascade-connected to get the needed voltage rating. But a better way now being tried in Sweden involves the use of cascaded thyristors. Circuit interruption technique—still pretty much of a black art—will have to be improved for hvdc systems, in which voltage recovery transients can be as high as 5 kilovolts per microsecond.

Cooling to superconductive temperatures—too expensive and exotic a process for power companies to use in the past—may deserve another look as a means of handling overloads on a limited scale.

Despite the clear challenge to electronics engineers posed by the power industry, the most perspicacious forecaster would be hard put to predict how rapidly the power market will grow. Nevertheless, it's worth noting that new capital investment in the domestic power industry last year totaled $7.8 billion, a figure that's expected to exceed $10 billion annually by 1972.

The quick and efficient application of electronics to the power field depends on good communications between electronics engineers and power people, but even more on the ingenuity of the electronics industry.

Electronics Newsletter

November 11, 1968

Camera-vtr combo will cost $400-$500

Engineers at Dubow Chemical Corp. in New Hyde Park, N.Y., have developed a 7-pound, battery-operated combination camera and video tape recorder that looks and operates like a home movie camera. Using Du Pont's chromium dioxide half-inch tape in an endless-loop cartridge, the helical-scan vtr records black-and-white pictures under normal room lighting. Each tape cartridge records for up to 6 minutes.

At a private demonstration in New York last week, the camera-recorder took pictures that were flawlessly played back on a standard monochrome tv set. To play back, the unit is connected to the tv set's antenna leads.

Nick Mascara, Dubow's executive vice president, says the unit will sell for between $400 and $500 and will be available at dealers some time next fall.

Dubow is now negotiating with an electronics manufacturer to produce and market the unit.

GE readies 5-watt IC

GE will soon put a low-cost, 5-watt integrated circuit for use as a power amplifier on the consumer hi-fi and industrial markets. Insiders say the key to the high power is an improved plastic dual in-line package that provides low thermal resistance between the chip and the attached heat sink.

The IC, the PA246, will be the first U.S.-produced device that can supply 5 watts of continuous audio power. Sinclair Radionics of Cambridge, England, recently announced that it would soon market a similar 5-watt integrated circuit at a price of about $7. But it now may delay the introduction "several months" [for details, see p. 306].

Erbium-yag laser said to be safer

Because of the hazards of laser use [see p. 193], increasing attention is being focused on an erbium-doped yttrium aluminum garnet laser. The material, under development at Martin-Marietta's Orlando, Fla., division, is stirring interest because the division's researchers say that its wavelength, at 1.6 microns, is less dangerous to the eye.

The 1.6-micron region is relatively safe because this light is more easily absorbed in the cornea and the aqueous medium; less light gets to the retina, where it can cause serious damage.

The device could be used in military range-finding and tracking systems. The output energy of the pulsed laser is 120 millijoules, and although efficiency is only 0.05%, the developers expect to raise it to 0.5%, adequate for most military systems.

Another problem is that available detectors, such as germanium avalanche diodes, aren't frequency-compatible with yag. The company is trying to develop improved germanium photodiodes or mercury-cadmium-teluride devices instead.

Motorola expands radiation-resistant IC capabilities

Motorola's Semiconductor Products division is broadening its capacity to produce radiation-resistant monolithic integrated circuits. The firm has set aside 17,000 square feet at its Mesa, Ariz., IC center for an independent group that will design and build standard dielectrically isolated IC's, and plans to hire additional engineers to augment the group already turning out radiation-hardened circuits for such programs as Minuteman 2. Seven modified Series 930 diode-transistor-logic IC's will be the first standard radiation-resistant circuits Motorola will offer. They'll be ready in a few months and will be followed early next year by a dielectrically isolated plug-in replacement for the 709 operational amplifier.

These moves are apparently aimed at keeping Motorola up with Fairchild Semiconductor and Radiation Inc., which recently won contracts to set up production lines for radiation-resistant IC's for the Poseidon missile guidance computer [Electronics, Oct. 28, p. 52]. A companion contract went to Motorola, but that award covered only transistors.

FCC may clear way for private network of microwave links

A network of private microwave links serving large commercial users may soon spring up. The President's Task Force on Telecommunications hopes to persuade the Federal Communications Commission to permit the establishment of private data-transmission services subject only to the availability of frequency space [see related story, p. 68].

The task force, due to report its findings to the White House before Dec. 1, contends that private microwave systems do not compete directly with existing common carriers, and it will urge the FCC to drop regulations protecting common carriers from microwave operators promising lower rates.

A test case is now before the FCC. Microwave Communications Inc. is seeking authorization to set up a flexible data-transmission voice-circuit service between St. Louis and Chicago. The commission is believed to be deadlocked on the issue but H. Rex Lee, who assumed his seat late last month, will probably cast a tie-breaking vote in favor of the company's application.

The granting of a license in this case would encourage the many other firms planning similar links and there's a movement afoot to fashion the small microwave operations into a loosely organized grid or network, though details haven't been worked out.

Union seeks to link layoffs to imports

The International Union of Electrical, Radio, and Machine Workers (IUE) is expected to demand U.S. Tariff Commission hearings on its charges that electronics imports are causing layoffs. The IUE will cite the television industry as a major example of this trend, but will claim that the situation exists "throughout the electronics industry."

One complaint is that electronics companies have violated those provisions of the Tariff Act that require added compensation for workers laid off because of imports.

Addenda

The Air Force says it will let two contracts by the end of the year for competitive approaches to a multifunction modulation technique for its integrated communications, navigation, and identification (I/CNI) system. The Rome Air Development Center is now evaluating proposals for the exploratory studies. The awards will be the first in the I/CNI program, according to a Rome spokesman [Electronics, Aug. 19, p. 33]. . . . NASA's Electronics Research Center is seeking companies to study requirements for an "experimental Saturn 5 television broadcast satellite system." NASA apparently feels that a satellite-borne transmitter can achieve the required radiated power, but no money has yet been earmarked for the hardware.

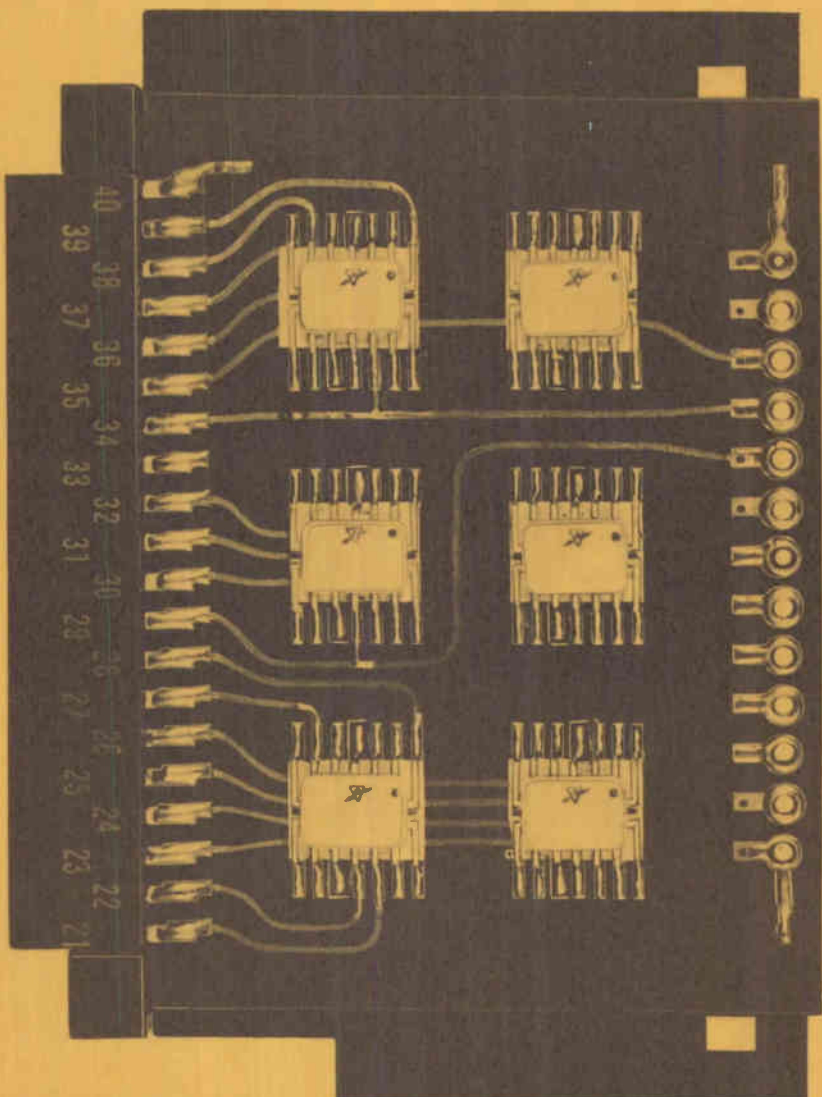
Component and Circuit Design IDEAS

FROM SYLVANIA

IDEAS/*Circuit Assemblies*

Solve your noise problems with circuit modules.

We told you in the past how our circuit modules reduce noise. Now we've improved them even further.



Multilayer construction of Sylvania circuit cards brings IC leads within 1/64" of power and ground planes.

An additional reduction in noise figures of from 30 to 50 percent has been obtained by circuit improvements in Sylvania's popular line of circuit modules. The 13 new modules added to the line are completely compatible with previous units.

The key to improved noise reduction is the addition of a leadless low-inductance capacitor between the power and ground planes. This improvement is in addition to the already low noise figure of our circuit card that is achieved by

Continued on next page

This issue in capsule

New Circuit Module Cards

Type	Function
262	Memory card (2 bit x 64 word)
263	Memory select driver card
264	Encoder
265	Dual eight-bit register
266	Quad four-bit register
267	Quad four-bit binary divider
268	Up/down counter
269	Series/parallel converter
270	Dual four-bit/five-word storage register
271	Five-bit comparator with storage
272, 273	5.55 MHz bi-phase clock
276	13-bit digital delay generator
285	Test card

its unique construction and inherent low noise of Sylvania's SUHL integrated circuits.

Until the development of our circuit modules you couldn't take full advantage of the speed capability of our SUHL II 50-MHz logic. Noise levels limited practical operation to speeds of about 20 MHz. Now you can approach the full 50-MHz capability of these devices when you buy them on our circuit boards.

The circuit module is made up of two four-layer boards mounted on either side of an aluminum "backbone." Each board has two signal planes plus distributed power and ground planes. When necessary, the signal planes can be electrically interconnected with plated-through holes. The distributed power and ground plane construction allows every IC lead on the board to be within 1/64" of the power and ground planes. The result is extremely short lead lengths and, thus, low noise pickup.

Typical of the new circuit boards is our #262 memory card and #263 memory select driver. Here, we've done your memory design work for you. The #262 is a 128 bit card (2 bits x 64 words). Combined with the #263 memory driver, it gives you a sophisticated systems-oriented building block that can solve your memory problems with a minimum of interconnections.

CIRCLE NUMBER 300

New CRT brightens picture for air controllers.

Scan conversion system using Sylvania CRT makes airport tower radar displays visible in bright sunlight.

Airport towers, where lighting conditions can vary from darkness to 4,000 foot-candles, put tough demands on the contrast and brightness of radar displays.

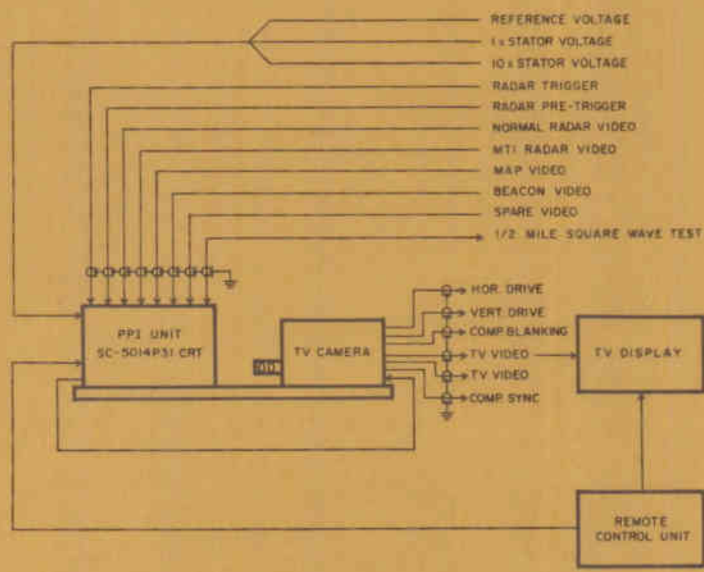
As a result of considerable research and development work within the Federal Aviation Administration, bright radar displays for use by air traffic controllers have become a reality. Based on an FAA-issued specification, ITT Industrial Laboratories, Fort Wayne, Indiana has come up with an optical scan conversion system that solves the problem for FAA flight controllers. The system uses a special long-lag vidicon camera optically coupled to a Sylvania 5-inch CRT to convert the PPI radar display into a high-brightness 945-line TV display.

The high-resolution requirements put a stringent demand on the CRT used in the conversion process. To meet the need, Sylvania developed the SC-5014P31. This tube provides a 0.0015-inch line width on a 5-inch optically flat faceplate. The neutral gray non-browning faceplate is designed to give optimum photographic quality. Brightness is enhanced by the use of an aluminized screen.

In operation the PPI unit in the diagram accepts the normal radar inputs and displays the radar video on the face of the Sylvania CRT. The vidicon camera is focused on the CRT display and converts it to a uniform bright TV display. The long-lag photoconductive surface of the vidicon retains images of moving aircraft so that a minimum of five trails are visible to indicate direction of movement.

The composite EIA video signal is fed to a special 12-inch CRT for viewing by the flight controller. The display has a highlight brightness of up to 500 foot-lamberts giving the controller an acceptable display in the tower at any time of the day or night.

It is in applications like this, where the demands on CRTs are exacting, that Sylvania's experience and technical know-how really pay off.



Scan conversion system for radar display using the SC5014P31 CRT.

CIRCLE NUMBER 301

How compact surge arrestors offer low-cost circuit protection.

The gas-filled spark gap surge arrestor is one of the simplest ways to protect equipment against damaging voltage surges. But just because it's simple, don't underestimate its capability.

A spark gap represents an almost ideal device for the job of protecting equipment against voltage surges. Under normal load conditions it presents a very high impedance (100 megohms). If a surge occurs, the gap breaks down and appears as a virtual short circuit. When the overvoltage drops below the extinguishing voltage of the gap, the device immediately returns to the high impedance state.

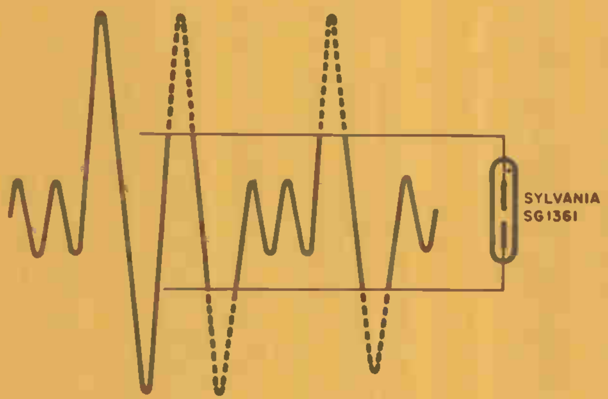
Sylvania's SG-1361 argon-filled spark gap is a miniature unit designed to protect low power components such as relays, capacitors, coils, and active devices from overloads. It has a nominal firing voltage of 600 V at 60 Hz and a firing voltage range of 500 to 900 V, 60 Hz. Maximum firing current is 25 mA.

The SG-1361 can be used with higher energy circuits if a series resistor is used to reduce the amount of energy transferred by the spark gap to ground. When used as a secondary protector, along with a primary surge arrestor, the SG-1361 can protect components against lightning strikes and other high-transient overloads.

Its small size (¾-inch long and 0.215-inch in diameter) and its simple economical construction make the SG-1361 an easy component to fit into any system. Since it comes with pretinned Dumet leads the device can be wired directly into the circuit without the use of adapters or clip-type holders.

SG-1361 Electrical Data

Firing Voltage at 60 Hertz	600 volts
Firing Voltage Range (at 60 Hertz)	500-900 volts
Maximum Firing Current (time duration = 30 sec. max.)	25 mA
Maximum Operating Temperature	80°C
Minimum Open Line Impedance	100 Meg.



Voltage spikes are shunted to ground by Sylvania's SG-1361 spark gap.

CIRCLE NUMBER 302

How to design with the SA-20 wideband amplifier.

External access to every element of Sylvania's SA-20 linear amplifier makes it easy for you to modify its characteristics to fit your application.

Sylvania's SA-20 is a versatile general-purpose wideband amplifier. Its characteristics include a high gain-bandwidth product, large signal swing and excellent linearity.

The SA-20 has three direct-coupled NPN transistors in a single-ended configuration. Bias for the input transistor is established internally by divider R_1 and R_2 (Fig. 1). Zener diode D_Z raises the bias level of Q_2 to permit operation of Q_1 in the linear range. Emitter follower Q_3 buffers the output load circuit from the intermediate stage, Q_2, thereby giving a higher total open-loop circuit gain even with low-value loads. Series DC negative voltage feedback is applied from the output of the emitter follower to the emitter of Q_1 by divider R_4 and R_6.

The major power supply current path is through the output transistor, Q_3. Total device current drain is therefore strongly related to the quiescent output voltage and the value of R_6. The output transistor has a maximum current capability of 50 mA. Maximum junction and case temperature for the device are 200°C and 155°C, respectively. Worst-case thermal gradients of the dual inline package used for the SA-20 are $\theta_{JA} = 0.15$°C/mW and $\theta_{JC} = 0.075$°C/mW.

In most instances the base current of the input tran-

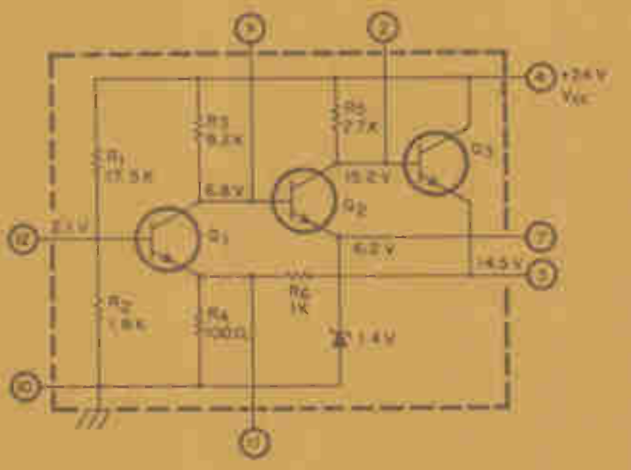


Fig. 1 Circuit of SA-20 linear amplifier.

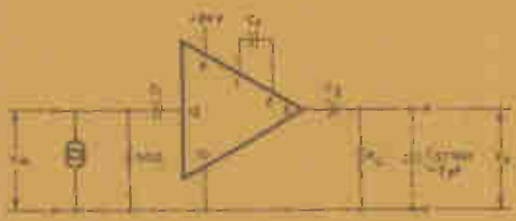


Fig. 2 Standard configuration for SA-20.

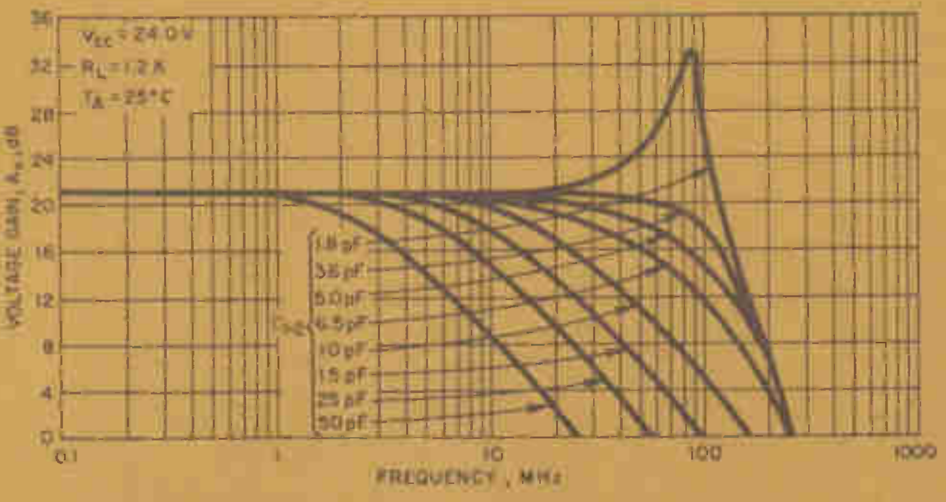


Fig. 3 Typical gain-versus-frequency curves for SA-20 in standard configuration.

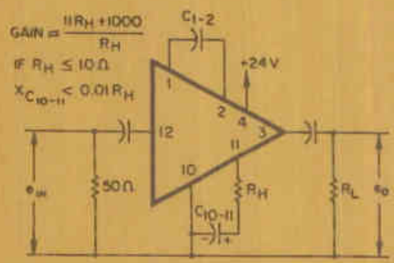


Fig.4 High gain configuration for SA-20 linear amplifier.

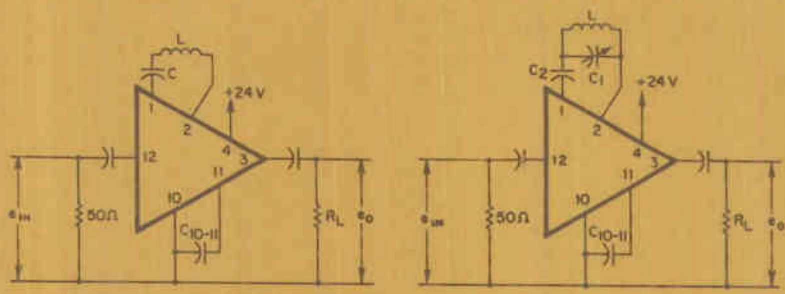


Fig. 5 Selective amplifier configuration with C and L in parallel and series connections.

sistor is small relative to the current in the input divider. Under these conditions input quiescent voltage is:

$$V_{Qin} = (V_{CC}R_2) \,/\, (R_1+R_2)$$

Bias level of the input transistor may be varied by shunting resistors R_1 or R_2. However, consideration must be given to the effect of a change in V_{Qin} on such factors as current drain and output quiescent voltage.

The output quiescent voltage, V_{Qout}, is:

$$V_{Qout} = \frac{R_6+R_4}{R_4}\left[\left(\frac{V_{CC}\,R_2}{R_1\,+\,R_2}\right) - (V_{BE})\right]$$

V_{Qout} can thus be changed by external resistive shunting of any of the four resistors in the expression.

The maximum voltage swing of the device with an $R_L = \infty$ is essentially a function of the supply voltage and the zener-diode voltage. In the positive direction the voltage is limited by the voltage drop across R_5 and the base-emitter voltage of Q_3. The voltage swing in the negative direction is limited by the zener voltage plus the saturation voltage of Q_2 minus the junction drop of Q_3. With a high R_L the device will normally swing between 22.5 V and 6.5 V. If the quiescent output voltage is at the optimum level of 14.5 volts, the AC swing at the output, assuming negligible resistive loading, is approximately $\pm$8.0 V.

Current restrictions limit the maximum possible voltage swing when using AC-coupled resistive loads of more than approximately 600 ohms.

In the case, when R_L is low, the maximum output voltage is

$$e_{o\ max} = \frac{V_{CC} - V_{BE} + [(R_5V_{Qout}) \,/\, (\beta_3+1)\,(R_L)]}{1+(R_5) \,/\, (R_L)\;(\beta_3+1)}$$

Assuming a typical device with $V_{CC} = 24$ V, an AC-coupled 50-ohm load and $\beta_3 = 100$ which is normally the case, the maximum absolute voltage level as seen at the emitter of Q_3 is $e_{o\ max} = 16$ V.

The maximum positive swing as seen at the load is therefore 1.5 V. The negative-going swing from the quiescent voltage level is a function of the quiescent current of the device. In terms of absolute voltage the minimum output voltage, $e_{o\ min}$, of the device with low value of AC coupled load is:

$$e_{o\ min} = V_{Qout} - \left[\frac{V_{Qout} - (V_{Qin} - V_{Be})}{R_6}\right] R_L$$

Again, assuming a typical device and AC-coupled load of 50 ohms, $e_{o\ min} = 14.5 - 0.675 = 13.8$ V.

The maximum linear swing with an AC coupled 50-ohm load is therefore 1.5 V above and 0.67 V below the quiescent voltage.

It is possible to increase the swing capability of the device in the negative-going direction when driving low-resistance loads by increasing the quiescent current. This may be accomplished by a DC resistive load or current source. A 1000-ohm DC resistive load increases the negative-going voltage swing across an AC-coupled load from 0.67 V to 0.67 + [(14.5 V) 50 / 1000] or 1.4 V. Thus the swing can be made symmetrical.

The three-stage open-loop gain of the SA-20 is about 900. Closed-loop voltage gain is:

$$A_{VCL} = \frac{A_{VOL}}{1+A_{VOL}\,\beta}$$

where $\beta = R_4 / (R_6+R_4)$.

Resistors, R_4 and R_6, are 100 and 1000 ohms, respectively. Since the quantity $A_{VOL}\beta$ at low and medium frequencies is significantly greater than 1, the expression for closed-loop gain simplifies to $A_{VCL} = 1/\beta = 11$. By shunting R_4 or R_6 with an external resistor, the gain of the circuit can be varied. However, as shown previously, other characteristics such as V_{Qout} and associated parameters are also changed by padding either of these resistors. To change the mid-frequency gain without affecting the quiescent level, it is necessary to shunt the internal resistor with a series RC network.

To maintain AC stability a shunt-type feedback loop using an external capacitor is required between the base and collector of Q_2. Phase margin of a typical device is $>45°$ when the feedback capacitor is 3.6 pF.

The SA-20, when connected in the standard configuration, as shown in Fig. 2 exhibits the characteristics shown in Fig. 3. It can be seen that by varying the value of the shunt-feedback capacitor, C_f, the bandwidth of the device can be varied considerably.

In the maximum-gain configuration shown in Fig. 4, AC series feedback is removed from the circuit by shunting R_4 with a capacitor. With the device connected in this manner, the shunt-feedback capacitor which is normally connected between pin 1 and pin 2 is not required. The gain of the amplifier with all forms of AC feedback removed, is about 60 dB up to 5 MHz. From 5 MHz to 100 MHz, the amplifier rolls off at an average rate of − 8 dB/octave.

In the selective-amplifier configuration of Fig. 5, the circuit functions as bandpass and notch amplifiers. Series or parallel tuned circuits are used in the shunt feedback loop to achieve the desired response.

CIRCLE NUMBER 303

For short pulse detection: try back diodes.

High sensitivity, low video impedance and low 1/f noise make back diodes ideal as short pulse detectors.

Microwave designers have a wide choice of devices when it comes to video detectors. Few of these choices, however, have all of the advantages of back diodes when it comes to short-pulse response and fidelity. Among the features of back diodes are high sensitivity, low video impedance and low 1/f noise.

Sylvania's new planar germanium back diodes have all of these features plus a few others including high reliability, and improved temperature stability.

Typical values of tangential signal sensitivity range from −56 dBm (10 MHz video bandwidth) at L-band to −50 dBm at X-band. Low video impedance is a unique feature of back diodes and it is obtained without the use of any noise-generating DC bias. Impedance values in the hundreds of ohms range are commonly obtained, and in some cases can be as low as 100 ohms. Impedance levels like these mean shorter time constants in the video output circuit, which in turn means better pulse fidelity. Noise figure is another area where back diodes shine. Even where a substantial self-bias current or a DC bias is a must, 1/f noise is minimal thanks to the low resistance and inherent physical qualities of the device.

In Sylvania back diodes, ruggedness and reliability are assured by the use of bonded, brazed and welded construction. The Sylvania diodes are available in the 048 pill package that is ideal for stripline circuitry. They are also available in other package configurations or in chip form.

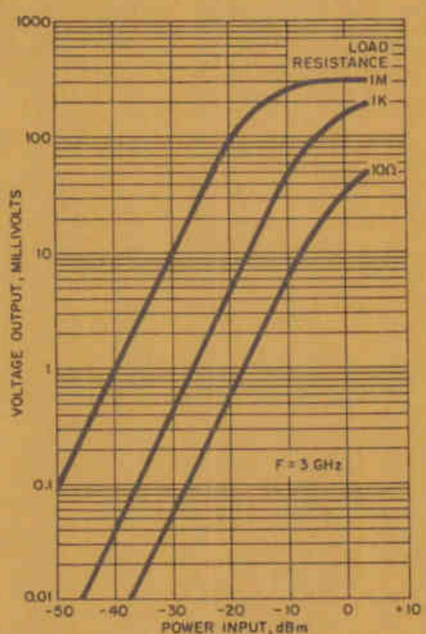
CIRCLE NUMBER 304

Back Diode Electrical Characteristics

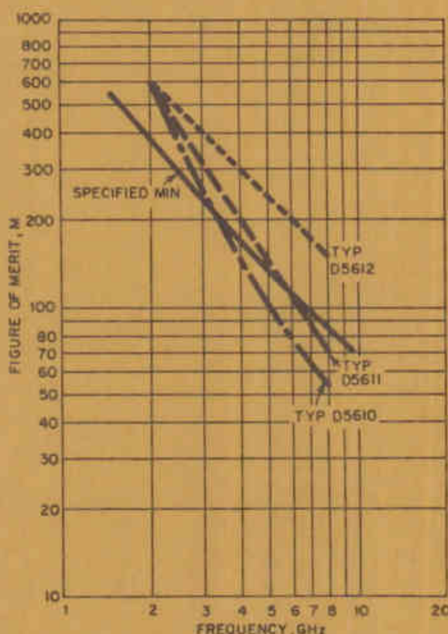
	Test Frequency GHz	Tangential[1] Signal Sensitivity (TSS) −db min	Figure of[2] Merit (M) min	Video Impedance (R_v) ohms max
D5610	2	56	400	1,000
D5611	4	52	180	1,000
D5612	8	49	85	1,000

[1] Video Bandwidth = 10 MHz

[2] $M = \frac{\gamma}{\sqrt{R_v}}$ where γ = mv/mw measured at −20 dbm in an optimized holder.



Voltage output versus power input as a function of load resistance.



Back diode figure of merit versus frequency.

Electroluminescent clocks will time Apollo flights.

When astronauts head for the moon they'll be reading flight times from Sylvania EL displays.

A total of 46 electronic clocks have been designed and built by Sylvania Electronic Systems for use in upcoming Apollo missions. The clocks display hours, minutes, and seconds on a 2 x $4\frac{1}{2}$ inch electroluminescent display panel. Two clocks are used in each Apollo command module and one is used in the lunar excursion module.

Electroluminescent readouts were selected for a number of reasons: they are not prone to catastrophic failure, they give off almost no heat and require much less power than conventional light sources. Since the EL readout is a planar display there are no parallax problems when viewed from an angle.

The clocks used in the command module are used to keep a record of mission time and provide a reference for activities prescribed in the astronaut's flight plans.

The clock in the lunar excursion module will be used to time the landing and take-off on the moon. This seven-digit clock can display elapsed time up to 1,000 hours.

Both the clocks and the electroluminescent displays are hermetically sealed. They are designed to withstand extremes of shock and vibration over a temperature range from 0°F to 140°F.

In addition to these basic clocks, the Apollo astronauts will also carry a number of Sylvania electroluminescent timers. These are designed to time individual experiments on board the lunar module. These units display minutes and seconds on a 2 x 4 inch electroluminescent panel.

Sylvania's electroluminescent panels are available in a wide range of display patterns. The relative ease with which they can be modified makes them readily adaptable to a wide variety of display applications.

CIRCLE NUMBER 305

How synergism brings you new and better circuit assemblies.

A business-oriented definition of synergism might be: "The total strength of an organization is greater than the sum of its individual strengths." At Sylvania Electronic Components, this definition is continually being applied to satisfy both industry needs and company objectives. Certainly, our newest addition, the Circuit Assemblies Operation, is a perfect example of this type of synergism at work.

The key consideration in any successful product development, regardless of company goals or objectives, must be user benefit. Put in a different way, if our new products don't help solve a problem for you, then it's just a wasted effort for Sylvania.

With our new Circuit Assemblies Operation, however, we feel we're on safe grounds. Electronic circuitry is becoming increasingly more sophisticated, and bigger performance is being demanded from smaller systems. The result is that package design and density have become crucial considerations to the circuit engineer. The industry need, therefore, is for economically produced circuit assemblies manufactured with high reliability and in high volume. And that's what our new operation is all about.

In addition to user benefit, however, there are two other criteria that must be met. The new product must have profitability and viability (the ability to grow). Thus, before entering the circuit assembly marketplace, Sylvania went through several stages of product evolution.

First of all, there was an *exploration* stage which quickly showed that circuit assemblies would allow us to optimize the total spectrum of technologies within Sylvania Electronic Components. This included the capabilities to manufacture not only the basic circuit boards, single, double sided or multilayer, but also integrated circuits, diodes and rectifiers, hybrid thick-film circuits, and even vacuum tubes. These capabilities provide a giant step toward the concept of added value.

Then, a *screening* stage proved the idea to be pertinent enough to merit further study. Next was a *business analysis* stage which confirmed that the explosive growth in electronic hardware had established significant trends in the circuit assembly business.

Then *development, testing, and commercialization* were undertaken. In this case, these stages were easily achieved since a full-scale circuit-board facility was already operating as a feeder plant to Sylvania Electronic Systems. It was simply a matter of taking their products to the customer. And that's being accomplished by the efforts of the Sylvania Electronic Components sales force.

With circuit assemblies, therefore, the synergistic effect has combined the efforts of a number of strong elements within the Sylvania Electronic Components group to produce a new and better product line for you.

But the synergistic part was the easiest part to achieve—it was already there.

P. K. Packard
Product Marketing Manager, Circuit Assemblies

This information in Sylvania Ideas is furnished without assuming any obligations.

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Look at the rugged portable design of the CMC Model 616, with its sturdy valise grip and its solid well-balanced frame. Here's an instrument that's equally at home in the lab, on the production line, or in the field. You can rack mount it, too. And its all-silicon solid-state circuitry gives it an extended operating range from −20°C to +55°C.

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price	$1295	$1275
ranges	3	4
overranging	5%	20%
accuracy— 24 hours	.05% r. ± .01% f.s.	.01% r. ± .01% f.s.
3-month stability	.05%	not specified
noise rejection		
common mode, 60 Hz	30 - 70 dB	not specified
normal mode, 60 Hz	30 db	30 dB
input resistance—10-volt range	10.2 megohms	1000 megohms
TO MEASURE MILLIVOLTS		
price	$1610	—
accuracy—100 mV	.10% r. ± .05% f.s.	—
3-month stability	.05%	—
input resistance	10.2 megohms	—
common mode noise rejection	100dB	—
autoranging—100 mV to 1000 V	yes	—
TO MEASURE AC VOLTS (100 kHz)		
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ranges	3	4
basic accuracy	.10% r. ± .02% f.s.	.10% r. ± .02% f.s.
auto ranging	no	yes
common mode noise rejection	not specified	not specified
TO MEASURE OHMS		
price	$1525 (incl. mV and current)	$1385
ranges	5	5
basic accuracy	.30% r. ± .01% f.s.	.05% r. ± .02% f.s.
max. voltage across unknown	1.0v	1.2v
MULTIMETER CAPABILITY		
price	—	$1895
functions	—	dc, ac, mV, ohms, current
source of data	catalog—1968	#7000 - 8/67

NLS X2 SERIES	DANA 4400 SERIES
$1180	$1150
3	4
20%	20%
.02% r. ± .01% f.s.	.01% r. ± .01% f.s.
not specified	.01%
100 dB	100 dB
30 dB	60 dB
10 megohms	1000 megohms
$1630 (incl. ohms)	$1395
.06% r. ± .05% f.s.	.01% r. ± .01% f.s.
not specified	.01%
100 megohms	100 megohms
not specified	100 dB
no	yes
$1480	$1450
4	4
.05% r. ± .02% f.s.	.10% r. ± .02% f.s.
yes	yes
not specified	60 dB
$1630 (incl. mV)	$1795 (incl. mV and ac)
5	5
.02% r. ± .06% f.s.	.01% r. ± .02% f.s.
16v	1.2v
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SQ-10A — MINI-PRICED, but a top performer in general purpose applications. Only $10.50 each in hundred quantities.

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CIA-2 — LOW PROFILE, HIGH PERFORMANCE. Thick-film hybrid, 80,000 gain, ±5μV/°C input voltage offset.

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QFT-2 — TOP-GRADE PERFORMER. Gain 200,000, slew rate 10V/μsec, 10 pA input bias current.

Q103A — HIGH INPUT IMPEDANCE, LOW BIAS CURRENT. Input voltage offset ±2μV/°C. Only $25.50 each by the hundred.

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Q25AH — WIDEBAND FET HYBRID. 600,000 hours of operation with no failures. Small size TO-8 package, hermetically sealed.

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PP45U — 100 MHz BANDWIDTH. Slew rate 200V/μsec. Excellent for broadband inverter applications.

1016 — FAST, HIGH POWER. fp>1 MHz. Full output of ±10V, ±100 mA to 1 MHz. CMRR 100,000. E_{os} T.C. is 10μV/°C. A_o at 750,000.

1011 — LOW PROFILE, FAST SETTLING TIME FET. 15 MHz bandwidth, slew rate 70V/μsec. Delivers ±11.5V output. Settles in 1.5 μsec to .01%, 0.4 inches high max.

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ESL-1 — WIDE SUPPLY VOLTAGE RANGE, ±8 to ±16V. CMRR 1,000,000:1, common mode input resistance 1.5 G ohms.

USL-1C — HIGH STABILITY. Wide range of supply voltages from ±8 to ±26V. Input voltage offset ±1μV/°C. Low drift.

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MLF-100 — ±100 VOLT OUTPUT at 10mA. FET input amplifier. Short circuit protected.

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Q-200A — BATTERY OPERATED. ±50μA quiescent drain. Ideal for OEM battery operated and airborne instrumentation.

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S-52 — LOW, LOW COST IC. Easy to stabilize. Dual in-line package. $5 each in quantity.

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PHILBRICK/NEXUS RESEARCH

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Everyone talks correed reliability,

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Switches under glass.

The heart of every AE correed is a reed switch consisting of two overlapping blades. For protection, we seal them inside a glass capsule. But only after we pull out all the dirty air and pump in a special, pure atmosphere. That way there's no chance of contact contamination or oxidation. Ever.

Notice our terminals are one piece. A special machine delicately forms them to precision tolerances. It's a lot of work, but one-piece terminals have distinct advantages over the two- and three-piece kind.

For one thing, there's no extra joint so you're always assured of a positive contact. Also, one piece terminals are more reliable when the correed is used to switch low-level analog signals. That's because thermal EMF is reduced to practically zero.

A different kind of bobbin.

Since we go through so much trouble with our correed capsules, we designed a special bobbin to protect them.

It's molded of glass-filled nylon. (You know how plastic chips and cracks.) Moisture and humidity have no effect on this stubborn material. No effect means no malfunctions for you to worry about. No current leakage, either.

Running the full length of the bobbin are a series of slots. They pamper the capsules and keep them from getting damaged or jarred.

And to help you remember which terminal is which, we mold the terminal numbers into the end of the bobbin. You can read them at a glance.

Little things mean a lot.

Reliability means that we pay attention to the little things. Like the tiny pressure rods we use in every miniature correed. They're placed at each end of the bobbin, across the one-piece terminals. What they do is prevent stresses from being transmitted from the terminals to the reed blades. This keeps the contact gap right on the button. All the time.

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Coiled by computer.

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Our next step is to protect the coil. We do that with more protective insulation.

A coat of iron.

On top of the insulation goes a layer of annealed iron. It acts as a magnetic shield and minimizes interaction between coils. Also, it improves the sensitivity of the entire unit. A coat of iron is standard on all AE correeds.

Finally comes super wrap.

To wrap it all up, we use some very special stuff. A layer of mylar laminated material. It's so tough we guarantee it to withstand all cleaning solvents known to man.

It's attention to detail that helps us keep our miniature relays miniature. Now we're just waiting to show you how perfectly it measures up to your specifications. Automatic Electric Company, Northlake, Illinois 60164.

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Cimron's environmental multimeter is a pretty insensitive brute

To abuse, that is! Not that we actually took a club to it, but no ordinary multimeter could take the punishment it has and still run, let alone provide accurate measurements. Built to meet Mil Spec T-21200F, Class 3, this instrument is rugged enough to give you lab precision anywhere from the arctic to the jungle. And it's the second generation design. Over 300 first generation models are now in use in harsh environments around the world. Certified test data show it has an accuracy of .001% F.S. + .005% of reading, can take a 15g shock, vibration up to 55 Hz, and run through extremes of temperature and humidity. 6 digits, including 10% overrange. Solid state logic tracks as fast as the voltage changes; response time is faster than 100 milliseconds. And with it goes all of Cimron's customer concern — the technical support that helps you get all the performance it can give. For details on Model E4600, write to Cimron®, Dept. C-114, 1152 Morena, San Diego, California 92110.

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Go 90-Watt Plastic In Your General Purpose, Silicon Power Designs!

You can set new standards of economy and performance in the power transistor portions of your system designs with the new, MJE3055 Thermopad* silicon power transistor — metal-spec'd but plastic-packaged version of the popular, general-purpose 2N3055.

The 12 A, 60 V NPN device furnishes a full 90 watts of power through an exclusive, direct, chip-to-heat-sink thermal path of only 0.030" — first power transistor to break the higher-wattage, plastic-package barrier. Beta is spec'd at two points, too, affording the engineer a complete picture of its high-gain capabilities.

For those wanting a fast, economical switch the MJE3055 offers high frequency response and good switching time. The unit is also ideal for series and shunt regulators and high fidelity amplifiers and exhibits excellent beta linearity over its entire operating temperature range.

$1.00† buys the new MJE3055 . . . a call to your franchised Motorola distributor puts one on your prototype workbench the same day!

Eighteen other rugged and reliable Thermopad plastic power transistors — including the broadest line of NPN/PNP complementary pairs for cost-cutting, circuit-simplifying, direct-coupled designs — are also available from your Motorola distributor. Write Box 20912, Phoenix, for data sheets on Motorola Thermopad plastic silicon power transistors — then design them in!

90 W Power Dissipation

Type	Polarity	I_C (Cont) A	V_{CEO} (Sus) V	h_{FE} @ I_C (min)	$V_{CE(sat)}$ @ I_C (max)	f_T MHz
MJE3055	NPN	12	60	20 @ 4A 5 @ 10A	1.1 @ 4A	2

40 W Power Dissipation

2N5190, 91 & 92 2N5193, 94 & 95	NPN PNP	4	40, 60 & 80	25 @ 1.5A	0.6 @ 1.5A	4

30 W Power Dissipation

2N4918, 19 & 20 2N4921, 22 & 23	PNP NPN	3	40, 60 & 80	20 @ 0.5A	0.6 @ 1A	3

*Trademark Motorola Inc.
†100-up

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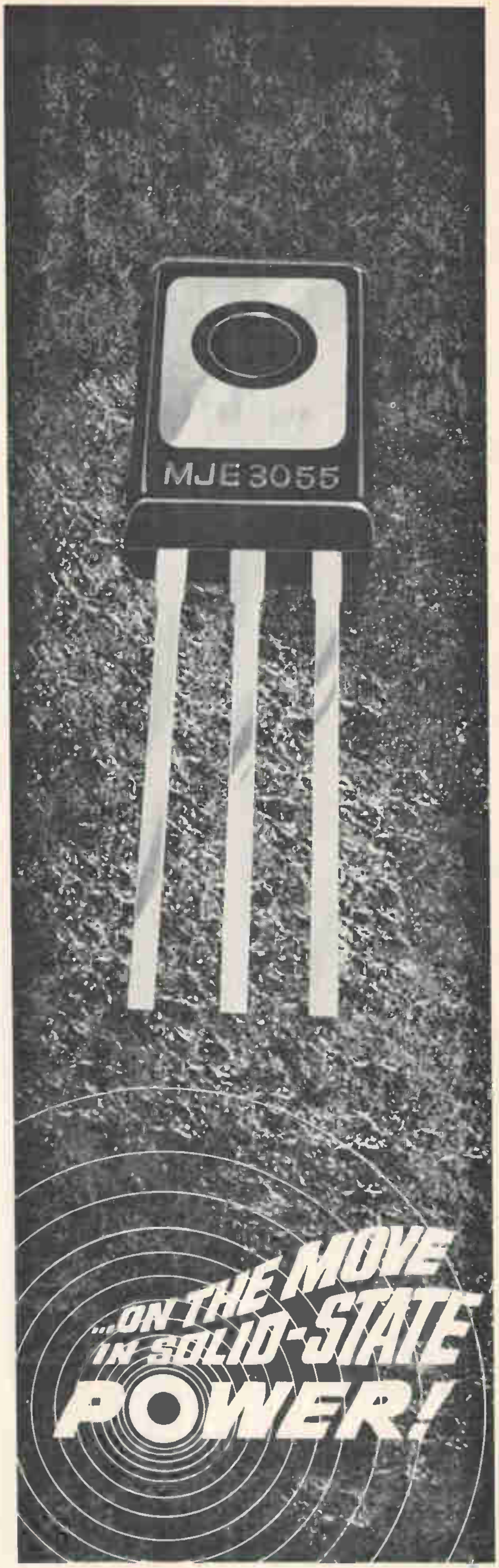


Investigate Random or Periodic Processes with Correlation Function Computers

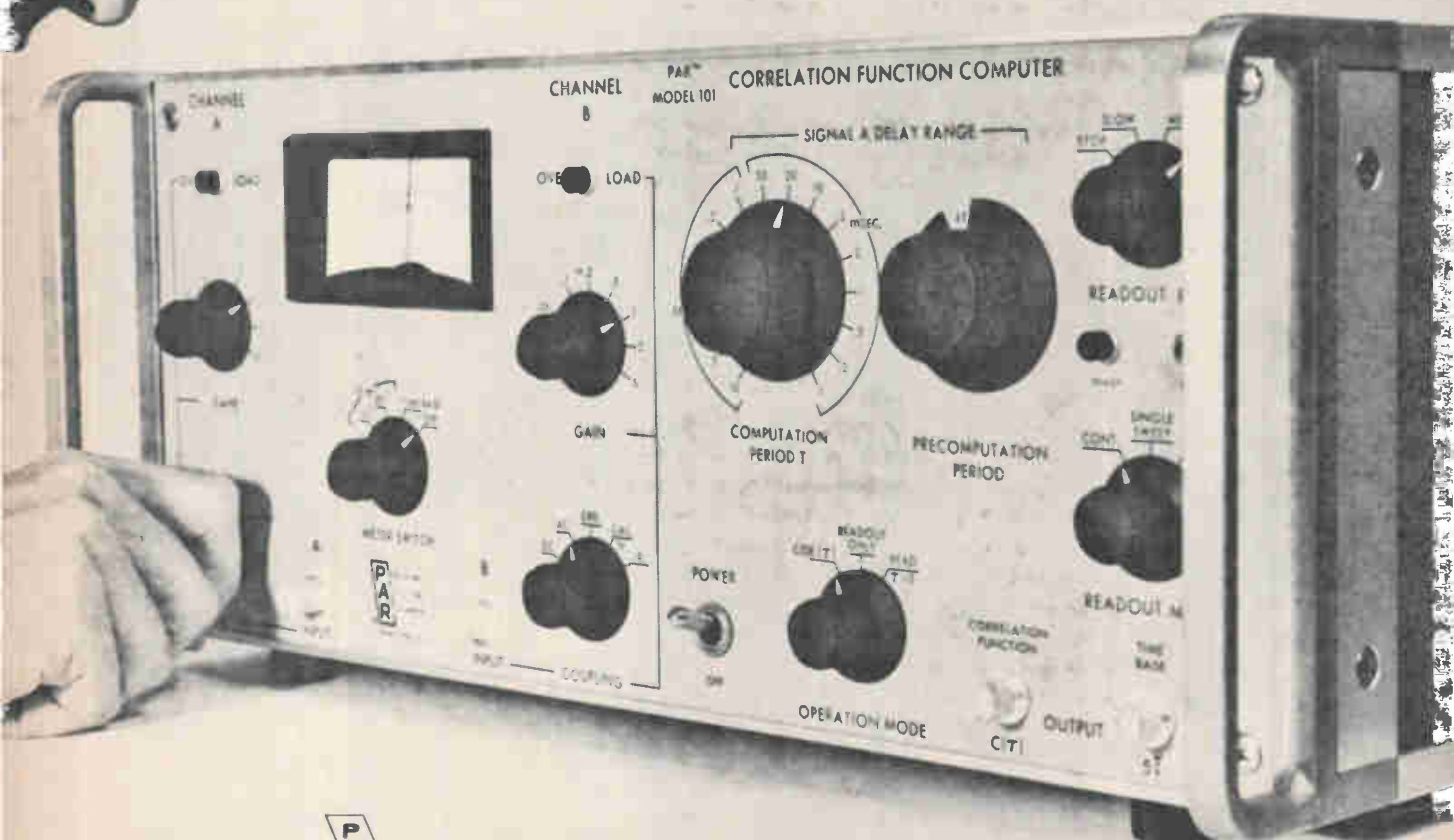
Correlation functions occupy a cardinal position in modern information theory and are basic to the analysis of random or periodic processes and the complex signals they produce. In many application areas, autocorrelation analysis allows noisy periodic or random signals to be defined, whereas crosscorrelation can determine the degree of conformity between two different noisy signals as a function of their mutual delay.

PAR™ Models 100 or 101 Correlation Function Computers simultaneously compute 100 points of the auto- or crosscorrelation function in real time over delay spans from 100 microseconds to 10 seconds. The Model 101 includes the capability for insertion of fixed delay increments ahead of the 100 computed points of the function, thereby providing greater resolution. The correlation function readout which may be obtained continuously as it is computed, is available at various rates consistent with the speed of the external readout device, e.g. oscilloscope or X-Y recorder.

Vibration analysis, radio astronomy, laser research, geophysics, radar, plasma physics, aero- and hydrodynamics, and biophysics are only a few of the fields where correlation techniques are useful.

Price of the Model 100 is $8,500. The Model 101 is priced at $9,500 to $12,900. Export prices are approximately 5% higher (except Canada).

For additional information, write Princeton Applied Research Corporation, Box 565, Princeton, New Jersey 08540 or call 609-924-6835.



P A R PRINCETON APPLIED RESEARCH CORPORATION

November 11, 1968

Electronics Review

Volume 41
Number 23

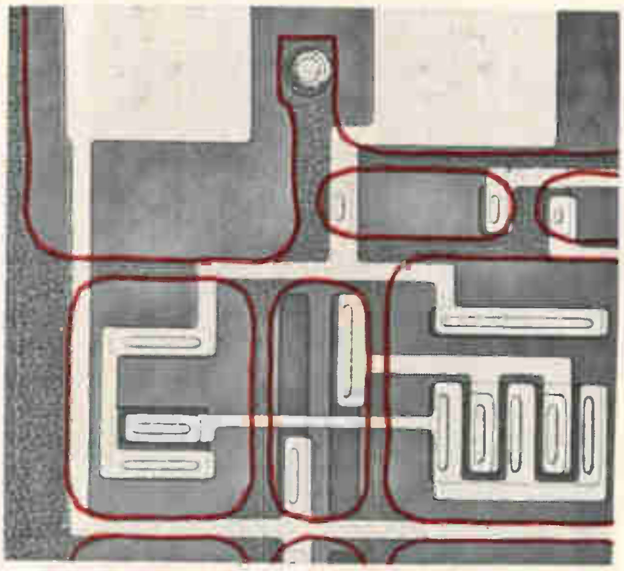
Integrated electronics

High-voltage IC's

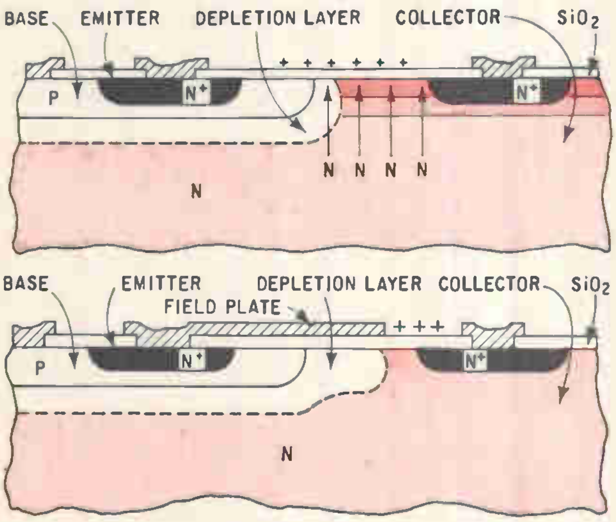
Breakdown voltages in integrated circuits are generally limited to about 50 volts for two basic reasons. Positive charges in the surface oxide pull electrons toward the surface, reducing the resistivity of the internal silicon and thus lowering its breakdown voltage. And a high-resistivity n epitaxial layer can be grown on a p substrate only with great difficulty; this makes high breakdown voltage hard to achieve even without the surface-charge problem.

But the Signetics Corp. has found ways of circumventing these problems and has developed IC's that won't break down even at 300 volts and more.

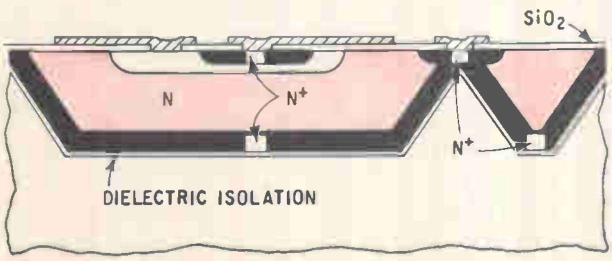
The company will begin marketing its high-voltage circuits around June of next year as video amplifiers and deflection amplifiers. By the end of next year, the IC's will be offered as operational amplifiers and regulators.



Starter. Signetics first high-voltage IC will be a video amplifier. In this development version the operating voltage is 150 volts and the gain is 50. The frequency response extends to 7 megahertz, and the total power dissipation is 300 milliwatts. The red indicates isolation channels.



Repulsion. Ionic charges in the SiO_2 layer at the surface of a planar device (top) increase the electron concentration there, resulting in low breakdown voltage. A metallic field plate, however, pushes the depletion layer deep into the device, where breakdown occurs at a much higher voltage.



Selective. Signetics anisotropic etching process removes silicon selectively, along certain crystal planes.

In the bulk. Signetics avoided the surface-charge problem by designing a "field plate" structure on the surface. The field plate is connected to the most negative potential available to neutralize the positive oxide charge. It therefore prevents electrons from accumulating at the surface; breakdown occurs in the bulk and at a much higher voltage.

To get high-resistivity n material on a p substrate, Signetics adopted dielectric isolation. With this process, the collector region is formed from grown and refined silicon, rather than epitaxial material, so that it's possible to get an almost defect-free region of virtually any desired resistivity.

The company uses an anisotropic etchant to isolate the components on the silicon chip; the widths and depths of the isolation channels are precisely related to the widths in the mask pattern because the etchant attacks the silicon only along certain crystal planes.

Less power. The high-voltage IC's will consume less than a third the power of the discrete circuits they'll replace, according to Leonard Brown, marketing manager for linear IC's.

The industrial and consumer markets will be the primary targets. Signetics attaches particular importance to color tv, a market IC's haven't been able to penetrate extensively because of their voltage limitations.

"Now," says Brown, "we can economically make high-voltage monolithic circuits with enough passive devices to get high-frequency performance."

He sees as a suitable application any high-voltage display system in which the cost of discrete devices and a surfeit of external components have created insurmountable design limitations.

High-gain transistors

If the emitter of a transistor on a monolithic integrated circuit is diffused deeply into the base, the transistor will have extremely high current gains, of around 5,000—even at collector currents of less than 1 microamp. This is 10 times the gain of discrete transistors. But because the collector and the emitter are nearly shorted in this so-called "punch-through" transistor, it has a breakdown voltage as low as 5 volts. Designer Robert J. Widlar of National Semiconductor has devised a way of using the high current gain while sidestepping the low breakdown voltage.

At the Northeast Electronics Research and Engineering Meeting (Nerem) in Boston last week, Widlar described an operational amplifier with four transistors in the input stage: two bootstrapped high-beta primaries, operated at zero volts, cascaded with two high-voltage secondaries. The technique takes advantage of the high gain of the input transistors and uses it to get a high voltage from the secondaries.

Widlar says an op amp designed with this type of input stage could provide an input current two to three orders of magnitude lower than those of present designs.

Low input. The point is to allow the op amp to operate at extremely low input currents, so as to minimize offset voltage in the differential input stage, yet still produce sufficient current at the output.

Junction field effect transistors, which have excellent current gains, are widely used in discrete op amps, but they are extremely difficult to match on an IC chip. Bipolar transistors match very well, but they have low current gain at low currents.

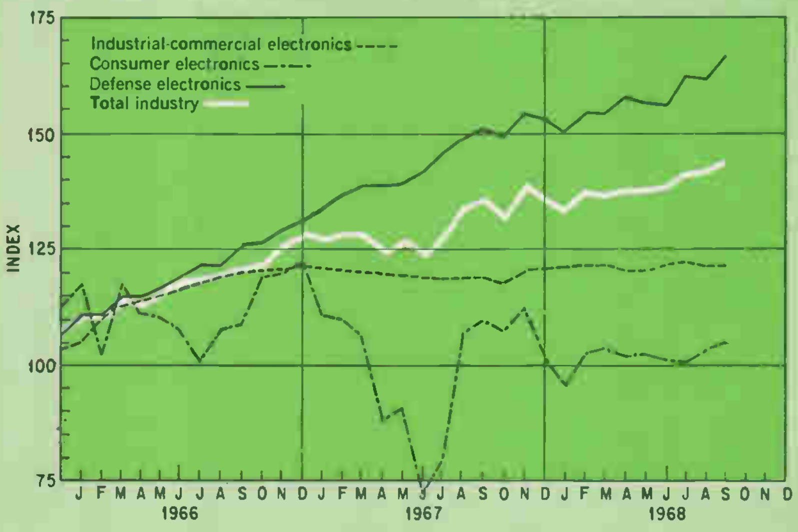
Widlar points out that bipolars can be made with high gains if one is willing to live with the low breakdown voltage. "It is interesting to note that transistors that have been driven into punch-through exhibit less fall-off of current gain at low collector currents," he says. "This probably happens because there is a large difference between the emitter-base turn-on voltage in the bulk near the collector-base junction and the turn-on voltage near the surface. A greater difference in these voltage reduces the collector current at which the fall-off occurs."

Widlar has already designed a circuit using this design, and it has been marketed by National for nearly a year. This is the LM102, a high-impedance op amp designed for unity-gain voltage-follower applications [Electronics, Jan. 22, p. 173]. But Widlar has not yet put the new input stage into a general-purpose op amp; the Nerem paper is the first clear indication that he intends to.

Last month, National cut the price of the LM101, Widlar's improved version of his 709, by 50%. At the same time, the company in-

Electronics Index of Activity

November 11, 1968



Segment of industry	Sept. 1968	Aug. 1968*	Sept. 1967
Consumer electronics	105.8	104.1	109.2
Defense electronics	166.4	162.1	153.1
Industrial-commercial electronics	121.7	121.6	118.5
Total industry	143.0	140.4	135.5

Electronics production advanced 2.6 points in September from August and 7.5 points from September 1967. The largest gain was in defense electronics: for the month the gain was 4.3 points and for the year 13.3 points. The consumer index advanced 1.7 points in the month but fell 3.4 points in the year. The industrial-commercial index inched up 0.1 point in September and rose 3.2 points from 1967.

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.

* Revised

troduced a new op amp, dubbed the LM101A; it sells for the same price as the old 101, but performance over the entire military temperature range has been drastically improved. The 709 and the 101 have input offset current of 500 nanoamps, bias current of 1,500 and offset voltage of 6 millivolts; in the 101A, the values will be 20-na offset current, 100-na bias current, and 3-mv offset voltage.

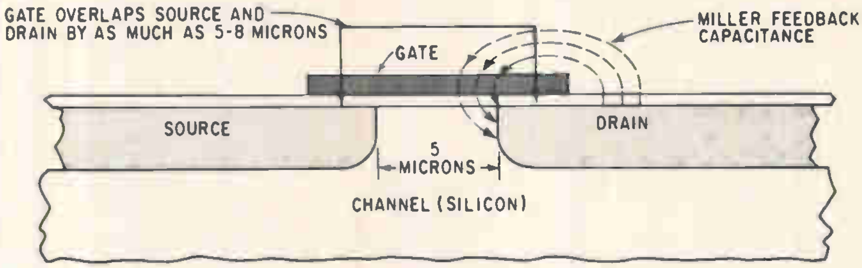
Sticky and tricky. "To go from the 709 to the 101A was a matter of improving the process," Widlar says. "But to do more merely by raising transistor current gains is sticky. You run very quickly into the tradeoff transistor current gain and breakdown voltage."

Fabrication of the chip requires an extra processing step, since the transistors are made with separate emitter diffusions—one deeply diffused for high current gain and the other with a normal diffusion for breakdown voltages above 50 volts.

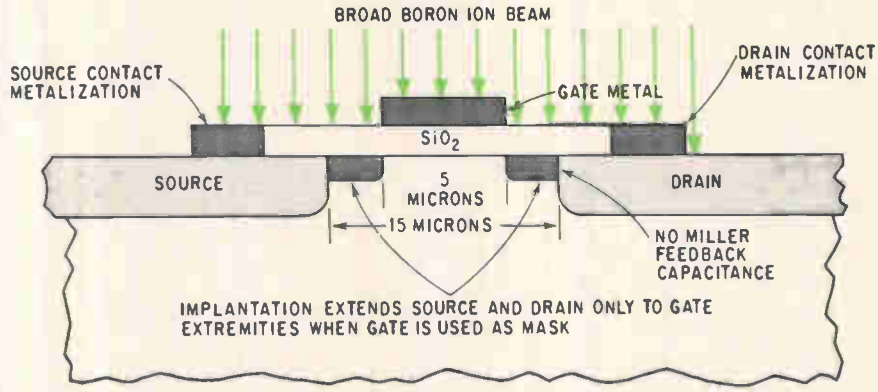
However, Widlar points out, the processing itself is much less critical than for a conventional design, since the diffusion need not be so closely controlled. Pushing current gains at the expense of breakdown voltage can lead to some very tricky diffusions, Widlar says, since there is a danger of going into punch-through unwittingly. Eliminating the tradeoff also eases the diffusion tolerances.

National is mum on when a successor to the 101A can be expected, but in his Nerem paper, Widlar predicted that the primary application of punch-through transistors in IC's would be in general-purpose op amps. With a year's experience on the 102, National may not have to delay too long on the general-purpose circuit.

MOS FET PRODUCED BY DIFFUSION ALONE



MOS FET PRODUCED BY DIFFUSION PLUS ION IMPLANTATION



Ion-implant serendipity

A dash of serendipity went into the recipe that has put Hughes Aircraft within reach of using ion-implantation techniques to produce metal oxide semiconductor field effect transistor arrays [Electronics, Oct. 14, p. 33].

The happy tale is told by Robert Bower, manager of the applied solid state research department at the Hughes research laboratories, Newport Beach, Calif. By coincidence, a strong effort to improve MOS FET and microwave devices was under way at the labs simultaneously with an ion-implantation program. During the work the lab realized that MOS FET's happened to be a good vehicle for ion implantation because they have a single p-n junction. They don't require the complex dopant profile needed for double-junction devices such as bipolar transistors.

Barring breakdown. Bower says Hughes has overcome many of the problems that caused others to despair of mastering ion implantation through a good silicon dioxide layer. These problems included implanting at room temperature or below; damaging the oxide, causing disturbed passivation characteristics; and charging the surface of the p-channel devices positively to a very high voltage, causing it to break down.

Hughes implants boron ions at 100,000 volts and temperatures of 250° to 350°C, then anneals out any implantation damage in the silicon crystal structure by soaking wafers at 550°C for a few minutes. "We also pin the surface potential—prevent it from charging positively—by showering the whole surface with low-energy electrons," Bower explains. Many more electrons than boron ions arrive at the surface, he notes. But the neatest trick—using the gate as the source-drain mask—is the step that ensures full compatability with production techniques.

Using diffusion alone, three masking operations are required to diffuse the p+ source and drain regions into the p-type silicon at high temperatures—about 1,100°C. Then the oxide layer is grown at a slightly lower temperature, and a fourth mask is used to form the gate that covers the p-type channel between the source and drain. Bower notes that with conventional diffusion the aim is to keep the gate narrow enough (5 microns is recommended) to minimize stray capacitance between the gate and channel.

Excess capacitance. But intermask tolerances are such that the gate must overlap the source and drain by 5 to 8 microns to be sure of covering the entire channel. As a result, parasitic capacitances from gate to source and gate to drain are as great as that between the gate and channel.

"You have three times the capacitance needed, degrading device performance," Bower says. "But things get worse. When you operate a three-terminal device, there's a voltage gain that multiplies the capacitance between the gate and drain. This is the Miller effect, and the voltage gain on the average circuit is two, so that a typical high-quality MOS FET made by diffusion alone has five times the input capacitance needed," he says.

In the Hughes method, the p+ regions that will form parts of the source and drain are diffused in, and the gate oxide is grown in the usual way, but the mask spaces the p+ regions 15 microns apart, instead of 5 as in MOS FET's made by diffusion alone. The gate oxide is then selectively removed over parts of the diffused source and drain to allow formation of the gate electrode and source-drain metallic contacts, so that metalization takes place before implantation. Although the gate is only about 5 microns wide, it acts as a mask, and when boron ions bombard the structure, they penetrate the exposed oxide region and form a p-n junction about 0.4 micron deep into the channel region.

Faster devices. With ion implantation, there is virtually no lateral spread of the dopant as there is with diffusion. This means that the junction has the exact dimensions of the mask. There is no overlap of the gate over the source and drain areas, and consequently no parasitic capacitance between source and gate and drain and gate. The source and drain are extended during implantation beyond their diffused-in dimensions, but only to the edges of the gate acting as a mask.

By combining diffusion and ion implantation, then, Hughes can put the gate down before implantation and after all diffusion has taken place. This makes implantation and annealing the last steps before wafer passivation and dicing, and because implantation is done at low temperatures, a normal gate metal, such as aluminum, can be used.

The input capacitance is cut to a fifth of that occurring with simple diffusion. Hughes' studies show that reducing parasitic capacitance will make MOS devices—shift registers, large-scale integrated arrays, and commutator switches—three to five times faster than devices made with simple diffusion. About 100 ion-implanted MOS FET wafers have been processed. Tests with an MOS integrated-circuit ring oscillator showing average propagation delays per stage of 4 to 4.5 nanoseconds for diffused and ion-implanted devices—versus 20 to 25 nanoseconds for devices made by diffusion alone—lead Bower to project a speed of 30 megahertz for a dual 25-bit, two-phase MOS shift register within six months. Today's best speed is about 10 Mhz.

Bower says an ion-implantation machine costing $30,000 to $35,000 that's much simpler than the engineering model in use now will put the Newport Beach facility into production with ion-implanted MOS circuits next year.

Displays

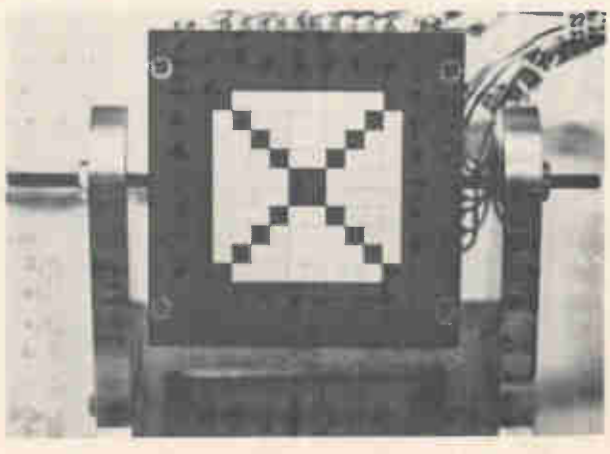
Controlling the view

Almost four years ago, the Electronic Systems division of Sylvania Electric Products got a contract from the Air Force's Rome Air Development Center for a flat-screen display. The model, using tiny electroluminescent panels, was to prove the feasibility of displays 8 to 10 feet on a side [Electronics, July 25, 1966, p. 144].

Now the Needham, Mass., operation has delivered, and though the EL array is only about 1¼ inch square, Joseph L. Hallett, display and simulation laboratory section head, says it convinces his men that large displays could be made—perhaps at about 40 cents per glowing element.

Diode drawbacks. The military is trying several routes toward large-screen display technology, among them laser, film, and cathode-ray-tube projection systems. According to Hallett, such systems are costly to operate and maintain. And the space required for their projectors and projected beams, he says, makes them "just about impossible for airborne control centers."

"For alphanumeric data, a wall-screen, random-access, dot matrix display is most practical," says Hallett. This includes not only Sylvania's EL scheme but also diode displays. Failures of light-emitting diodes, however, tend to be catastrophic, while EL elements dim gradually, says Hallett. What's more, he points out, the high current densities diodes require make for interconnection problems, especially if the display is to be built in an IC-like format. Finally, he adds, it's not always possible to get a desired color with diodes. "Some display schemes even use an image converter to change the diodes' output to visible radiation, and that's costly and inefficient,"



EL display. This 1¼-inch-square, 100-unit display may be the forerunner of 10-foot-square models. Larger displays could have as many as a million units.

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Enlarged unretouched photograph showing multi-chip junction construction.

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the Sylvania official adds.

Sylvania's display has had problems of its own. Most deal with control of the EL units—singling out one while keeping others off; making sure the display stays lit; switching the high voltages needed while minimizing leakage during the off state.

Few connections. Sylvania tried five circuit designs before settling on one that met the criteria: the fewest external connections, the fewest power supplies, and the lowest power consumption. The final circuit (there are 100 in the model, one for each EL unit) has only four connections: two for address, one for B+ current, and one for the EL unit. Control and switching are handled by a pair of silicon controlled rectifiers—one high- and one low-voltage—plus four resistors and two zener diodes. Making this circuit was the toughest problem; the 100-element panel was adapted from the company's standard product line.

The high-voltage SCR must have low leakage, because the EL units use about 250 volts a-c but only about 200 microamps in the on state.

With such a small current requirement, leakage through the SCR would have let unused elements glow, reducing contrast. Hallett's group estimated that it could allow only 2 picofarads of leakage in the high-voltage switch.

Good isolation. The engineers rejected diode isolation as having too much short-circuit potential. Oxide isolation would have required moats on the chip 7 or 8 mils deep and wide. They finally settled on beam leading for both the high-voltage SCR and the other circuitry. The beam-lead format resulted in good isolation and, by getting the SCR out of its package, reduced parasitic capacitances. "This is a unique SCR," says Hallett. "It has no commercial counterpart."

The circuit that controls it is also beam-leaded. This time, breakdown voltages of only 7 to 9 volts are enough, so all the other components of the circuit (zeners, low-voltage SCR, and so forth) can be put in one IC and assembled on an alumina substrate with the high-voltage switch to form the control circuit.

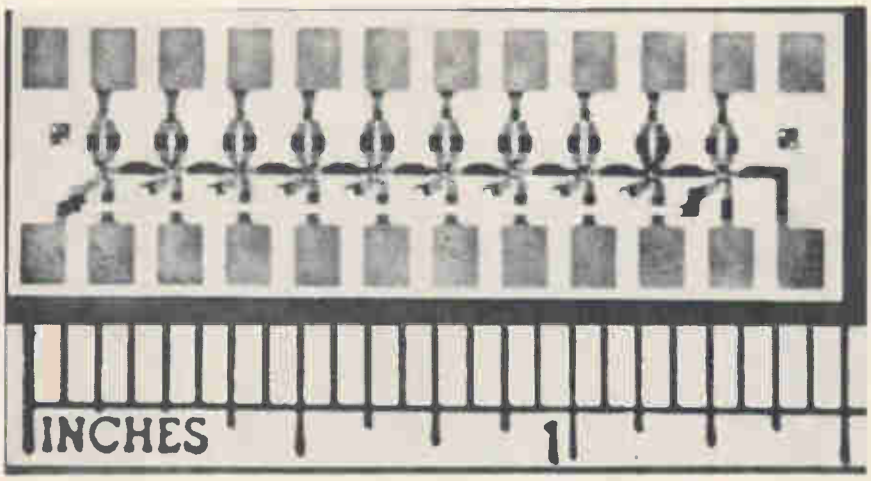
This circuit depends on pulses of opposite polarity sent to the two address inputs of the IC. These pulses indicate the x and y coordinates of the EL panel to be lit. The control circuitry ignores any x pulse without a simultaneous y pulse at the other input, so only the desired EL panel is lit.

The x and y pulses' relative potential exceeds the zener voltage for the diode pair in the gate leg of the low-voltage SCR. This triggers the switch, which in turn triggers the high-voltage device. To keep from having to "refresh" the display, Sylvania used a latching arrangement. B+ current holds the high-voltage switch on until two simultaneous erase pulses appear at the address inputs to turn off the low-voltage SCR, and thus the high-voltage one.

On view. Hallett's group had set goals of a 15-microsecond switching time and a display brightness of 20 foot-lamberts. The model exceeds both marks; switching takes 3.6 microseconds at worst, while brightness is easily in the 35-to-40-foot-lambert range—enough for easy viewing in a lighted room.

Part of Sylvania's task was price prediction for large displays, perhaps with a million EL units. Hallett figures that EL displays could be made for 40 cents per unit—including the control circuits. To reach this price, he would combine the control IC and the high-voltage SCR into a single beam-lead chip, and perhaps adapt the EL panel for duty as a hybrid substrate. Thus a future display might have EL units on one side of a single substrate and control circuitry on the other.

The Air Force, however, would like a cost of about 10 cents per unit. Hallett doubts that any present technique can reach this level but says batch processing and monolithic fabrication are being studied to find out how much they would cut costs.



In command. In the control circuitry for the electroluminescent display, beam-lead IC's and SCR's on this hybrid pick one of 10 EL units, switch on the high voltage needed to make it light up, and keep the display refreshed.

Packaging

Fairpak finale

The new boss of integrated-circuit production at Fairchild Semiconductor is former Motorola executive Eugene Blanchette, and—in the Motorola tradition—he has already taken drastic steps to cut costs and boost volume. One of his first actions upon moving to Fairchild was to stop production of the Fairpak, the flip-chip package that had defeated all cost-cutting attempts since the company introduced it nearly two years ago. Then last month, in an unrelated action, Blanchette hired John Husher, an IC production specialist, away from Sprague Electric's semiconductor

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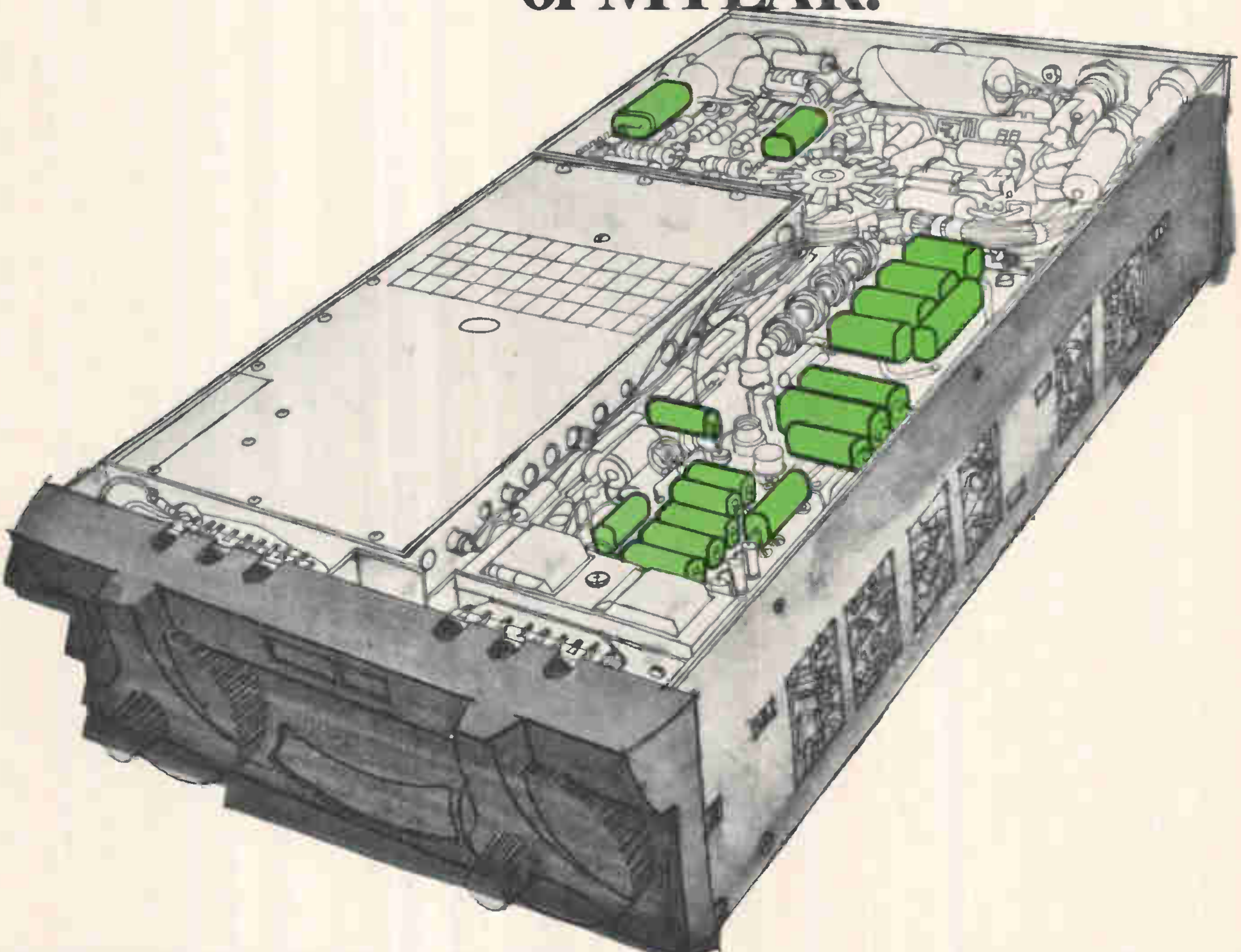

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operation and put him in charge of a unique satellite operation at Fairchild's South Portland, Maine, facility.

Blanchette had never been enchanted by the Fairpak; shortly after arriving at Fairchild he noted that "the metalized ceramic substrate puts it out of the ballpark for really low cost."

The coup de grace for the package may have been the development of a radically new kind of aluminum beam-lead device that's produced by a technique far simpler than Bell Laboratories' air-isolated, back-etch method for gold beam leads. Devices have already been assembled by this process and are undergoing reliability tests. Blanchette is closemouthed about how they're made or when they'll be introduced, but this aluminum beam-lead approach is the only one of four methods of one-shot bonding to which he has assigned a development task force. (The others under study at Fairchild are gold beam leads, spider bonding for plastic-packaged flip-chips, and bumped chips for multichip packages.)

The Fairpak, the first commercially available flip-chip package [Electronics, Feb. 20, 1967, p. 49], contains aluminum-bumped chips bonded face down on a metalized ceramic substrate and capped with a little glass-ceramic seal. Fairchild introduced it for four diode-transistor-logic circuits, switched it over to its slow-selling transistor-transistor-logic line shortly thereafter, and has resolutely refused to publicize it after the first splash. Blanchette says the company will still make it for anyone who insists.

Independent. The South Portland experiment will be the total responsibility of Husher. The operation will do its own scheduling, make its own masks, and fabricate IC's from the wafer level through packaging.

In general, South Portland will produce the older lines of Fairchild IC's—DTL, CTL, and the 9000 line of TTL. Mountain View, Calif., will concentrate on linear circuits, medium-scale integration, micro matrixes, computer-aided design, MOS, and memories. When Mountain View needs space to turn out new products, the older lines will be transferred to South Portland.

"In 1971, the IC market will amount to $800 million," Blanchette says. "If Fairchild, as a leader, is to have a quarter of that market, there has to be another plant in which to make the circuits. And we also have to find a way to move the newer, more sophisicated products onto the market fast but without ignoring the volume lines."

Husher will become a director under Blanchette. He will be headquartered at the parent plant in Mountain View and will have his own development group to pass research and development improvements on to the South Portland operation. Orders entering the company will be scheduled independently—"but in total visibility," as Blanchette puts it delicately—by Husher.

The move means a substantial increase in the engineering staff at South Portland. Blanchette says new—and presumably automated—assembly techniques will be introduced there in 1969.

Industrial electronics

Keeping in touch

Municipal police forces may someday have an easier time keeping track of their wayward "Car 54's." The Department of Housing and Urban Development is studying a program called Pulse (for public urban locator service) that would give dispatchers of public and commercial vehicles a constant picture of the vehicles' location.

HUD would like to develop such a system as a nationwide public utility, ensuring coordinated planning by requiring private and public customers to use the same service.

To get an assessment of the program, the agency last month sponsored a technical conference in Washington attended by 20 electronics firms. Most of the engineers present agreed that such a system

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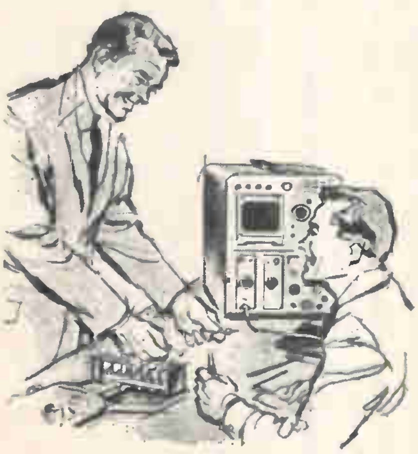

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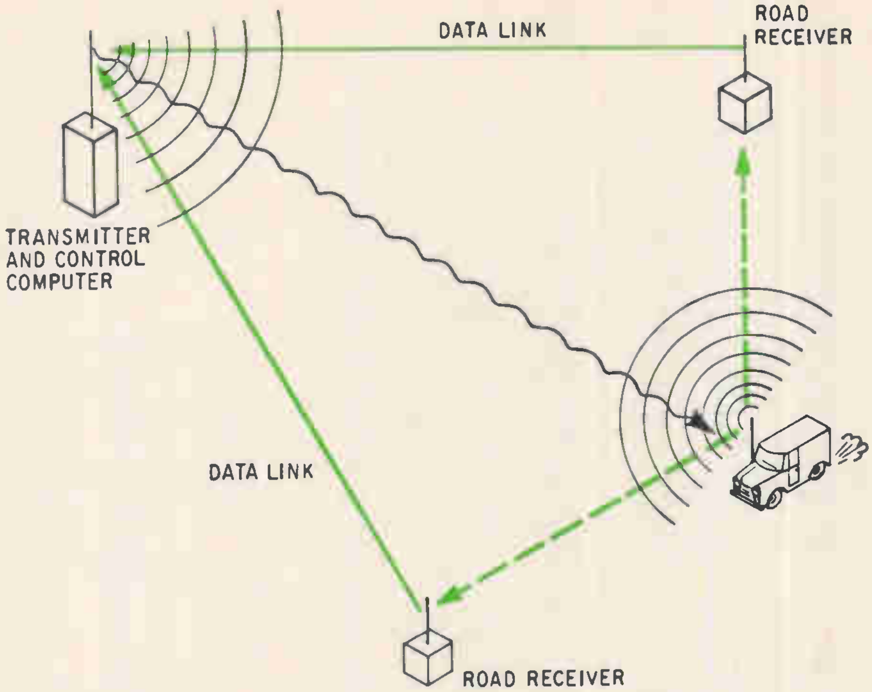

Traffic signals. System under study by the Government would keep track of vehicles and display their locations.

was feasible. It was noted, though, that the capital and installation costs might be prohibitive.

Meeting of minds. Surprisingly, most of the companies at the meeting had independently arrived at similar conclusions as to the best technical approach to the system. Generally they suggest that the vehicles involved be equipped with inexpensive transponders that would pulse out short-range radio signals. Each vehicle would have its own code signal, and this would be picked up by receivers strategically spotted around the city. Hundreds of receivers might be necessary in a large city. The message from the receivers would be flashed via telephone lines or coaxial cables to a central computer, which would then calculate the location of the vehicle and store or display the data as needed.

The hardware market created by a nationwide system would be tremendous—millions of vehicle transponders, thousands of location receivers, and possibly hundreds of computer-display complexes.

One setup involving scattered remote receivers is now being built by Motorola for the Chicago Transit Authority at a cost of $1.2 million. Two-way radios are being installed aboard 500 city buses under this system, which will monitor bus progress.

Further study. Both private and Federal officials concede that a nationwide program requires a great deal more study. Under a $200,000 grant, HUD has hired two Washington consulting firms—the Institute of Public Administration and Teknektron—to probe further into the system.

With technical details so vague, few are willing to estimate what a nationwide system would cost. When pressed, industry and Government officials put the cost "in the tens of billions of dollars." These figures give the program an unrealistic sound to many officials. But industry representatives see a tremendous market opening up even if the system is only partly implemented.

Military electronics

Counterrevolution

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"management revolution" led by former Defense Secretary McNamara is proving to be no exception. The weapons commonality idea has been under fire [Electronics, Oct. 28, p. 70], and now McNamara's firm fixed-price contracting policies are also under attack.

The Aerospace Industries Association recently complained to the Pentagon that too many fixed-price contracts were being used in major weapons systems development. Soon afterward, the department's own Armed Services Procurement Regulations (ASPR) Committee, in an apparently unrelated move, issued new rules that appear to meet some, but not all, of the objections. Both actions reflect growing suspicion that fixed-price contracts can impede technological advances and cut profits, especially in research and development efforts.

Bad feeling. Initiated several years ago, the fixed-price contracting policies were basically intended to save the Pentagon money on production contracts. But many service R&D commands felt they had to comply also and used the policies on contract definition and the following research and engineering phases of a system's life cycle.

Consequently, the AIA asserts that a contractor under a firm fixed-price or fixed-price incentive contract may see his profit decline when he has to solve one of the unforeseen technical problems common in the contract-definition phase. Often, too, subcontractors get saddled with rigid, unpleasant contracts. In every major weapons system development reviewed by the AIA, the company had to make substantial technical changes to meet the contract specifications.

Such fixed-price contracting occasionally led to bad feeling between contractors and the service command and, within the command, between the program officer who had the final say on selection of the type of contract and the technical and legal sections.

Flexibility. The AIA suggests instead that the choice of the final contract type for engineering development be made after the contract-definition phase and that the contracts be made flexible to accommodate the degrees of technical difficulty involved in the system. The AIA, however, strongly opposes "any return to older contract practices which rely upon cost-plus-fixed-fee contracting for major weapon systems development."

Specifically, the AIA recommends that the Pentagon:

- Choose the contract for each individual weapon system that is appropriate for the technical uncertainties involved.
- Establish a board to review each contract.

The new ASPR regulations make the contracting officer the final arbiter of contract type, but he must make his decisions with the advice of the technical sections, discuss the types of contracts to be used with the contractors (who may offer alternate suggestions), and make a written report of his reasons for choosing a certain contract type. The ASPR changes don't satisfy the AIA desire for a central Pentagon review board. The AIA thinks that the decisions on contract type are made by middle managers who are hard to reach and whose decisions can't be appealed.

Unk unks. As the complexity and cost of programs increase, the AIA contends, the problems and uncertainties of contractors will multiply. Engineering development costs are currently from 60% to 70% of total development costs and from 10% to 30% of life-cycle costs, it notes.

The chief cause of the industry's complaints are the "unk unks"—the unanticipated unknowns—that cannot be forecast on the basis of paper design and analytical studies, the AIA says. These are contrasted to the anticipated unknowns, "the things you know you don't know."

The AIA sees a trend of diminishing profits caused by more companies bidding on the fewer but bigger contracts available. The Pentagon discourages "buying in" (purposely bidding low to get in a favorable position to bid for the production contract), but the AIA says the current defense market is unintentionally producing a similar

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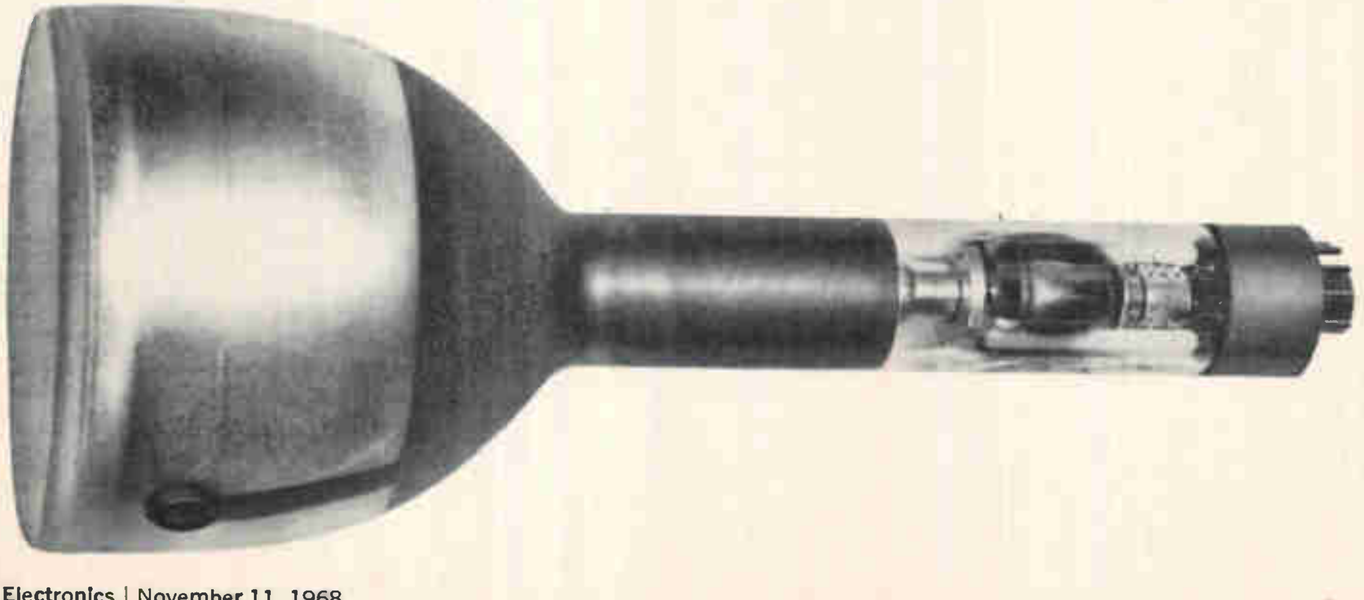

result. Companies may opt for a large profit on total business by stringing together tiny profits on many contracts.

No official Pentagon reaction to these complaints is expected until the new Administration takes office in January.

Advanced technology

Beyond microwave IC's

Even as microwave integrated circuits gain their first large markets, researchers are trying to make them obsolete with the new technique called praetersonics. Using microwave-frequency sound waves interacting with piezoelectric and semiconductor materials, they are already building the first models of parts for praetersonic signal-processing systems and other sections of radar and communications gear.

Lately, schemes using waves propagating over the surface of such materials have come into vogue, replacing similar acoustic devices that use waves propagating through the bulk of the material. But a key part of any surface-wave system — a microwave-frequency amplifier — is still lacking. Surface-wave amplifiers have yet to operate above about 300 to 500 megahertz because the transducers that convert electromagnetic energy to acoustic surface waves become so small that they are hard to make and performance is unrepeatable.

Up, up. Now scientists at Raytheon's Research division, Waltham, Mass., are developing what may be a high-frequency successor to such acoustic amplifiers. Using ferrite rather than piezoelectric substrates, scientific fellow Ernst F. Schlomann and senior research scientist Carl E. Patton have developed an amplifier design that should work into the 3- to 4-gigahertz region, and perhaps beyond.

The first version of the new amplifier would use a slab of yttrium iron garnet about a millimeter thick and 1 by ½ centimeter long and wide. It is bathed in a constant magnetic field across its width.

Lying flat. At either end of the flat surface of the garnet is a short stub antenna that allows microwave energy to be converted into magnetoelastic waves, which then propagate over the surface of the YIG.

This in itself isn't enough to cause amplification, although according to Patton, the YIG is just about lossless. To amplify, an overlay of high-mobility semiconductor such as indium antimonide is placed atop the slab in a layer as thin as 3,000 angstroms. A d-c pulse is applied to the ends of the semiconductor layer through ohmic contacts, with the direction of current flow the same as that of the magnetoelastic waves.

Positive feedback. Now, as waves propagate through the YIG, the weak magnetic fields accompanying them will extend into the semiconductor and induce a current flow at right angles to the applied d-c. This new current will have a magnetic field of its own, which will augment the magnetoelastic waves.

"It's a positive feedback system," says Schlomann, "since each of the two magnetic fields strengthens the other. This is how we hope to achieve gain."

The new device would be very small, since its size would be determined by the wavelength of microwave frequencies propagating in solid materials. Other workers in the field of praetersonics would have said that by switching from waveguide to acoustical or magnetoelastic propagation it would be possible for a centimeter-long circuit to do the work of a mile of waveguide or coaxial cable.

Unlike surface-wave amplifiers using piezoelectric materials rather than YIG, the Raytheon device would be tunable over a broad band. It would be tuned by varying the otherwise constant magnetic field applied across the width of the YIG slab: the stronger the applied field, the higher the amplifier's center frequency.

Schlomann and Patton hope to have their first model operating in late November or early December. In the meantime, Schlomann will detail the device and the theory behind it in a paper at the 14th

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Communications

Opening up the spectrum

In about three weeks, the President's Task Force on Telecommunications will report what everyone in the electronic business has known for a long time: there is no shortage of space on the frequency spectrum, just an unfortunate lack of understanding about how to use it.

The report, which isn't intended for public distribution until after the election, outlines a comprehensive plan for improving the utilization of frequency space [Electronics, Sept. 16, p. 67].

Not surprisingly, the Presidential panel will point to the Government itself as the leading culprit. It will charge that the Government has reserved too much of the microwave bands for potential satellite needs and is holding too much spectrum space for anticipated Federal law-enforcement needs.

New agency. The far-ranging report will suggest that users pay a license fee based on the amount of frequency space used and the profit realized by using it. It will call for the establishment of a new agency with broad frequency-allocation powers, and will advocate the transfer of some spectrum now reserved for ultrahigh-frequency tv to land-mobile radio operations.

Many of the recommendations aren't new, but the task force may succeed where others have failed in getting them implemented. How well it succeeds will be up to the new Congress and Administration.

The task force, headed by Presidential adviser Eugene V. Rostow, has been working on the report since August 1967. Most members of the panel are officials of various Government agencies and none are engineers. The technical staff was drawn from Federal agencies.

In brief, the group will urge the Government to:

Make any frequency space available to other users if the one to which it was allocated lets it lie dormant.

Establish and continuously update equipment standards and operating practices (including criteria for frequency sharing, channel loading, or both) to cut down on nonproductive "pollution" of the spectrum.

Phase out point-to-point trunking with high-frequency bands (3-30 megahertz) except as a backup to satellite and cable facilities, and use this space exclusively for maritime and aeronautical mobile services.

Allow present users of the 30 to 1,000 megahertz range to continue their use, but institute operational constraints (such as power and frequency controls) and frequency-sharing to permit land-mobile use of the space.

Set up new equipment and operating standards for land-mobile operators to ensure that the same frequencies can be used by base stations short distances apart.

Encourage the development of common-user and common-carrier mobile radio systems with intermittent requirements by sanctioning joint licensing arrangements.

Auction land-mobile frequency space to the highest bidder when a dispute among applicants cannot be resolved on its merits.

End the distinction between local and Federal police frequencies so the local forces can make use of the sparsely used Federal bands.

Begin a broad, comprehensive study of the technical and economic feasibility of moving television broadcasting to higher-frequency bands—the microwave or millimeter-wave regions.

Be prepared to consider ending tv broadcasts in the uhf bands when cable and other tv distribution means become practical.

Establish improved modulation and antenna directivity standards to permit greater frequency re-use in the microwave bands (1-10 gigahertz).

Continue sharing the 4- to 6-Ghz band between communications satellite and radio relay systems until a domestic satellite system has been

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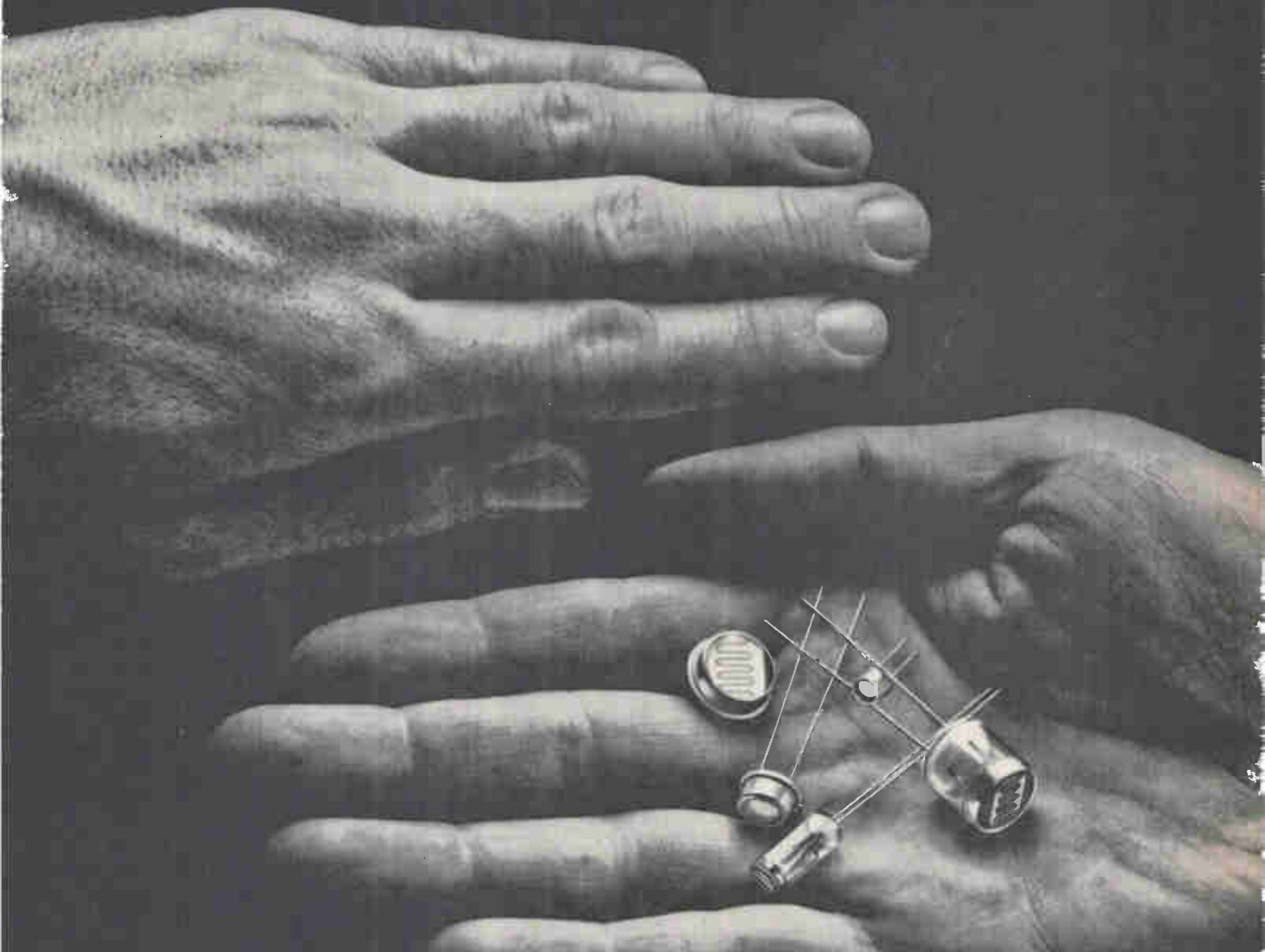

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fully worked out.

Authorize the sharing of the 7- and 8-Ghz bands, now allocated solely to Government (military) systems, by both domestic and military satellite systems.

Encourage the trend among common carriers toward low-noise systems in the microwave bands. This involves the use of horn-reflector antennas, and of wide-deviation frequency-modulation and pulse-code modulation, for example.

Create a new executive-branch agency to handle both Government and private allocations. (Under this plan the FCC would continue to parcel out specific frequency licenses, but the block designations would be made by the new agency).

Appoint regional coordinators to supervise allocations and assignments.

Consolidate spectrum research and development in the new agency, except the mission-oriented research of other agencies. Sharply increase Federal funding for spectrum R&D.

Instruct the agency to take an interdisciplinary approach to spectrum utilization by employing engineers, economists, lawyers, and social scientists.

Components

Up the ladder

Until recently, precision resistor ladder networks with an accuracy of 14 bits have been laboratory items, and the integrated-circuit digital-to-analog and analog-to-digital converters that rely on hybrid or discrete resistor ladder networks have been limited by ladder accuracy. But three new developments from the microcircuits operation at Beckman Instruments' Helipot division have just been incorporated in the division's model 811 hybrid thick-film cermet ladder network, making 14-bit ladders available in quantity.

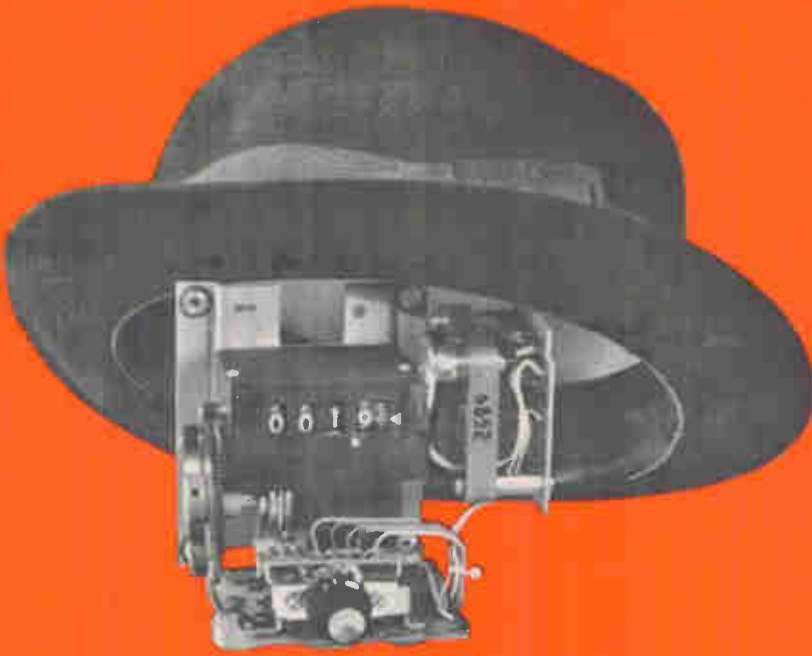
The new developments are a cermet material that will yield typical resistor temperature-tracking capabilities of 0.5 part per million per degree C, tailoring equipment that will trim the ratio of each resistor to within 5 ppm of others in the network, and measuring equipment that can test ladders with accuracies up to 14 bits to within ±2 ppm of the desired ratio. It tests 200 to 300 of these an hour.

Perfect tracking. William Kelly, materials supervisor in the microcircuits operation and the man chiefly responsible for the new cermet material, says all resistors in a precision ladder network should have the same temperature coefficient. If they do, they are said to have perfect resistor-temperature tracking. Kelly says Beckman's best previous cermet materials gave them typical resistor-temperature tracking of 2.5 ppm/degree from −55° to +125°C.

This kind of tracking allowed Beckman to produce many ladders with accuracies of 10 and 11 bits, and some with 12 bits. Commercially available materials (most of which are silver-palladium) that Beckman has tested show typical resistor-temperature tracking of 10 ppm/degree C. With them, Kelly says, a good many 9-bit ladders can be made, but only a few with accuracies of 10 and 11 bits.

Details of the new Beckman cermet are secret. Kelly says only that it is not silver-palladium and that it is produced by close control of three factors—particle-size distribution, thickness of the material to get an even deposition on the substrate, and firing temperature. "It's very important," he continues, "that firing temperature be rigidly controlled so that each resistor in a network 'sees' the same temperature—because once they're formed, their stability and temparature coefficient are locked in."

Ratio tailoring. Beckman engineers are equally stingy with information about their precision tailoring and measuring equipment. They point out, however, that they know of no other equipment that does ladder-network ratio tailoring. Other trimmers adjust to absolute resistance values. George Smith, supervisor of product design in the microcircuits operation, points out that commer-



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cially available trimming equipment is accurate to only 5,000 ppm absolute of the actual resistance value.

The real key to Beckman's tailoring equipment is the electronic system designed in-house to control the air-abrasion trimmer. "We have to do everything possible to prevent harm to the cermet material," Kelly points out, "so we've designed control electronics that allow us to trim and measure the adjustment as rapidly as possible and not change the cermet properties."

Beckman engineers had to design the final test equipment themselves because they couldn't buy hardware that tested to the accuracies they needed. The system, built outside, looks and works much like an IC tester. It has five wells containing liquid Freon at —55°, —20°, +25°, +80°, and +125°C. A socket accepts the finished ladder network pins. For the rate of 200 to 300 per hour, an analog signal triggers a light bulb showing the ladder has an accuracy of 9, 10, 11, 12, 13, or 14 bits.

Print-out data. A printed tape similar to that fed out by desk calculators is produced by the tester if detailed information on a given ladder network is sought. For example, in testing a 12-bit ladder, the machine will print out a ratio error for each of three application resistors compared with the ladder. This, in effect, tests the ladder in a circuit, with the applications resistors performing like feedback resistors, in an operational amplifier. The ratio printed out for the application resistors is the ratio of the feedback resistance to the Thevenin equivalent resistance of the ladder network.

Then each of the 12 bits in the ladder is switched in and its ratio error in ppm is printed out. Finally, the operator can push a button and get a summation of the errors of each of the 12 bits. Smith says the summation is the information the man using the ladder wants to know, but Beckman gives him the application resistor printout as well to give him an idea of how the ladder will work in a system.

For the record

Geiger gauge. The Lockheed-Georgia Co. has successfully demonstrated a nucleonic fuel-measuring system in its C-141 Starlifter and says it can be used in any type of aircraft. The system is simplicity itself: a radiation source sends gamma rays through a fuel tank and a Geiger Mueller tube on the other side of the container detects them; the amount of radiation reaching the detector is inversely proportional to the amount of fuel in the tank. For a plane the size of the giant C-5 transport, as many as six systems would be used for each of the 12 fuel tanks.

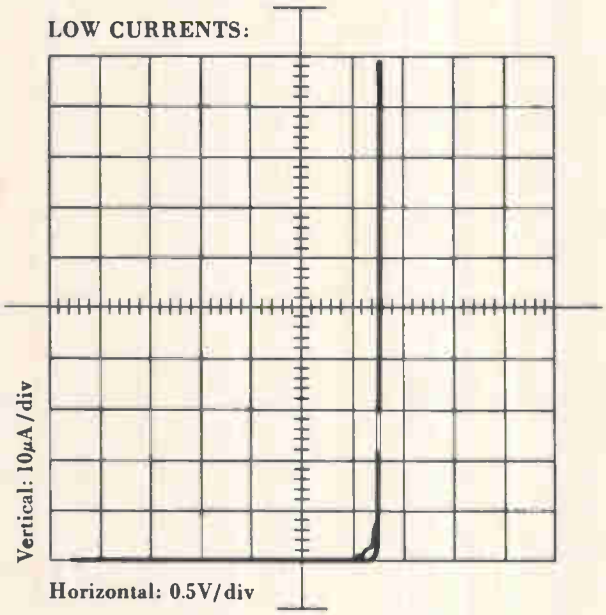
Because this setup, unlike conventional fuel monitoring systems, requires no probes inside the tank, there's no need for safeguards against electrical arcing or for internal maintenance. Lockheed says readings are unaffected by fuel densities, temperature fluctuations, or changes in aircraft attitude because the system measures the mass of the fuel rather than sensing levels.

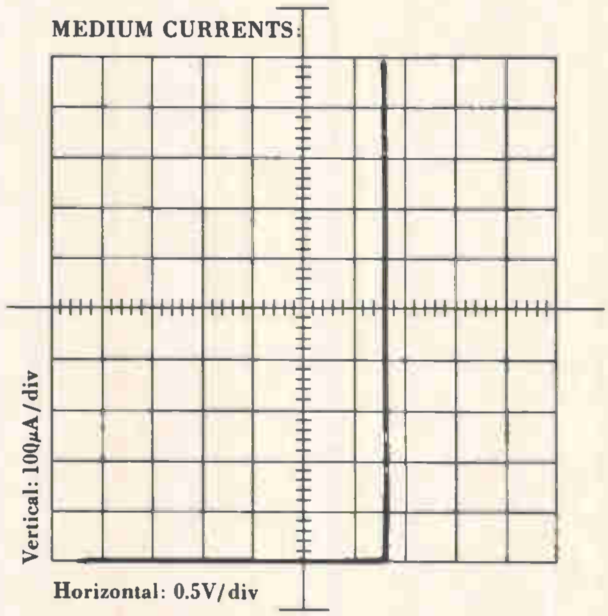
The idea isn't new, but Lockheed's will be the first operational system of this type. Giannini Controls (now Conrac) tried in 1964 to develop a similar system for the Apollo program but was unable to meet specifications.

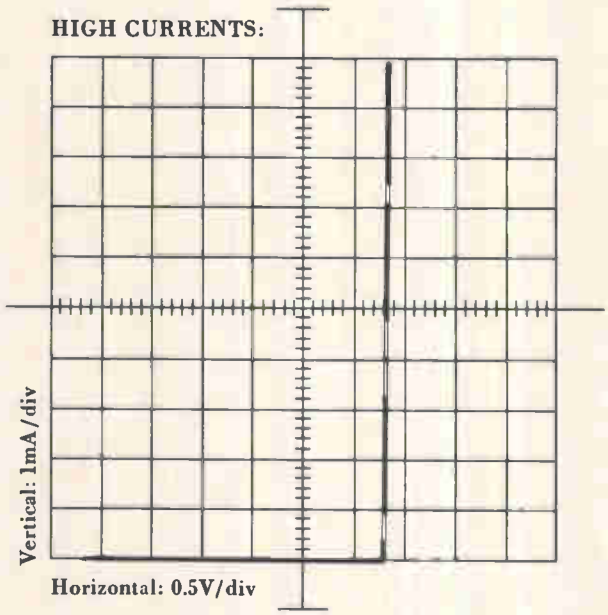
If at first . . . This week NASA will launch the second of four Orbiting Astronomical Observatories. The shot comes about 30 months after the first OAO achieved orbit but failed in its second day because of malfunctions in the power supply and high-voltage arcing in the star-tracking apparatus. The second and more complex OAO has a completely redesigned battery-charging system. The star trackers have also been modified to prevent corona discharges and the high-voltage arcing. More sophisticated than previous U. S. unmanned satellites, OAO carries 11 optical telescopes.

Evasive action. Trying to avoid antitrust action, IBM has trans-

The deflection plate aligner







\$4.50 buys you the only zener that can give you these traces. At any of ten voltages from 5.6V down to 2.4V. Or all the way down to 2.2V, 2.0V and 1.8V if you insist. And the voltage you choose will typically vary 15mV from 100μA to 1mA (or 125mV over its full 10μA to 10mA range).

Ask for it by name—the LM103.

National Semiconductor

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ferred its time-sharing subscriber services from the Data Processing division to its independently operated subsidiary, the Service Bureau Corp. A 1956 antitrust consent decree prohibits IBM from operating a service bureau business as part of the parent company's operation.

Early last month it was learned that the Justice Department was investigating the possibility of taking legal action to force IBM out of the time-sharing business. Possibly related to the move was the accusation by other time-sharing service companies that IBM's centers got their computers at much lower prices.

Roll 'em. The Kalvar Corp. has developed a vesicular photographic film that's said to be 10 times faster than present counterparts, although it's still much slower than conventional silver-halide films. Vesicular film does not use silver; it is exposed with ultraviolet light, and is processed by heat and light instead of chemicals.

Dash dashed. When the Navy started its unmanned helicopter program, called Dash, it expected the drones to be able to hunt down and destroy submarines. But now, some seven years later, the Navy admits that the program has been something less than a complete success; in fact, no more drones will be bought. So far, more than 230 of the choppers have crashed, many after only a few hours of total flying time, at a cost of about $25 million. The crashes have been attributed to avionics problems. Often, says the Navy, the craft respond to spurious radio signals and end up in the drink. Other failures were laid to faulty gyroscopes, altimeters, or decoding equipment.

Laser in the field. Hughes Aircraft, which in 1960 became the first firm to demonstrate laser action, received a $2.7 million Army contract to produce laser range finders for the M-60 tank. Hughes says the devices will be the first completely militarized lasers.

Vin automatique. That little ol' wine maker is remote controlled at the Pleasant Valley Wine Co. The Hammondsport, N.Y., winery has installed an electronic system to handle all processing from the time the grape juice leaves the presses. It controls temperatures, blending, fermentation, racking, clarification, filtering, storing, and bottling. The wine is sold under the trade name Great Western.

Comsat gains. The Communication Satellite Corp. reported an earnings surge in the first three quarters of 1968 to $5 million, or 50 cents a share, from $2.8 million, or 29 cents a share, in the year-earlier period. Operating revenue climbed to $22 million from $12 million.

Crystal growing. Tyco Laboratories of Waltham, Mass., says that under an Air Force contract it has developed a technique for producing single-crystal sapphire filaments as long as 100 feet. The filaments can be grown in a variety of shapes—thin and thick tubes, ribbons, rods, and T's. Because of sapphire's unique dielectric properties, the processed crystal might be useful in lasers and fiber optics, and as a substrate for thin-film circuits or a base for the epitaxial overgrowth of silicon for IC's.

3-D in sequence. Holographic "movies" have been made at Hughes Aircraft's research laboratories with a system that's said to have 10 times the energy output of previous stop-action holographic units. Hughes scientists use a giant-pulse ruby-laser oscillator and amplifier that delivers 30-nanosecond pulses at up to 10 joules to produce a stream of images; the output is fully coherent at full pulse energy. The oscillator is a 4-inch-long, ¼-inch-diameter ruby rod sandwiched between two linear flash lamps in a double elliptical cavity. A 12-inch-long ruby rod ⅝ inch in diameter and pumped by four linear flash lamps makes up the amplifier. The system's maximum peak power output is 300 milliwatts. The oscillator has a 3-milliwatt output.

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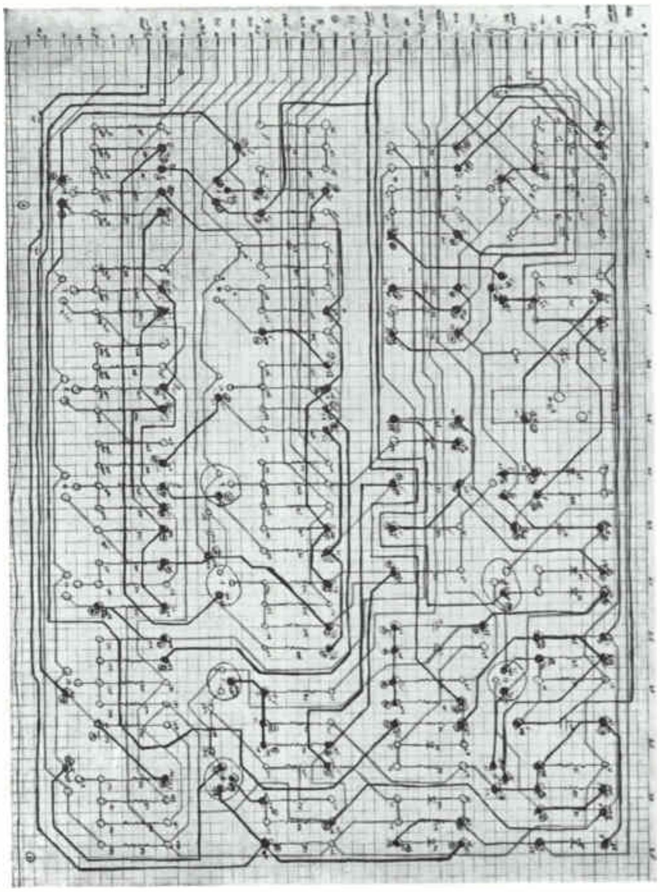

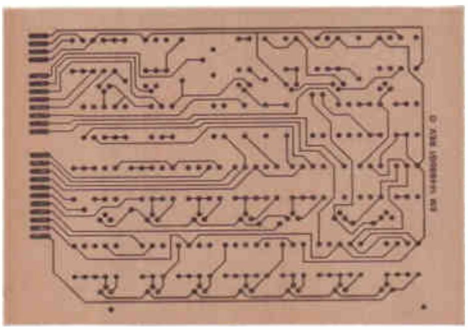

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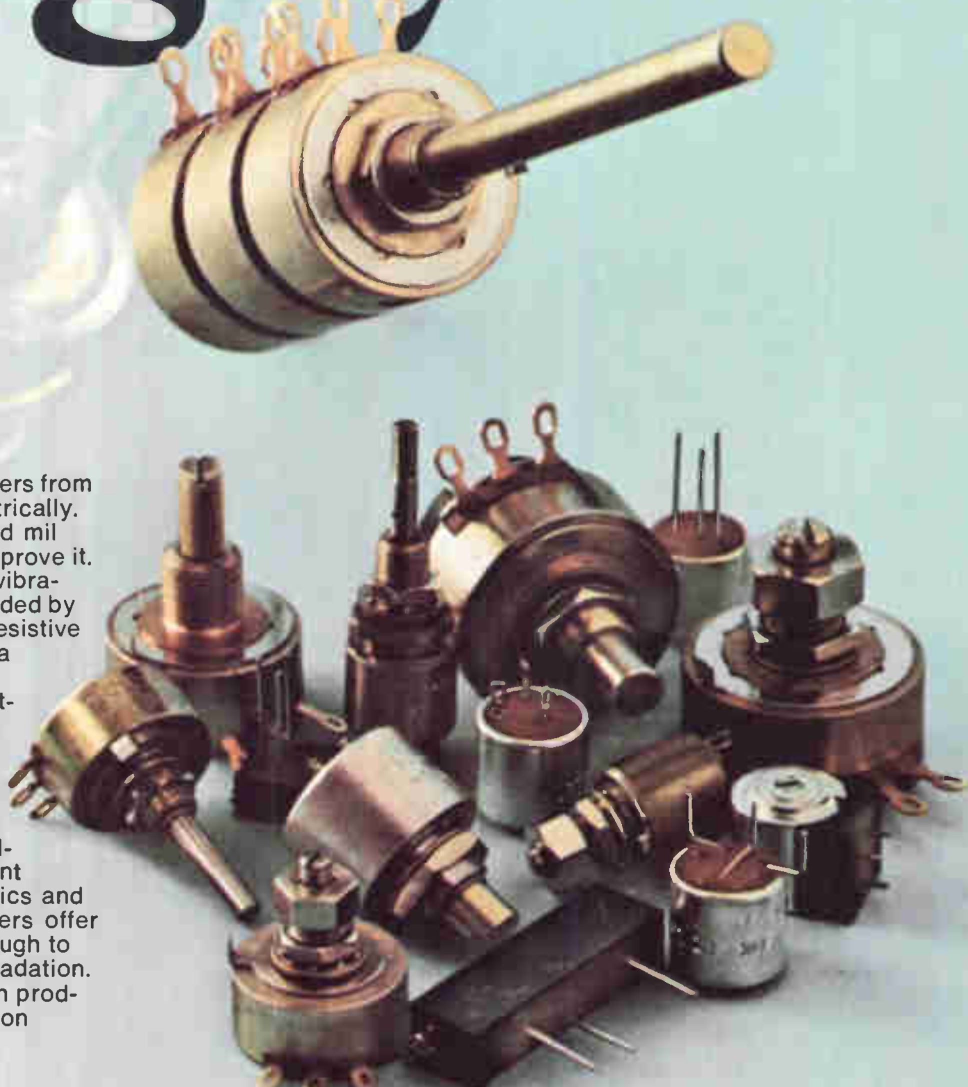

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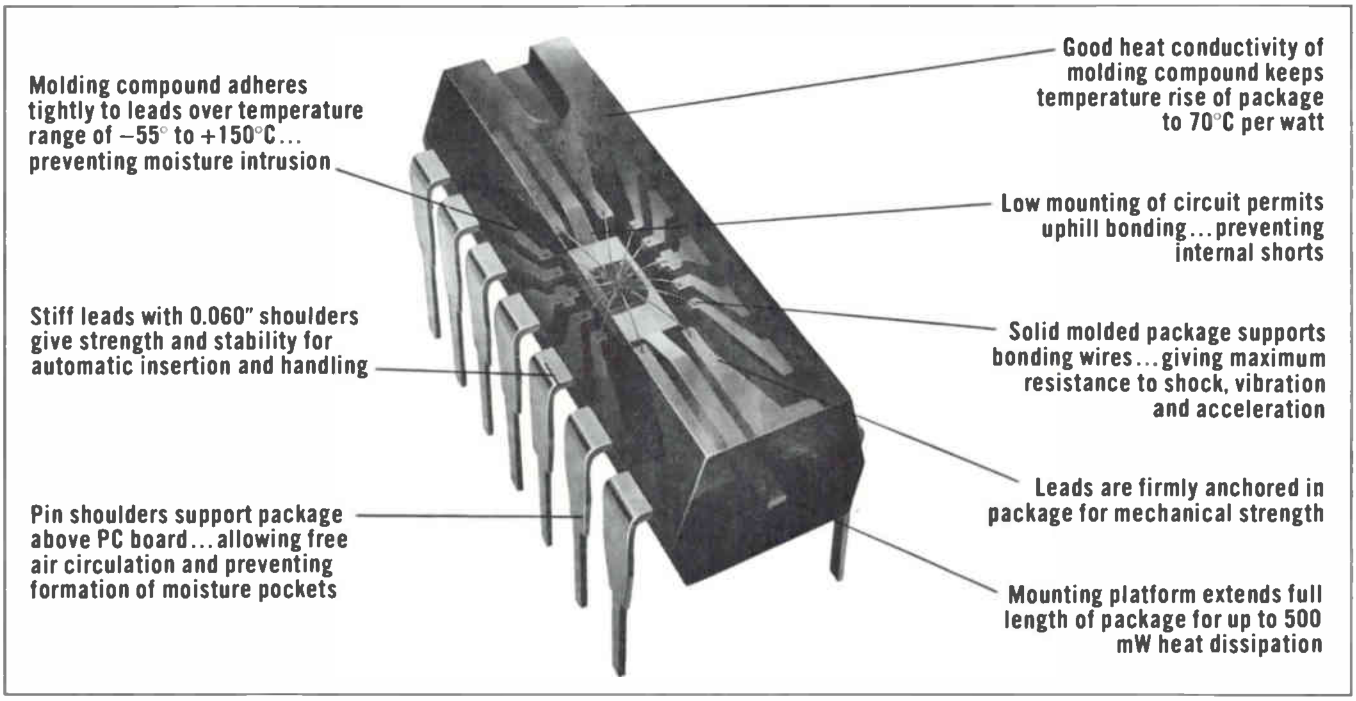

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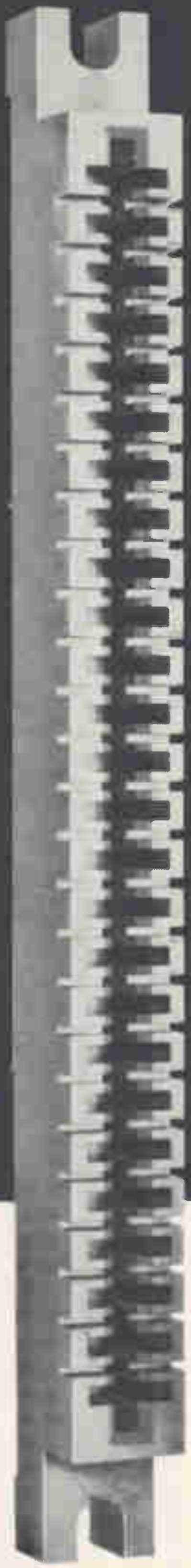

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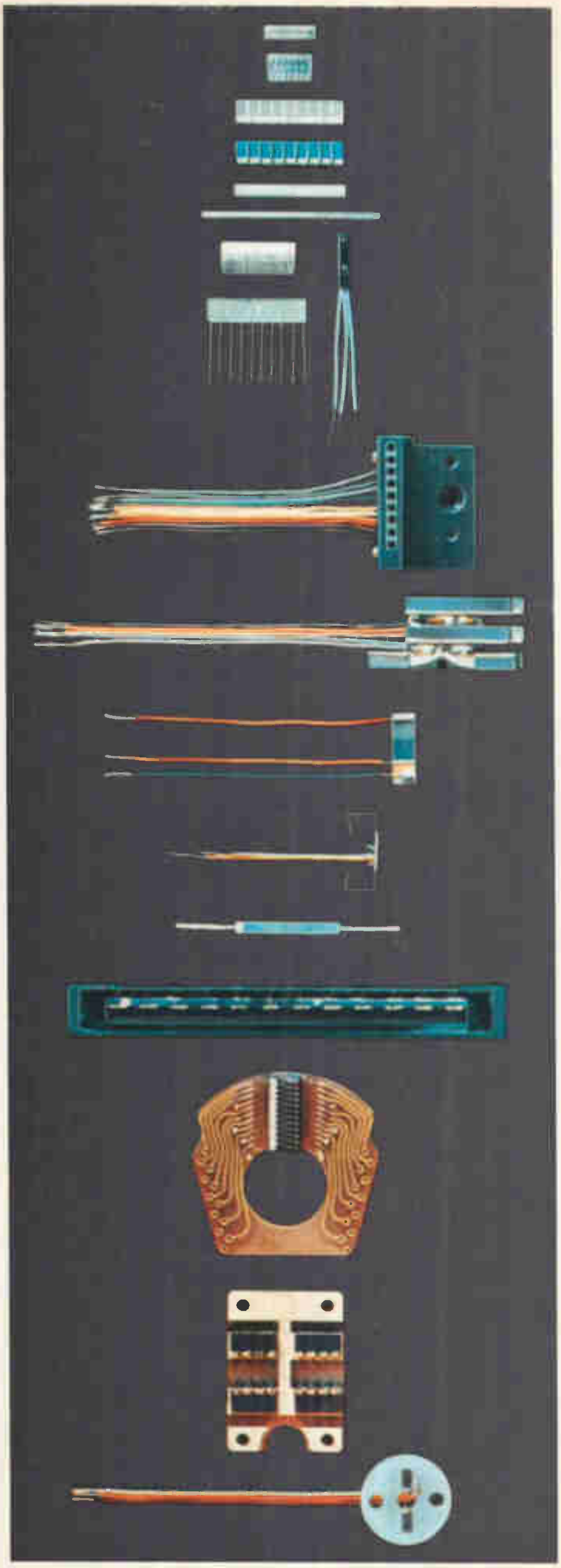

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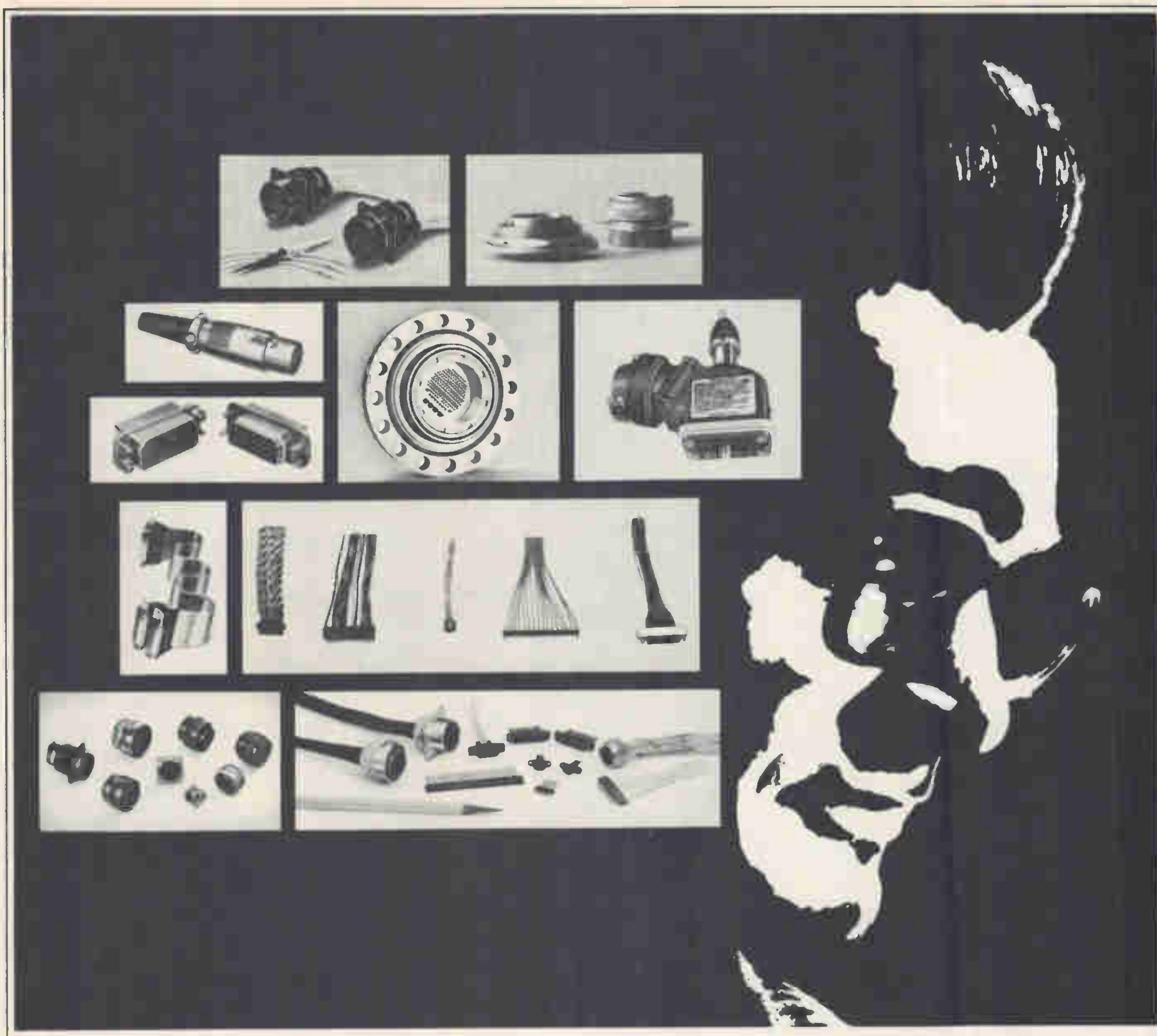

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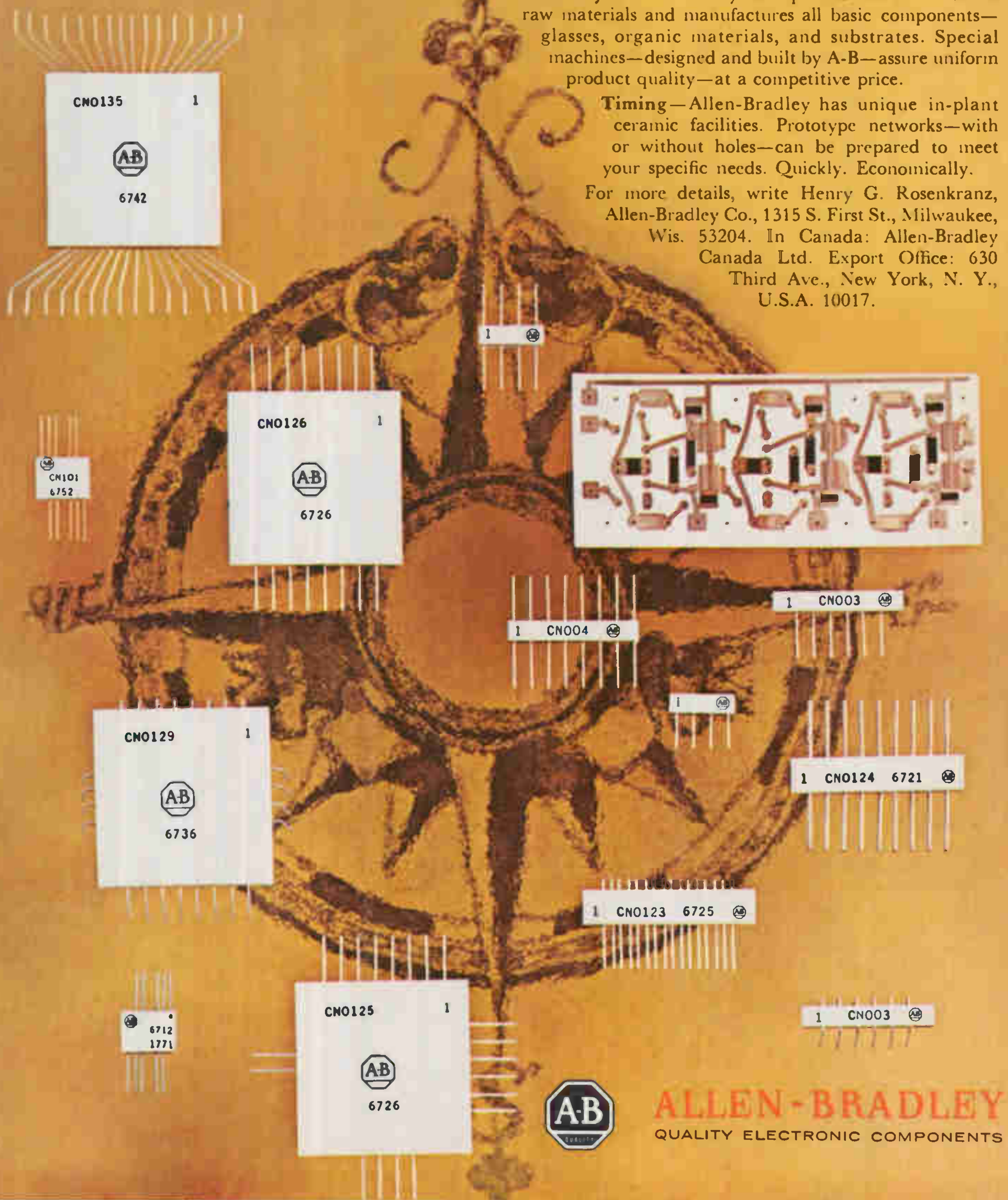

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Resistor Networks

Tolerances: ±1.0% to ±0.01%

Resistance Matching: to 0.005%

Temperature Range: −65°C to +175°C

Temp. Coef.: to ±5 ppm/°C

Load Life (Full load for 1000 hr @ 125°C): 0.2% maximum change

Ladder Networks

Full Scale Accuracy: 10 bits or less, better than ±¼ least significant bit. More than 10 bits, better than ±½ least significant bit.

Frequency Response: Less than 100 nanosecond rise time or settling time

Temp. Coef.: Less than 10 ppm/°C

Temperature Range: −65°C to +175°C

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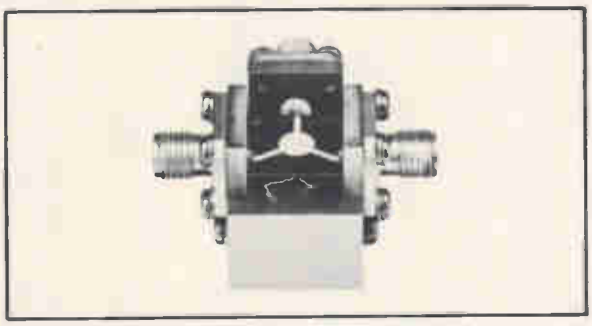
REPORT #4

PACT cuts losses in latching microstrip circulators 80% in twelve months

Engineers at work in Sperry's PACT (Progress in Advanced Component Technology) Program have announced outstanding success in an intensive 12-month campaign to cut insertion losses of external loop latching microstrip circulators.

When the effort began, the loss figure was 2.5 db at X-band; today, Sperry has built external loop latching circulators with insertion loss of only 0.5 db at the same frequency.

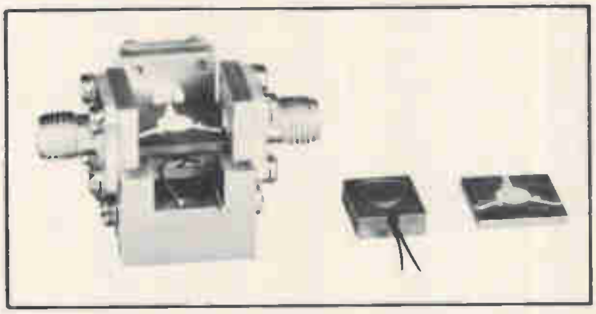
PACT's latching circulator work actually began with an internal loop configuration. YIG subtrates were prepared with loops of .005" and .010" platinum wire fired in place. Test data were taken at substrate thicknesses of .100", .075" and .055". Results showed that, while fixed bias performance improved as thickness decreased, other factors caused latching performance to deteriorate.



INTERNAL LOOP X-BAND LATCHING CIRCULATOR

While the test results obtained with the internal loop device were generally satisfactory, PACT engineers felt that the configuration had some inherent disadvantages. Among these were difficulty and expense of fabrication, and unsuitability for use in modules. This led to extensive investigation of the external loop design.

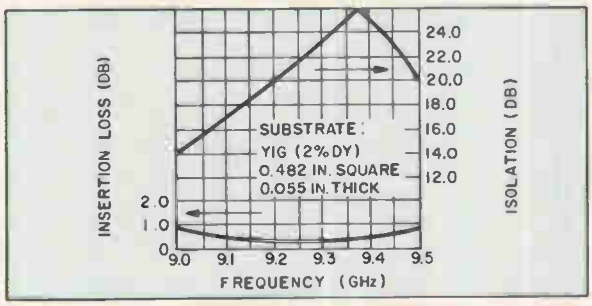
PACT personnel found one immediate advantage: when working with external loop, they could consider the substrate and the latching plate independently. Intrinsic and physical properties of the substrate material could be chosen for good microwave performance, while latching plate design need only consider hysteresis and other switching parameters.



EXTERNAL LOOP X-BAND LATCHING CIRCULATOR, WITH LATCHING PLATE AND SUBSTRATE SHOWN SEPARATELY

Since temperature and high power stability are prime design parameters, the program settled on a design using .482" square x .055" thick hybrid YIG substrate. Lithium ferrite — a material with saturation magnetization of about 3500 gauss, a coercive field of 2.0 oe, and a very square hysteresis loop — was chosen for the latching plate. The switching loop was four turns of #24 copper wire.

Using this configuration, PACT engineers have achieved switching times of less than 1 microsecond, with performance as indicated in the accompanying curve.



PERFORMANCE OF EXTERNAL LOOP LATCHING CIRCULATOR

For further information about PACT work on latching microstrip circulators and their coming application in microwave IC's, contact your Cain & Co. Representative, or write Sperry Microwave Electronics Division, Sperry Rand Corporation, Clearwater, Florida.

For faster microwave progress,
make a PACT with people
who know microwaves.

SPERRY
MICROWAVE ELECTRONICS DIVISION
CLEARWATER, FLORIDA

Washington Newsletter

November 11, 1968

'McNamara line' probably had role in bombing halt . . .

Electronics probably played a major role in President Johnson's decision to stop all bombing of North Vietnam. **It appears that U.S. field commanders went along with the halt because of the successful operation of the top-secret "McNamara line"—the electronic guard along the demilitarized zone** [Electronics, Sept. 18, 1967, p. 52]. The sensor network enables them to keep track of troop and supply movements into the south. The makeup of the network has been kept so secret that, according to one anti-intrusion radar manufacturer, "We don't even know what we're doing for it." **Several code names are said to be used in procuring equipment.**

The system consists of many short links because most sensors operate best at short range. Sensors had to be operational last year when the go-ahead was received to build the top-priority line. An elaborate telemetry network links every sensor—many kinds are used in a random mix—to a control station. **Sensors that were available for the net included active-infrared, seismic, pressure, magnetic-strip, acoustic, and simple breakwire devices** [Electronics, Aug. 7, 1967, p. 46].

. . . and Army eyes new tactical radar

Though the "McNamara line" apparently is working well with existing sensors, **the Army is moving toward a major procurement of new portable tactical radars** for battlefield surveillance and infiltration detection.

Designated AN/PPS-9 and AN/PPS-10, the 10-pound radars are now being field-tested in Vietnam and are reported to be meeting military requirements. **Both General Dynamics Electronics and RCA have delivered units for the tests,** but a half-dozen or more manufacturers will compete for production orders, estimated at $15 million or more in this fiscal year.

Mariner-Mars may take on a new look

NASA's 1973 Mariner-Mars missions appear to be undergoing significant changes in emphasis. The program fared so poorly in the fiscal 1969 budget that space agency officials apparently feel that they might as well start again from scratch.

As originally proposed, the probes were to have culminated in rough landers, but NASA's Langley Research Center has just been briefed by firms doing study work, **and it's known that soft landers are being seriously considered.**

The space agency would like to use Titan 3C boosters for these missions and for other launches, including the ATS-F and G. It will try to get them by joining forces with the Air Force in the budget scramble; the rationale is that both will stand a better chance of success if they submit their requests for the rocket as a single volume order.

Tacsatcom, DSCS may be consolidated

Pentagon planners are now seriously considering **combining the third-generation Defense Satellite Communications System (DSCS) and the next stage of the Tactical Satellite Communications program into a single global system.** The DSCS was originally envisioned as a system of small satellites relaying strategic trunkline traffic to large ground stations, while Tacsatcom plans call for a big satellite and small tactical ground terminals. But these distinctions have been blurred in second-phase DSCS designs, which slate spacecraft about as powerful and complex as the Tacsatcom's [Electronics, July 8, p. 64].

Design of the next generation of Tacsatcom and DSCS satellites will begin early next year, or soon after the contract for the second-generation DSCS is awarded. It's also possible that the Defense Department will simply add to DSCS-2 as the need arises, replace the entire system, go ahead and build two separate systems, or use the two for both tactical and strategic communications.

The present timetable gives the Pentagon ample time to decide. The Air Force Space and Missile Systems Organization will receive contractor proposals for the DSCS-2 in two weeks. The $100 million-to-$200 million award, expected as early as February, will cover six stationary satellites, including backups. Delivery is expected 22 months after award. The experimental Hughes-built Tacsat is to be launched next year.

Added Nimbus job proposed by IBM

An additional mission that could lead to more accurate weather forecasts has been proposed for the Nimbus program of experimental meteorological satellites. IBM gave NASA an unsolicited proposal to study the space hardware needed to chart cloud motion on a global basis. Such information could be used to make a worldwide index of wind velocity. Meteorologists say the index could improve forecast accuracy for periods up to two weeks.

One problem, however, is that the plan would require four satellites. A NASA official points out that the Nimbus program is unlikely to have more than two spacecraft up at once, even though four launches are scheduled in the next four years. Other craft, such as future Applications Technology or ESSA satellites, would have to be used.

Television cameras and infrared radiometers on the satellites would send data to the ground for analysis by a digital computer. IBM suggests low-orbiting craft but points out that synchronous types could be used.

Army will choose PWI system soon

The Army expects to choose soon—possibly this month—between Bendix and Honeywell designs for a lightweight pilot warning indicator (PWI) for slow aircraft. Five firms originally submitted off-the-shelf units for evaluation at Ft. Rucker, Ala., but the Motorola, Goodyear, and Melpar entries washed out.

Designed for use with the TH-13 training helicopter, the 8-to-10-pound PWI's use either vhf or doppler radar signals to give pilots both audio and visual warnings of other craft within 2,000 feet of them. The units could also be used in civilian aircraft.

Addenda

The Navy has received Pentagon permission to complete its Omega navigation system by adding four stations to four already in operation. The new very-low-frequency shore-based transmitters will be situated in the areas of the western Pacific, Tasmanian Sea, and Indian Ocean, and in southern South America; they should be operational by late 1972. The U.S. will receive some foreign financial support for the system, which could be used by commercial vessels as well as warships. . . . The Army is again considering Ryan Aeronautical's AN/APN-182 doppler radar navigator. The set was bought by the Navy for ASW helicopters but has twice flunked Army tests.

New Sorensen High Power DCR's:

The addition of 6 new models now brings the total number of Sorensen regulated, high power, high efficiency DCR's to 34—the widest product line from the industry's leader in both DC and AC power supply technology and production.

The DCR Series covers the voltage ranges of 0-20/0-40/0-60/0-80/0-150/0-300/0-600/ and even up to 6000 Vdc at power levels of 400, 800, 1500, 2400, 5000, 10,000 and 20,000 watts. And — Sorensen's 25 years experience in design and manufacture makes it possible to offer these power supplies from stock at prices as low as 19¢/watt.

The DCR Series offers all of the standard features found in state-of-the-art power supplies including Voltage/Current Regulation, Low Ripple, Remote Programming, Remote Sensing, Operating Temperatures to 71°C and compliance with MIL-I-26600 and MIL-I-6181D.

FREE! An illustrated data package containing detailed electrical and mechanical specifications for each DCR power supply and a new CATALOG featuring 176 different Sorensen regulated DC and AC power supplies.

Contact your local Sorensen representative or Raytheon Company, Sorensen Operation, Richards Avenue, Norwalk, Connecticut 06856. TWX 710-468-2940

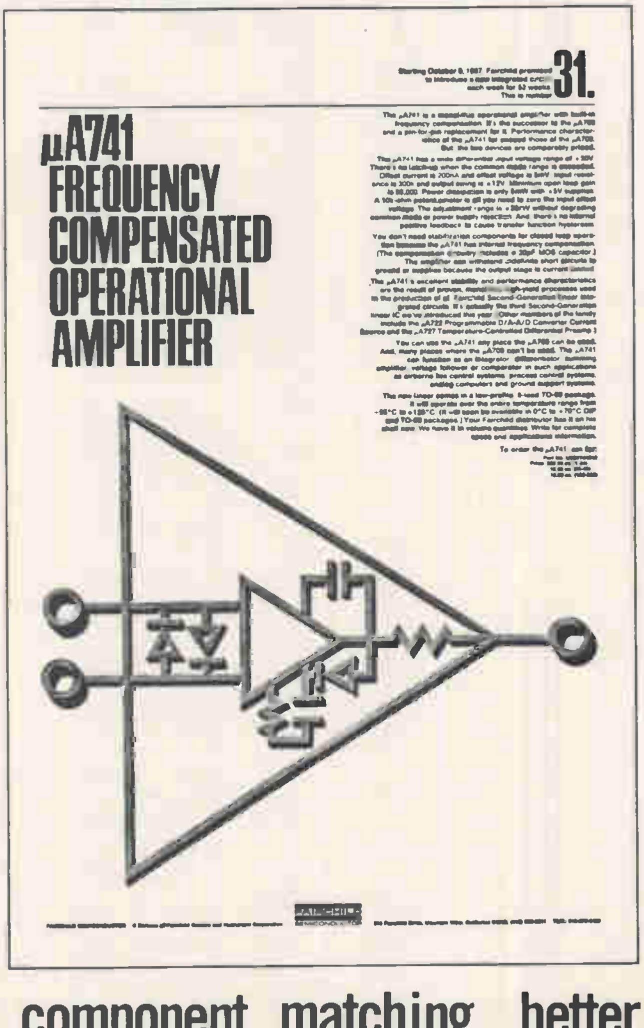
RAYTHEON

for more data on this versatile instrument . . . **Call Sorensen: 203-838-6571**

If you don't know the μA709 has been replaced, we have a little surprise for you: The μA741.

The μA741 is the only monolithic operational amplifier that has frequency compensation built right on the chip. It's a pin-for-pin replacement for the μA709. An improvement in performance without an increase in price:

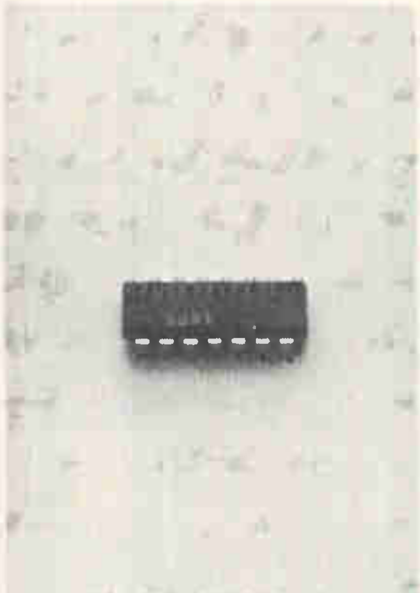
Differential Input Voltage	±30V min.
Offset Current	200nA max.
Offset Voltage	.5mW max.
Input Resistance	300k min.
Output Swing	±12V min.
Power Dissipation	5mW with ±5V supplies typ.
No latch-up when the common mode range is exceeded.	
Package	hermetic DIP
Order Number	U6E7741393
Price	$3.25 (100 up)



The μA741 is a key member of Fairchild's family of Second Generation linear integrated circuits. Basic building blocks for virtually any linear application. New devices with better component matching, better specifications, increased chip size and higher complexities.

Other members of the family include the highly versatile μA723 Precision Voltage Regulator, μA727 Temperature-controlled Differential Preamp, μA733 Wide Band Differential Amplifier and the μA722 MSI Programmable D/A - A/D Converter Current Source. □ Compare our Second Generation Linears with any Linear ICs on the Market. You'll find there's a big difference between price/performance and price-per-product. □ Write for detailed specs on the entire linear family.

Unity gain amplifier built with μA709.



Unity gain amplifier built with μA741.

FAIRCHILD SEMICONDUCTOR

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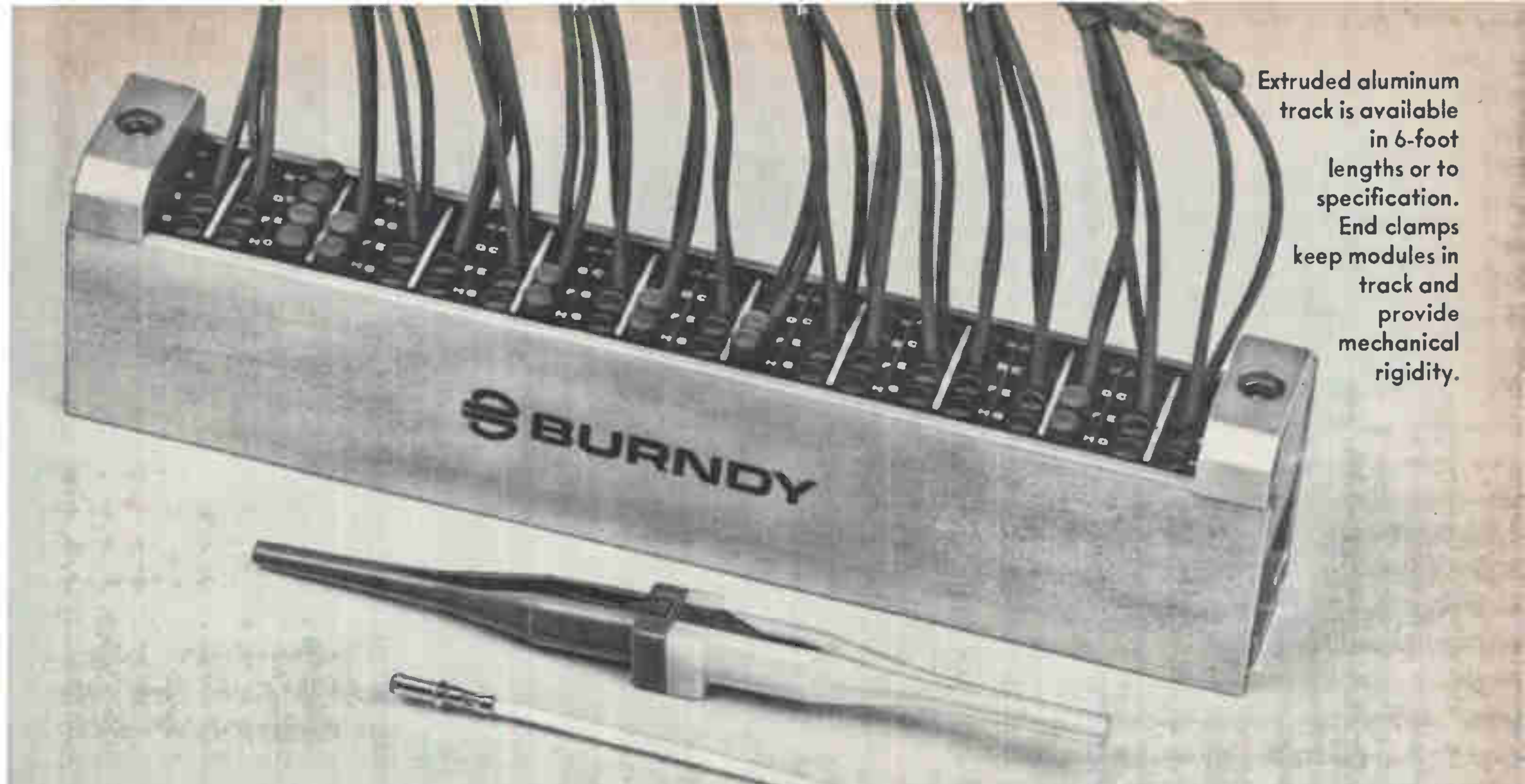
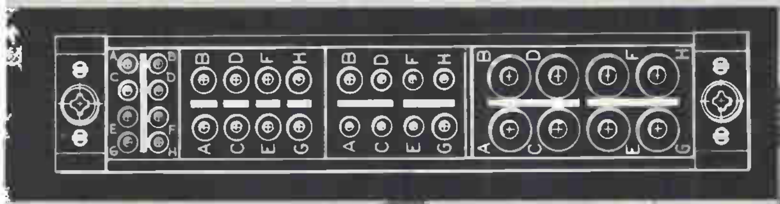
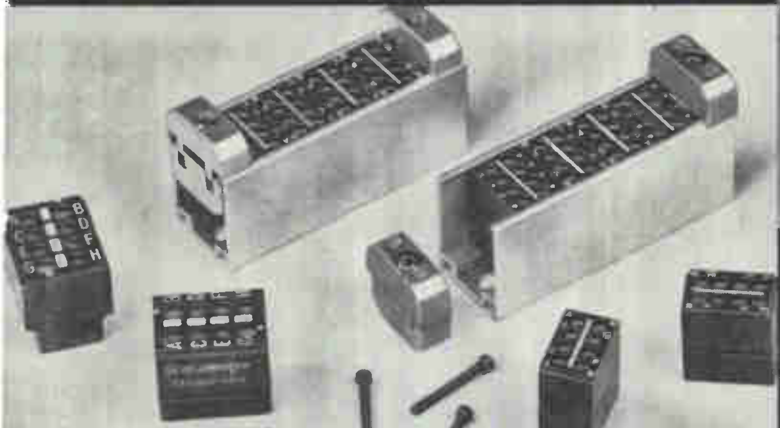
Circle 91 on reader service card



Extruded aluminum track is available in 6-foot lengths or to specification. End clamps keep modules in track and provide mechanical rigidity.

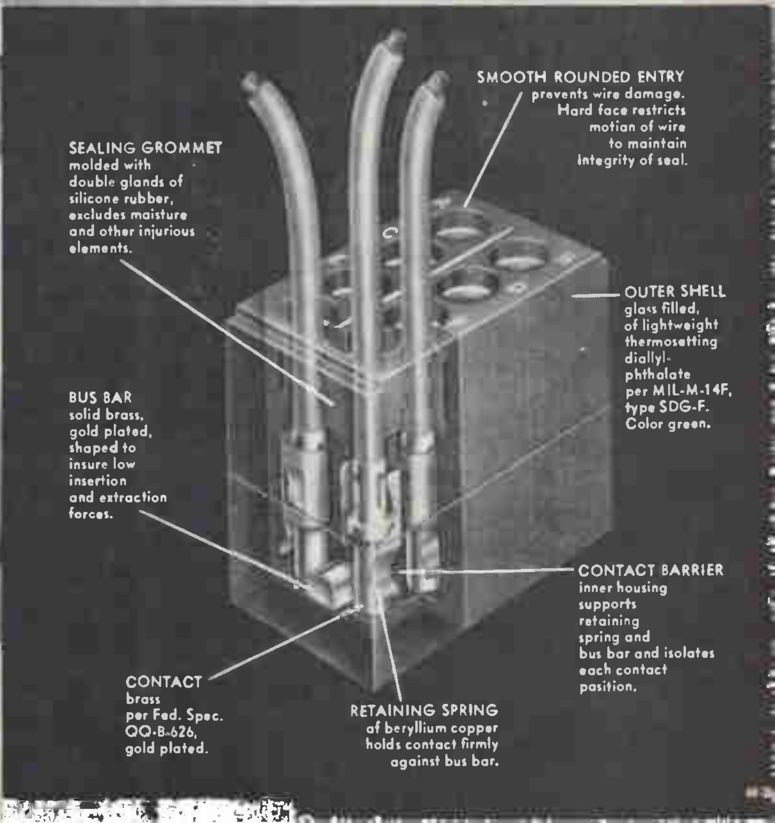
(below) Plan view of Sealok modules shows clear identification of contacts and bussing arrangements. Different bussing arrangements available in each module size.

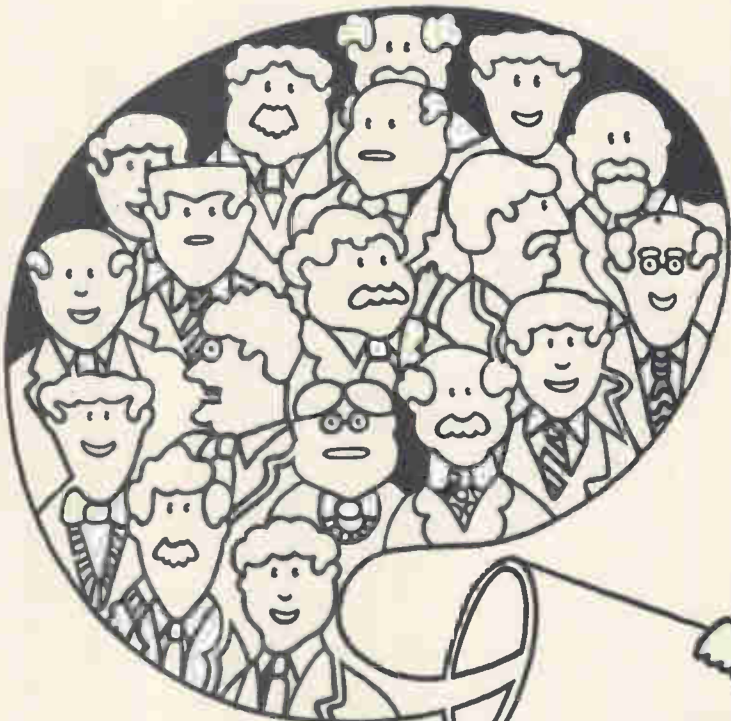


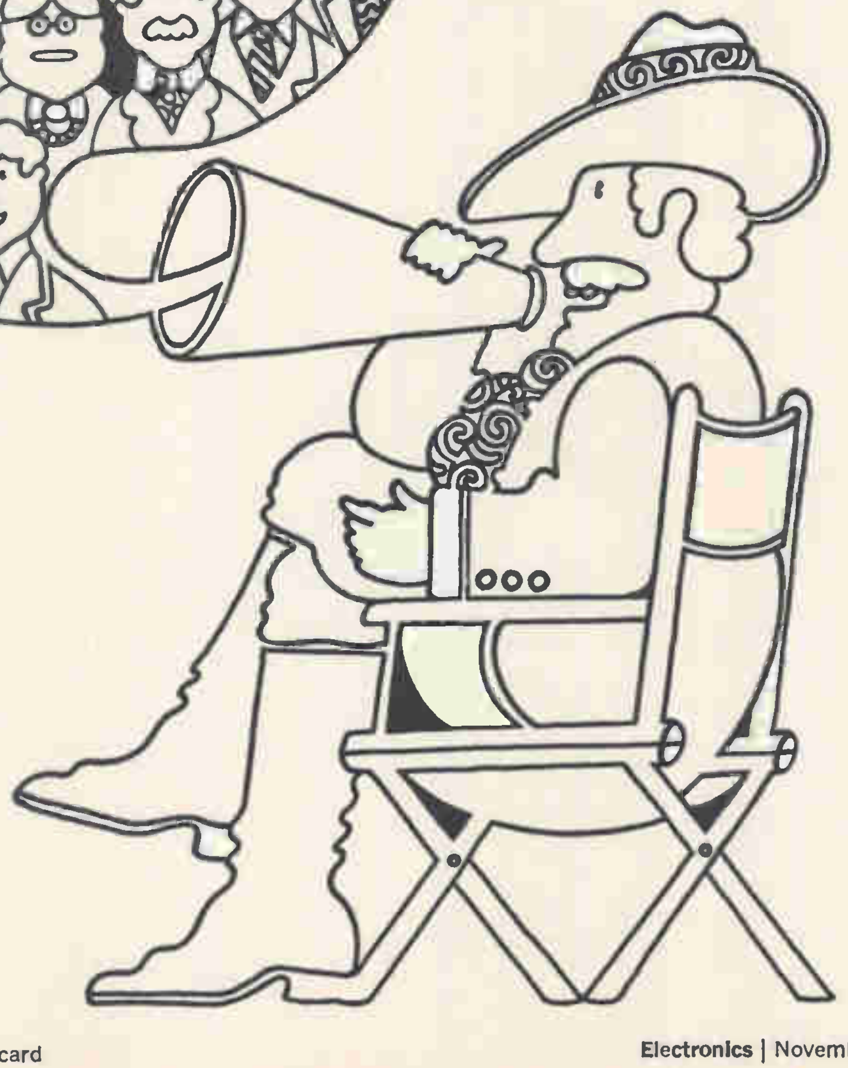


Track features recessed mounting hardware so there is no interference with removal of modules. Two-piece end clamp construction permits insertion from ends or top anywhere along track.

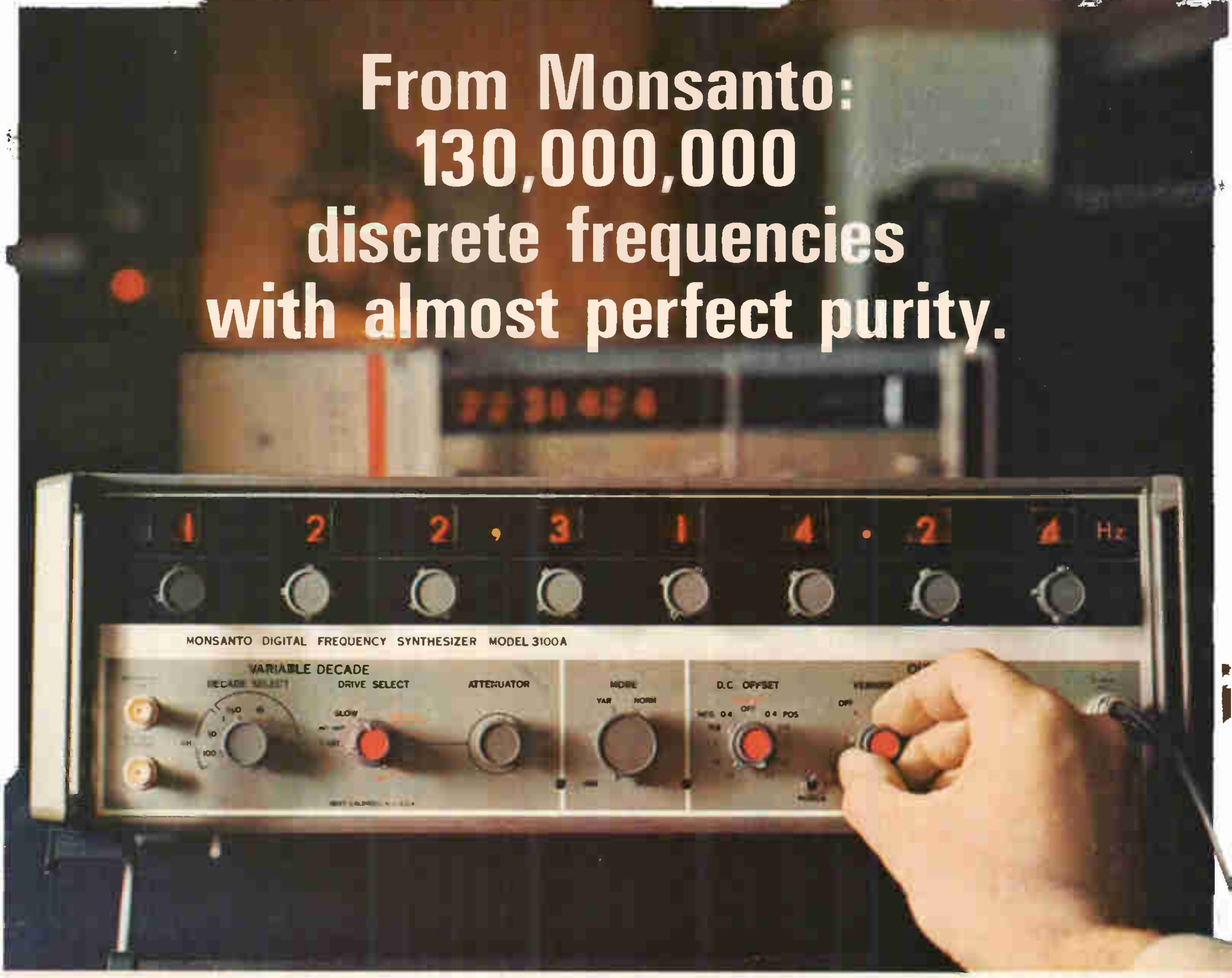
Modules can be easily inserted and removed with inexpensive stainless steel tool.







From Monsanto: 130,000,000 discrete frequencies with almost perfect purity.



New "4th generation" digital frequency synthesizer achieves new level of perfection in signal generation with computer-aided design and I-C construction.

Monsanto's new Model 3100A Digital Frequency Synthesizer obsoletes just about every present concept of general purpose signal sources.

Pick your frequency from 0.1 Hz to 1.3 MHz in 0.01 Hz steps. The result —signal purity you can get only from Monsanto, with a stability of one part in 10^9 per day.

Other refinements include: internally supplied rapid or slow sweep and provision for external sweep; continuous control of output level over a 90 db range; provision for both amplitude modulation and frequency modulation or both, simultaneously; in the remotely programmable version, switching time is less than 20 microseconds.

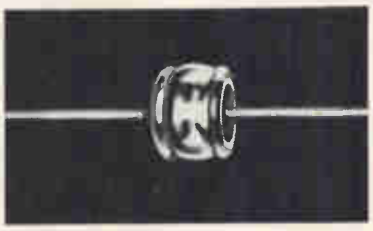
You can put this *better way* of signal generation to work for you for only $3950.00, FOB West Caldwell, N.J.

For a demonstration, or for full technical details, call your local Monsanto Field Engineer now or contact us directly at: Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006, (201) 228-3800.

Circle 97 on reader service card

Monsanto

SIEMENS

Do you have the question to this  answer?

The only limits to the questions answered by the Siemens Gas-filled Surge Voltage Protector are your needs, and your imagination.

Tiny, lightweight, a handful can protect a ton of sensitive electronic equipment, especially supersensitive solid state circuits. They give you tailor-made protection in hundreds of places throughout circuitry. With current carrying capacities up to 5,000 amps. With DC striking voltages from 90V to 1000V. With reaction speeds in the nanosecond range. And with a cost of less than $1 in quantity.

Lightning strokes, static charges, internal switching, short circuits—all these transient dangers are guarded against by these tiny, tireless sentries—Siemens Gas-filled Surge Voltage Protectors. If you've got a protection question, call Siemens America Incorporated for immediate protection delivery.

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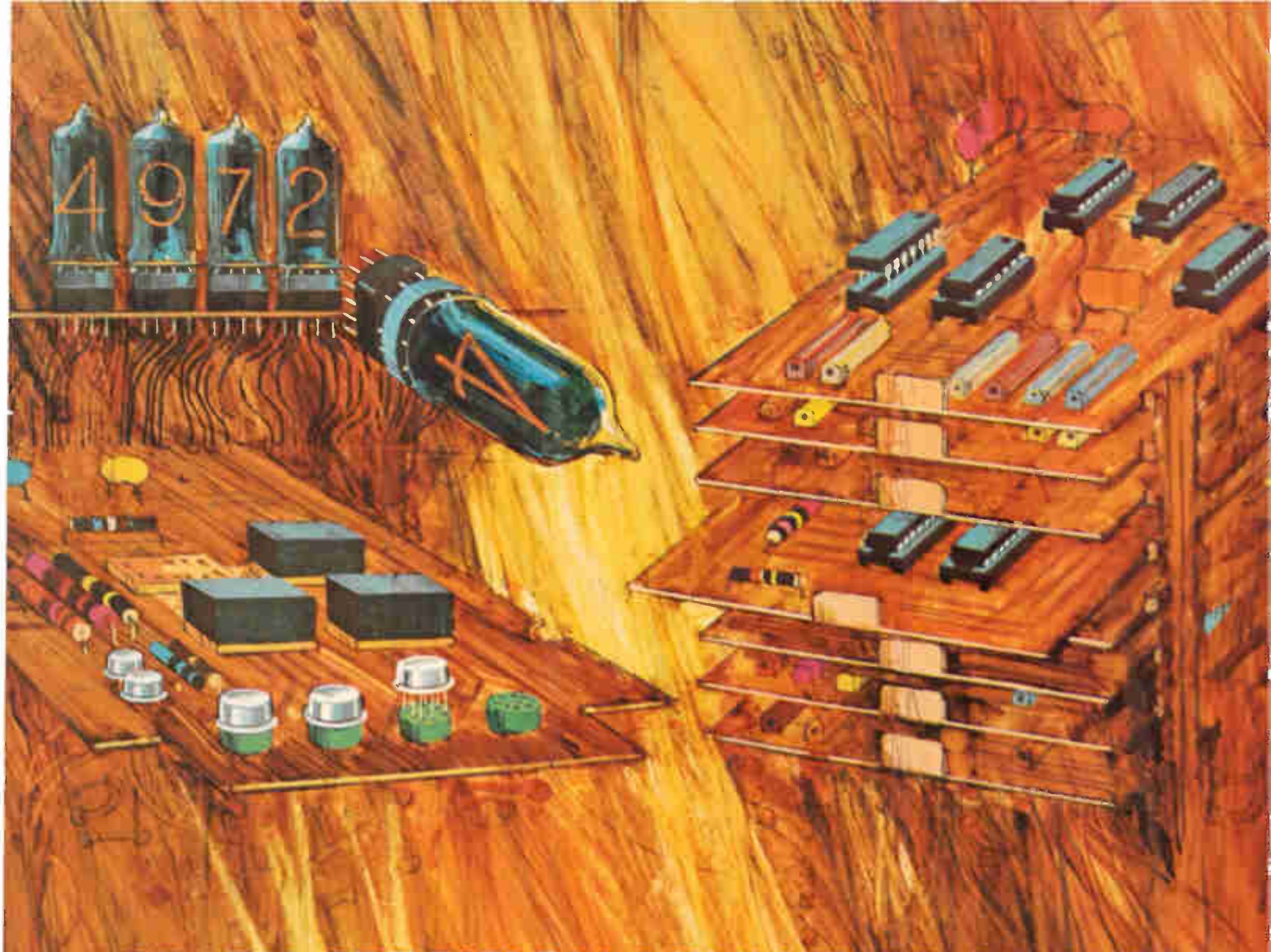
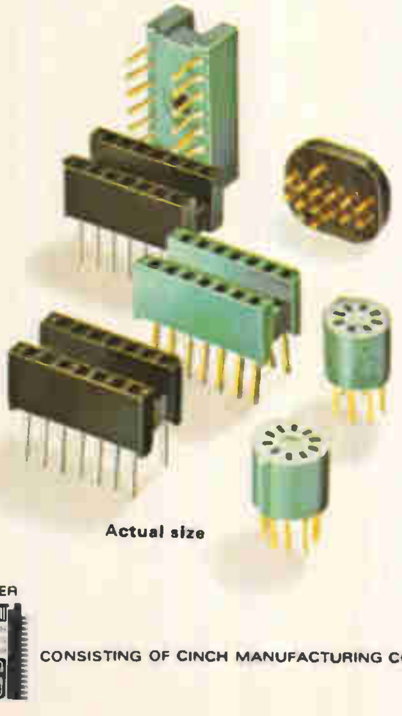


CINCH PRECISION MINIATURE SOCKETS

INSURE EQUIPMENT DEPENDABILITY



Actual size

Equipment design frequently involves problems of field maintenance or circuit updating. Cinch component sockets provide inexpensive and effective solutions without compromising reliability.

DIP sockets for 14 and 16 lead DIP's are typical of Cinch specialized miniature sockets. Available in GP black phenolic or SDGF diallyl phthalate, they have extremely high resistance to shock, vibration, humidity and corrosive atmospheres. Contacts are gold or cadmium plated beryllium copper with low contact resistance.

IC sockets for 6, 8 and 10 pin TO-5 cased devices, miniature *NIXIE Tube* sockets and *Subminiature relay* sockets are just a few of the other component sockets Cinch manufactures.

For information on DIP sockets and other Cinch interconnection devices, write to Cinch Manufacturing Company, 1501 Morse Avenue, Elk Grove Village, Illinois 60007.

C-6818

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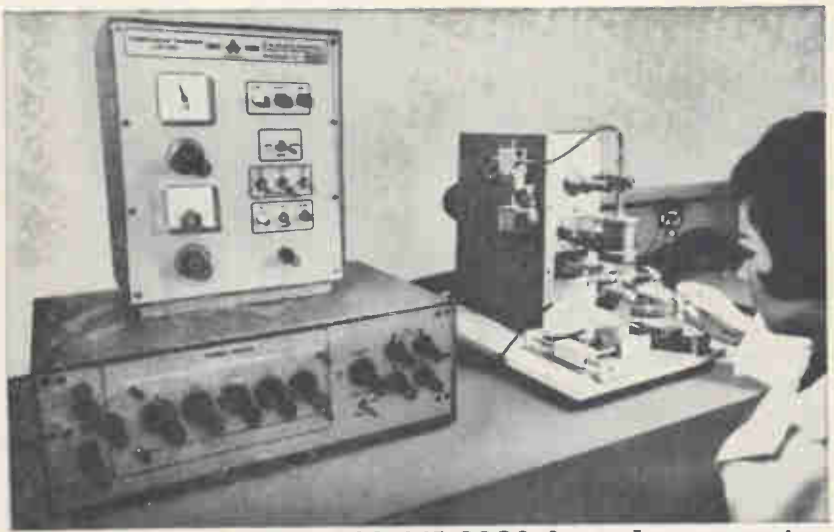
Circle 99 on reader service card

Model LAT-100
The $6,000* Resistor Trimming System



The number to call is 212-661-3320 for a demonstration like this—and you can bring your wife along if you like.

CALL us collect or write to arrange for a demonstration of S. S. White's new LAT-100, the complete, low-cost resistor trimming system for R & D and prototyping.

The LAT-100 automatically trims, monitors, and inspects PAF resistors to tolerances within 1%. That's guaranteed. In tests, 0.5% is often achieved. A precise 4-wire Kelvin bridge is integral to the system, which, with the optional plug-in decade box, permits the system to be programmed through five digits and three multipliers—from 0 to 10K and from 0 to 1M. Tolerances may be programmed from 0 to ±11%. Panel controls permit operator to overide the automatic cycle at will.

A holding fixture takes substrates up to 2x2 inches. A precise X-Y stage has 4"x4" movement. The trim slide has an automatic fast-return to place it exactly for the start of each trim. Tungsten carbide probes are mounted in a 14-position mounting ring. An efficient dust-removal system permits the LAT-100 to be operated in clean rooms. Installation requires a 110 VAC outlet and a level spot.

Without further detail, the LAT-100 does everything it's bigger brothers the AT-701 and AT-704 do—a little less accurately, to be sure, and not nearly as fast—but what can you expect for a trifling $6,000?

A step up from the LAT-100 is the AT-701, a no-nonsense production machine. The AT-701 can produce 600 trims per hour with guaranteed accuracy of 0.5% and attainable accuracy of 0.1% when things are going your way. The AT-701 with a decent amount of employment (say 1000 hours per year) produces trims at about ½¢ each—including labor, materials, maintenance, and amortization. How about *that?*

Model AT-701 garners accolades at IEEE show—top scientist says "Gee whiz."

But say you're big. Really big. We've got our big Bertha model for you, otherwise called the AT-704, which produces 4,000 trims per hour with accuracy and cost similar to those of the AT-701.

S. S. White resistor trimming systems are based on the proven Airbrasive® concept, controlled by precision electronics. The Airbrasive method of removing resistance material produces neither heat nor shock, does not alter substrate—yields of 100% can be attained with any of the S. S. White resistor trimming systems at some sacrifice of speed and tolerance. Each of the systems trims and monitors simultaneously and inspects after each trim.

Big Bertha: Model AT 704 trims at 4,000/hour pace for high volume producers.

Up to now we've been able to offer fast delivery on all systems; however the enthusiasm we've encountered over the LAT-100 suggests that you'll be wise to place your order early for this model.

Call us or write to arrange for a demonstration of the LAT-100, the AT-701, or (if you're really big) the AT-704. Or ask for bulletin RT-14—it's great to read on planes.

Inquire, S.S. White Industrial, Dept. R, 201 East 42nd Street, New York, N.Y. 10017. Telephone 212-661-3320.

*Base price, $5,950.00 each. With optional decade box, illuminator, foot-switch operation, $6,350.00.

S. S. WHITE INDUSTRIAL
A DIVISION OF PENNSALT CHEMICALS CORPORATION

If you buy any of Honeywell's standard Series 70 Taut-Band Meters, here's what you'll get:

The Basics.

A plain square case.

A clear Plexiglas cover.

Large, plain markings. (You can read them at arm's length without squinting.)

And the simplest meter mechanism known to man: Honeywell's new Auto-Torque mechanism. (It has about 50% fewer parts than pivot-and-jewel.)

This is a meter with no frills.

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However, frills are available:

Fancy dials, with multiple scales and multi-colored sectors. (A fancy dial looks great on a plain meter.)

Lighted dials.

Mirrored scales.

Behind-panel mounting with a bezel. (For 2½", 3½" and 4½" meters.)

Plus just about any other modification you might have in mind.

The specs.

The taut-band mechanism is completely frictionless, so it responds to the slightest inputs. Hysteresis-free, so its repeatability is near perfect.

And it costs less than pivot-and-jewel.

Honeywell's Series 70 Meters come in 33 standard ranges. And 5 sizes (1½", 2½", 3½", 4½" and 6").

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It takes all kinds of meters to make the Honeywell line.

Circle 101 on reader service card

Circle 103 on reader service card→

Goldilox™ built-in protection system gives DTLs high noise margin with Mil Spec reliability.

And that's no fairy tale.

	Function	Prices (100 or more)
WCZ 261	Dual NAND gate	$1.60
WCZ 236	Triple NAND gate	1.65
WCZ 226	Triple NAND gate	1.65
WCZ 216	Triple NAND gate	1.65
WCZ 266	Quad NAND gate	1.75
WCZ 246	Quad NAND gate	1.75
WCZ 298	Monostable	1.65
WCZ 220	Dual driver	1.65
WCZ 275	Dual J-K flip flop	3.85

Only from Westinghouse—the WCZ 200 series of high threshold logic, with a noise margin of 5 Volts DC, and operating on the popular 12 Volt power supply.

This series of DTLs also has the exclusive Goldilox protection system that's built right into the product. Goldilox protects ICs against current leakage, moisture, and the interaction of different metals at the contact points. The WCZ 200 series is capable of collector OR-ing, is compatible with standard DTL devices, and comes in dual-in-line packaging.

Look at these prices. Then you'll know why the WCZ 200 series with Goldilox protection is your best buy in high threshold logic. For full application data, call our local sales office, or Westinghouse Molecular Electronics Division, Elkridge, Maryland (301) 796-3666. J-09150

You can be sure . . . if it's

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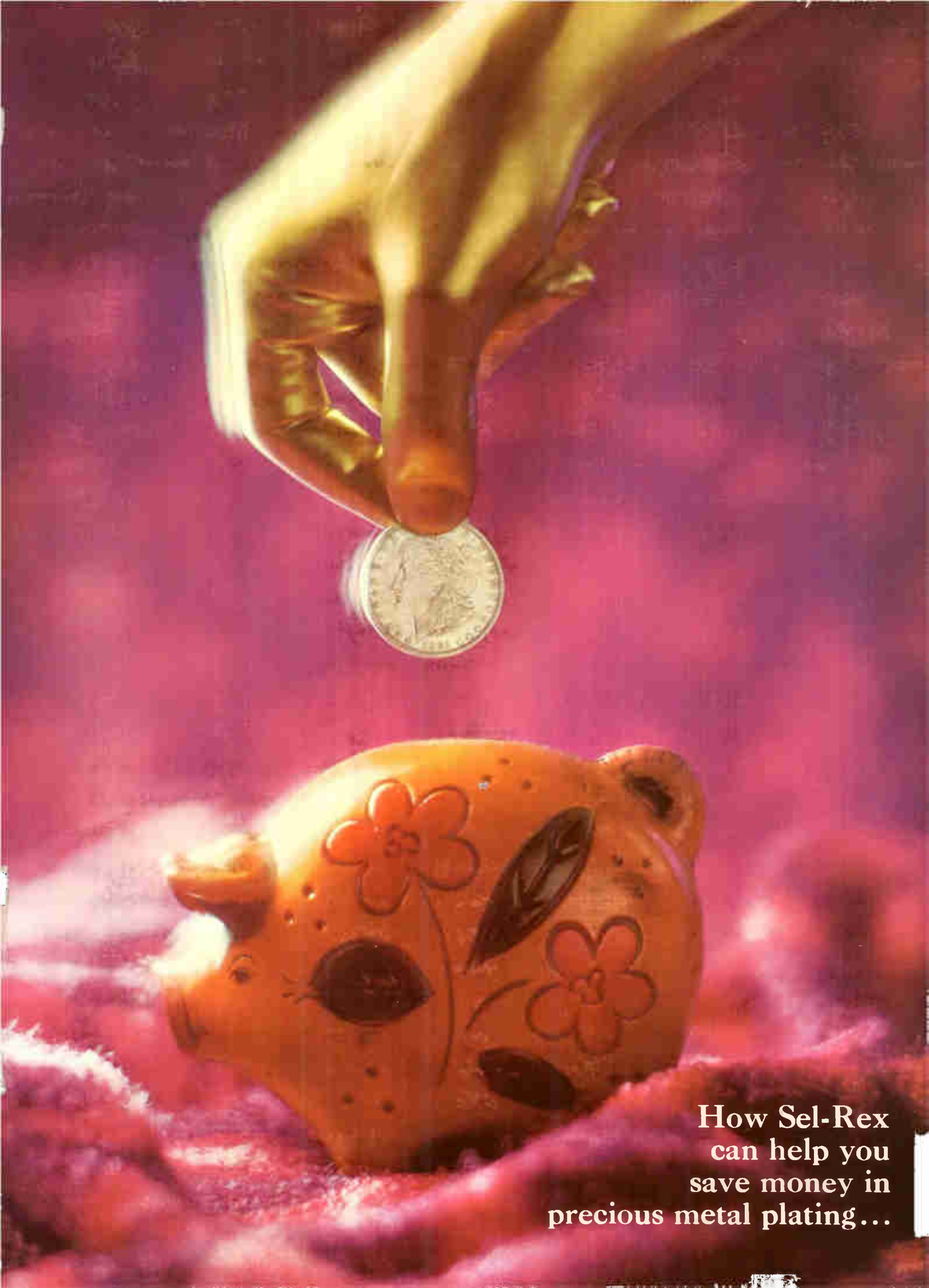
Goldilox ICs block out noise.


How Sel-Rex
can help you
save money in
precious metal plating...

The five cost factors in

...and the advantages to you of the

The ultimate cost of precious metal electroplating is affected by a number of factors– both within and outside your plant. Five of them are the keys to vendor selection. These factors are interrelated, and if not considered as a whole, there is a likelihood that your precious metal electroplating may cost you more than it should.

1. The Process Itself
The selection of the "right" precious metal plating process is not a casual matter. We work diligently with our customers to make sure that the processes they use give optimum results. With almost two dozen Sel-Rex gold-plating processes alone for industrial applications, there's no need to compromise on results. Equally important is a review of your needs from time to time, to verify optimum performance in light of current conditions.

More companies use Sel-Rex precious metal electroplating processes than those of any other supplier in the world. Because of this, there's a greater likelihood we can meet your needs more precisely than anybody else.

2. The Equipment
The Meaker Company (a Sel-Rex subsidiary) specializes in equipment to meet the unique needs of the electronics manufacturing industry, watchcase and jewelry manufacturers, and others who demand absolute precision in plating. Not only does properly designed equipment facilitate the processing of your product, it also provides for efficient maintenance of plating baths and other solutions.

Meaker manual and automatic equipment is designed not only with your present needs in mind, but also in keeping with the direction of your growth. Modular "packaged" equipment by Meaker has been a significant contribution to the field – saves time and money in setting up, in operating, and in modifying to meet changing needs.

precious metal electroplating
Sel-Rex "total approach" to your problem

3. Technical Assistance

We regard our relations with our customers as a partnership. To this end, the largest and finest technical service staff in the industry is committed to helping our customers obtain maximum benefits in their precious metal electroplating activities. Analytical and metallurgical laboratories, and modern prototype plating facilities are located not only at our central headquarters, but also in the field, to be closer to you.

All in all, with Sel-Rex you have access to the greatest storehouse of technical experience in the precious metal plating field. You save down-time and gain work-time with this kind of service.

4. Research Support

Your ultimate costs may be more directly affected than you realize by the quality of research available to you from your supplier. Sel-Rex research can be a competitive advantage to you. Our long-range research has lead to such developments as the first bright gold, the first acid gold, and the first non-cyanide gold processes for industry. But we are also continually "researching" our present processes to make them work better for you.

A constant interface between our research and technical service groups brings new developments to bear on your needs quickly and efficiently. By giving additional valuable characteristics to pure gold deposits. Sel-Rex research recently helped more than a few of our customers reduce costs substantially. Significant cost reductions are also being obtained at a number of accounts with our new 18-Karat (75% gold alloy) deposits—suitable for both decorative and engineering applications.

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We want you to use our gold – not lose it. For plating lines, we have developed ion-exchange equipment that keeps precious metals from going down the drain. But our services wouldn't be complete without a concern for total precious metal accountability in your plant.

We start with a review of scrap segregation and salvage procedures in your plant to insure minimum refinery handling charges. We utilize the latest techniques for sampling and assaying. Our first-of-its-kind published schedule lets you know the value of all forms of precious metal material. A recently expanded refinery devoted solely to precious metal recovery provides the capability to extract maximum value from your scrap. Another Sel-Rex factor in keeping your costs down.

Save with Sel-Rex. We have listed five specific areas in which we can help you control costs. Together they make up our Total Approach to your precious metal electroplating needs.

Sel-Rex®


Sel-Rex
TOTAL
EXCLUSIVE PROCESSES
EQUIPMENT SYSTEMS
TECHNICAL SERVICE
RESEARCH SUPPORT
MAXIMUM RECOVERY
Add to the five factors listed here one more —Sel-Rex serves you wherever you are.
Subsidiaries and associated companies in Canada, Great Britain, Switzerland, France, Holland, and Japan, together with a network of technically skilled distributors, provide Sel-Rex products and services throughout the world. So, whether you reckon your costs in dollars or any other currency, you can save with Sel-Rex.
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700V

HIGH VOLTAGE NPN Silicon Power TRANSISTORS from Solitron

2N5467

TO-3

80W @ 100°C
1.25°C per W

2N5469

TO-66

40W @ 100°C
2.5°C per W

SPECIFICATION RATINGS:

V_{CEX} = 700V min
V_{CEO}(sus) = 400V min
h_{FE} = 15-60 @ 3.0A
V_{CE}(sat) = 0.5V @ 3.0A

Also available in 500 Volt V_{CEX} versions, 2N5466 and 2N5468; all other specifications identical.

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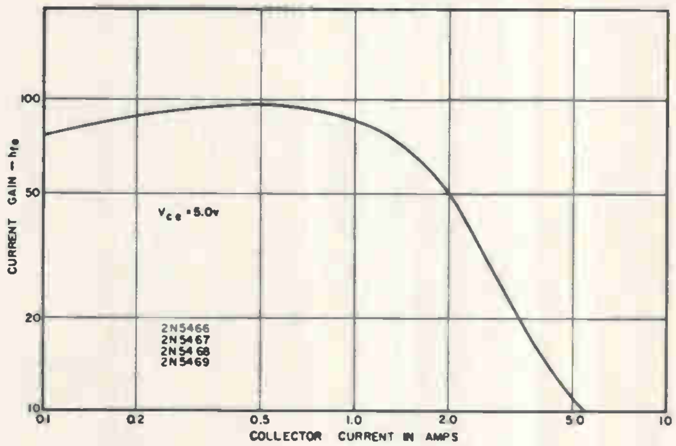

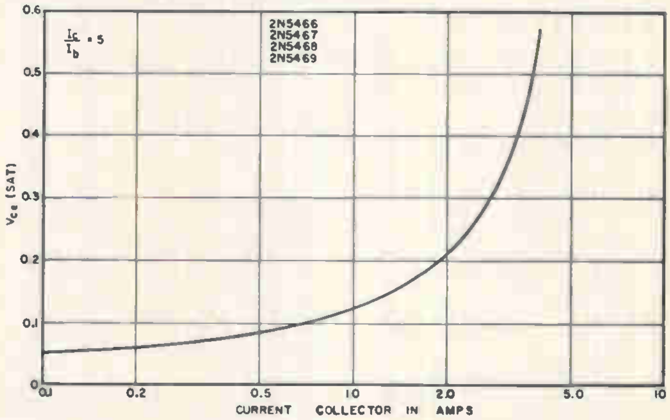

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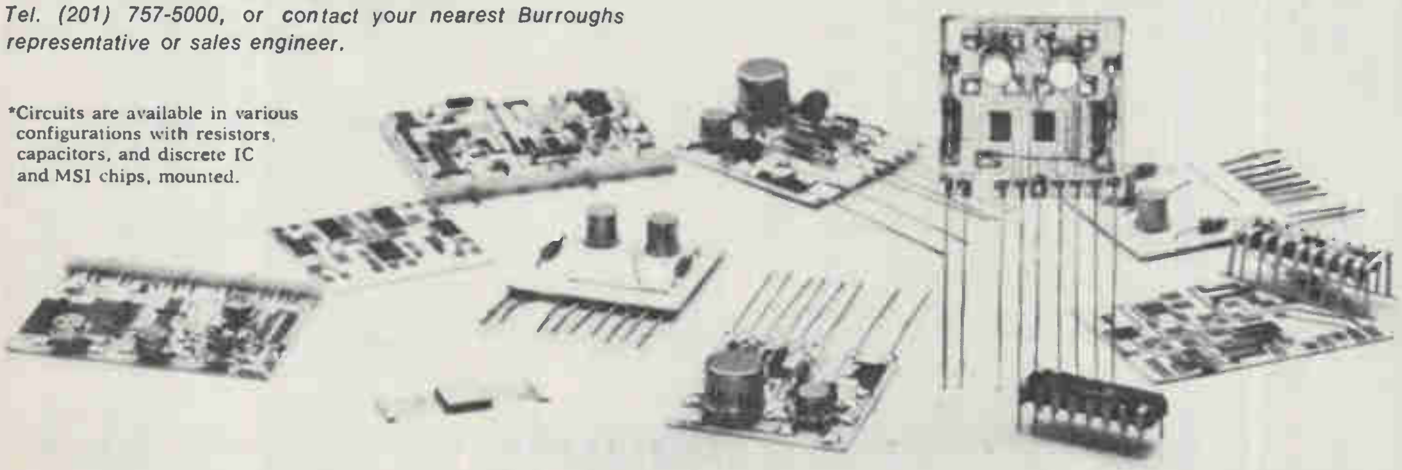
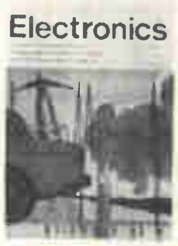


Burroughs

Circle 110 on reader service card

Technical Articles

Analyzing air pollution with infrared and logic
page 112



Parallel active filtering and pattern-recognition logic give a prototype pollution analyzer more versatility than conventional models. The electronics portion of the system takes over many functions usually performed by the optics, allowing the analyzer not only to detect polluting substances but to identify them, distinguishing among those with similar infrared spectra. The electronics carries out Fourier-transform spectroscopy and indicates whenever a contaminant exceeds an acceptable level.

Where things stand with cylindrical film memories
page 124

Cylindrical film memories are coming into their own. Authors from three companies specializing in these types have contributed articles to Electronics' continuing series on memory technology. Since commercially introducing plated wire two years ago, Univac is forging ahead with this technology, and its prospects are good. National Cash Register has gone all out with plated rods in its Century computer, unveiled earlier this year. And Librascope, a division of Singer-General Precision, continues to develop woven-wire memories for aerospace applications.

Taking shortcuts in color tv cameras
page 134

Highly stable solid state circuitry permits the elimination of many sophisticated trimming circuits in a new color television camera costing a quarter the price of conventional studio units. And even with such inexpensive optical components as vidicon pickup tubes and standard 35-millimeter lenses, the camera, when used with an image enhancer, produces broadcast-quality pictures.

MOS multiplexer avoids high-frequency hazards
page 152

When signal frequency goes much above 1 kilohertz, the performance of metal oxide semiconductor switches can deteriorate seriously. The signal can feed through from an off channel to one that's on, it can be attenuated significantly, and the switching transients can become very large. Fortunately, however, mathematical analysis of these effects makes it possible to design circuits that are immune to them.

Coming

Faster IC chip connections

A wide-ranging look at various efforts to improve semiconductor chip mounting by such schemes as beam leads, spider bonding, and flip chips.

Industrial electronics

Pattern-recognition logic analyzes infrared signals

Prototype pollution detector uses an optical interferometer but can identify several contaminants because its logic and active parallel filters enable it to distinguish among those with similar spectra

By Alan Bessen
Ford Instrument Division, Sperry Rand Corp., Long Island City, N.Y.

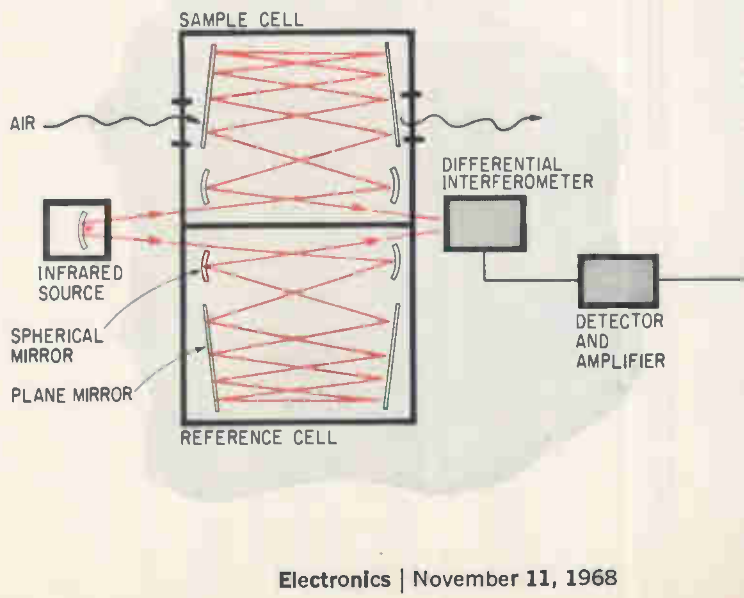
Long a junior partner to optics in infrared contamination analyzers, electronics assumes the senior role in a prototype unit with the addition of parallel active filters and standard logic elements. This new analyzer not only detects several pollutants but identifies them accurately. The electronic data-analyzer unit carries out Fourier-transformations and decision rules, and turns on a light when a given contaminant exceeds a threshold level.

Most conventional instruments are designed to measure only one contaminant—sulfur dioxide, for example—at a time. When the environment contains several contaminants with similar spectral patterns, such instruments can't tell them apart and can thus produce erroneous readings. And the use of a battery of analyzers, each responding to only one contaminant, may be very costly in such applications as area surveys. While it's possible to use several conventional analyzers, with more sophisticated optical configurations to improve selectivity, doing so can sharply increase cost and mechanical complexity.

The prototype analyzer, however, can handle several contaminants without changing optics because its filtering and logic enable it to discriminate between those with similar spectra. An optional interferometer that periodically scans a wide range of the infrared spectrum detects traces of gases, vapors, and areosols that absorb energy in this region. The resulting signal is processed using Fourier-transform and decision-theory methods. The analyzer can be tuned to distinguish another set of pollutants by simply changing the logic cards.

One data analyzing unit can handle several remote sensors, giving a readout from each location every second. Since its output signal ranges from 70 to 100 hertz or some other frequency band in the audio range, the sensor can be connected to its central logic unit by fixed wiring or telephone lines.

Infrared absorption spectroscopy depends on the natural vibrations of atoms held together by chemical bonds within a molecule. These motions produce a corresponding periodic change in the molecule's dipole moment, causing the oscillating dipoles to interact with radiant energy of the same frequency in a kind of resonance. The result of this phenomenon is that incident radiation is absorbed at these frequencies. Since the absorption frequencies are unique to the type of molecule involved, the resulting infrared spectrum identifies the sub-



stance. Furthermore, the concentration is directly related to the amount of absorption at a given frequency and over a given path length.

Many solid, liquid, and gaseous substances possess an infrared spectrum that can be detected under suitable conditions. Gases such as sulfur dioxide and carbon monoxide—most important in air-pollution studies—exhibit characteristic spectra in the intermediate infrared region. Others, like carbon dioxide and water, are relatively transparent in at least part of this region and won't interfere with measurements. Normal atmospheric constituents such as nitrogen and oxygen absorb no energy in the intermediate i-r band.

In the sensor shown on the preceding page, an infrared source illuminates two absorption cells with beams of equal intensity. The cell containing the sample of air is continuously refilled. The other holds air that's free of the pollutants being sought; this air is used as a reference and is periodically changed. Normally, there's only negligible absorption due to atmospheric constituents in the reference cell.

The outputs of the two cells go to the interferometer, which measures the spectrum of the absorption difference between the two beams. The differential nature of the measurement makes the system relatively insensitive to such things as variations in the intensity of the infrared source and changes in electronic-amplifier gain since these factors affect both signals equally. And interfering "background" materials (dust particles, ozone) with absorption characteristics within the system's passband usually turn up in equal amounts in the sample and reference cells so their effect is also largely cancelled out.

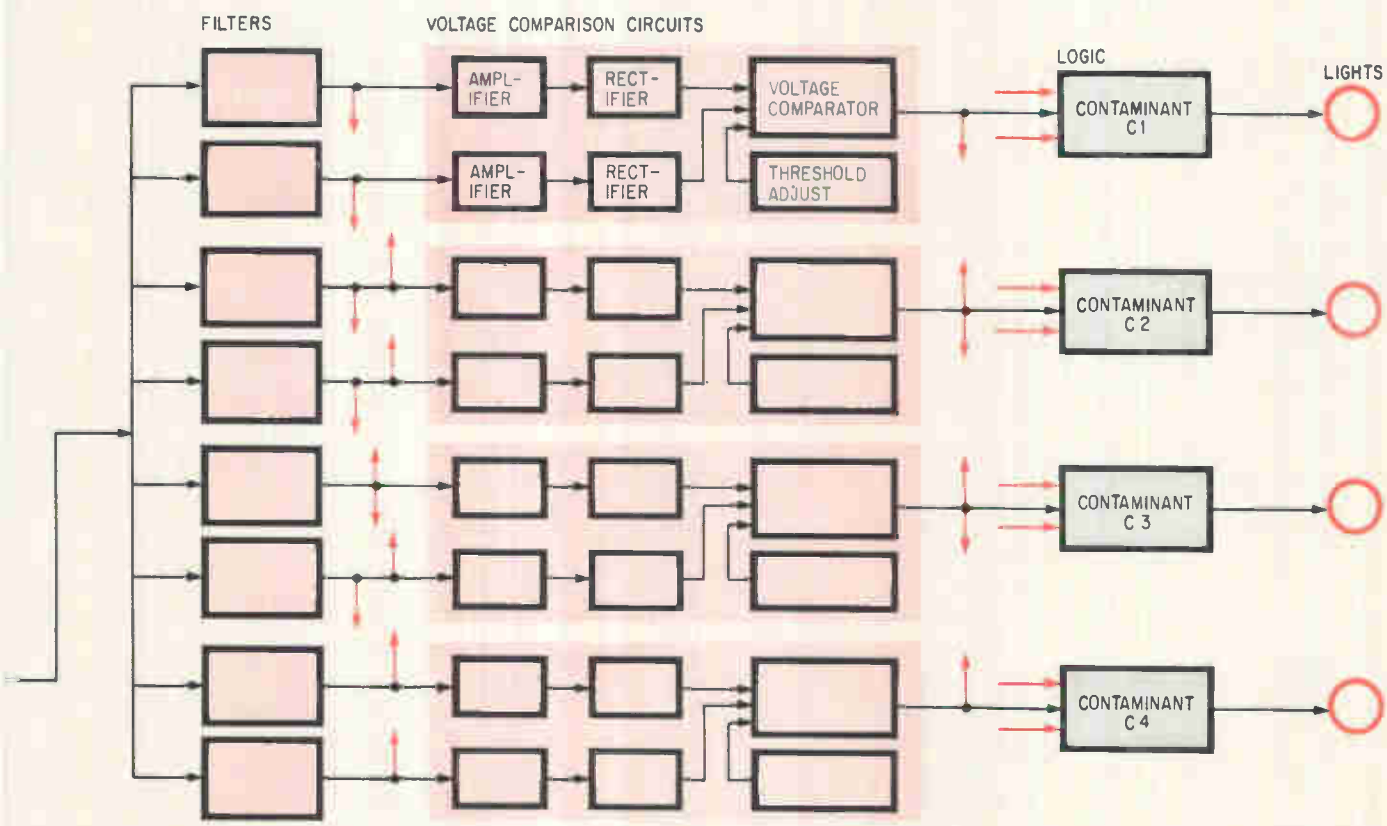
All these effects would be taken care of by the discrimination capability of the logic anyway, of course, but the differential approach—equivalent to common-mode rejection—reduces the required dynamic range of the electronics.

The changes in energy level resulting from radiation absorption are so small that the interferometer must have excellent sensitivity. The rapid-scan Michelson interferometer is thus better in this application than the conventional infrared spectrometer.

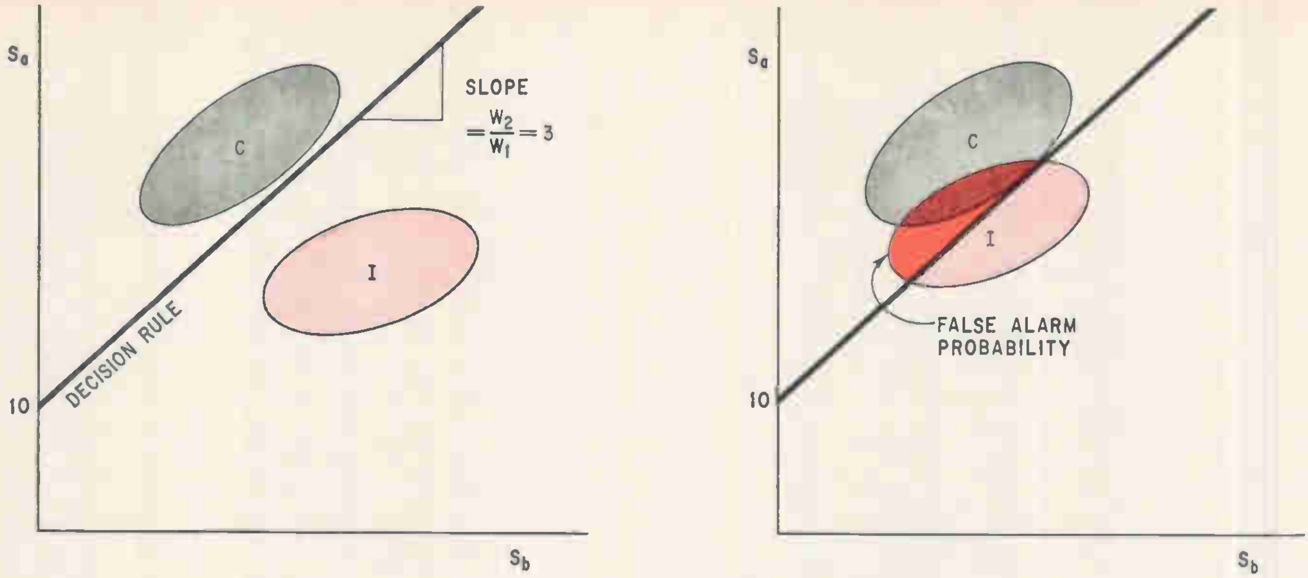
Separating wavelengths

Conventional spectrometers generally employ the dispersion provided by a prism or grating to separate the radiation into its spectral bands. The energy within a particular band of the dispersed radiation is selected by a narrow slit and measured by an i-r detector, while the energy in other bands is wasted.

As the prism or grating rotates, the detector sees each band sequentially and measures its relative intensity. To enhance the signal-to-noise ratio by data averaging, the detector should look at each



Discriminating. Because the filter and voltage-comparison circuit outputs can be connected to any channel (as indicated by colored arrows) the same logic packages can distinguish among many contaminants.



Decisive. A reading above the decision rule means contaminant is present in the air sample.

band for as long as possible. However, this limits the speed at which the optics rotates.

For a given resolution, then, signal-to-noise ratio can be traded off for speed. Similar restrictions apply to a spectrum analyzer using the recently developed optical wedge filter, a thin-film interference device with a narrow passband and a transmission wavelength that varies continuously over a range as the filter is rotated.

The limitations of the conventional spectrometer are overcome by Fourier-transform spectroscopy, a technique that's based on the use of the rapid-scan Michelson interferometer and which permits, in effect, all wavelengths in the spectral range of interest to be measured simultaneously for the entire scan cycle. And since the Michelson interferometer doesn't require a narrow slit, there's no loss of radiation-gathering power.

Parallel filtering

The use of an interferometer spectrometer introduces a problem in data analysis, though. The device's output, called an interferogram, is a voltage that varies with time and whose frequency components represent the desired spectrum. Mathematically, the interferogram is the Fourier transform of the power spectral density of the sensed radiation, but since it is not a spectrum, it can't be compared directly to the known spectra of contaminants.

To reproduce the spectrum, the inverse Fourier transform of the interferogram must be obtained. This can be done by digital and analog computer processing, analysis by an audio-frequency wave analyzer, or other means. The computer processing techniques are expensive, though, and the wave-analyzer technique requires such a time-consuming tuning procedure that it's impractical for a real-time instrument system.

A tunable-wave analyzer must be swept through its range and the speed at which this can be done is limited by the transient response of the tuned circuit. Since the time constant of the tuned circuit is inversely proportional to its bandwidth, high selectivity and fast tuning can't be achieved at the same time.

In the prototype atmospheric-contamination detector, the interferometer's output is analyzed by a comb filter, a paralleled set of highly selective electronic bandpass filters with fixed center frequencies as shown on page 113. The filters are active networks that use an RC combination in the feedback path of a linear amplifier to develop a sharp peak at the resonant frequency. The outputs give the same information as would the output of a wave analyzer tuned to the same frequencies. The more filters used, the more points at which the spectrum can be sampled, and the more contaminants that can be identified.

An important advantage of this technique over the sequentially operating wave analyzer is that all the comb filter outputs are available simultaneously, making for rapid instrument response. After detection, the output of each filter is integrated by a low-pass filter to improve the signal-to-noise ratio. All filter signals are used together in a spectrum-comparison procedure to identify contaminants.

Conventionally, a substance is identified by comparing the continuous shape or contour of its infrared spectrum with one like it from a catalog of corresponding shapes for known substances. The Michelson interferometer, however, doesn't produce a continuous spectrum; discrete measured data from the filters corresponds to sampled values of the spectrum only at selected frequencies. There's some uncertainty about the data too. Electrical noise in the system and variations in the composition of the background cause a statistical distribution of the sampled spectral values so that they're represented by a circle or oval rather than a point, as shown at the left. The pattern formed by the data denoting the presence or absence of a contaminant can be recognized by computer logic.

To identify a contaminant and to distinguish it from similar interfering substances requires a discrimination test. One suitable test compares a linear combination of sampled spectral values with a decision level D:

$$\sum_{i}^{N} W_i S_i \geq D$$

where S_i is the amplitude of the sampled spectrum at the ith wavelength and W_i is a weighting factor for this wavelength. The particular linear combination is called a decision rule.

If the measured data meets or exceeds the decision level for a particular case, the specified contaminant is considered to be present; otherwise, it's considered absent. The weighting factors assigned to a given contaminant can accentuate the difference between contaminant and interferent. Qualitatively, this can be done by assigning a relatively large weighting factor at wavelengths where there is a large difference between the average spectra of the contaminant and of the class of possible interferents. Similarly, a relatively small weighting factor would be assigned where the statistical dispersion in either spectrum is large. If the contaminant is more absorbent than the interferent at one wavelength but less absorbent at another, the contrast between the two substances can be increased by assigning weighting factors of opposite sign at these two wavelengths.

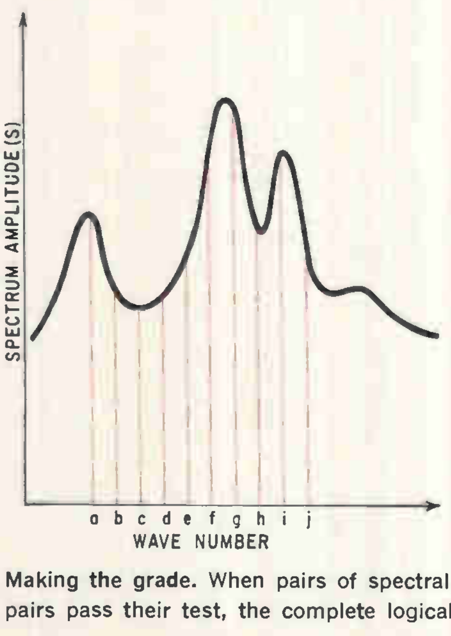
Consider the illustration on page 114, which shows the distribution of sampled spectral values S_a and S_b for a contaminant C and interferent I at wavelengths a and b. The decision rule here is $S_a - 3S_b \geqq 10$. In one set of measurements there's no overlap between the areas C and I, so the decision rule clearly separates the substances. There is an overlap, though, in another set of measurements. The same decision rule will always identify the presence of the contaminant, but since the interferent may also appear to be a contaminant, it may register a false alarm, as indicated by the shaded area.

The quantitative determination of the best weighting factors for given criteria regarding the detection and false-alarm probabilities is a classic problem in statistical decision theory. However, statistics on the spectra of contaminants and interferents aren't readily available, so a simplified identification technique—implemented by standard diode-transistor logic functions—was used in the prototype system.

The difference between sampled spectral values at various pairs of selected wavelengths are determined and compared with corresponding threshold decision levels. In the typical situation illustrated below, the particular contaminant is identified as being present if the differences in all four wavelength pairs exceed their corresponding thresholds. The thresholds were chosen to at least exceed the electrical noise level of the system.

Furthermore, the wavelengths used for comparison in each test were chosen so that spectra of other contaminants and selected interferents would fail to satisfy at least two of the tests and thus would not cause false alarms. In this manner, logical tests enhance the selectivity of the contamination detection system.

The spectral comparison technique depends on the relative intensities of absorption bands in a spectrum as well as the wavelengths at which these bands occur. The characteristics of the spectrometer system will, however, modify the shape of a measured spectrum. A detailed analysis of the



LOGICAL TEST FOR C1	RESPONSE OF OTHER SUBSTANCES					
	C2	C3	I1	I2	I3	I4
$S_f - S_d > D_{fd}$	PASS	FAIL	PASS	FAIL	FAIL	PASS
$S_g - S_j > D_{gj}$	PASS	PASS	FAIL	PASS	FAIL	FAIL
$S_a - S_c > D_{ac}$	FAIL	FAIL	FAIL	PASS	FAIL	PASS
$S_i - S_n > D_{in}$	FAIL	PASS	PASS	FAIL	FAIL	FAIL

Making the grade. When pairs of spectral samples, left, are compared with their decision levels, and the four pairs pass their test, the complete logical test indicates the presence of contaminant 1.

system has been made to determine the precise nature of these spectral modifications; a mathematical model defining the pertinent characteristics of the spectrometer, infrared absorption cell, and data processing circuitry was developed and programed on a digital computer to simulate the operation.

In the basic Michelson interferometer shown at the right, the incident radiation, a, is divided into transmitted, b, and reflected, c, components of equal intensity by the beam splitter. After reflection by the stationary and moving mirrors, each component is again divided by the beam splitter. Part of the radiation in each component is transmitted to the detector in direct beam, d, and part is reflected back to the entrance window in a complementary beam, e.

Consider only the direct beam, d, and assume a monochromatic input of radiant power $E_I(\nu)$, where the wave number, ν, is the reciprocal of the wavelength. The moving mirror's position is shifted along a straight line so that the difference in the optical path lengths of components b and c varies with a constant velocity, v. As a result, the relative phase between the components that combine to produce the direct beam varies linearly, causing alternate constructive and destructive interference. Specifically, $E_D(\nu)$, the resulting power in the direct beam, varies according to

$$E_D(\nu) = \tfrac{1}{2} E_I(\nu)\,(1 + \cos 2\pi\nu vt)$$

The time-varying term in the above equation

$$I(t) = \frac{E_I(\nu)}{2} \cos 2\pi\nu vt$$

contains the information that results in an interferogram.

The interferometer thus acts as a modulator; for a monochromatic radiant-source input, the interferogram is a cosine wave with an amplitude proportional to the intensity of the radiation, E_I, and frequency, $f = v\nu$ proportional to its wave number. By proper choice of the moving mirror's velocity, the output frequency will lie in the audio range and may readily be sensed and converted to an electrical signal (70 to 100 hz) by an infrared detector such as a thermister bolometer bridge.

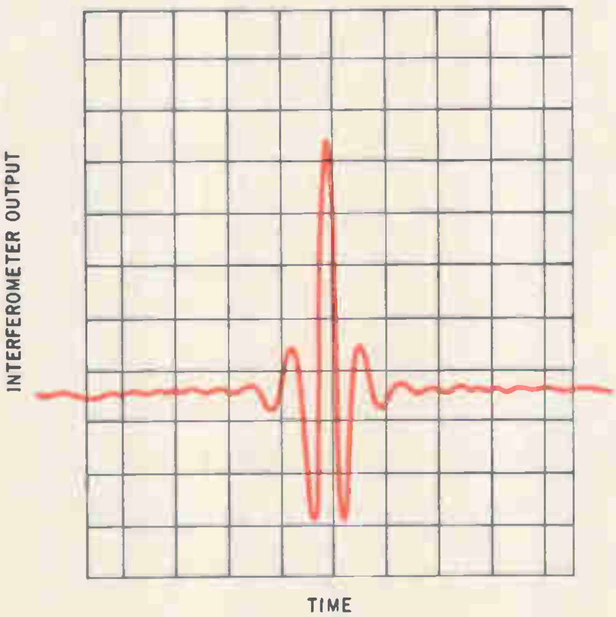
Generally, though, the input radiation is not monochromatic, but has a continuous spectrum. For such an input source, the output is proportional to the integral of the above equation, so that the interferogram is

$$I(t) = \tfrac{1}{2} \int_0^\infty E_I(\nu) \cos 2\pi\, ft\, df$$

where $E_I(\nu)$ now represents the power spectral density of the input radiation. The interferogram for a Nernst-glower (a heated metal-oxide element) continuous-spectrum input is shown below.

An interferogram contains the same basic information as the spectrum of the input radiation that generates it. In fact, the interferogram is the cosine Fourier transform of the desired input power spectral density. As noted earlier, to reconstruct the input spectrum it's necessary to determine the inverse Fourier transform, which, for the ideal interferometer described above, is

$$E_I(\nu) = \int_0^\infty I(t) \cos 2\pi ft\, dt$$



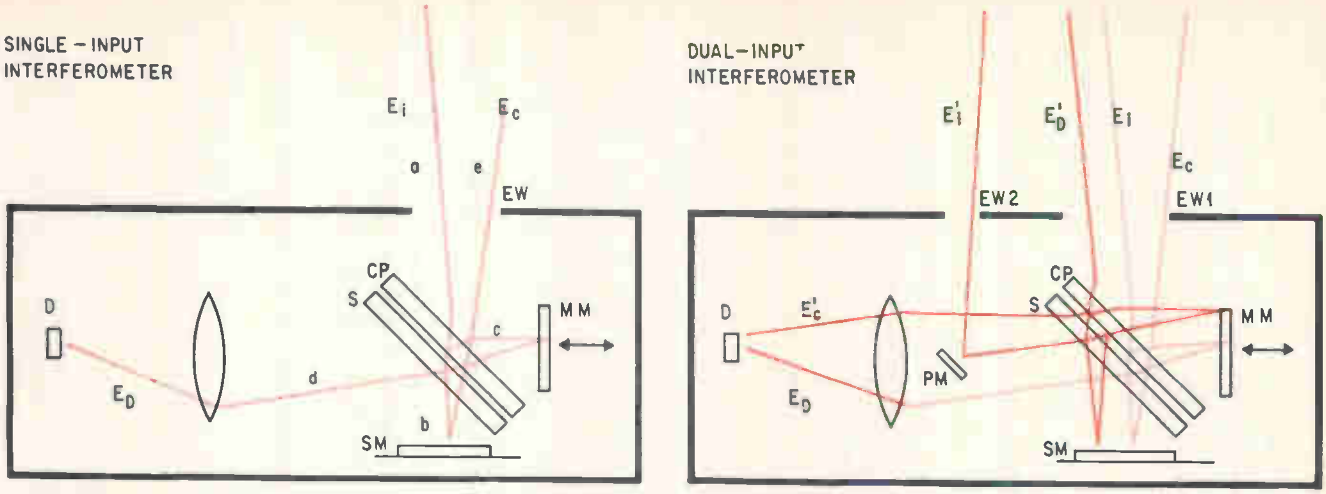
Interferogram. Output of Michelson spectrometer is a time-varying signal, this one of a broadband i-r source.

Before describing the determination of the input spectrum, it's important to consider the generation of a difference spectrum. This could be found by measuring the spectra of the sample and reference cells individually—either with two interferometers or by time-sharing a single unit—and then subtracting one from the other electronically. However, it's simpler to do this subtraction optically within the interferometer itself by adaptation of the device involving the complementary beam. If a low-loss dielectric beam splitter is used, the complementary beam in the schematic on page 117 represents the difference between the input radiation and the radiation in the direct beam reaching the detector.

$$\begin{aligned} E_C(\nu) &= E_I(\nu) - E_D(\nu) \\ &= \tfrac{1}{2} E_I(\nu)\,(1 - \cos 2\pi ft) \end{aligned}$$

To make differential spectral measurements, the conventional interferometer is modified to accept a second input, $E_I'(\nu)$, via a second entrance window and a small mirror, as shown on page 117. $E_I'(\nu)$ is incident on the beam splitter perpendicular to $E_I(\nu)$. The second input is modulated in the same way as the first to produce direct and complementary beams, $E'_D(\nu)$ and $E_C'(\nu)$.

Output E'_D appears at the first entrance window and output E_C' at the detector. The spectral power sensed by the detector thus consists of the direct



SM – STATIONARY MIRROR
MM – MOVING MIRROR
S – BEAM SPLITTER
CP – COMPENSATING PLATE
EW – ENTRANCE WINDOW

EW1 – FIRST ENTRANCE WINDOW
EW2 – SECOND ENTRANCE WINDOW
D – DETECTOR
FM – FOLDING MIRROR

Beam splitters. Basic Michelson interferomoter, left, doesn't use the complementary beam, e put the dual-beam type at right does use it to optically subtract beams from the sensing cells.

beam of the first input plus the complementary beam of the second.

$$E_o(\nu) = E_D(\nu) + E_C'(\nu)$$

$$= \frac{E_i(\nu)}{2}(1 + \cos 2\pi ft) + \frac{E_i'(\nu)}{2}(1 - \cos 2\pi ft)$$

In the detection system, the first interferometer input is the output of the sample cell and the second is the output of the reference cell. When the cells are empty of air, the two inputs have the same spectral power and each is proportional to the spectral radiance of the source multiplied by the spectral reflections or transmittance of the various elements of the optical system.

When the sample cell contains an absorbing material with spectral transmission $\tau(\nu)$, the direct beam of the first input is attenuated by this factor. Assuming no absorption in the reference cell, the complementary beam of the second input remains unchanged. The time-varying component of the detected signal, the interferogram, is therefore

$$E_o(\nu) = -\frac{E_i(\nu)}{2}\alpha(\nu)\cos 2\pi ft$$

where $\qquad \alpha(\nu) = 1 - \tau(\nu)$

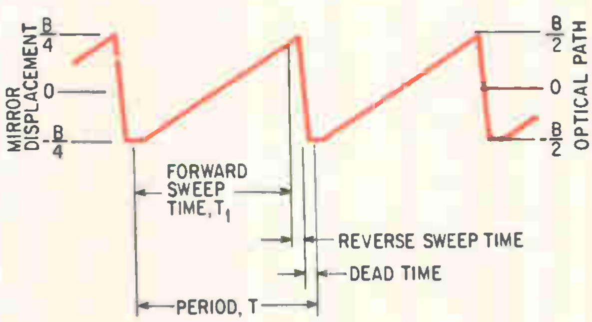
is the spectral absorption coefficient of the sample. By optical subtraction, then, the amplitude is proportional to the difference between radiation inputs to the two windows at the corresponding wave number.

Until now it has been assumed that the interferometer mirror moves indefinitely and produces a nice continuous signal. But for practical reasons, this motion must be limited to a rather small excursion. As a result, the spectral content of the interferogram differs somewhat from that of the radiation to be measured. The mirror is driven by an electrically controlled actuator in a sawtooth fashion, as shown below. Each forward sweep of the mirror, which occurs at a constant velocity, generates an interferogram, during each rapid-return sweep, the detector output is blanked. Therefore, for a monochromatic input at wave number ν_a, the interferogram consists of a repeated sequence of cosine wave segments, as shown on page 118, rather than a continuous cosine wave.

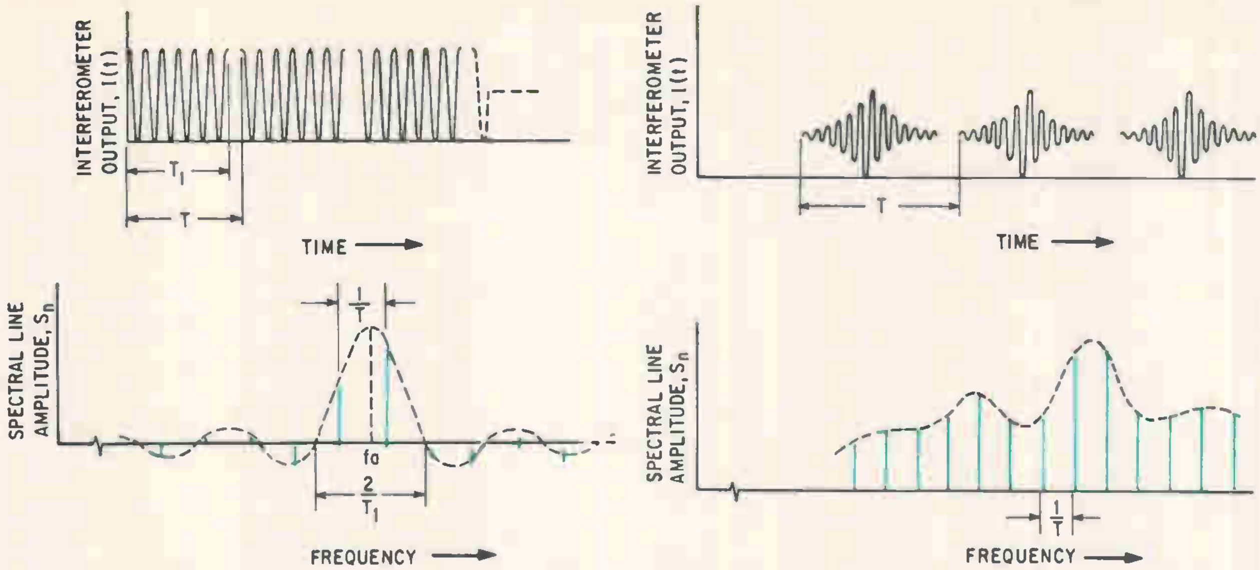
Since this waveform is periodic, its spectrum is given by the coefficients of a Fourier series expansion rather than by the Fourier transform. Good approximations of these coefficients are

Monochromatic source—

$$S_n = KE_i(\nu_a)\,\alpha(\nu_a)\frac{\sin \pi T_1 (f_n - f_a)}{\pi T_1 (f_n - f_a)}$$



Blackout. Moving mirror sweeps a limited distance, so a signal develops only during forward sweep.



Consider the source. A monochromatic i-p source would weld chunks of cosine waves (left). But interferograms for a broadband source looks like those at right. Discrete spectral amplitudes are shown at bottom.

$$e_o\ (\text{rms}) = \left[\frac{1}{2} \sum_{n=1}^{\infty} \left| Y\left(\frac{j\,2\pi n}{T}\right) \right|^2 \left[\int_0^{\infty} KE_i(\nu)\,\alpha(\nu)\,\frac{\sin \pi T_1 (f_n - f)}{\pi T_1 (f_n - f)}\,df \right]^2 \right]^{1/2}$$

where f_a is the frequency corresponding to ν_a or ($f_a = B\nu_a/T_1$); f_n is the nth harmonic frequency or ($f_n = n/T$); and K is the proportionality constant.

The resulting discrete spectrum, shown above, left, consists of harmonics at integral multiples of the repetition frequency, n/T. In practice, a monochromatic radiant source won't be used. The prototype contamination system needs a heterochromatic—or broadband-input—source, the Nernst glower.

For heterochromatic radiation, the interferometer output consists of a repeated sequence of interferograms such as those above, right. The expressions for the spectral lines may be obtained by integrating the Fourier series coefficients over all frequencies present in the input spectrum.

Heterochromatic source—

$$S_n = \int_0^{\infty} \frac{KE_i(\nu)\,\alpha(\nu)\,\sin \pi T_1 (f_n - f)}{\pi T_1 (f_n - f)}\,df$$

Again, the measured spectrum shown right, is discrete. Its envelope approximates the spectrum of the input radiation but exhibits a smearing because of the constrained duration of each interferogram. This smearing limits the measurement resolution – the ability to distinguish between closely spaced spectral lines in the input.

Resolution is also affected by the electronics in the system. Since each filter analyzing the interferometer output has a finite bandwidth around its center frequency, its output contains contributions from all interferogram frequencies in its bandwidth.

This effect can be expressed quantitatively by considering the response of a bandpass filter represented by a frequency response function, Y (jω), to a complex periodic waveform represented by the integrated Fourier series coefficients above. That is, the combined effect of the interferometer and filter can be found by considering the harmonic components of the interferometer output as the filter's input. The filter-output equation, without further mathematical development, is shown immediately above.

This combined-effect equation, which represents a mathematical model of the system, was used in the computer simulation mentioned earlier to determine the identification logic. The simulation program took into account the effects of the infrared source's emission spectrum, the reflection and transmission spectra of the optics, and the interferometer and filter response functions.

A given computer run yielded the response of each filter channel to the absorption spectrum of a specified substance. Using experimental data on the spectral characteristics of the system components and published data on the spectral properties of various contaminants and interferents, the system response to each substance was determined.

Circuit design

Designer's casebook

Synchronizing a camera with a flash tube

By Robert C. Wenz
Alpine Geophysical Associates Inc., Norwood, N.J.

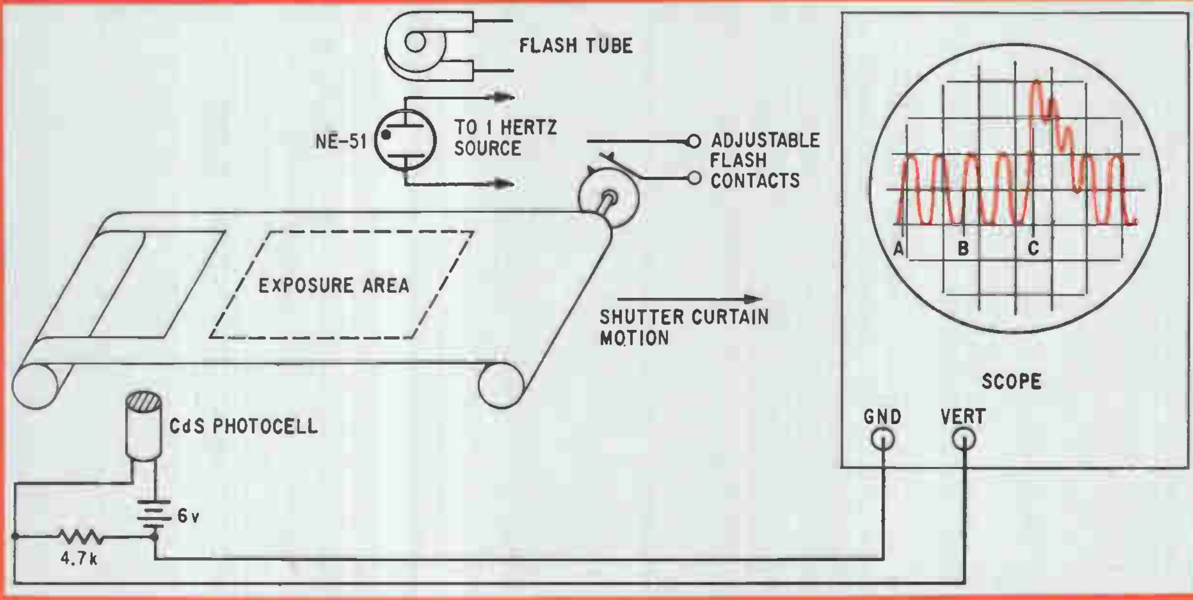
During the manufacture of underwater cameras the cam-actuated contacts for the flash unit must be synchronized with the shutter. With a 1/50-second focal-plane shutter, the entire frame is open for only 2 or 3 milliseconds. It's during this short interval that a flash must be triggered to ensure that the entire frame is exposed.

A simple, low-cost photoconductive cell can be used to adjust the synchronization. Cadmium selenide types are satisfactory and require no further amplification.

A neon lamp such as the NE-51H is placed in front of the shutter and supplied with a 1-kilohertz voltage source. The photocell is placed inside the camera behind the leading edge of the shutter curtain, with all ambient light excluded. A 6-volt d-c supply is used with a 4.7-kilohm load resistor in series with the cell. Finally, an oscilloscope with a triggered sweep is connected across the load resistance so the firing point can be determined.

As the shutter is released, the oscilloscope will display the series of timing pulses produced by the exposure of the photocell to the neon lamp for the duration of the shutter opening. Since the lamp is excited by a frequency of 1 khz, each pulse represents 1 msec. The flash unit is placed in front of the shutter so some of its light will also enter the camera. As the shutter is tripped, the series of pulses are displaced vertically on the scope at the instant the flash is detected. The exact time of the flash in relation to the shutter opening is determined by counting the pulses up to the point of displacement. Measurement accuracy can be increased by simply raising the frequency of the exciting voltage to the neon lamp.

One of the advantages of this system is that the measurement is independent of the characteristics of all components, including the time base of the scope.



In sync. Cam actuated switch for a strobe light is adjusted by counting pulses on an oscilloscope. The neon lamp is excited by a 1-kilohertz source and thus the scope displays 1-millisecond pulses. When the strobe is triggered, the pulses are displaced and the exact firing point can be determined.

High-current switch is driven by an IC

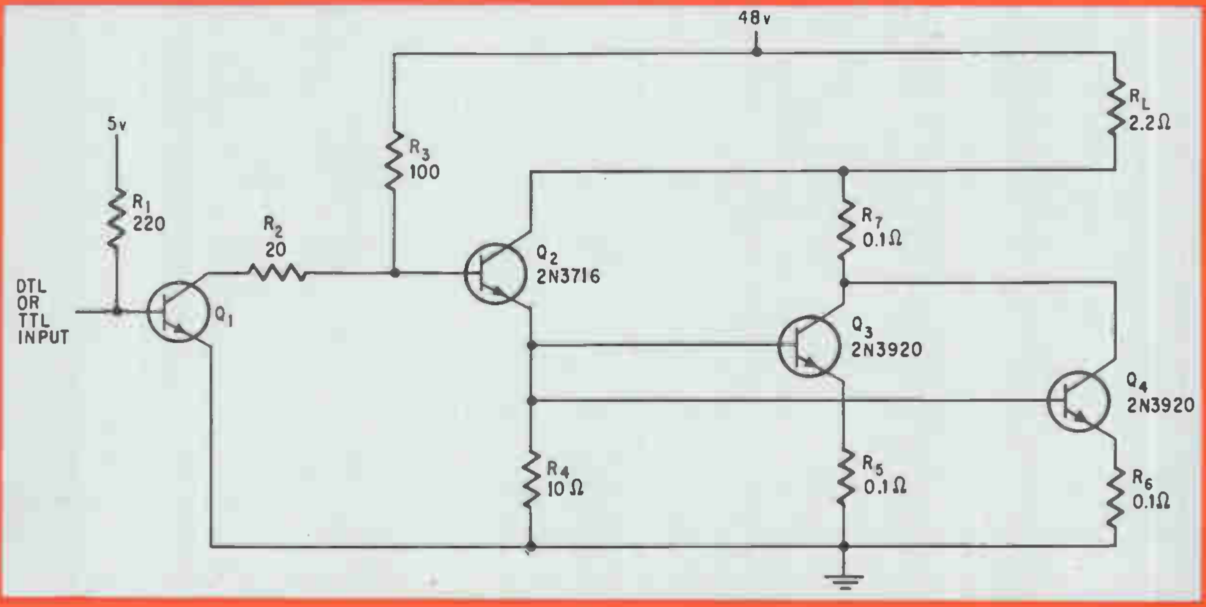
By Lynn S. Bell

Burr-Brown Research Corp., Tucson, Ariz.

A complementary compound switch, operated by a buffer transistor, interfaces current loads as high as 20 amps with conventional digital integrated-circuit logic elements.

Resistor R_1 provides the base drive required to saturate the buffer transistor, Q_1, when the input logic level is high. R_2 sets enough Q_2 base current to turn on Q_3. Transistors Q_3 and Q_4 saturate because of the current through R_7, thus minimizing the circuit's power dissipation.

Turn-off switching losses are reduced by supplying reverse base current to Q_2, Q_3, and Q_4 by means of the voltage drop across R_3, R_4, R_5, R_6, and the load. If fast turn-off isn't required, R_5 and R_6 can be eliminated, further reducing dissipation. If this is done, Q_3 and Q_4 must be matched to ensure that the load current is properly shared between them.



Digital control. Integrated circuits can be interfaced with high-power loads with the assistance of this switch. When a logic signal is applied to the base of Q_1, it saturates turning on Q_2. Q_2 then turns on Q_3 and Q_4 which are each capable of carrying 10 amperes.

Differential amplifier uses two IC's

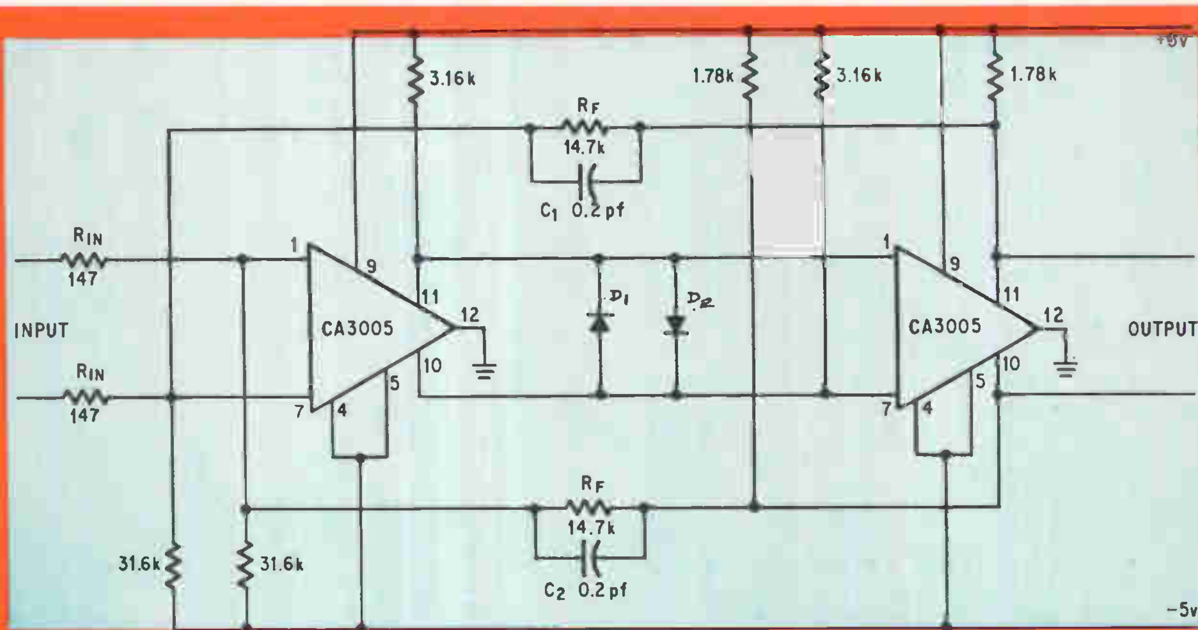
By C.J. Ulrick

Collins Radio Co., Cedar Rapids, Iowa

Monolithic r-f amplifiers are often useful for functions other than those intended by their designer. The circuit shown, for example, uses two such r-f amplifiers as a stable and reliable wideband differential amplifier. The gain is set by a resistor ratio, as in an operational amplifier; in the circuit shown, the gain is R_F/R_{IN}—in this case, 100. The gain can be varied by changing R_{IN}.

The rolloff capacitors, C_1 and C_2, may be needed to hold the bandwidth down if there isn't enough inherent capacitance in the resistors used for R_F. The capacitors must be chosen so that the gain is less than unity at the frequency where the amplifier's phase shift is 180°, or the amplifier will oscillate.

Clamp diodes D_1 and D_2 are required when the



Pair. Two RCA CA 3005 r-f amplifiers combine to form a wideband differential amplifier. The gain is controlled by the ratio of R_F/R_{IN}. Capacitors C_1 and C_2 aren't needed if the two R_F resistors have enough inherent capacitance.

amplifier will be driven into overload by large differential inputs. The diodes cause the output to clip symmetrically and ensure fast recovery.

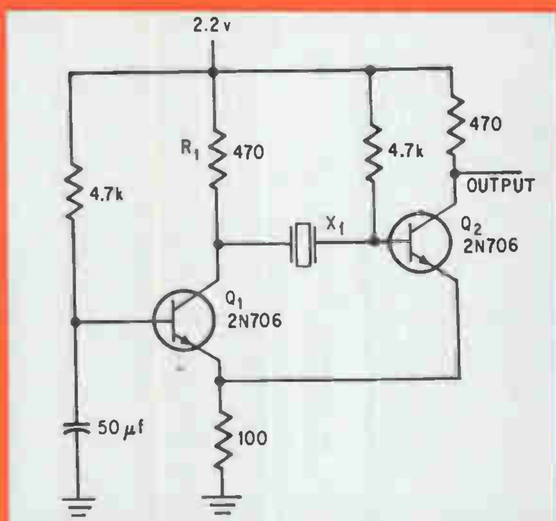
The bias and load resistors are not critical, but they should be 1% units so that the gain will stabilize at the desired value. For the values shown, the amplifier has a bandwidth of 20 megahertz and a delay time of 20 nanoseconds.

Crystal gives precision to a stable multivibrator

By Gordon W. Harrison

Randwick, Australia

A **crystal-controlled** squarewave oscillator was needed to drive a chain of synchronized divide by 10 multivibrator stages for use in calibrating the time bases of precision oscilloscopes. An emitter-coupled multivibrator using a crystal instead of a timing capacitor makes an excellent pulse generator. The circuit operates like any conventional multivibrator, except that the output of Q_2 is used to excite the crystal instead of charging a capacitor. Because of this, the circuit is forced to oscillate at the crystal frequency and is thus more accurate.



Crystal swap. Crystal replaces a capacitor in an emitter-coupled multivibrator to form a highly-accurate pulse generator.

Current limiter improves power supply

By Jan K. Studebaker

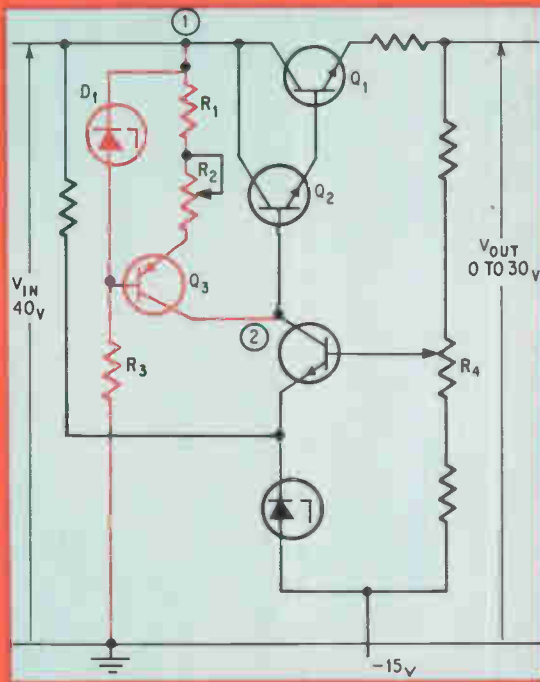
Los Alamos Scientific Laboratory, Los Alamos, N.M.

Simple additions to a variable transistor-regulated power supply results in better regulation, less ripple, and complete overload and short-circuit protection, including a variable current limit.

The added components, shown in red, replace a resistor that would normally be connected between points 1 and 2. The voltage between points 1 and 2 varies with the power supply's output voltage—as the output decreases, there is a higher potential difference between 1 and 2 and thus more current flows through Q_1. If the power-supply load is a high resistance, very little current flows through Q_1. But if the load resistance is lowered—by a short-circuit for example—the current increases, causing Q_1 to draw too much current. If the resistance between points 1 and 2 were higher, the overconduction of Q_1 could be eliminated, but the power supply would no longer regulate properly.

The substitution of a current source between points 1 and 2 permits the power supply to regulate over a wide range and restricts the short-circuit current to a value determined by the current source and the equivalent beta of Q_1 and Q_2.

In operation, R_1 functions as a maximum current limit control. The higher the resistance in the emitter circuit of Q_3, the lower the current from the current source. The variable high-resistance potentiometer R_2, in series with R_1, allows the maximum current limit of the supply to be lowered, from the value preset by R_1 to any smaller value. R_3 should be large enough to prevent burn-out of D_1, and small enough to ensure that the current through D_1 is at least 20 times the base current of Q_3.



Preregulator. Replacing a resistor with the components shown in red makes for better regulation and gives short circuit protection.

Zener triggers a-c alarm circuit

By Willard L. Fadner

Mankato State College, Mankato, Minn.

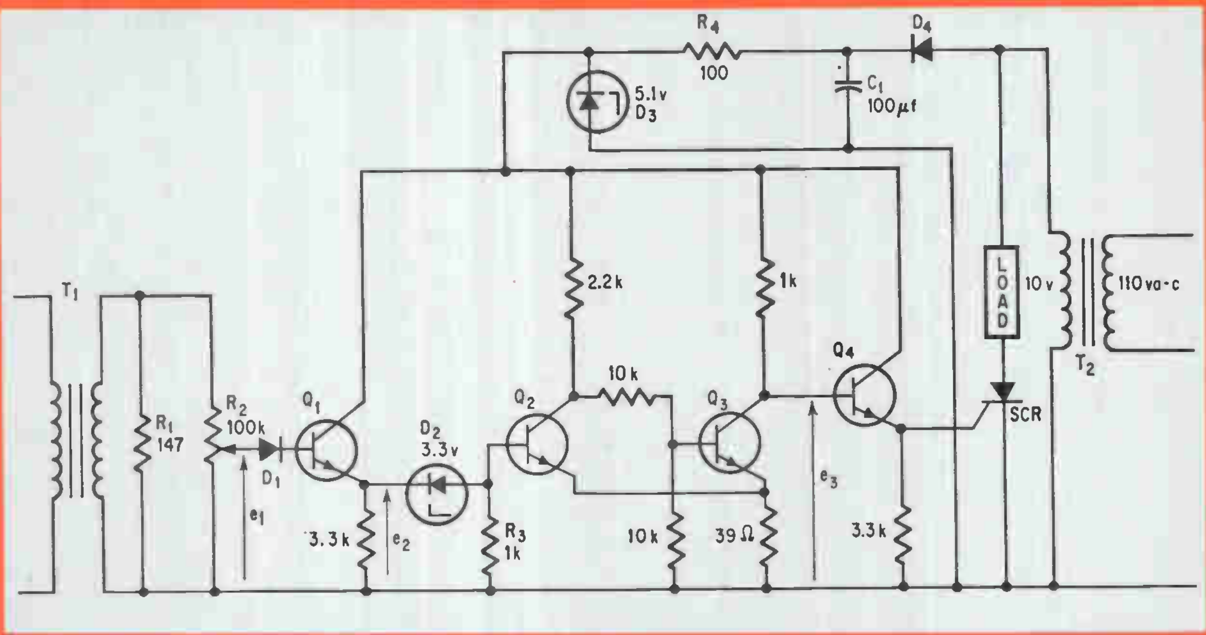
A zener diode can fire and turn off an alarm circuit without backlash. And because of the zener's temperature stability, the firing point is constant over a wide temperature range.

A current of up to 40 amperes flowing through the primary of T_1 produces a voltage drop across R_1. A portion of this voltage is picked off by R_2, which sets the firing point of the alarm, and is rectified and fed to the emitter follower, Q_1. This stage is needed to limit the current through R_2 and D_1 and thus limit the current that D_2 draws.

If e_2 is greater than the zener voltage—3.3 volts here—the Schmitt trigger composed of Q_2 and Q_3 is fired. As a result, e_3 rises abruptly to the power-supply level, causing Q_4 to conduct and triggering the SCR. The load, in this case an alarm buzzer, is fired once every half cycle. Q_4 is used to match the impedance between the SCR and Q_3.

R_3 is needed to prevent thermal runaway of Q_2, but it's large enough to draw very little current through D_2, D_3, D_4, R_4, and C_1 form the circuit's power supply. For proper operation, the secondary of T_2 must be in phase with e_1.

The circuit can also be used for a d-c alarm



Alternating sound. Alarm circuit can be set to trigger at a precise point because the firing is controlled by a zener diode. The zener, D_2, fires a Schmitt trigger that turns on the SCR. Depending upon the type of transformer used for T_1, up to 40 amps can initiate operation.

by eliminating T_1 and D_1. And part of the circuit—all components except T_1, R_1, R_2, D_1, and the SCR—can replace the Schmitt trigger in a high-frequency, pulse-shaping circuit.

Capacitor slows down stabilized power supply

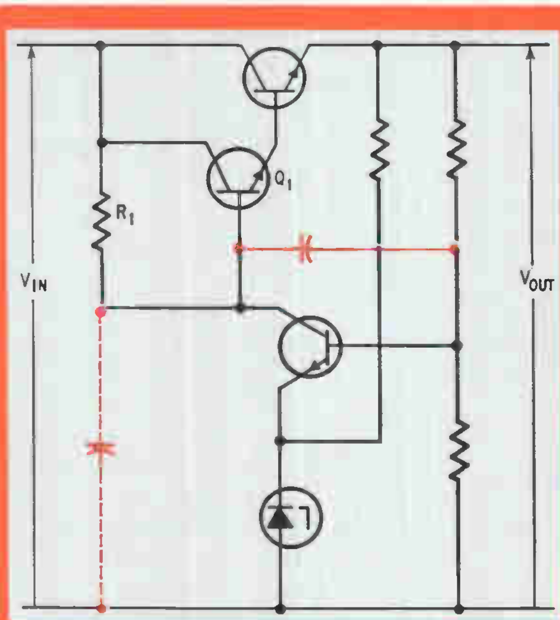
By A.G. Ogilvie

Holstebro, Denmark

It's often desirable to turn on a high-voltage power supply slowly. For example, if the full supply voltage is suddenly applied to a hi-fi amplifier, a loud pop is heard when the output capacitor charges up and the speaker may be damaged. With the addition of a capacitor, the series regulator circuit can be modified to turn on slowly.

In a basic series regulator, the voltage at the base of Q_1 rises exponentially as C charges through R; hence the output voltage gradually increases. To obtain a rise time of 3 seconds, for example, a 400-microfarad capacitor is required.

The same rise time can be obtained by connecting the capacitor in the manner indicated by the solid red line. Since the effective capacitance is $(h_{fe} + 1)C$, a much smaller capacitor can be used.



Users' choice. Capacitor can be connected as shown by dotted or solid lines. The latter offers longer delays for smaller capacitance.

Plated wire: a long shot that's paying off

By George A. Fedde

Univac division, Sperry Rand Corp., Blue Bell, Pa.

Eighteen months ago, plated wire was described as "Univac's bet to replace toroidal ferrite cores." Well, Univac is still in the game, which now has many more players than it did then. The division has met its cost-performance goals and is reasonably confident in predicting major improvements.

Production of plated-wire memories is expanding at about six times as fast a rate as the over-all production of random-access memories in the U.S. This is partly due to the fact that the base rate is very small, but it also indicates that significant progress has been made overcoming production problems. Current annual output of plated wire is about 2.5% of the estimated total for all types of random-access memory this year, and most of this production is going on at Univac for the division's 9000 series computers.

By and large, plated-wire memories are being used in new products requiring higher speeds and lower costs than ferrite technology can provide. For example, the Univac 9000 series computers wouldn't operate at both the speed and cost that they do if they had ferrite-core memories. Plated wires aren't replacing ferrite-core memories, nor are they expected to replace them, in the sense of production changeovers. They're being applied in areas that core arrays haven't been able to penetrate.

But an evolutionary replacement of ferrite cores in the main memories of new computers is just starting. This period of profitable coexistence is expected to last at least through 1972, at which time plated-wire units may account for 10% to 20% of the production of random-access memories production in the U.S.

Bandwagon

Univac's decision to develop and produce plated-wire memories has been followed recently by similar decisions at other firms. Their present substantial efforts, added to Univac's, are moving plated-wire technology at an accelerating pace.

> This is the second installment in a series of articles on memory technology. The first installment, which included articles on ferrite core memories and planar thin films, appeared in the October 28 issue of Electronics. —W.B.R.

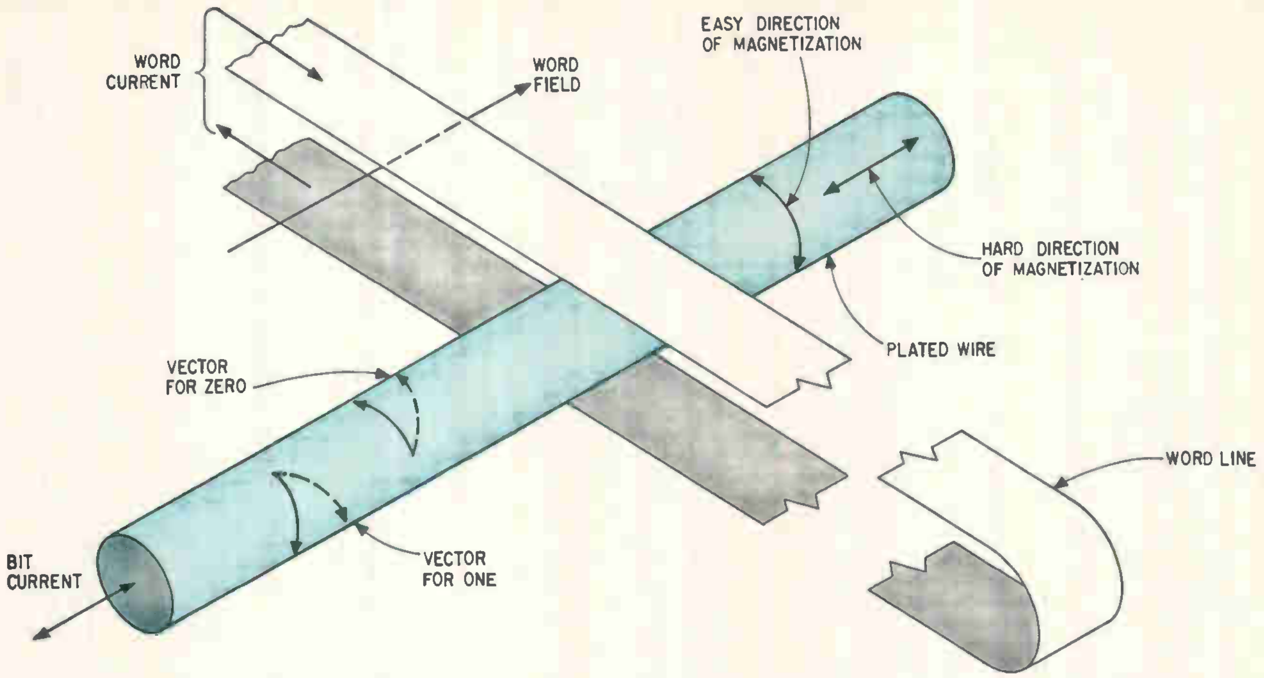
For example, Honeywell Inc. is now building plated-wire memory stacks for Government-funded programs [see cover photo] and may soon offer them commercially. Toko Inc. of Japan and its licensee, the Librascope Group of Singer-General Precision Inc., also offer plated-wire memories and stacks [see p. 131]. The National Cash Register Co. has been producing plated wire with somewhat different magnetic characteristics for some time [see p. 128], and the volume may soon increase substantially in the wake of the company's recent announcements of new equipment using the wire.

Other companies working on various aspects of the technology include the Electronics division of the Lockheed Aircraft Corp.; Electronic Memories Inc.; RCA; the Autonetics division of the North American Rockwell Corp.; the Stromberg-Carlson Corp., a subsidiary of the General Dynamics Corp.; the Indiana General Corp., the Ferroxcube Corp. of America; Philips' Gloeilampenfabrieken; Plessey, Ltd.; the Nippon Telephone & Telegraph Public Corp.; Siemens A.G. and government-supported laboratories in France and Japan.

Definition

Plated wire is a specially cleaned and prepared beryllium-copper wire 5 mils in diameter that's electroplated with a layer of magnetic alloy about 30 microinches thick. The alloy is about 80% nickel and 20% iron, and, like most thin films, is magnetically anisotropic—it can be more easily magnetized in one direction than in another.

A current in the wire during the plating process



One-turn coil. A current in the word line tilts the vector magnetization from its rest position, shown in solid lines, toward the hard axis of magnetization, generating a pulse in the plated wire.

establishes the magnetic easy axis circumferentially around the wire. Thus a particular spot on the wire can be magnetized either clockwise or counterclockwise, corresponding to the 1's and 0's of binary data. The same current applied while the wire is heated in a reducing atmosphere at the end of the plating process anneals the wire and stabilizes the film so that it retains its magnetic properties indefinitely. Without this step the wire's characteristics would deteriorate too rapidly for practical application.

The closed flux path offers significant advantages over the open path that is characteristic of single planar thin-film elements. With an open flux path, the element would tend to demagnetize itself unless it were made of a material with high coercive force —particularly if it were small. But with the closed path, the film thickness is not dictated by considerations of self-demagnetization. With no gaps in the path, the minimum bit current is obtained for a given material and path length.

Twenty bits can be stored in each inch of the wire, which is plated, annealed, and tested in a continuous process, and then cut into segments a foot or two long for incorporation into a memory system.

The size and position of the bit storage cell is set by the interaction of the magnetic drive field generated by current in the word line, as shown above, with digit write current in the wire. Each word line forms a solenoid of a few turns around all the parallel wires in a memory module, or one turn around 160 wires in Univac's 9000 series.

The plated wires are inserted in "tunnels" 30 mils apart in a layer of plastic, and the word lines are on printed-circuit boards on both sides of the plastic. An unplated dummy wire is inserted in intermediate tunnels at intervals as a noise source to cancel the common-mode noise in the plated wire, and six unconnected plated wires at each edge of the array provide the same magnetic environment for the outermost connected wires as for wires in the center.

This storage element has a number of special characteristics that are particularly interesting when compared with those of conventional ferrite cores and planar thin films. Also, the single drive line in a plated-wire storage element is its own sense-digit line. Also, plated wire has an explicit output for a 0 readout. Cores ideally would have no output, but they always generate a little noise. Planar films have explicit 0 outputs, but in most versions, the signals for 1 and 0 are smaller than those in cylindrical films; the flux path of a single planar element is open, and that of two coupled planar elements has two air gaps in it. The one disadvantage of plated wire at the present state of the art is its relatively low bit density.

Nondestructive readout

But plated wire is capable of nondestructive readout, which isn't available with the mass-produced versions of the other two types of memories. This NDRO capability reduces the amount, and therefore the cost, of the peripheral electronic circuitry required by a two-dimensional memory, and permits an organization similar in some ways to the 2½-D ferrite core layout, which attains high speed at low cost even in small module sizes. Plated-wire memories are most economical when the word drive current has the same amplitude for reading nondestructively as for writing.

[The alert reader will note an apparent contradiction between this statement and Al Bates' contention on page 115 of the October 28 issue that NDRO is more expensive than DRO. But both authors are correct, given their companies' approaches. Burroughs would achieve NDRO by tickling the memory with a smaller current than is used for writing. This would require either separate circuits for reading and writing, or a more complex and expensive circuit capable of delivering two levels of current. Univac, on the other hand, uses equal word currents for reading and writing; the extra wallop to wipe out old data when new data is being written comes from the bit current. This means that new data can be written in only part of a word if necessary.]

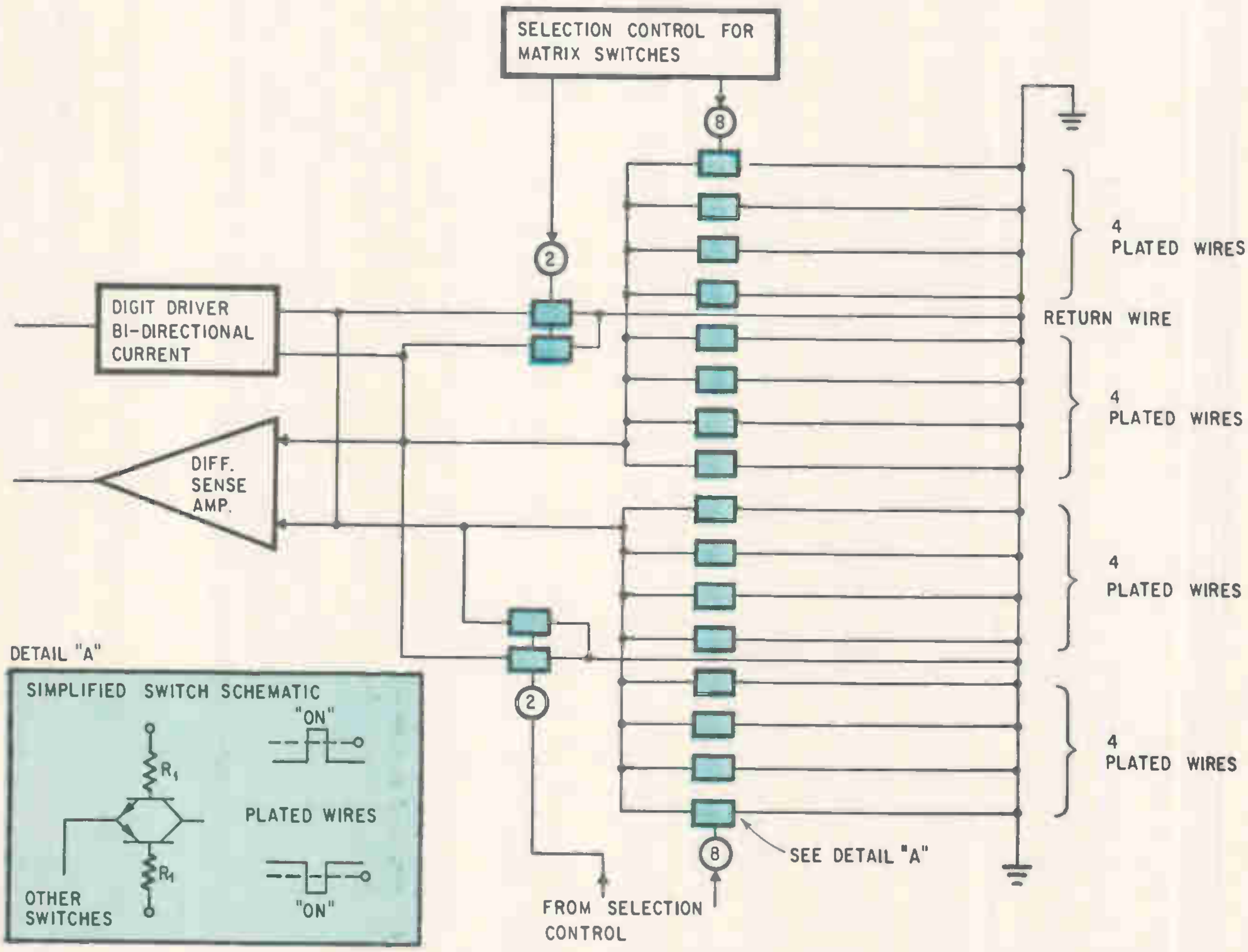
NDRO also reduces processing time in a computer by one-third, if, as is typically the case, the computer takes about four read cycles for each write cycle. With nondestructive readout, read instructions can be executed in half the time required by a ferrite-core or other DRO memory. Reading out a core clears, or destroys, the data in it, so a rewrite is necessary after every readout. And every write instruction must be preceded by a clearing out of the old data. Thus four reads and one write require 10 operations—five read-write pairs. The same instructions require only six operations in this NDRO memory: four reads and one clear-write pair.

Few rejects

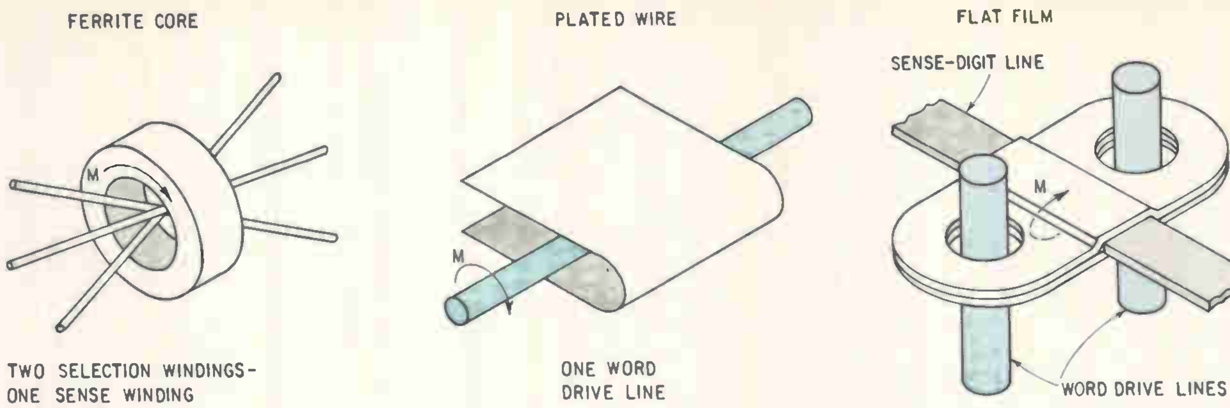
The production of plated wire at Univac has more than doubled over the past two years. Although this is partly due to an increase in the number of plating machines in the production line, it also reflects improvements in yield and quality control.

The individual bit yield is now 99.61%. With 270 bits on a single length of wire, the wire yield is about $(0.9961)^{270}$ or 0.445; actually it varies between 35% and 60%.

Thus an average of one bit in every 256 is bad at the output of the plating process, where testing occurs. Most are eliminated then and there by cutting the wire as soon as a defective bit is located. A few slip through, and a few wires are found to have bad spots later on. Nevertheless,



Sixteen to one. One sense amplifier or bit current driver is connected to one of 16 plated wires and to one of two dummy wires through a matrix of switches that permit high-speed operation at low cost.



Competitors. Plated wire, like planar thin films, switches 10 to 30 times as fast as ferrite cores with perhaps 1/15 the energy per element, and occupies about 1/100 the volume. Both plated wire and planar films have bipolar output signals, but the wire's output is about 10 times as large as the film's, and 1/4 as large as the core's.

only about one in 10,000 bits is defective after the memory plane is assembled.

It's become possible in the past year to measure and control the magnetostriction coefficient, a very important parameter, on the moving wire in the plating machine.

The relative concentrations of nickel and iron in the plating bath are now being controlled continuously. This maintains the optimum levels more closely than formerly, when discrete portions of each element were added as needed.

The electronic circuits and the memory planes containing the plated wires are undergoing evolutionary changes, most of them represent attempts to improve the signal-to-noise ratio. They include a new low-gain preamplifier stage, layout changes in the sense amplifier and signal strobe circuits, and improved low-level switching circuits.

These low-level switches connect one sense amplifier or bit current driver to one of 16 sense-bit circuits, as shown at left, and to one of the two unplated dummy wires associated with the 16 circuits. Write current passes along both wires. If a read operation is to ensue immediately, either both the plated wire being read and the selected dummy wire must have been used in writing, or neither of them. Otherwise, one of the wires would have a decaying voltage on it that the sense amplifier would see as noncommon-mode noise.

Through any given cycle, 15 switches are off to prevent the unselected sense lines from reducing the sense signal available to the amplifier or from diverting bit current from the selected plated wire during a writing.

Three goals

Current research and development programs are giving special attention to semiconductor circuits in three particular areas.

For one thing, if the plated-wire memory is to have a 100-nanosecond cycle time, it needs a new low-level switch. The present switch produces an offset voltage when it's on; a switch made with a field-effect transistor would have no offset voltage, but wouldn't operate at cycle times much below a microsecond. The switch must also be capable of carrying the 40-milliampere digit drive current. The right combination of fast turn-on and turn-off times with low capacitance, resistance, and cost is being sought.

All plated-wire memories require a magnetomotive force of 750 to 1200 ma-turns. When a one-turn word coil is used, the necessary current is easily carried by discrete or hybrid-chip semiconductors. To use monolithic integrated circuits in the drive circuits, the amount of current must be reduced to about 30% to 40% of its present value. Experiments indicate that low-reluctance paths for the word-line flux may make such a reduction possible. Such paths can be established through a magnetic keeper—a layer of magnetic material on top of the word lines.

Present plated-wire memories operating at 500-nsec cycle times have a diode in series with each word line, permitting a very economical transistor switch matrix to select the word lines. These matrixes would be feasible down to about 150 nsec. An alternative scheme, which would work at both faster and slower speeds, would replace the diode with a transistor whose base and emitter are connected to switch matrixes. This method would be especially attractive with monolithic integrated circuits, and would reduce the noise coupled into the sense lines by permitting the grounding of one end of the word lines.

Not that all research and development on the plated-wire element has come to a screeching halt. A whole new optimum set of magnetic parameters will probably have to be worked out for tomorrow's high-speed systems, covering such things as film thickness, coercive force, and anisotrophy field. Coercive force is the minimum magnetic-field intensity required to remove the residual magnetism from a saturated material; anistropy field is a measure of the magnetic field that saturates an anistropic film in its hard direction.

A thinner film would mean fewer milliampere-turns required in the word line, higher coercive force, and a smaller change of flux coupled to the sense line during readout. The output signal would be smaller, but that would be compensated for, at least in part, by the fact that a very fast memory requires a short rise time on all input and output signals, which maintains the peak amplitude and shortens the signal duration.

Some researchers are exploring the advantages of a thinner wire. For a given film thickness and bit length, a smaller diameter would reduce the flux coupled to the word drive line, without affecting the output signal's amplitude. Slimmer wires would also permit the word lines to be placed closer together, reducing the fringing of the drive field to adjacent bits and possibly leading to a higher bit density. But the thinner wire would be harder to handle than the present variety, and would tend to increase signal attenuation because of its higher resistance.

For all this, though, today's R&D efforts should produce memory systems in the not too distant future with module capacities of 100,000 to 1 million bits, cycle times of 100 nsec, and access times of 55 to 60 nsec—at a cost only slightly higher than that of present 500 to 600-nsec cycle memories. Plated wire is also attractive for very large memories of up to 100 million bits. These memories were estimated early in 1967 to cost significantly less than one cent per bit, but recent developments indicate that the estimate was quite conservative. However, until production capacity can catch up with demand, plated wires aren't likely to be used commercially in such sizes.

The next step will probably be the production of larger modules with cycle times down to about 200 nsec. The next three to five years should see the introduction of 100-nsec random-access memories with capacities up to a million bits, and submicrosecond memories in the 100-million-bit range.

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Memories VI

Rods look like wires, act like cores

By Donal A. Meier

National Cash Register Co., Hawthorne, Calif.

Cylindrical, thin magnetic films plated on wire with axially oriented storage states have replaced ferrite cores as the storage medium in high-performance digital computer memories at the National Cash Register Co. Unlike those used in other forms of plated-wire and thin-film memories, these films are isotropic and are made of a material with a high coercive force.

These two film characteristics give the wires, or rods, a number of advantages. Like cores, the films retain their magnetic characteristics indefinitely without annealing even though the flux path is open. This is true whether they are repeatedly switched back and forth or made to retain a fixed magnetic state for a long period of time.

Also, the plating process can be relatively speedy —much faster than the plating of wires with a circumferential anisotropic film. Finally, problems of magnetostriction, skew and dispersion, which plague designers of planar thin-film memories and plated wires with circumferential storage states, are avoided here. [An article on skew and dispersion problems will appear in a future issue of Electronics.]

Magnetic rods, which are organized in arrays like cores, have been used in many experimental and commercial memories. Of these, the most practical have been the two-dimensional organization in NCR's 315 RMC computer, the 2½-D form in the company's new Century series computers, and a structure with two rod elements per bit. This setup, analogous to the two-core-per-bit arrangement, was used in an experimental memory that achieved 100-nanosecond cycle times.

First of its kind

Rods were introduced in the 315 RMC (for rod memory computer) machine, the first commercial computer with an all-thin-film memory. The 315, brought out in 1965, is being phased out of production, having been superseded by the recently announced Century series.

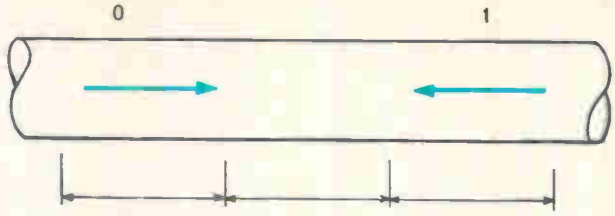
In the rods, the axially oriented magnetization reverses its direction by 180° when switching between binary 1's and 0's, as shown at right. The continuous plating, an alloy of 98% iron and 2% nickel, switches when subjected to a magnetizing force greater than 16 oersteds. [The corresponding energy is about 2×10^{-10} joule; compare this with the plated-wire figure of 1×10^{-10} joules.]

The rods used in the RMC processor are made from a continuous length of beryllium-copper wire 10 mils in diameter. This wire is passed at a speed of 15 feet per minute through a series of baths that deposit the plating material on it. When the wire emerges from the last bath it is immediately and continuously tested, helically wound with a copper ribbon, and cut into pieces seven inches long.

Fine wires wound on these lengths of wire establish the bit cells, typically 10 of them per linear inch of rod. The windings are interconnected between bit cells and between rods in a two-dimensional arrangement, as shown below. Word windings are machine-wound solenoids of 10 turns over a distance of 50 to 60 mils along the wire; digit-sense windings are continuous machine-wound helixes of about 95 turns along the entire 7-inch rod. The solenoid's intersection with the helix defines a storage cell. Yield for the whole 7-inch length has been greater than 85% during the four years in which this RMC memory has been in production.

New whiskers

The newer Century series computers contain rod memories of a different design suitable to semiautomatic fabrication in large batches without the yield problems usually associated with batch fabrication.

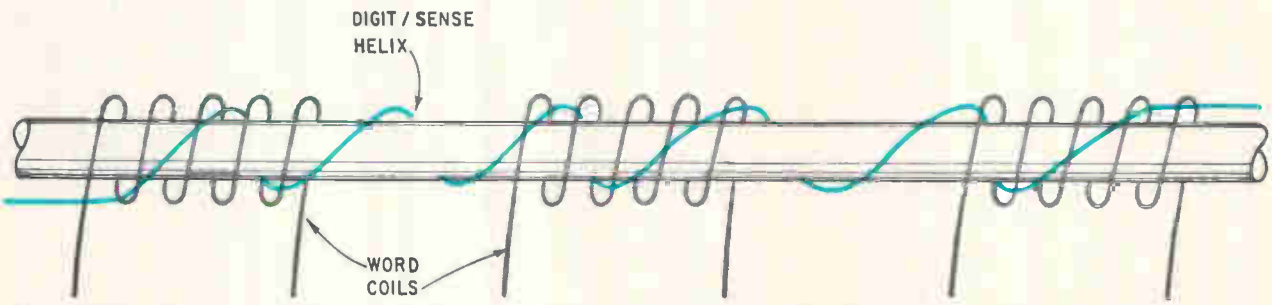


Reversal. Magnetized thin film on a rod is oriented parallel to the rod's axis, in opposite directions corresponding to binary 1's and 0's.

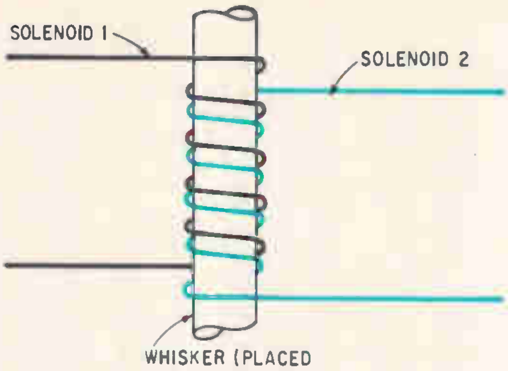
In the Century, the memory is assembled from modules of approximately 16,000 bytes. Each module contains 32 planes of 4,608 bits in a 64-by-72 array. Each bit is stored in a separate length of rod, or "whisker," about 1/10 inch long and 6.5 mils in diameter, with its own set of windings.

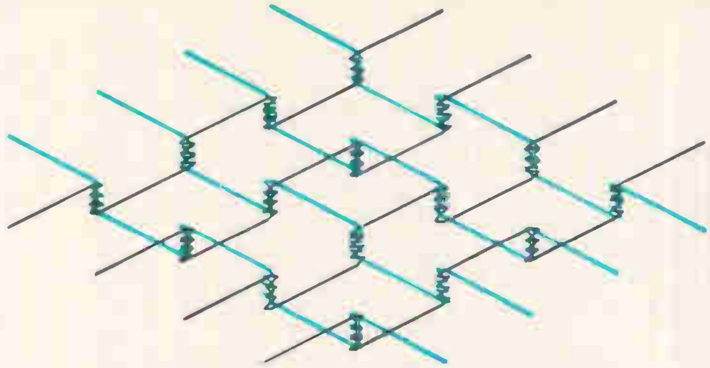
Whiskers are made in essentially the same way as rods except for the on-line cutting. Following a testing step primarily aimed at monitoring the plating process, the wire is coated with 0.2-mil layer of plastic to keep the iron from oxidizing. It is then baked and wound on a take-up spool. In a separate off-line process, the wire is tested again and cut mechanically into whiskers at a rate of 1,000 per minute.

The solenoid array in which the whiskers are mounted is made in a frame by a machine that winds interlinked 10-term solenoids in each of two perpendicular directions (page 130, top). A sheet of plastic is then vacuum-formed across one side of the array to establish a "bottom." The rods are automatically dropped into place in the interlinked solenoids, using a mask and an alternating magnetic field. The mask is placed over the solenoid array, an oversupply of whiskers is poured on it, and the whole is placed in the magnetic field. The field causes the whiskers to stand upright and dance about; when the array is tilted, the whiskers march across the surface and fall into the individual



Double helix. Two windings over a section of a seven-inch rod define a bit cell on the rod. One of the windings is continuous along the full length of the rod; the other is about 1/10 inch long and connects with coils on other rods.





Interlinked. Two solenoid windings are interlaced in a special machine that winds them both at the same time, in a pattern for the whole plane that resembles a chain link fence. One whisker fits in each solenoid (photo, right).

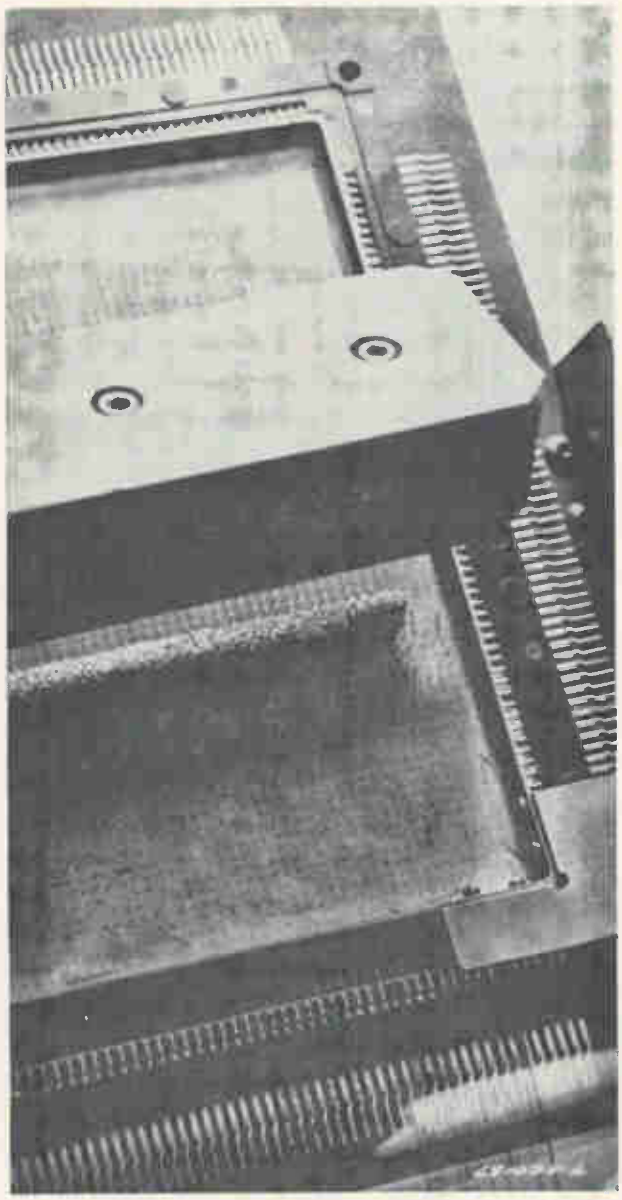
solenoids through holes in the mask, as shown at right. Surplus whiskers pile up at the edge of the array, and are lifted off with the mask. Another layer of plastic is formed over the top to encapsulate the array, which is then tested as a unit. If a bad whisker happens to find its way into the array, it can be removed individually and replaced by another without endangering the array in any way.

Familiar pattern

Modules made from this standard array are laid out in a two-wire, 2½-D organization for good performance at low cost. The interconnections and operation are essentially the same as those in the two-wire, 2½-D ferrite-core array. This causes the delta noise, induced in the sense winding by half the whiskers, to cancel that induced by the other half. As a result, superimposed oscilloscope traces of all 4,608 bits in a single plane are remarkably similar to the oscilloscope trace for a single bit.

Memory cycle time in the Century series is 800 nanoseconds. In the case of the experimental 2-D, two-element-per-bit experimental organization that attained a cycle time of 100 nsec, the rods were only partially switched—that is, only part of the film under each winding was axially magnetized. The part that was magnetized was nevertheless saturated. This is possible because, just as a core switches first around the hole and then in concentric rings outward, a rod switches first at its midpoint and then in both directions toward its ends.

The two elements for each bit must be electrically and magnetically identical, a requirement met by arranging the elements adjacent to one another on the same rod a few hundredths of an inch apart. The wiring is basically the same as in the 315 RMC memory, except that the roles of the digit and word lines are interchanged and two digit lines are selected for each bit instead of one. The two ele-



On the march. An alternating magnetic field set up under the large horizontal pole piece stands the whiskers on end and marches them across the plane. One whisker drops through each tiny hole into a pair of linked solenoids beneath the plane. Surplus whiskers accumulate at the edge of the plane and are lifted off with the mask.

ments store complementary bits; when writing, the noise from these bits, which doesn't decay until well into the subsequent read cycle, appears at the sense amplifier as common-mode noise, and is therefore rejected. Because the sense amplifier can recover quickly from this noisc, the memory can operate at high speed.

The experimental 100-nsec rod memory contained 10 bits per linear inch of rod, even with the doubled-up windings. With further research and development, strip lines could be substituted for the digit solenoids to produce a large-capacity, high-performance rod memory.

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Memories VII

Weaving wires for aerospace jobs

By Richard A. Flores

Librascope Group, Singer-General Precision Inc., Glendale, Calif.

Woven plated-wire memories have demonstrated their mechanical and electrical integrity when operated in a simulated aerospace environment. They dissipate very little power and potentially can be manufactured very economically.

The Librascope group of Singer-General Precision Inc. has since 1964 devoted a research and development program to devising woven-wire memories capable of nondestructive readout and producible at low cost. This effort has produced a line of NDRO memory products for use in severe aerospace and military environments. They're made from wide-tolerance plated wire by a weaving process that reduces the number of connections required by other manufacturing techniques.

Librascope's work is carried out under terms of a license from Toko Inc. The Japanese firm has continued developing the process for commercial applications, and recently announced arrangements for the use of the woven memories in a Japanese version of Univac's 9000 series computers [Electronics, Sept. 16, p. 236].

Warp and woof

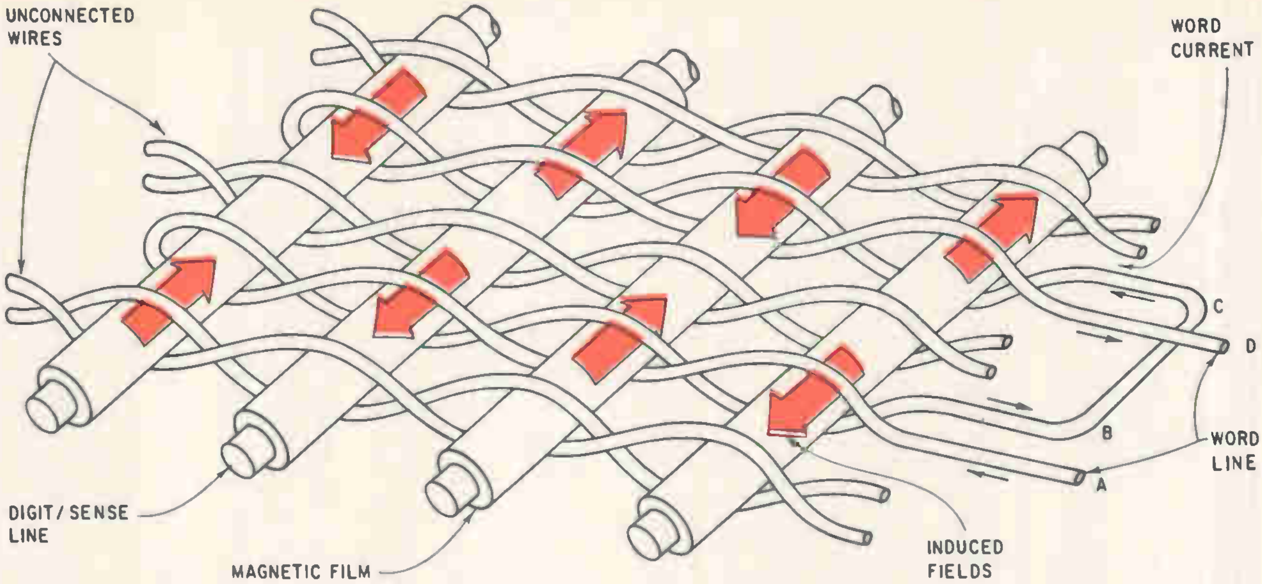
In the first step of the manufacturing operation, the wire is plated, tested, and cut to length. [This much of the process is basically similar to Univac's, described on page 124.] The wires are then inserted in tunnels in a mat woven on an automatic loom. These mats, typically 4 inches square, consist of straight wires 5 to 8 mils in diameter—what textile weavers call the woof—with smaller wires—the warp—woven across them in an over-and-under pattern. When the larger wires are pulled out of the mat, they leave tunnels into which the plated wires can be inserted. The mat can be woven directly on the plated wires, but at some risk of putting kinks in them that would affect their magnetic properties.

Wherever the smaller wire crosses the plated wire, it defines a bit cell on the plated wire. These smaller wires are spaced typically 40 to the inch along the plated wire, although their exact spacing depends on the intended application.

A particular advantage of the weaving technique is that it can produce rather complex multiturn coils that require lower word currents and less expensive electronics than single-turn coils, and dissipate less power.

For example, in the word-line pattern shown on page 132, an individual line weaves across the array of plated wires in an over-and-under fashion and returns in an under-and-over pattern. The result is that every plated wire has a current loop around it with exactly one turn, and the turns around adjacent wires are in opposite directions. That line can be the word line by itself if the application requires it, or it can be connected in series with other word lines to produce coils of as many turns as desired; the diagram shows a two-turn coil. Alterations in the weaving process produce different numbers of turns and different directional patterns in a practically infinite variety.

Two other important features of the weaving technique appear in the diagram. First, some of the warp wires are left unconnected to provide spacing within and between the word coils. Because of this, the field can be shaped for optimal operation in a



Woven plane. Word lines passing among plated wires in an over-and-under pattern make coils that can be interconnected to produce any of a wide variety of field patterns (color) in the plated wire.

specific application and for reduced interaction between coils.

Second, adjacent coils can have opposite magnetic polarity so that the magnetic fields are closed through them rather than between them. Thus, current entering a terminal A and passing over the first plated wire, returns under it to point B. But this is connected to C, from whence the current passes under the wire and returns over it to terminal D. The polarity reversal reduces the line's self-inductance, so that low-voltage constant-current drive circuits can be used. These circuits further cut electronic costs and power dissipation.

Besides the spacer wires and coils, the mat contains a magnetic keeper wire plated with permalloy in somewhat the same way as is the main plated wire. It increases the homogeneity of the drive field and reduces creep between bits—a characteristic of films that under certain conditions can destroy the data in a particular bit cell when the adjacent cell is repeatedly cycled. The keeper wire is essentially a low-reluctance path between word coils on a single word line, as at top right.

When adjacent word coils are opposite in polarity, these low-reluctance paths between them permit each coil to produce a larger field without disturbing the bits under adjacent coils. And the coils produce a sufficient field with word currents

Over the hurdles

The computer industry has been rife with rumors about Librascope's difficulties with the woven-wire memory. The company has indeed had problems, but it seems to have largely overcome them.

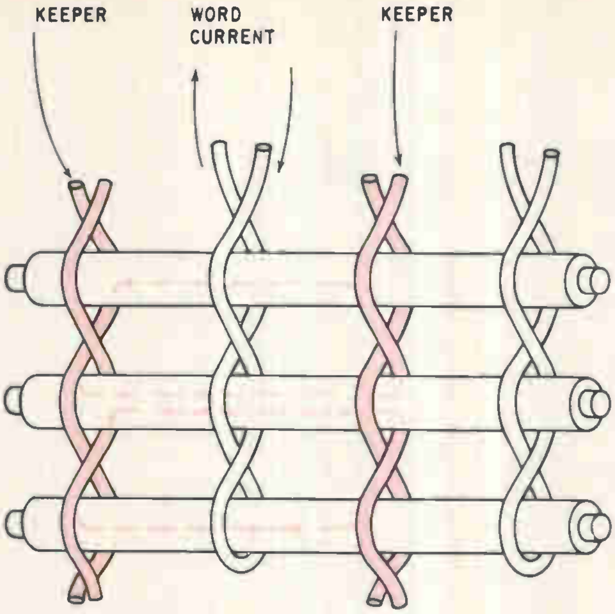
One of the biggest cropped up a year or so ago when Librascope built an 8,000-bit breadboard model for an aerospace customer. The breadboard worked well and Librascope was asked to build a larger version, but the customer's funds were curtailed. So, under a cooperative compromise, Librascope built two more stacks and the customer built the associated electronic circuitry. Unfortunately, these memories didn't turn out too well; the weaving technique still had some bugs in it, and the customer's electronics didn't mate properly to the stacks. But the customer had to accept the memories because both his money and time were running out.

Along with these woes, some of Librascope's key people chose that moment to seek greener pastures.

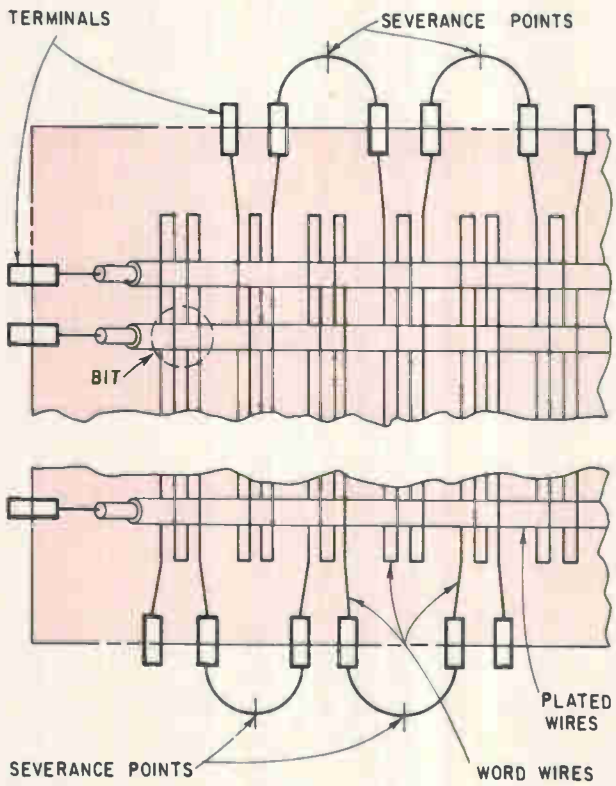
Nevertheless, development has continued; the company has set up a pilot production line and landed three contracts that could lead to substantial production rates later on. Based on the 64,000-bit module it announced last summer [Electronics, July 8, p. 176], Librascope can turn out perhaps 100 stacks a year with its present equipment and people. The company considers that module its basic building block; it is now concentrating on cost reductions.

Librascope's disk memories, made by the same division that handles woven wires, have been so successful that they've been rewarded with more R&D money than woven wire. But the latter isn't quite a poor relation. When the Singer Co. acquired Librascope's parent, General Precision, Inc., last spring, it took a hard look at the woven-wire operation and seems convinced of the technique's utility and potential market.

—Lawrence Curran, Wallace B. Riley



Keepers. Plated wires woven into the mat along with the word lines improve memory operation.



Continuous. A single wire woven into the mat can be cut afterward, simplifying interconnections.

that are reduced 25% by the use of a keeper. Likewise, output voltages are increased by a similar percentage because the field is homogeneous.

The effect of the keeper is localized—it does not load all the word coils, as a continuous ferrite keeper would. The latter is a sheet of magnetic material laid down over the mat or array of wires, also to provide a low-reluctance path; some experimenters have tried it.

The weaving operation takes place on a converted textile loom, which can weave any number of configurations and has two significant features:

- It can weave word line coils as one continuous strand with terminals at the ends of each coil. This minimizes the number of interconnections, thus reducing fabrication costs and increasing the reliability of the woven mats. In the most common pattern for a random-access plane, the wires are cut after weaving at points between word coils, as shown at bottom left.
- It has a Jacquard head, allowing individual control of each wire, and of the weave pattern, by either punched paper tape or punched cards. With this control, woven-wire mats can be fabricated with the data permanently and unalterably woven into the matrix, a capability unique to woven-wire technology. The loom controls the way a word coil intersects a digit line, thus producing special patterns automatically. The polarity of each bit location within a word coil is established when the weave goes over or under that particular location.

Weaving for read-only

For example, an adjacent pair of plated digit wires can be connected in series and segmented in 0's and 1's, depending on whether the word-coil pattern is over-and-under or under-and-over at a particular bit cell. If the word pulse current travels under the first digit wire and over the second, the bit stored will be a 1. If the converse is true, it will be a 0.

These permanently woven read-only memories provide nondestructive readout storage that cannot be altered and is unsurpassed for holding repetitive data such as tables, fixed programs, or reference information.

Using this basic technology, Librascope has demonstrated fully operational stacks at the shock, acceleration, and vibration levels called for by the appropriate military specifications.

A full memory system has been breadboarded and tested over a temperature range from −20° to +85° C. This system, weighing less than 4¼ pounds and displacing less than 40 cubic inches, stores 4,096 words of 20 bits each and dissipates 250 milliwatts of power when cycling at 100 kilohertz. Its standby dissipation is only 5 mw.

The cost advantage of woven-wire batch fabrication has yet to be demonstrated. However, fully automating the processes of wire fabrication and testing will reduce the basic costs of a woven plated-wire memory. The weaving process is inexpensive. Soldering mat connections to the printed-circuit board that supports it could be done quite rapidly, and inserting the plated wire into the woven mat and connecting the wire to the circuit board could be greatly speeded by inexpensive tooling. It therefore appears quite feasible to build a low-cost aerospace memory on a production-line basis.

Shortcuts in tv camera design make for big cuts in price

Elimination of some controls and expensive trimming circuits results in a vidicon color unit for studio use that weighs but 65 pounds and costs 75% less than the average broadcast camera

By Frederick J. Haines
International Video Corp., Mountain View, Calif.

"The first thing broadcasters ask us about our newly acquired IVC color camera is 'what's missing?'," says Ron Renaud, chief engineer at WWJ-TV, NBC's associate station in Detroit. The reason, he explains, is the camera's low price—about one-quarter the cost of other studio cameras—and the mistaken belief that vidicon tubes can't be used to produce good color pictures at normal studio lighting levels.

Sharp contrast

Color tv pictures generally lack the sharpness of the black-and-white variety. They have a tendency to become soft, and the colors reproduced aren't always of the right shade. Studio engineers attribute this problem at least partly to the wide use of Plumbicon tubes, which have low resolution and limited spectral response. This has caused camera designers to make compromises that result in color errors.

A new technique called image enhancement has been introduced within the past year to correct the problem. The method essentially improves resolution and color fidelity by rearranging the elements of a color picture.

Developed at CBS Laboratories, the image-enhancement circuit takes a single line of video and compares it, element by element, with the lines preceding and following it. Any differences are added to the original signal in the proper phase to reinforce the difference between the lines compared, thereby enhancing the picture outlines and contrast.

John D. Drummond

Admittedly, a 65-pound, self-contained vidicon camera that requires only a power cord for full operation and a single coaxial cable to carry the output NTSC-encoded color signal can't have all the niceties of the higher-priced 130-to-400-pound units equipped with image orthicon or Plumbicon tubes.

But not a single essential performance feature has been sacrificed. We've simply taken advantage of the high stability of solid state circuitry and eliminated a number of costly and sophisticated trimming circuits. And we've reduced the number of controls on the remote control panel to about one-third the normal complement. Controls that have been dropped include SKEW, normally used to eliminate registration distortion; SHADING, used to compensate for color shifts; and GAMMA, for trimming gray scale response.

A major cost reduction has been achieved by eliminating the camera control unit, which normally houses the video processing circuitry and power supply. With these circuits built right into the camera unit, the number of conductors linking the camera to the outside world has been reduced from 80 to 50.

Innovations

Because the vidicon target drive voltage had to be reduced considerably—typically to 15 volts from 40 to 60 volts—to reduce the tube's inherent lag, or persistence characteristics, it was necessary to design special low-noise, high-gain preamplifiers.

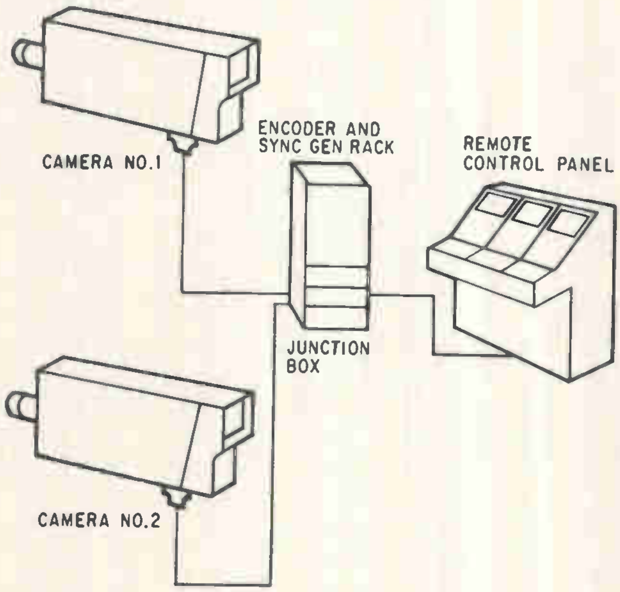
And a number of important innovations have been made in the optical system to allow more light to reach the image tubes. Standard silver-surfaced reflecting mirrors have been replaced by

Self-contained. Equipped with three separate mesh vidicons, the camera includes 6:1 zoom lens, external color encoder, studio junction box, and remote controls.

dichroic mirrors with a thin-film coating. The chemical formula for this coating was calculated with the aid of a computer, which factored in the dispersion of the materials. By using expensive precision tooling to achieve extremely close manufacturing tolerances, it was possible to set the mirrors in slots in the base casting and then seal them in place permanently with epoxy, eliminating any need for adjustments.

The net result is a camera that can be used with the CBS image enhancer—standard gear in most tv studios—to produce quality color pictures indistinguishable from those turned out by the more expensive studio cameras. And the price of the new camera is only $18,500, compared with an average of about $75,000 for most studio units.

Despite its compactness, the International Video Corp.'s camera is quite versatile. For closed-circuit tv, it can produce an NTSC-type picture for display on a monitor or for recording on a video tape recorder. It's also compatible with standard studio cabling, junction boxes, remote-control panels, external encoders, and master sync generators, as shown at left. All remote controls are on its control panel, including master gain, master pedestal, centering trims, and red-green-blue targets and pedestals.

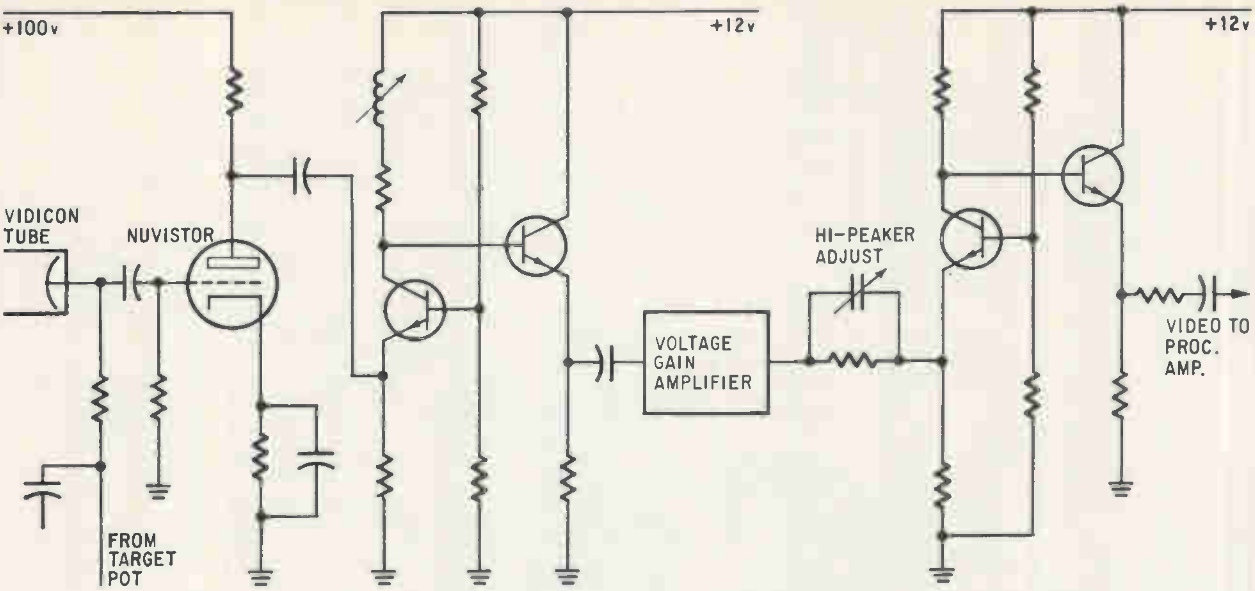


Hookup. In a broadcast application, the cameras are linked to standard studio equipment without interfaces.

Getting a boost

Special low-noise preamplifiers are needed to boost the low-level red, green, and blue signals from the vidicons to a usable level—typically 200 to 300 millivolts.

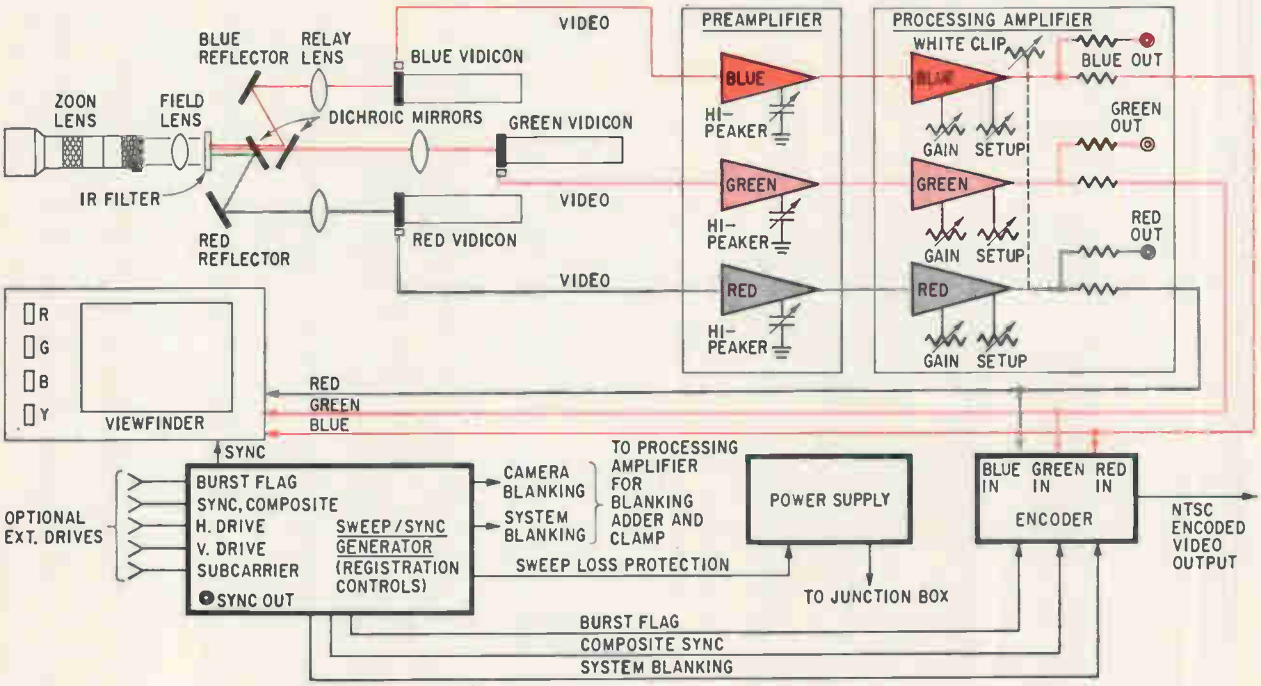
The over-all signal-to-noise ratio of the camera is effectively determined by the signal-to-noise



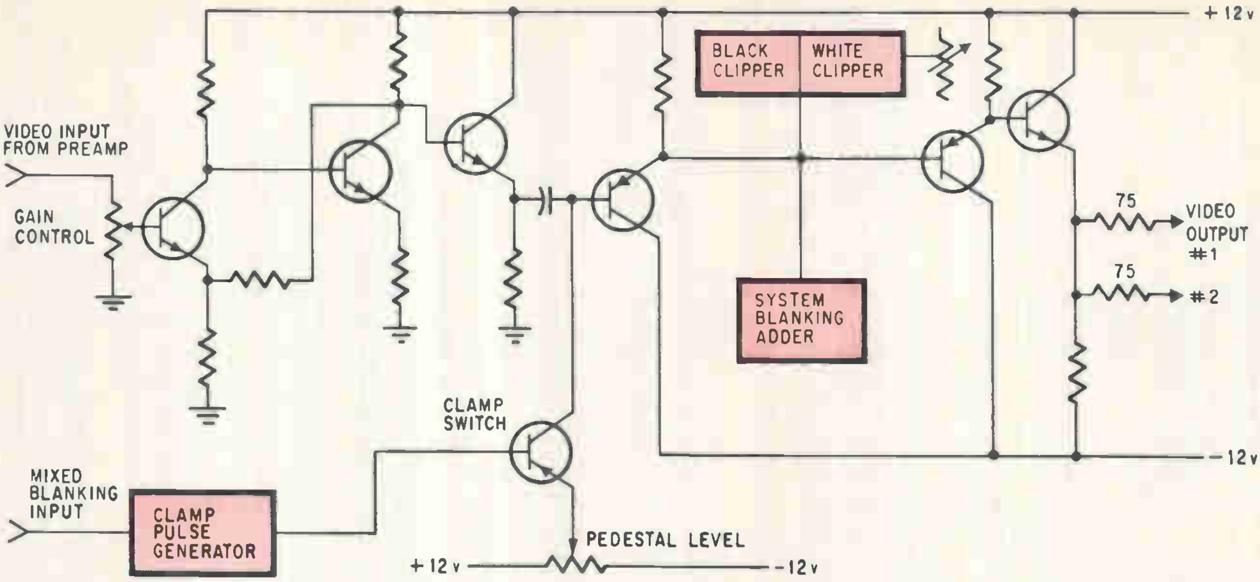
Video preamplifier. Low-level signals from the red, green, and blue vidicon tubes are boosted to desired levels by the preamplifiers, which feature a hybrid cascode input stage for low signal-to-noise ratio.

ratio of the pickup tubes' preamplifiers. Since transistors act as noise generators at lower frequencies, a hybrid Nuvistor-transistor stage is used at the amplifier input, as shown in the simplified schematic diagram above. The cascoded input stage is emitter-coupled to a voltage gain amplifier followed by a common-base amplifier and another emitter-follower stage. The output goes to the video processing amplifier. The hi-peaker capacitor allows trimming of the amplifier frequency response to correct for the high-frequency rolloff produced by stray capacitance, which shunts the high output impedance of the vidicon tube.

The processing amplifiers provide video gain control for the respective channels, as well as a line-by-line clamping to restore low-frequency response. They also add system blanking and remove voltage spikes and other irregularities that might be introduced into the video signal by the image pickup tubes.



Data flow. The information from the vidicon tubes is fed to red, green, and blue inputs on the internal encoder circuit board. The encoder combines these signals to produce an NTSC-compatible video.



Processing amplifier. In addition to gain and pedestal control, this circuit restores low-frequency response, adds the system blanking, and provides black and white video clipping to limit overshoot of the video signal peaks.

As the schematic shown above indicates, the amplifier also includes circuits to limit peak video signals to preset black and white levels. The video output is either applied to the encoder and the viewfinder switching matrix, or fed to an external studio encoder.

Simplified encoder

The encoder accepts separate outputs from the processing amplifiers' red, green, and blue channels and combines them into a compatible NTSC color signal. As the most complex circuit in the camera system, it represents a major cost factor.

Since a decision was made at the outset of development to eliminate the camera control unit, it was necessary to devise an encoder circuit small enough to fit into the camera package. The result is an encoder mounted on a double-sided printed-circuit board measuring 6 by 7 inches.

In a standard broadcast encoder, the "I" signal channel, which handles colors ranging from cyan to orange, has a 1.5-megahertz bandpass; the "Q" channel, which produces colors from yellowish green to purple, is given only a 0.5-Mhz bandpass. Because of its wider bandpass, the I signal has a shorter delay than the Q, and a delay line has to be inserted in the I channel to provide time compensation. The problem with the delay line is that it introduces a phase difference that must be canceled out by additional circuitry.

The IVC encoder circuit doesn't operate that way, however. Instead of working with I and Q signals, it matrixes the red, green, and blue signals into R — Y and B — Y chrominance signals. This scheme greatly simplifies the circuit since the bandpass of both channels can be identical, eliminating any need for a delay line and compensating circuits. In the new process, the burst-flag signal is added to the B — Y signal before band limiting is effected; hence, the R — Y and B — Y signals are in phase and no special burst-flag delay or color-burst phase control is required.

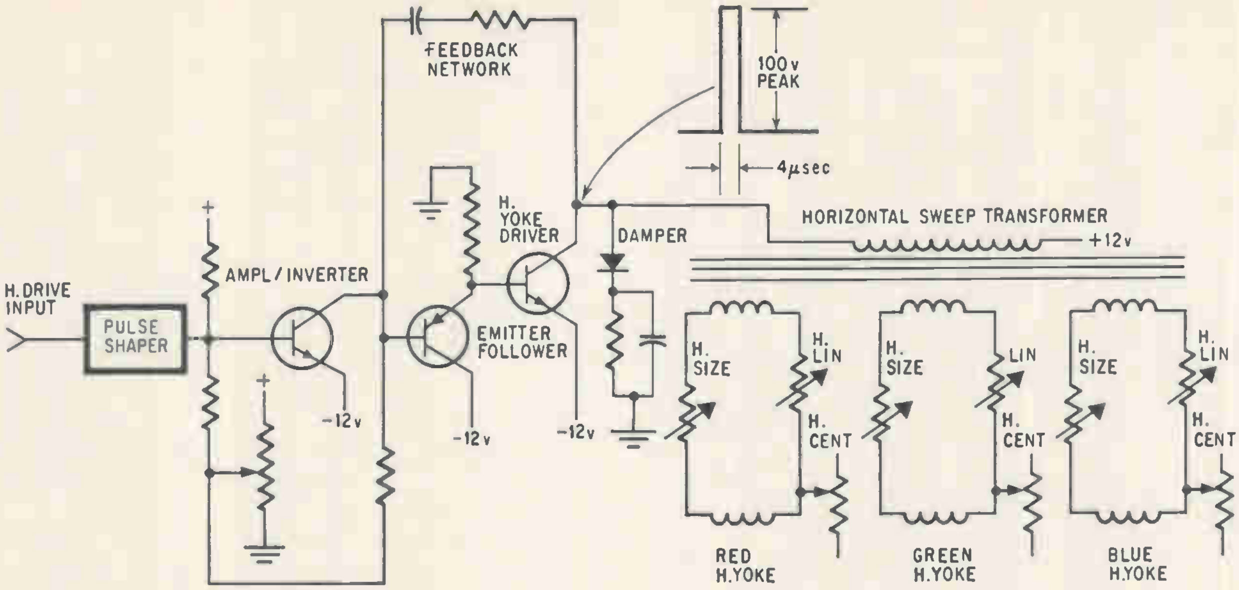
In operation, the R — Y and B — Y signals directly modulate the subcarrier in a quadrature relationship—the phase of the subcarrier being modulated by the B — Y signal lags behind the R — Y-modulated subcarrier by 90°. The color subcarrier is essentially invisible even at close viewing distances, and therefore needn't be locked to the scanning frequencies. This feature permits the use of a sync generator independent of the color subcarrier, which is produced by a free-running crystal oscillator in the encoder. However, the encoder can also accept an external color subcarrier and can therefore encode a signal with locked color if that is desired.

Surprisingly, the greatly simplified encoder circuitry doesn't in any way cause a degradation of the reproduced color information since all available viewing devices, including studio monitors and home receivers, employs R — Y, B — Y, or equivalent bandwidth decoders, and the higher potential resolution promised by the I-Q system is never fully achieved in practice.

Luminance signal

To derive the Y (luminance) signal, the red, green, and blue information is added or matrixed in proper proportions, and the combined signal is amplified and inverted.

The luminance signal is processed in an aperture-correction network that enhances the higher-frequency information attenuated by the camera pickup components. However, the aperture correction may be turned off, if desired. After aperture correction, the luminance is band-limited, delayed,



Horizontal sweep. Multiple secondary transformer windings effectively isolate all d-c components, permitting horizontal centering of each channel without interaction. Linearity and size controls are also shown.

and combined in correct time and phase with the chroma signal to create the composite color video signal. Sync is then added to this signal at the output of the encoder.

A separate optical channel has been provided so that green can be used as luminance, but the two chrominance signals are still created as previously described and the composite color video output signal is entirely compatible with the NTSC signal. Use of the optional "luminance-from-green" circuit provides a measure of horizontal image enhancement, though it does introduce slight errors in color saturation.

An optional self-contained EIA synchronizing generator gives frequency interlace and equalizing pulses during the vertical blanking interval. The time base jitter of this sync generator is in the order of 8 to 10 nanoseconds, against typical figures of 30 to 80 nanoseconds for other systems. This level is achieved largely through a countdown originating from 14.32 Mhz, rather than the usual 3.58 Mhz.

For use in closed-circuit tv, where NTSC standards need not be followed, the camera is provided with a built-in, 2:1 interlace sync generator that produces all the pulses needed for sweep, blanking, color burst, and synchronization; these are added to the encoder video signal. A 31.47-kilohertz crystal is used to drive a binary countdown circuit that produces the 59.94-hertz color vertical-drive frequency. In broadcast generators, the countdown from 31.47 khz is initiated from the 3.58-Mhz color subcarrier oscillator or from some multiple of 3.58 Mhz.

In the IVC camera, as noted earlier, the 3.58-Mhz color subcarrier is produced on the encoder board by a crystal oscillator whose frequency is unrelated to the horizontal or vertical drives in the sync generator. During closed-circuit operation, therefore, the IVC camera isn't color-locked (frequency interlaced) with the sync generator. It's color-locked only when it's under control of the built-in EIA generator or an external studio sync generator. But regardless of how the camera is used, the color produced by the built-in generator is indistinguishable on a color monitor from that produced by the color-locked generator.

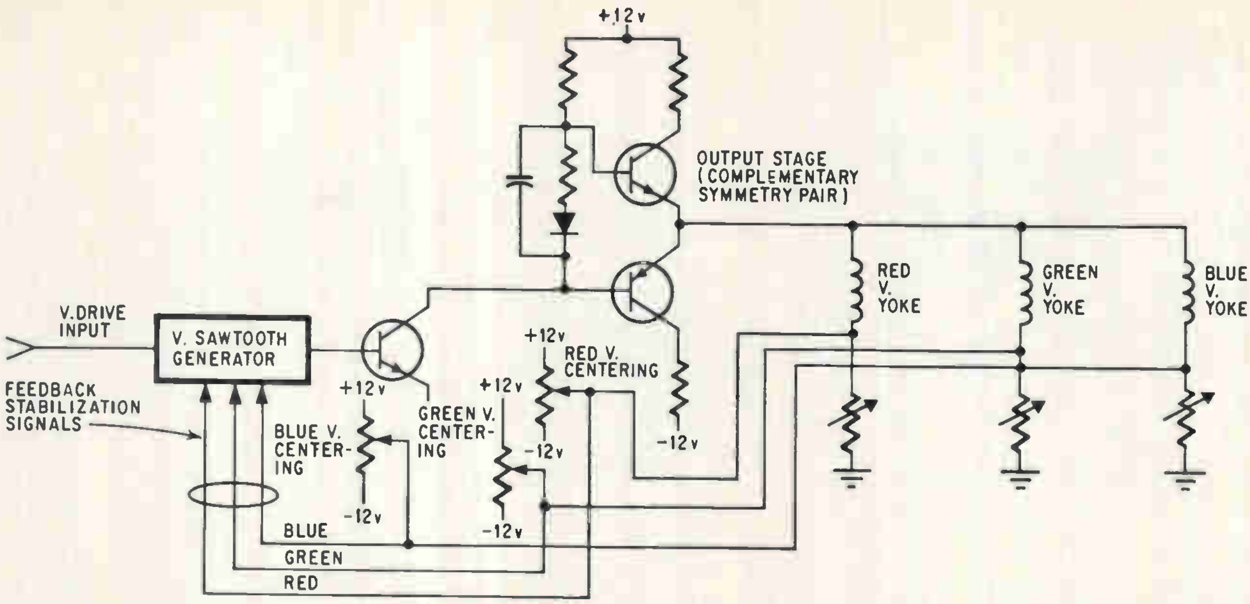
Besides the binary countdown circuitry the generator uses integrated-circuit logic to produce the horizontal-drive, vertical-drive, mixed blanking and sync, and burst-flag pulses.

Deflection

For purposes of economy and ease of operation, a simple yet stable deflection system has been developed for the vidicon. Vertical and horizontal deflection for each yoke are controlled by a common generator. As shown in the simplified schematic, the horizontal coils are effectively paralleled by multiple secondary windings of the transformer. This feature serves to isolate the d-c components so that a current-bridge technique can be used for centering.

Because the voltage waveform across the transformer primary is closely controlled by feedback, the deflection currents can be set by the yoke inductances. The sweep circuit provides individual size, linearity, and centering controls for the horizontal system. In operation, it accepts horizontal-drive pulses from the sync generator and from them generates new pulses with controlled rise times and durations. The reconstituted pulses are then used to apply a high-voltage pulse across the primary of the horizontal sweep transformer.

Any ringing is eliminated by a damper diode and RC network. A significant feature of the circuit is



Vertical deflection. The deflection yokes are driven by the complementary-symmetry transistor pair in the output stage. The diode and RC network in the base circuit ensure against crossover distortion.

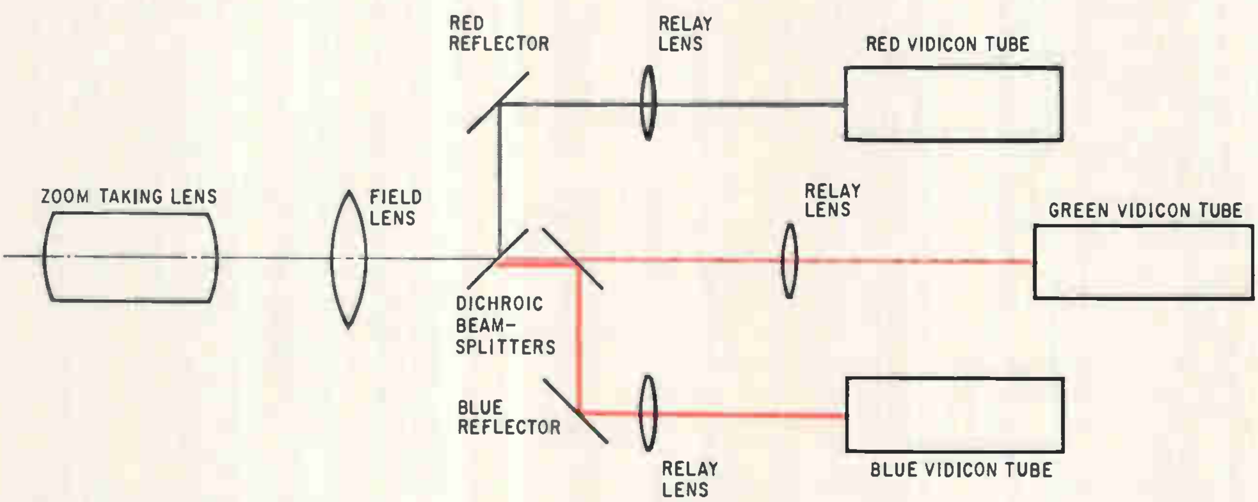
that the driver transistor is cut off during the 4-microsecond retrace period and serves as a highly stable feedback amplifier during horizontal scan. With separate transformer secondaries, d-c centering currents can be injected without interaction.

In the vertical deflection circuit shown above, the yokes are driven in parallel by a transistor pair arranged in complementary symmetry and operating in series for d-c components. The diode and RC network in the base circuit correct for crossover distortion, which would show up as a black horizontal line near the center of the picture. Like its horizontal counterpart, the vertical circuit is designed with carefully chosen feedback values to ensure the best possible sweep stability. Changes in the centering currents are sensed and compensated for.

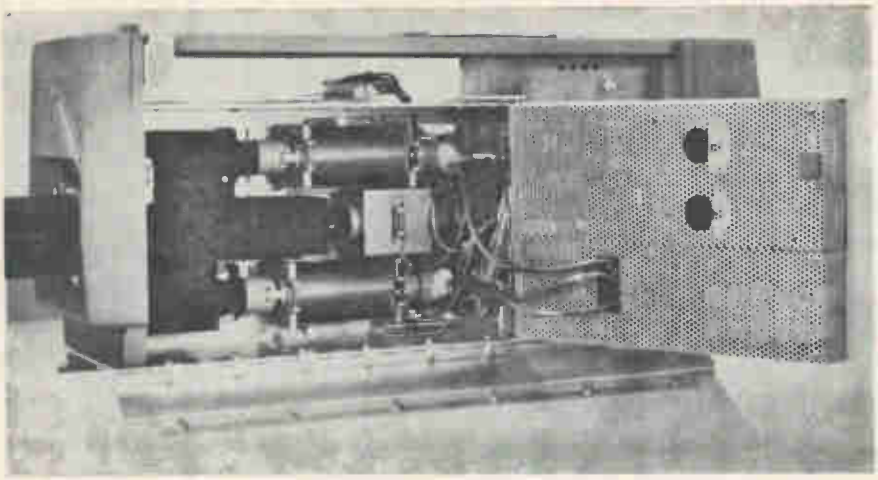
During camera operation, the horizontal and vertical waveforms are monitored to protect the vidicon target layers from the effects of sweep-circuit failure.

Optical system

The innovations introduced in the optical system are aimed essentially at cutting the cost of the package without seriously degrading the over-all performance of the camera. For example, rather than adopt the widely used and costly 40-millimeter image orthicon taking lens, the engineers specified a standard 35-mm single-lens-reflex-format design that can be purchased off the shelf. These lenses, with an image diagonal of about 43 mm—are very



Optics. The image created by the taking lens is focused through a field lens on dichroic beam-splitters. The red, blue, and green particles of the scene are directed to the vidicon tubes through relay lenses.



Easy access. Sync/sweep panel on left side of camera swings out for easy maintenance. The dichroic optical subassembly is at the left and the vidicon pickup tubes are at the right.

similar to the broadcast variety but, because of volume production, a lot less expensive.

The exact lens employed is an Auto-Nikkon f/4.5, 50-to-300-mm zoom lens, the type used in Nikkon F photographic cameras. The relatively slow speed of this lens is effectively increased to f/1.9 by using relay lenses as on page 139, to increase the back focus of the taking lens.

The relay lenses also demagnify the effective zoom range to between 18.5 and 110 mm. The ratio of the image diagonal of the 43-mm taking lens to the image diagonal of the vidicon tube's faceplate, which measures 15.88 mm, is approximately 2.73:1. Therefore, both the f stop and the zoom range are altered by that factor, in the direction of improved performance, by demagnification of the image size.

The first color cameras with image orthicon tubes had optical systems designed for a 1 to 1 ratio between the size of the image on the taking lens and the one on the pickup tube. This was a quite costly scheme because of the difficulty of producing relay lenses with unit magnification. In order to achieve an f/2, for example, the lens has to be capable of f/1 at infinity in one direction while being able to project a sharp image onto the target or film at close range in the other direction. In other words, fast lenses are designed to operate best at infinite distances, but still quite well at ranges of only a few feet.

Because of limited demand and high cost, lenses designed for 1:1 magnification are seldom available commercially and must be made up as required. But with the 2.73:1 demagnification of the IVC color camera system, a standard f/1.4 lens can be operated as a relay element with an aperture equivalent to f/1.9. This is an important consideration because the effective aperture of the relay lens is the factor that determines the speed of a camera.

Passing the light

The optical paths from the zoom lens to the vidicons have been greatly simplified to ensure that all of the available light from the scene reaches the tubes' target surface. To this end, the usual color trimming filters and the neutral density filters for the red and green channels have been left out. But this doesn't degrade the camera performance in any way. Highly efficient dichroic trimming reflectors are used with the main dichroic beam-splitters to shape the red and blue light-transmission characteristics. And because more light can pass through to the target, over-all sensitivity is greatly improved.

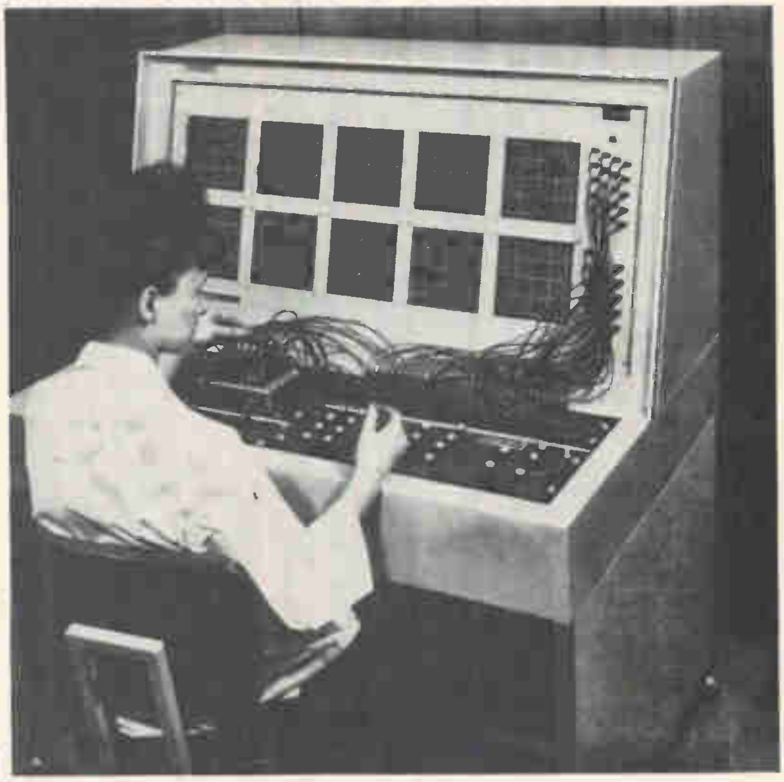
The bottom surface of the first dichroic beam splitter reflects the red light onto the red reflector, which in turn directs it through a relay lens to the red vidicon. The blue and green elements of the spectrum pass through to the second dichroic beam-splitter. The blue elements are reflected to the blue reflector, which directs them to the blue pickup tube; the green light elements aren't reflected and pass through to the green pickup tube.

A field lens mounted on the taking lens in an adapter tube ensures that all the light leaving the taking lens is directed to the relay lenses, thereby avoiding any "port-holing"—an effect that makes the center of the screen appear brighter than the periphery.

Besides the 6:1 Nikkon zoom lens, lenses with fixed focal lengths are available. Where a 10:1 zoom lens is required, the lower-cost image orthicon variety can be used. In fact, the camera can be operated with lenses as slow as f/5.3 and still provide a vidicon equivalent aperture of f/1.9, as described earlier.

During assembly, the relay lenses are set precisely and permanently locked in place. The three image-tube yoke assemblies are likewise aligned and locked into position. The entire optical system is held in the camera by dowel pins and can be removed in a matter of seconds for replacement of the vidicons. After a tube is replaced, the optics are reinstalled with the aid of the indexing pins to achieve exact realignment. And, unlike other systems which must be realigned on occasion, it needs no further adjustment.

solution to the LSI test dilemma:



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Liquid lasers: promising solutions

Problems of cost, optical damage, and low average power may dissolve when these organic and inorganic devices emerge from the laboratories

By Harold Samelson

General Telephone & Electronics Laboratories, Bayside, N.Y.

Intense luminescence—the basis of laser action—occurs in solutions of many organic and inorganic compounds when they're excited by light. Harnessing this luminescence has produced a new kind of laser that may become competitive with solid state and gaseous types.

Though liquid lasers are only at an early stage of development—comparable to that of solid state lasers five years ago—they're already cheaper to build, and their potential for high average powers is impressive. Already inorganic lasers using solutions of neodymium ions put out up to 40 joules in a 200-microsecond pulse—a pulse of 200 kilowatts.

At high power levels, circulation of the active liquid medium helps remove heat. The recent development of a lower-viscosity solvent has opened the way to using simpler circulating pumps, thus greatly simplifying the liquid laser. Both the inorganic and organic types now operate in the pulsed mode only, but researchers predict that a properly designed circulating pump will make it possible for inorganic liquid lasers to emit continuously.

Organic lasers won't be able to do this, because their transitions are so fast that an inordinate amount of energy would have to be pumped in and because their energy states aren't of the right type. However, they have one important advantage: they emit light over an enormously wide range of the spectrum—from about 4,000 to 11,000 angstroms. Their frequencies can be changed by simply changing the compound or its concentration in the solution.

Organic lasers can be adjusted to emit anything from virtually monochromatic light to light spread over wavelengths of 400A. Inorganic liquid lasers also can be made monochromatic, but their bandwidths are considerably narrower—between 15 and 30 A. Both types can be mode-locked [Electronics, Sept. 16, p. 112] to produce short, high peak power pulses, about 10 megawatts for the organic and up to a gigawatt for the inorganic. Pumping the organic laser with a mode-locked laser produces a mode-locked output, so picosecond pulses can be generated throughout the visible spectrum.

The liquid laser is being studied in this country and in France, Japan, and the Soviet Union. General Telephone & Electronics Laboratories, for instance, is seeking to develop the inorganic type for use both as an oscillator and an amplifier.

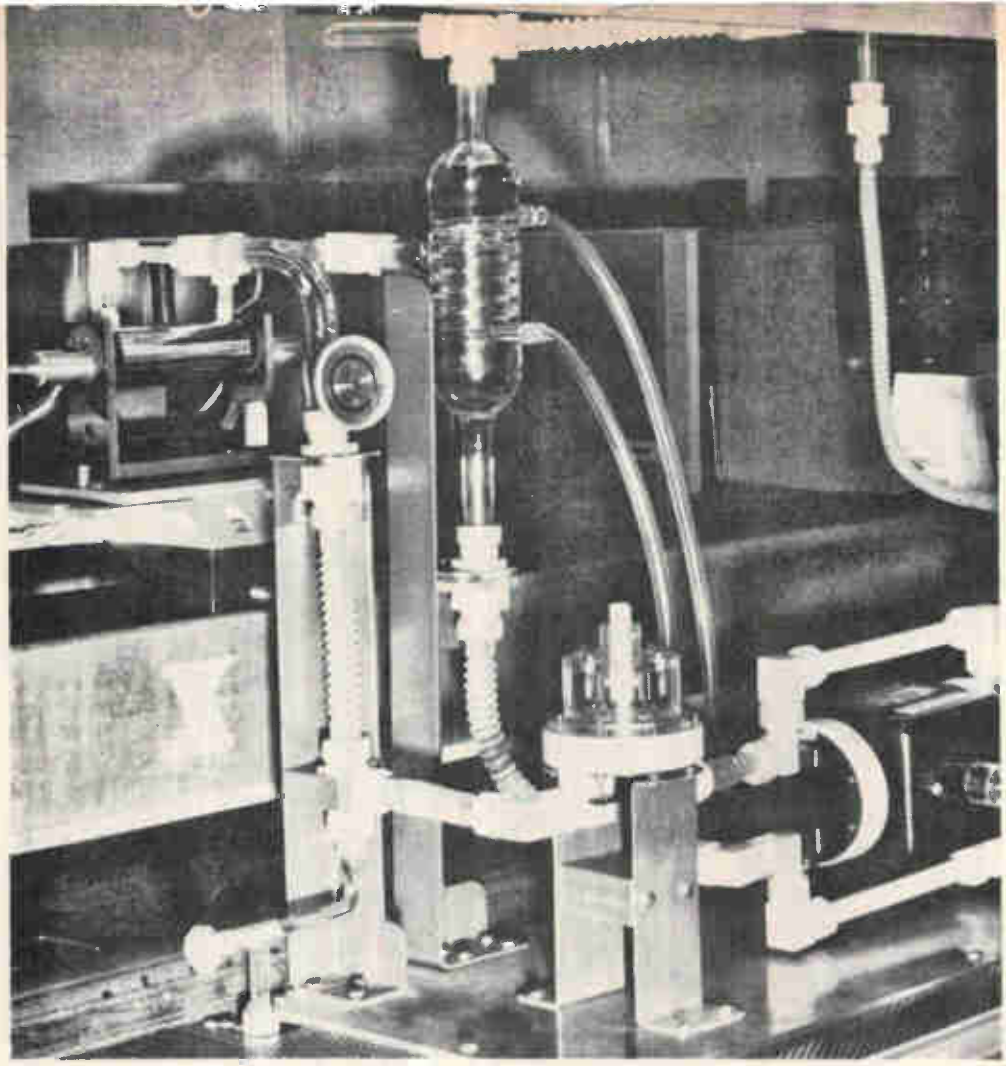
Caged light

The first liquid laser, developed in 1963, was a fusion of the present organic and inorganic types. Called a chelate laser, it consisted of a solution of organic, cage-like molecules surrounding a europium ion.

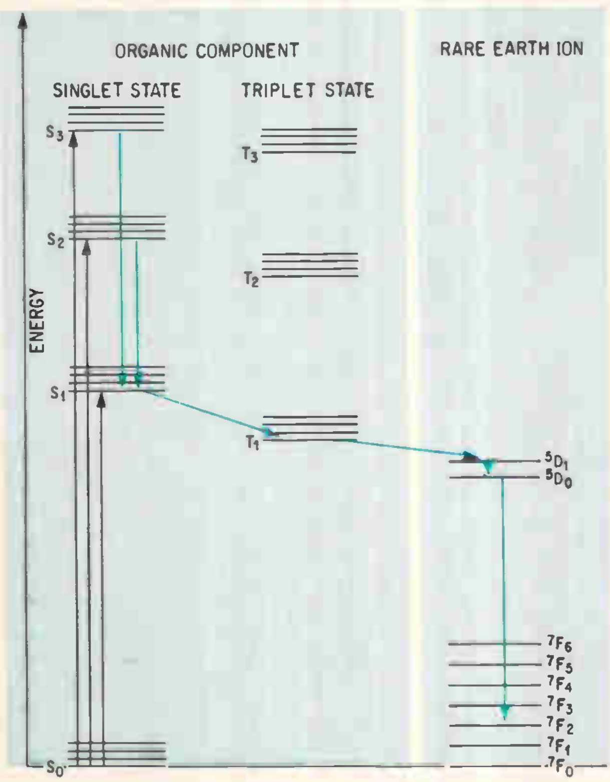
Then—as now—the trick was finding a way of dissolving the active materials and protecting them from elements with a low atomic weight, such as hydrogen, in the solvent. The energy levels of these elements are such that they tend to absorb energy emitted from the excited materials. Thus, the rare-earth ion could give up its energy to a hydrogen-containing molecule if it were not shielded, and laser action wouldn't take place.

However, the organic molecule in the chelate laser keeps the solvent from contacting the rare-earth ion, preventing the hydrogen-containing molecule from removing the excitation energy. In addition, the organic compound acts as a very efficient absorber of pump energy, which it then transfers to the europium ion.

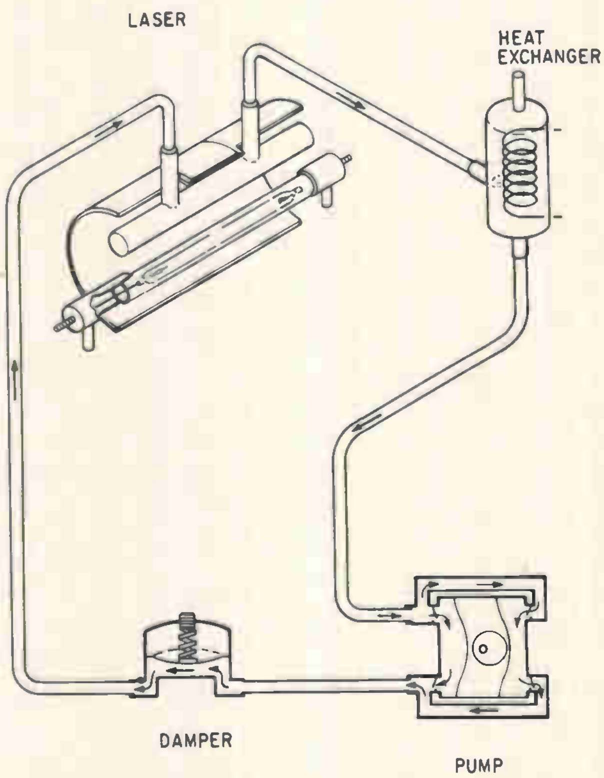
The energy-transfer mechanism in this early liquid laser was based on the fact that electrons in the organic molecule can exist in either a singlet state (two electrons spinning in opposite directions) or a triplet state (two electrons spinning in the same direction). The ground state—that is, the



Keeping cool. In GT&E inorganic laser, the liquid is pumped past a coil, that removes heat, easing cooling problems at high average powers. With a properly designed circulating pump, c-w operation should be possible.



Energy structure. Transitions in chelate laser are basic to understanding inorganic and organic types.

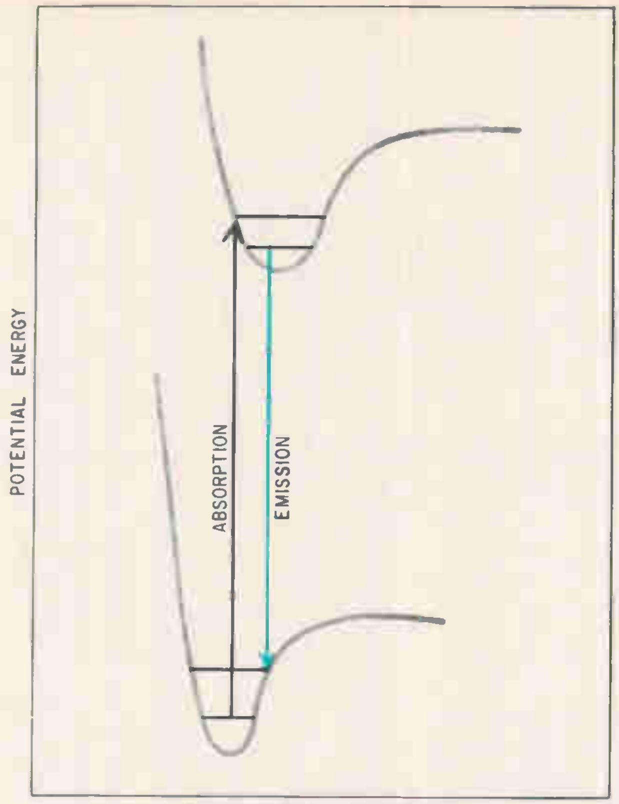


Circulation. Damper smoothes out pulsations of the diaphragm pump used in GT&E's circulating liquid laser.

one with the lowest energy—is a singlet in almost all molecules. Many rotational and vibrational states, each with its own discrete energy level, are associated with both the singlet and triplet states. The standard notation is $S_0 \ldots S_n$ for the singlet and $T_1 \ldots T_n$ for the triplet.

Normally, electrons can absorb or give up energy in transition from one state to another within either a singlet or triplet, but can't change from the singlet to the triplet state or back. However, substituting a rare-earth element in the molecule, as in the chelate laser, makes such transitions possible by perturbing the electronic structure. In this type of liquid laser such a crossover transition is an essential step.

The organic part of the chelate laser thus absorbs the pump energy, and the electrons are excited to one of the higher singlet states. Transitions back to the S_1 singlet are very rapid, taking about 10^{-12} second. Then energy in the S_1 state is transferred to the T_1 (metastable) triplet state of the organic compound. If the energy level of the state, T_1, is located properly with respect to one of the excited states of the europium ion, it transfers its energy to the ion, which then returns to the ground state, giving up its energy as radiation.



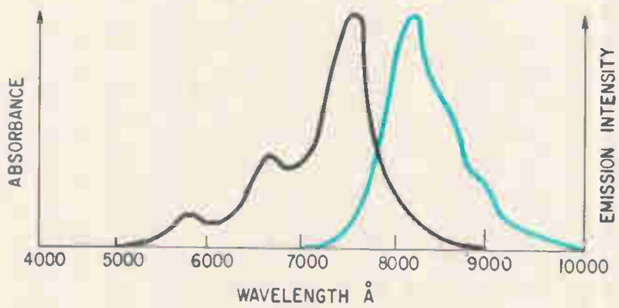
Organic states. There's a shift in distances between the various nuclei of the organic compound for the excited and ground states. As a result, the absorption and emission bands overlap somewhat.

Too much of a good thing

Researchers discovered a number of organic compounds and many solvents in which the europium ion ultimately was excited to the $^5D_0$ state and gave off a large number of photons in making transitions to the $^7F_2$ state. (These standard classifications describe such properties as angular momentum and spin.)

However, the intense singlet absorption of the organic molecule—so desirable for efficient pumping—created a problem. In the cylindrical laser cell, the liquid closest to the glass container absorbed a great deal of energy, blocking absorption by the rest of the liquid. This problem was solved by using a very thin cell, but it held so little liquid that the energy output was extremely low. And researchers found that only a few rare-earth ions could be made to radiate light. The organic cage doesn't protect most rare earths from the hydrogen atoms in the solvent.

Researchers then took two different approaches to liquid lasers. At GT&E Adam Heller developed a solvent, $SeOCl_2$, that would dissolve the Nd^{+3} ion. Since the solvent didn't contain hydrogen, the ion required no shielding and Heller could dispense with the organic molecule. At about the same time, Peter Sorokin at IBM got laser emission from a purely organic dye.



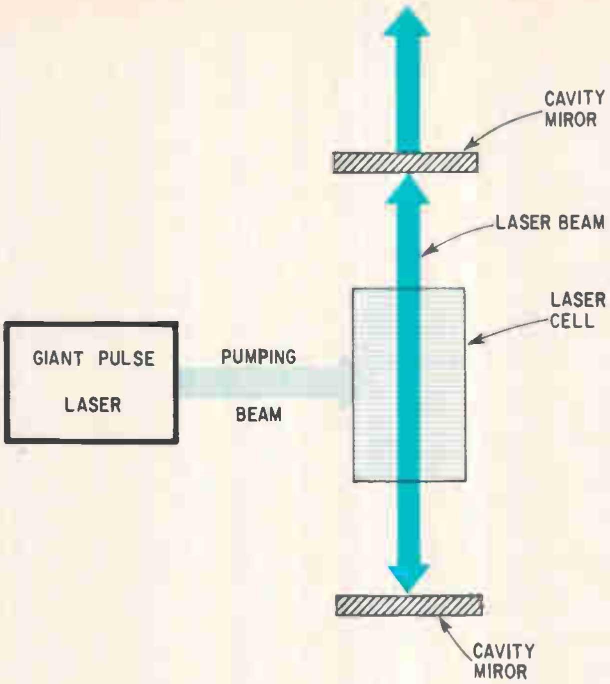
Tuning. The overlapping of the absorption and emission bands can be put to good advantage by varying the concentration of the organic dye, changing the balance of absorption and emission at a given frequency. It's thus possible to tune this type of liquid laser.

Colors of the rainbow

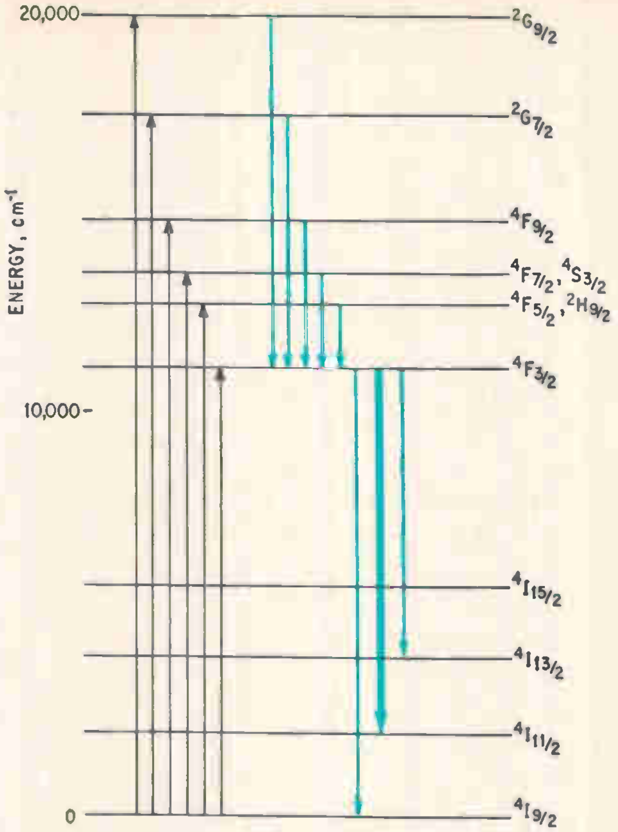
A distinct advantage of the organic liquid laser over the inorganic type is the wide range of compounds that can be used. Various classes, such as phthalocyanines and carbocyanines or polymethine dyes, have enabled the organic laser to span all of the visible as well as the near-infrared parts of the electromagnetic frequency spectrum.

These types of lasers generate high peak-power pulses either with a wide bandwidth of frequencies or with essentially a single frequency. And they can generate either one pulse or a repetitive mode-locked train. They should be of great value in spectroscopy and photochemistry.

When these lasers are pumped they are excited to the higher states of the singlet system and make transitions from them to the lowest excited



Pumping. In this typical experimental arrangement, an organic laser is pumped transversally by a high-powered pulsed laser. A frequency-doubling crystal can be inserted between the giant pulse laser and the liquid laser if pumping with the second harmonic is desired. Ruby-pumped organic lasers put out 6 megawatts of peak power with conversion efficiencies of 25%.



Popular ion. In a neodymium ion emission occurs from the $^4F_{3/2}$ state to the lower ^4I energy states.

state in about 10^{-12*} second. At this point, one of two things can happen. The molecule can give up its energy radiatively or nonradiatively from S_1 to S_0 in about 10^{-9} second, nonradiatively from S_1 to one of the triplet states in about 10^{-7} second, and then radiatively or nonradiatively from the lowest excited triplet state to the singlet ground state in about 10^{-3} to 10^{-6} second.

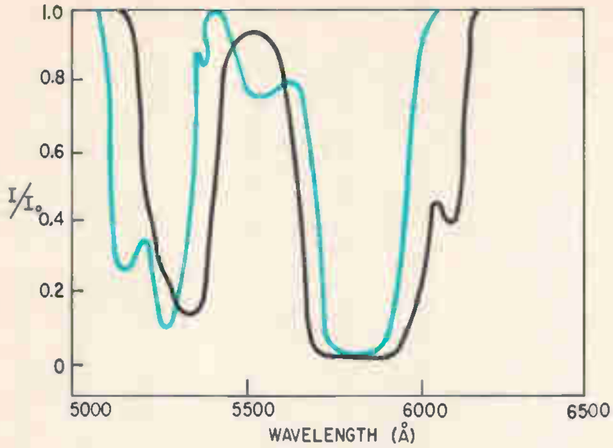
The emission spectra of organic lasers generally consists of a number of broad bands resulting from transitions from the lowest excited singlet to the various vibrational states of the ground singlet. There's a shift in distances between the various nuclei of the organic compound for the excited and ground states. As a result, absorption and emission bands overlap somewhat. This can be put to good advantage by varying the concentration of the organic dye, changing the balance of absorption and emission in a given frequency range. Thus, the organic lasers can be tuned to a particular frequency or frequencies.

The rapid transition rate between S_1 and S_0 requires that this laser be pumped with a short-duration pulse. The organic compound must be excited with enough power for population inversion to take place. An upper limit on the length of the pumping pulse is set by the probability of transitions to the triplet state. Selection of the organic compound is also vital. If there's any significant overlap between the triplet absorption and either the pump bands or singlet emission states, laser action won't take place or will be very weak.

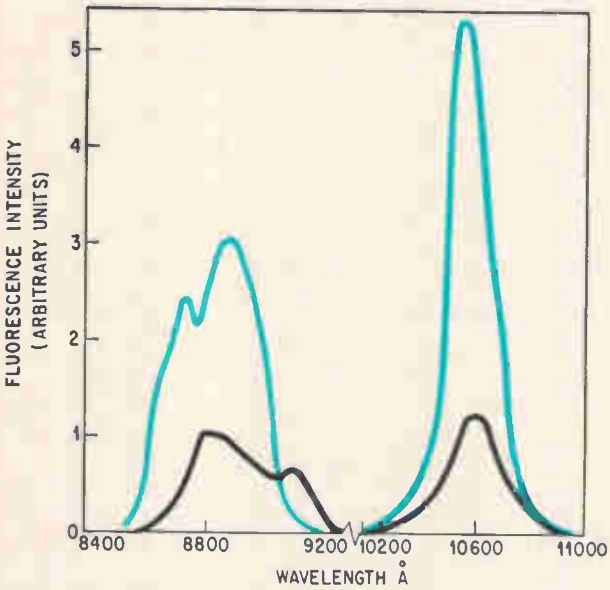
Beginnings

Initially, Sorokin used a high-power pulsed ruby laser to pump a solution of chloroaluminumphthalocyanine. Since it is possible to double the frequency of ruby and neodymium-doped lasers with reasonable conversion efficiency, a number of other organic compounds became candidates. But it's only in the past year that flashlamp-excited organic lasers have been developed. This not only made these lasers simpler and cheaper but also extended the list of possible organic compounds and increased the number of available output frequencies.

Outputs of the organic lasers depend on both the material and the pump. When a Q-switched laser pump or flashlamp pump is used with mode locking, the pulses are short—anywhere from 10 microseconds down to picoseconds—and the peak powers are high. A ruby-pumped organic laser, for instance, puts out 6 megawatts of peak power and has a conversion efficiency of 25%. Flashlamp-pumped organic lasers have peak powers of 0.1 megawatt and efficiencies close to 1%. Their energy output is about 0.2 joule. Their beam divergences are excellent—about 0.5 milliradian in a suitable cavity. Pulse repetition rates of about one



Absorption. In liquid (color) neodymium absorbs as much energy as in glass where the ion is more concentrated.



Light output. The ion's emission intensity in liquid (color) is much greater than it is in glass.

per second have been achieved.

As better flashlamps are developed, efficiencies and energy outputs of these lasers should climb. But the presence of the various triplet states makes continuous operation unlikely.

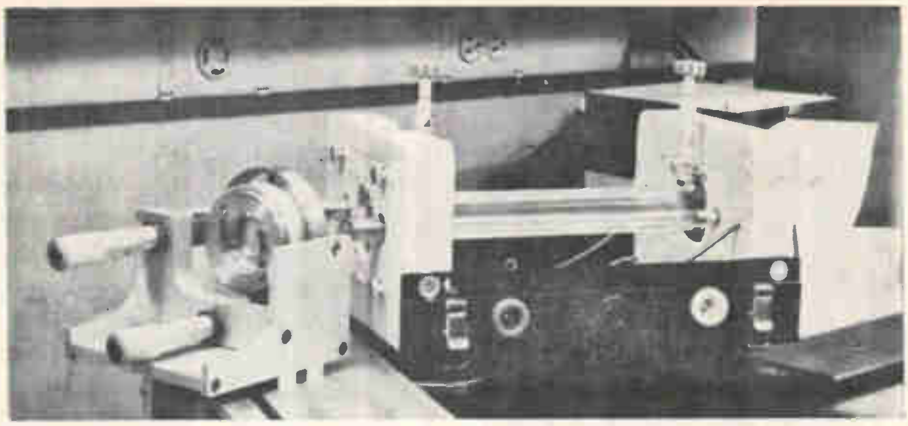
The problems precluding c-w operation in organic lasers—high pump powers and the triplet system—aren't present in inorganic lasers so that it should eventually be possible to operate the latter type continuously. In this laser, energy is pumped in to excite the Nd^{+3} ion from the $^4I_{9/2}$ ground state to the $^4F_{3/2}$ excited state and states above it. Laser emission takes place in the transition from the $^4F_{3/2}$ to the $^4I_{11/2}$ energy state. The neodymium ion absorbs less energy than does the organic compound in the other type of liquid laser, but absorption is far from negligible. Properties of the inorganic laser are similar to those of crystal

Organic Laser Compounds

Compound	Solvent	Laser Wave-length	Pump
chloro-aluminum phthalocyanine	ethyl alcohol	7550	L
3, 3′ diethyl thia TC iodide	ethyl alcohol	8030	L
acridine red	ethyl alcohol	5800	L, F
rhodamine 6G	ethyl alcohol	5500	L, F
	ethyl alcohol	5650	L
eosin	ethyl alcohol	5400	L
fluorescein	ethyl alcohol	5270	L, F
	water	5270	L
	water	5390	L, F
	water	5350	L
acridone	ethyl alcohol	4370	L
3, 3′ diethyl TC bromide	methyl alcohol	8130	L
1, 1′ diethyl γ nitro 4, 4′ DC tetrafluoroborate	ethyl alcohol	8050	L
1, 1′ diethyl γ acetoxy 2, 2′ DC tetrafluoroborate	methyl alcohol	7970	L
1, 1′ diethyl 2, 2′ DC iodide	glycerol	7700	L
1, 1′ diethyl 4, 4′ C iodide	glycerol	7450	L
3 ethyl aminopyrene 5, 8, 10 trisulfonic acid (sodium salt)	water	4410	L
2, 4, 6 triphenyl pyrilium fluoroborate	methyl alcohol	4850	L
rhodamine B	ethyl alcohol	6080	L, F
3, 3′ diethyl oxa DC iodide	methyl alcohol	6580	L
acriflavin hydrochloride	ethyl alcohol	5100	L
rhodamine B	ethyl alcohol	5770	L
rhodamine G	ethyl alcohol	5850	L
4 methyl umbelliferone	water	4540	F
3, 3′ diethyl 2, 2′ (5, 6, 5′, 6′ tetramethoxy) thia TC iodide	acetone	8530	L
3, 3′ diethyl 2, 2′ (4, 5, 4′, 5′ dibenzo) thia TC iodide	acetone	8600	L
3, 3′ diethyl 10 chloro 2, 2′ (4, 5, 4′, 5′ dibenzo) thia DC iodide	acetone	7740	L
3, 3′ diethyl 10 chloro 2, 2′ (5, 6, 5′, 6′ dibenzo) thia DC iodide	acetone	7140	L
1, 1′ dimethyl 4, 4′ QC iodide	glycerine	7490	L
1, 1′ diethyl 4, 4′ QC bromide	glycerine	7540	L
1, 1′ diethyl 2, 2′ QTC iodide	acetone	8980	L
1, 1′ diethyl 4, 4′ QTC iodide	acetone	10000	L
1, 1′ diethyl 11 bromo 2, 2′ QDC iodide	glycerine	8150	L
1, 1′ dimethyl 11 bromo 2, 2′ QDC iodide	glycerine	7450	L
1, 1′ diethyl 11 bromo 4, 4′ QDC iodide	methanol	8300	L
3, 3′ diethyl 2, 2′ oxa TC iodide	acetone	7420	L
3, 3′ dimethyl 2, 2′ oxa TC iodide	acetone	7440	L
1, 3, 3, 1′, 3, 3′ hexamethyl 2, 2′ indo TC iodide	acetone	8190	L
3, 3′ diethyl 2, 2′ selena-TC iodide	acetone	8260	L
3, 3 diethyl 2, 2′ (5, 5′ dimethyl) thiazolino TC iodide	glycerine	7170	L

Abbreviations used in this table are as follows:

Tricarbocyanine	TC
Dicarbocyanine	DC
Carbocyanine	C
Quinocarbocyanine	QC
Quinotricarbocyanine	QTC
Quinodicarbocyanine	QDC



Static laser. Most experiments with inorganic liquid lasers at GT&E have been done with noncirculating types such as this one. The data provides a reference for work with the newer circulating lasers.

and glass lasers, since the emission mechanisms are similar.

It wasn't until recently that scientists realized why fluorescence in liquids was so weak. They had been puzzled because the spectroscopy of solutions of rare earth ions suggested that their energy level structure was similar to that of the same ions in solid materials. Then it was realized that proton- or hydrogen-containing species in the solvent can deactivate rare-earth ions and quench fluorescent emission.

Based on this reasoning, Heller produced the first solvent that didn't contain hydrogen and could dissolve Nd^{+3} in high concentrations. However, this solvent, a mixture of selenium oxychloride and tin tetrachloride, was highly corrosive and toxic. To get around this difficulty, quartz and Teflon—both essentially unaffected by the solvent—were used to fabricate components in the inorganic laser. However, care had to be taken to guard against leakage of the toxic solvent.

Then, in the last few months, researchers developed a phosphorous oxychloride ($POCl_3$) solvent that is less corrosive and considerably less toxic. They found at first that they couldn't make a solution of dry phosphorous oxychloride and tin tetrachloride. However, by adding water and then carefully distilling it away, they got a stable solution. They suspect that the water reacts with the phosphorous oxychloride to form another phosphorous compound, stabilizing the solution.

Evaluations of this new solvent are by no means complete, but spectroscopic studies indicate that the potential power and efficiency of neodymium liquid lasers using this solvent would equal those of glass and yttrium-aluminum-garnet types.

For example, absorption spectra of neodymium-doped glass and neodymium-doped $SeOCl_2$ are quite comparable. Emission from the neodymium-doped solution is significantly greater than that from glass and laser emission is limited to many fewer wavelengths. Actually, the gain of the liquid neodymium laser lies between those of the glass and yag lasers.

Most experiments have been performed with noncirculating inorganic lasers. In the GT&E version of these devices, the cell holding the liquid is a hollow quartz or Pyrex cylinder mechanically and optically finished so that its ends are flat, parallel, and normal to the axis. End windows can be fastened into place in a variety of ways, and the seal between the window and cell is made with a Teflon-coated rubber O-ring. The energy output depends upon length; for example, a 6-inch cell puts out 10 joules with a slope efficiency of about 1%, and a 20-inch cell puts out more than 30 joules with even greater slope efficiencies.

The inorganic lasers can also be Q-switched and mode-locked by conventional techniques to produce up to gigawatt peak powers. They have an unusual property similar to one observed only in ruby lasers. If their cavity Q is adjusted to be low—that is, if the mirror reflectivity is decreased—their output consists of giant spikes. No additional active or passive element is required to produce the effect.

The reason isn't clearly understood, but this self Q-switching appears to be related to stimulated Brillouin scattering in the solution. A model has been suggested in which the laser cavity interacts with some highly polarizable component of the solution. As a result, there is a pronounced back scattering of the radiation—in effect, the light is reflected backward. Since the cavity has been adjusted to have low feedback, the sudden increase in reflectivity leads to a giant pulse.

Mobile medium

The real future of inorganic lasers, however, lies with the circulating system. The circulation not only cools the liquid but also compensates for any local inhomogenieties in the refractive index. Optical damage from high-powered laser beams doesn't occur, as it does in some solid state lasers. If a volume of a few hundred cubic centimeters of the liquid is used, circulation alone is sufficient to cool the laser—even at high pulse repetition rates.

The development of $POCl_3$ suggests that solvents that can dissolve other rare-earth ions may be developed. Researchers would like, for example, to make use of the europium ion. To date, however, they've been unable to get it to emit coherent light except in the chelate environment.

Calculating Gunn-diode output

Use of equal-area analysis and Fourier transforms provides a simple and straightforward method of predicting generated microwave power

By Mohammed N. Al-Moufti, Stanley V. Jaskolski, and T. Koryu Ishii
Department of Electrical Engineering, Marquette University, Milwaukee

The recent marketing of Gunn-effect microwave diodes is a prime example of the surprising speed with which devices based on new principles are moving from research lab to engineering bench. At the same time, the devices themselves exemplify how engineering techniques often lag behind technological innovations. For despite all the work that's been done on the domain physics of Gunn diodes, until recently there was no simple way to calculate the output of these power sources.

There is one now, based on an equal-area analysis of a curve relating the average carrier velocity to voltage. From this, the portion of the applied voltage absorbed by the moving high-field domain can be found. The generated r-f voltage can then be determined by a Fourier analysis of the sawtooth waveform assumed for the domain voltage, and with this, the output power can be calculated.

Earlier techniques were no more quantitative and a great deal more complicated. J.R. Gunn, the device's inventor, devised a method of determining the current waveform from a sample voltage, and a more general theory of the diode's efficiency was presented by W. Heinle, who employed a drift-velocity, field-strength characteristic to describe the device's dynamic behavior. But the new technique provides a far more straightforward way of computing absolute output power.

Domain propagation

During Gunn oscillations, a high-field domain forms at the cathode of the bulk-effect device and propagates through the bulk semiconductor sample to the anode where it vanishes. Another domain then forms and starts the process over again. The voltage absorbed by this domain is related to the generated microwave voltage, V_{rf}, and the microwave output power is equal to $V_{rf}^2/2Z_L$, where Z_L is the microwave load impedance.

Part of the external bias voltage, V, applied across the diode is absorbed by the high-field domain, whose voltage is V_D. The remaining bulk sample voltage (outside the high-field domain), V_L, is low. Thus:

$$V = V_D + V_L$$

To find V_L, a graph of the average carrier drift velocity as a function of the bias voltage can be constructed using

$$\bar{v} = V_o X_o \left(\frac{1 + QF}{1 + F}\right)$$

where

$\bar{v}$ = average carrier drift velocity
V_o = product of lower valley mobility and the sample threshold field $= \mu_L E_{peak}$
X_o = ratio of the applied electric field to the threshold field, $= E/E_{peak}$
Q = ratio of the upper to lower valley mobility $= \mu_U/u_L$
F = ratio of the upper to the lower valley carrier density

$$F = \left(\frac{V}{V_{peak}}\right)^B \left(\frac{1}{B - 1}\right)$$

$$B = \frac{1}{1 - \dfrac{J_P}{\sigma_o E_{peak}}}$$

J_p being the peak current density and σ_o the conductivity of the sample.

With equal-area analysis, the low-field voltage, V_L, can be obtained from a plot of the average carrier drive velocity versus bias voltage.

As an example, consider a Texas Instruments Gunn diode (the TI-G) whose typical value of electron upper-valley mobility, μ_U, is 50 cm² per volt-second, and whose electron lower-valley mobility, u_L, is 6,200 cm²/volt-sec. For this diode, therefore, $Q = 8.06 \times 10^{-3}$.

Now, $E_{peak} = V_{peak}/l$, where V_{peak} is the d-c bias voltage that produces the peak current in the volt-ampere characteristic curve and l is the sample length. In the case of the TI-G diode, V_{peak} is 3.8 volts and l is 10^{-3} cm. Therefore, E_{peak} is 3,800 volts/cm and

$$v_o = \mu_L E_{peak} = 2.36 \times 10^7 \text{ cm/sec}$$

Also,

$$X_o = \frac{E}{E_{peak}} = \frac{V}{3.8}$$

The peak current, I_p, of the TI-G diode is 160 milliamperes. With a cross-sectional area of 34×10^{-6} cm², the current density is thus $J_p = I_p/A$, or 0.471×10^4 amp/cm².

The low-field conductivity can be calculated from

$$\sigma_o = ne\mu_L$$

where n is the free carrier concentration and e is the charge of an electron. For the TI-G, n is 2.5×10^{15} electrons/cm³, and σ_o is therefore 2.48 mho/cm. Thus, with data for E_{peak}, σ_n, and J_p, B can be calculated to be equal to about 2.

Then,

$$F = \left(\frac{V}{V_{peak}}\right)^2$$

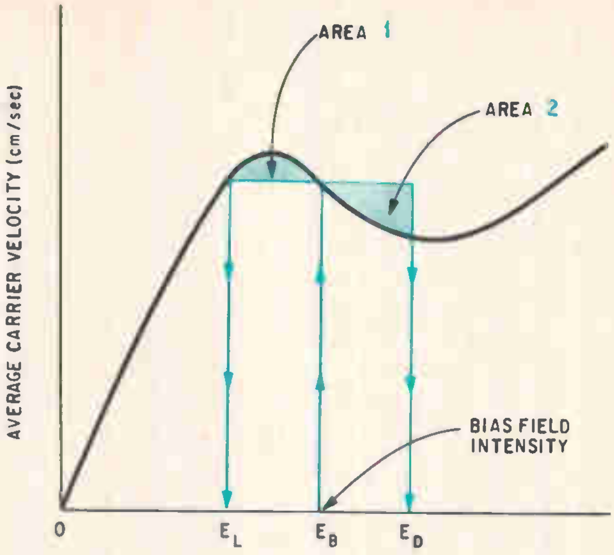
The average carrier drift velocity v as a function of the bias voltage V is thus

$$\bar{v} = 2.36 \times 10^7 \frac{V}{3.8} \; \frac{1 + 8.06 \times 10^{-3}\left(\frac{V}{3.8}\right)^2}{1 + \left(\frac{V}{3.8}\right)^2}$$

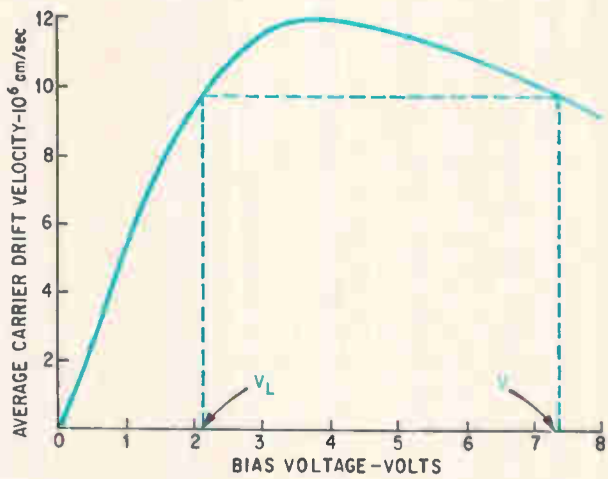
If this equation is plotted for V ranging from 0 to 8 volts, the curve at the right is obtained.

Once this volt-ampere characteristic curve is plotted, the minimum low-field voltage V_L can be obtained using the equal-area analysis, done as follows:

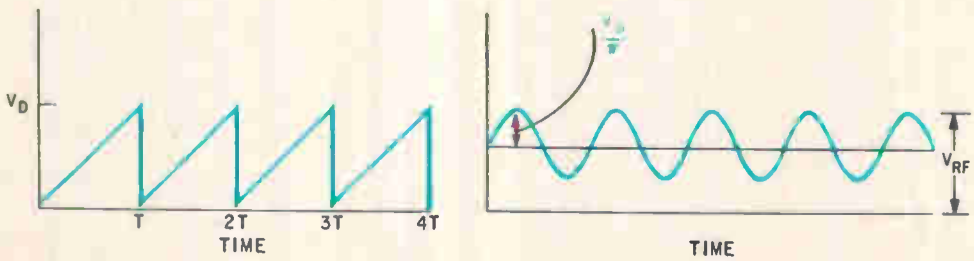
In the average carrier-drift-velocity-versus-sample-electric-field characteristic, a horizontal line is drawn to intersect the curve through a bias field point P_B. If the area surrounded by the curve and



Equal areas. Low- and high-field values are calculated by equating the two areas around the bias point.



Design calculations. For the example in the text, the low-voltage region is figured to be about 2 volts.



Sawtooth. The voltage across the high-field domain is assumed to rise linearly with time and then drop sharply in sawtooth fashion. Its fundamental sinusoidal component determines the microwave power.

the horizontal line, Area 1, is made equal to the area between the horizontal line and the curve, Area 2, as illustrated, the readings of the intersecting points on the abscissa—E_L and E_D, respectively —represent the minimum low electric field in the sample and the maximum high electric field in the sample's traveling domain. These electric field values can be converted to voltages by multiplying them by the active length of the diode.

Knowing the bias voltage and low-field voltage, V_L, we can now establish the voltage absorbed by the domain—their difference.

As the high-field domain drifts across the semiconductor, the absorbed domain voltage increases. Let's assume for simplicity that its waveform is approximately a linear sawtooth with period T, as on page 149 and reaches a maximum value, V_D, just before it discharges at the anode.

Resolving this into its Fourier components, we find the fundamental component, V_{rf}, to be approximately the generated fundamental microwave signal. The power output, P, of the microwave oscillation is then simply:

$$P = \left(\frac{1}{2Z_L}\right) V_{rf}^2$$

where Z_L is the load impedance of the Gunn device.

Comparison of results

To illustrate this method, its results will be compared with those obtained experimentally.

At bias voltages of 6.8, 6.9, 7.0, 7.3, and 7.5 volts, the corresponding low-field voltages are determined graphically from plots of the average carrier drift velocity as a function of bias voltage. V_D is established in this way, and this leads to a determination of V_{rf}.

The fundamental component of the sawtooth wave with peak value is

$$\frac{V_D}{\pi} \sin \omega t$$

so its maximum value is V_D/π. Therefore,

$$V_{rf} = \frac{V_D}{\pi}$$

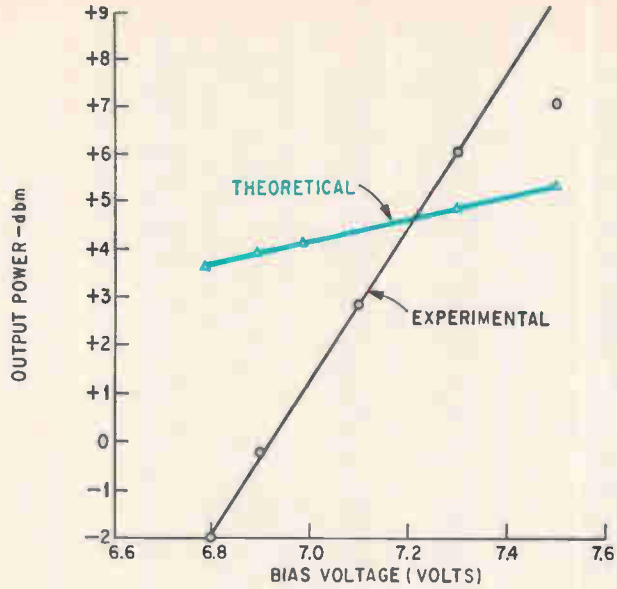
With V_L and V_{rf} known, and with Z_L equal to the characteristic impedance, Z_o, of the waveguide where

$$Z_o = 377 \frac{2b}{a} \frac{1}{\sqrt{1 - \left(\frac{\lambda}{2a}\right)^2}}$$

five values for the diode's microwave output are calculated using a = waveguide width, 0.9 inch; b = waveguide height, 0.4 inch; and λ = operating wavelength, 3 cm (f_o = 10 Ghz).

These theoretical values are plotted along with the experimentally obtained output power measurements, as shown above. The difference between the theoretical and experimental values is well within ± 3 decibels (or 6 db peak to peak). Given the present state of the art in the field, this discrepancy, though not insignificant, is quite acceptable.

The discrepancies between the observed results and theoretical predictions stem from the fact that the shape of the high-field domain absorbed voltage isn't exactly sawtooth, that the circuit interpretation is oversimplified, and that the definition of waveguide characteristic impedance is somewhat ambiguous.



Close enough. The theoretical and experimental values for a typical Gunn diode are within 6 db of one another.

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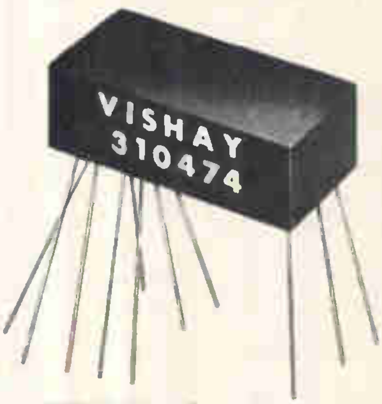

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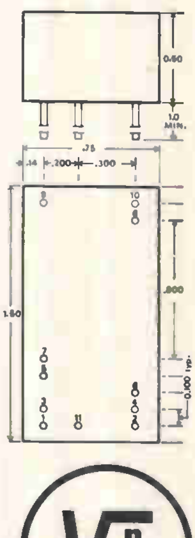

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MOS multiplexer switches can do well at high frequencies

Signal feedthrough, frequency limitations, and transients can become serious above 1 kilohertz, but mathematical models make it possible to design circuits whose performance isn't marred by these difficulties

By Per Mogensen and Wallace Chan
Fairchild Semiconductor, Mountain View, Calif.

The no-moving-part version of the relay, the metal oxide semiconductor multiplexer switch, is so superior that it has virtually replaced its mechanical counterpart in industrial and military applications. In equipment such as analog-to-digital converters, telemeters, multichannel data transmission and control systems, and computer input-output circuits, it has no peer. However, certain pitfalls can make the MOS switch less useful than the relay.

When MOS multiplexer switches are operated at signal frequencies above 1 kilohertz, capacitance effects become significant and can be serious if they are not allowed for in the design. These effects are:

- Signal feedthrough. A signal can feed capacitively through a channel that's off, causing an erroneous reading in another on channel. In a well shielded system, this coupling between input and output is mainly due to the capacitance of the multiplexer switch itself.
- Frequency limitations. The maximum signal frequency that the switch can transmit depends on how fast the signal source can charge the capacitance of the channel and external load through the channel on resistance and the source resistance. This maximum is usually expressed as the 3-decibel frequency.
- Transients. The capacitive coupling between gate and channel gives rise to a voltage transient on the signal output each time a channel is switched.

Mathematical models are available for each of these effects and can be used to predict high-frequency performance. The models described here are for a simple two-channel switch in an single package, but they can easily be extended to cover any number of channels in single or multiple packaging schemes.

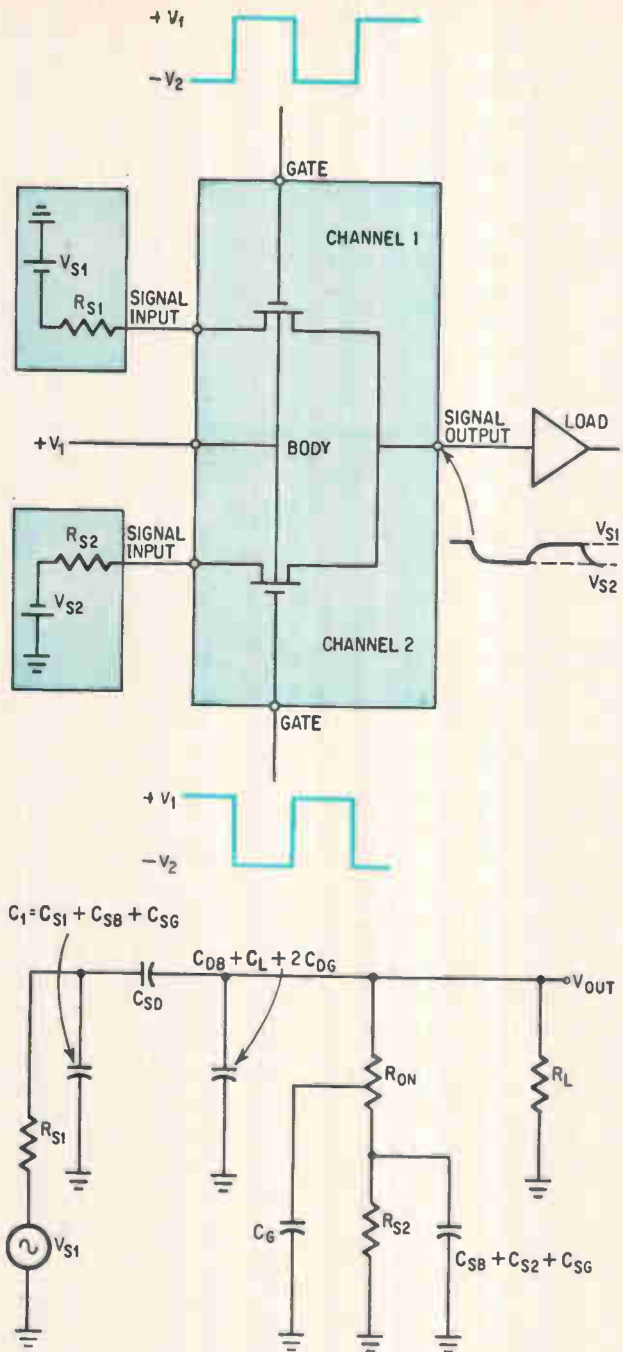
Finding feedthrough

Signal feedthrough—the ratio of output voltage V_{out} to the voltage V_{S1} at the input of the off transistor in the two-channel multiplexer shown on opposite page—is essentially a function of the resistance and capacitance of the combined circuits.

The equivalent circuit shown below the actual circuit applies when $R_{S2} >> R_{on}$ or $R_{S2} << R_{on}$. From

Symbols

V_{S1} = Signal voltage in channel 1
V_{S2} = Signal voltage in channel 2
R_{S1} = Signal resistance in channel 1
R_{S2} = Signal resistance in channel 2
C_{S1} = Wiring capacitance in channel 1
C_{S2} = Wiring capacitance in channel 2
C_{SB} = Source-to-bulk capacitance
C_{SG} = Source-to-gate capacitance
C_{DB} = Common-drain-to-bulk capacitance
C_{DG} = Common-drain-to-gate capacitance
C_{SD} = Source-to-common-drain capacitance
C_G = MOS-channel-to-bulk (and gate metal) capacitance
R_{on} = MOS-channel on resistance
R_L = Load resistor (generally $> > R_{on}$)
C_L = Load capacitance, including wiring
C_{in} = Multiplexer switch input capacitance
C_{out} = Multiplexer switch output capacitance



Multiplexer. Voltages on gates switch channels on and off to connect alternate signals to the load. Equivalent circuit at bottom is for feedthrough equations.

this circuit, the signal feedthrough can be calculated from

$$\frac{V_{out}}{V_{S1}} = \frac{j\,\dfrac{\omega}{\omega_3}}{\left(1 + j\,\dfrac{\omega}{\omega_1}\right)\left(1 + j\,\dfrac{\omega}{\omega_2}\right)} \qquad (1)$$

if ω_1, ω_2, and ω_3 are defined as shown on next page; ω without a subscript represents the radial frequency of V_{S1}. In most multiplexer switches available today, R_{on} is between 100 and 1,000 ohms, and R_{S1} and R_{S2} range from 0 to 10 kilohms.

Ordinarily, in a well shielded system, C_{SD} is between one and three orders of magnitude smaller than C_1 and C_2, so the expressions for ω_1 and ω_2 aren't nearly as formidable as they appear. They reduce to an equation in which ω_1 and ω_2 each assumes one of two values

$$\left.\begin{matrix}\omega_1 \\ \\ \omega_2\end{matrix}\right\} = \left\{\begin{matrix}\dfrac{1}{C_1 R_{S1}} \\ \\ \dfrac{1}{C_2 R_2}\end{matrix}\right.$$

where ω_1 is the smaller of the two quantities on the right.

The maximum signal feedthrough, from equation 1, is

$$\frac{V_{out}}{V_{S1}} = 20 \log\left(\frac{\omega_1}{\omega_3}\right) \text{decibels}$$

C_1 needs further explanation. It is the input wiring capacitance in parallel with the source-to-bulk capacitance and the source-to-gate capacitance. For practical purposes, C_1 equals the wiring capacitance in parallel with the channel input capacitance (the latter measured with the gate at ground).

For $R_{S2} << R_{on}$, C_2 is approximately equal to the multiplexer output capacitance in parallel with the load capacitance

$$\begin{aligned} C_2 &= C_{DB} + C_L + 2C_{DG} + \tfrac{1}{2}C_G \\ &\approx C_{out} + C_L \end{aligned}$$

And when $R_{S2} >> R_{on}$, it's necessary to add the capacitance from the input node of the on channel:

$$\begin{aligned} C_2 &= C_{DB}+C_L+2C_{DG}+C_G+C_{S2}+C_{SB}+C_{SG} \\ &\approx C_{out}+C_L+C_{S2}+C_{in} \end{aligned}$$

One needn't use equation 1 to construct a continuous curve of feedthrough versus frequency. A simpler procedure yields fairly accurate results: calculate the maximum V_{out}/V_{S1} from equation 1, construct a line corresponding to this value between ω_1 and ω_2, then draw lines dropping off at 20 db per decade on both sides.

An example: Fairchild's 3701 six-channel multiplexer switch has $C_1 = 5$ picofarads, $C_2 = 25$ pf, and $C_{SD} = 0.02$ pf. Assume that the system parameters R_{S1} and R_{S2} are 10 kilohms. Then ω_1, ω_2, and ω_3, expressed in cycles per second (hertz) instead of radians per seconds, are 0.64, 3.2 and 800 megahertz, respectively. The maximum V_{out}/V_{S1} is −62 db. Feedthrough can now be plotted as a function of frequency with the simplified construction. The result is acceptably close to the measured curve, as at top of page 155.

A multiplexer is ordinarily operated below ω_1. In this range the feedthrough depends on the product $C_{SD}R_2$—the smaller this product is, the less feedthrough.

The 3-db frequency

To find the maximum signal frequency, the equivalent circuit can be simplified even further, as on page 155. The transfer function—from which the 3-db frequency can be found—for this circuit can be calculated from

$$\frac{V_{out}}{V_{S2}} = \frac{1}{\left(1 + j\frac{\omega}{\omega_1}\right)\left(1 + j\frac{\omega}{\omega_2}\right)} \qquad (2)$$

if ω_1 and ω_2 are defined as shown in box below. It turns out that ω_1 and ω_2 are points at which the plot of transfer function versus frequency changes slope. And ω_1 is, in fact, the frequency at which the transfer function is 3 db down from its low

Feedthrough definitions

$$\omega_1 = \frac{(C_{SD}+C_1)R_{S1}+(C_{SD}+C_2)R_2 - \sqrt{[(C_{SD}+C_1)\,R_{S1}+(C_{SD}+C_2)\,R_2]^2-4\,[C_{SD}(C_1+C_2)+C_1C_2]\,R_{S1}R_2}}{2\,[C_{SD}(C_1+C_2)+C_1C_2]\,R_{S1}\,R_2}$$

$$\omega_2 = \frac{(C_{SD}+C_1)R_{S1}+(C_{SD}+C_2)R_2 + \sqrt{[(C_{SD}+C_1)\,R_{S1}+(C_{SD}+C_2)\,R_2]^2-4\,[C_{SD}(C_1+C_2)+C_1C_2]\,R_{S1}R_2}}{2\,[C_{SD}\,(C_1+C_2)+C_1C_2]\,R_{S1}\,R_2}$$

$$\omega_3 = \frac{1}{C_{SD}\,R_2}$$

The basic equation for feedthrough, from the equiv-alent circuit, is

$$\frac{V_{out}}{V_{S1}} = \frac{j\omega C_{SD}\,R_2}{(j\omega)^2\,[C_{SD}\,(C_1 + C_2) + C_1\,C_2]\,R_{S1}\,R_2 + j\omega\,[(C_{SD} + C_1)\,R_{S1} + (C_{SD} + C_2)\,R_2] + 1}$$

which reduces to equation 1 when ω_1, ω_2, and ω_3 aredefined as shown.

Three-db definitions

$$\omega_1 = \frac{R_{S2}\,(C_1 + C_2) + R_{on}\,C_2 - \sqrt{[R_{S2}\,(C_1 + C_2) + R_{on}\,C_2]^2 - 4\,R_{S2}\,R_{on}\,C_1\,C_2}}{2R_{S2}\,R_{on}\,C_1\,C_2}$$

$$\omega_2 = \frac{R_{S2}\,(C_1 + C_2) + R_{on}\,C_2 + \sqrt{[R_{S2}\,(C_1 + C_2) + R_{on}\,C_2]^2 - 4\,R_{S2}\,R_{on}\,C_1\,C_2}}{2R_{S2}\,R_{on}\,C_1\,C_2}$$

The transfer function, from the equivalent circuit, is

$$\frac{V_{out}}{V_{S2}} = \frac{1}{(j\omega)^2\,R_{S2}\,R_{on}\,C_1\,C_2 + j\omega\,[R_{S2}\,(C_1 + C_2) + R_{on}\,C_2] + 1}$$

This simplifies to equation 2 when ω_1 and ω_2 aredefined as shown.

Time constants

$$\tau_1 = \frac{2\,R_{S1}\,R_{on}\,C_1\,C_2}{R_{S1}\,(C_1 + C_2) + R_{on}\,C_2 - \sqrt{[R_{S1}\,(C_1 + C_2) + R_{on}\,C_2]^2 - 4R_{S1}\,R_{on}\,C_1\,C_2}}$$

$$\tau_2 = \frac{2\,R_{S1}\,R_{on}\,C_1\,C_2}{R_{S1}\,(C_1 + C_2) + R_{on}\,C_2 + \sqrt{[R_{S1}\,(C_1 + C_2) + R_{on}\,C_2]^2 - 4R_{S1}\,R_{on}\,C_1\,C_2}}$$

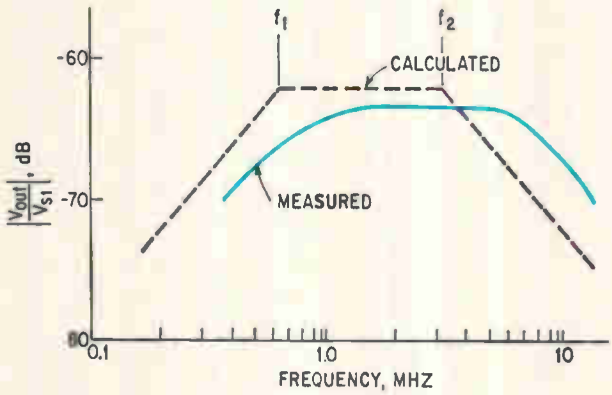
frequency value. As before, the frequency response curve can be approximated by straight lines connected at the critical frequencies, as below left.

If the signal source resistance R_{S2} is smaller than R_{on}, then

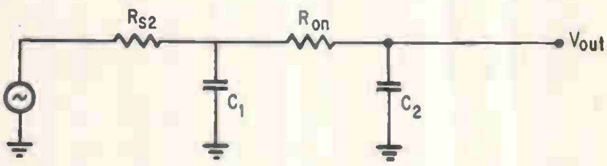
$$\omega_1 = \frac{1}{R_{on}\,C_2}$$

$$\omega_2 = \infty$$

On the other hand, if R_{S2} is much larger than the on



Close. The dashed line approximates the measured feedthrough well enough for practical purposes.

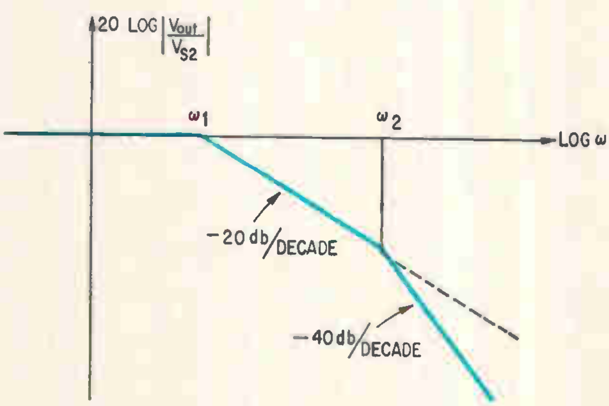


$C_1 = C_{S2} + C_{SB} + C_{SG} + 1/2\,C_G \approx C_{S2} + C_{in}$

$C_2 = C_L + C_{DB} + 2C_{DG} + C_{SD} + 1/2\,C_G \approx C_L + C_{out}$

$R_L \gg R_{on} + R_{S2}$

Another equivalent. A simplified version of the circuit is used for 3-db point and transient calculations.



Graphic. A simple construction approximates the attenuation of signal with frequency.

resistance

$$\omega_1 = \frac{1}{R_{S2}\,(C_1 + C_2)}$$

$$\omega_2 = \frac{1}{R_{on}\left(\dfrac{C_1\,C_2}{C_1 + C_2}\right)}$$

In other words, increasing the signal resistance rapidly degrades switch performance because the 3-db frequency $[f_{3db} = (1/2\pi)\,\omega_1]$ is inversely proportional to R_{S2} when $R_{S2} >> R_{on}$.

In the 3701, for example, R_{on} is 300 ohms. Assume that $C_1 = C_{S2} + C_{in} = 5$ pf and $C_2 = C_L + C_{out} = 20$ pf. If the signal resistance is large, say $R_{S2} = 10$ kilohms

$$f_1 = \frac{1}{2\pi} \cdot \frac{1}{10k\,(5pf + 20pf)} = 0.64 \text{ Mhz}$$

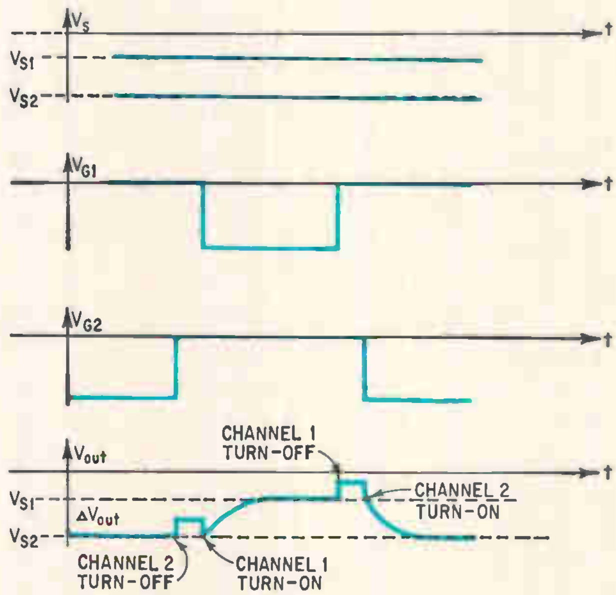
In contrast, when $R_{S2} = 0$

$$f_1 = \frac{1}{2\pi} \cdot \frac{1}{300 \cdot 20pf} = 27 \text{ Mhz}$$

Transient events

When one channel is switched off and another is switched on, the transient voltages at the gates feed through the drain-to-gate capacitance to the output. The sequence of events is shown in figure below; to make things clearer, the control voltages are staggered so that both channels are off simultaneously for a short time.

The drain-gate capacitance and the capacitance between output and ground form a capacitive voltage divider, making the voltage change (i.e., the



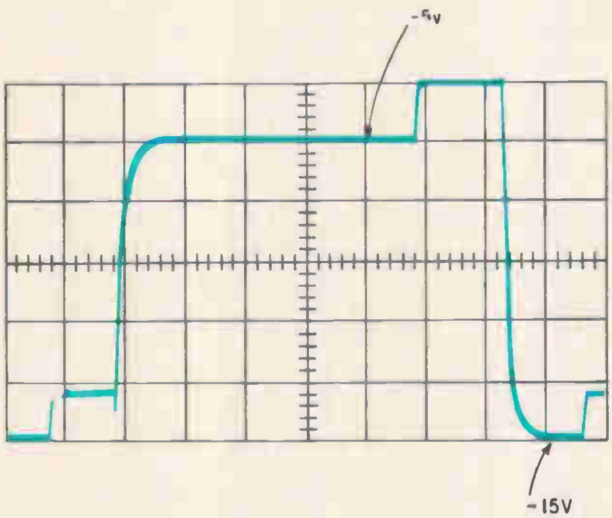
Sequence of events. Transient voltages occur when a channel is turned on while the other is off.

transient) at the output

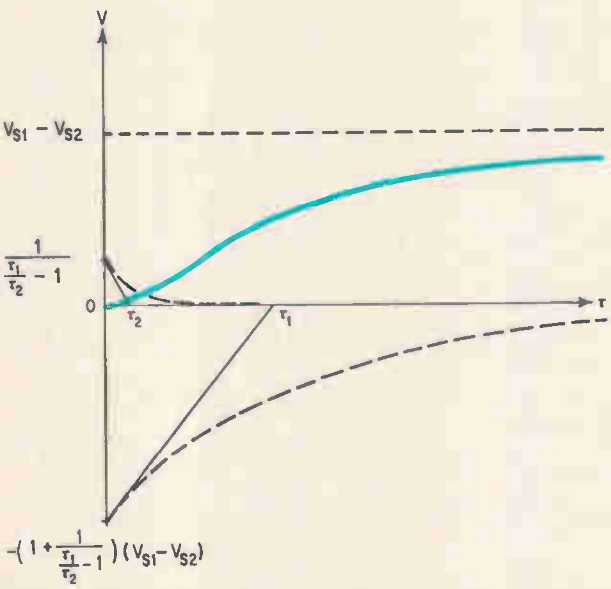
$$\Delta V_{out} = \frac{C_{DG} V_G}{C_{DB} + C_L + 2C_{DG}}$$

$$\approx \frac{C_{DG} V_G}{C_{out} + C_L} \qquad (3)$$

In this equation, it's assumed that the capacitors are voltage-independent, just as it was assumed that the capacitors and resistors were constant in the previous equations. This isn't true, of course; all capacitances and the channel resistance in MOS devices are voltage-dependent. But taking the dependency into account would make the analysis too complicated. Fortunately, the equations are accurate enough for practical purposes even if the voltage dependence is ignored.



Trace. Oscilloscope shows switching transients for 3701. Horizontal scale is 2 μsec per large division.



Turned on. The rise in output voltage after a new channel is turned on is a function of the time constants.

It has also been assumed that the time constants of the control circuits are small compared to the time constants of the multiplexer switch. This is always true when both channels are off; the output voltage is almost constant because the load is large —usually 100 kilohms or more. But as soon as a channel is turned on, the load is charged through the relatively small channel resistance. This reduces the multiplexer-switch time constant, but the time constants in the control circuits still must be much smaller for the ΔV_{out} expression to be correct.

The time constants are important for another reason, too—they indicate how often the multiplexer can switch from one channel to another. This maximum switching speed depends on how long it takes the output to settle to the signal voltage each time a new channel is turned on. The settling time, in turn, is a function of the switch's time constants.

The time constants associated with the change from both channels off to one channel on can be calculated from the equivalent circuit on page 155. For an abrupt change from V_{S2} to V_{S1}

$$V_{out} = (V_{S1} - V_{S2}) \times \left[1 + \frac{1}{\tau_1/\tau_2 - 1} e^{-t/\tau_2} - \left(1 + \frac{1}{\tau_1/\tau_2 - 1}\right) e^{-t/\tau_1}\right]$$

The time constants are defined in the box on page 154. When R_{S1} is much smaller or larger than R_{on}, the time constants reduce to simple expressions. For $R_{S1} << R_{on}$

$$\tau_1 = R_{on} C_2$$
$$\tau_2 = 0$$

and for $R_{S1} >> R_{on}$

$$\tau_1 = R_{S1} (C_1 + C_2) \qquad (4)$$

$$\tau_2 = R_{on} \left(\frac{C_1 C_2}{C_1 + C_2}\right) \qquad (5)$$

Imagine 30 volts on the gates of a 3701 multiplexer switch, with $C_{DG} = 1$ pf, $C_2 \approx C_{out} + C_L = 20$ pf, $C_1 \approx C_{S1} + C_{in} = 5$ pf, and $R_{S1} = 5.1$ kilohms. R_{S1} is much larger than the R_{on} of 300 ohms. Then the change in output voltage as channel 1 is switched on, with channel 2 remaining off, is

$$\Delta V_{out} = \left(\frac{1\text{pf}}{20\text{pf}}\right) 30\text{v} = 1.5 \text{ volt}$$

according to equation 3. The time constants, from equations 4 and 5, are $\tau_1 = 124$ nsec and $\tau_2 = 1$ nsec.

These calculated values compare fairly well with those from an oscilloscope trace, reproduced left, in which ΔV_{out} is about 2 volts, τ_1 is about 200 nanoseconds, and τ_2 is too small to read. The voltage changes aren't usually as abrupt, but when they are it's a good idea to allow a brief interval, as shown, between changes of state to prevent a short-circuit between the two signal voltages.

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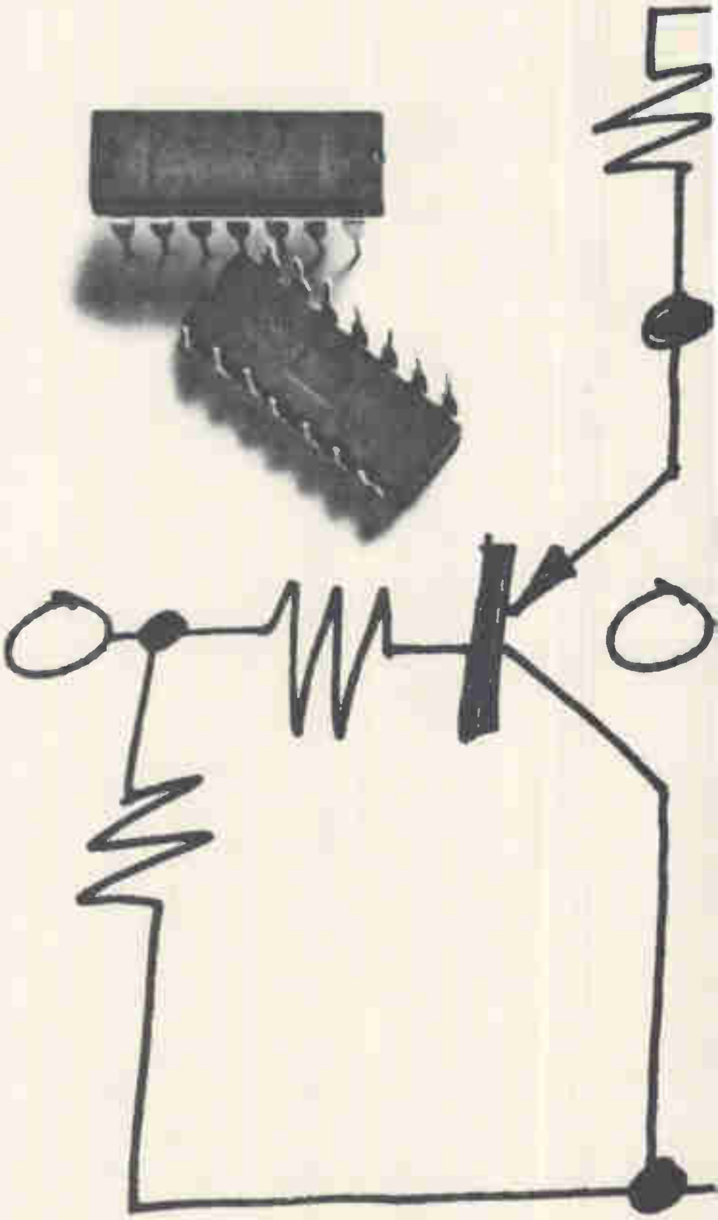

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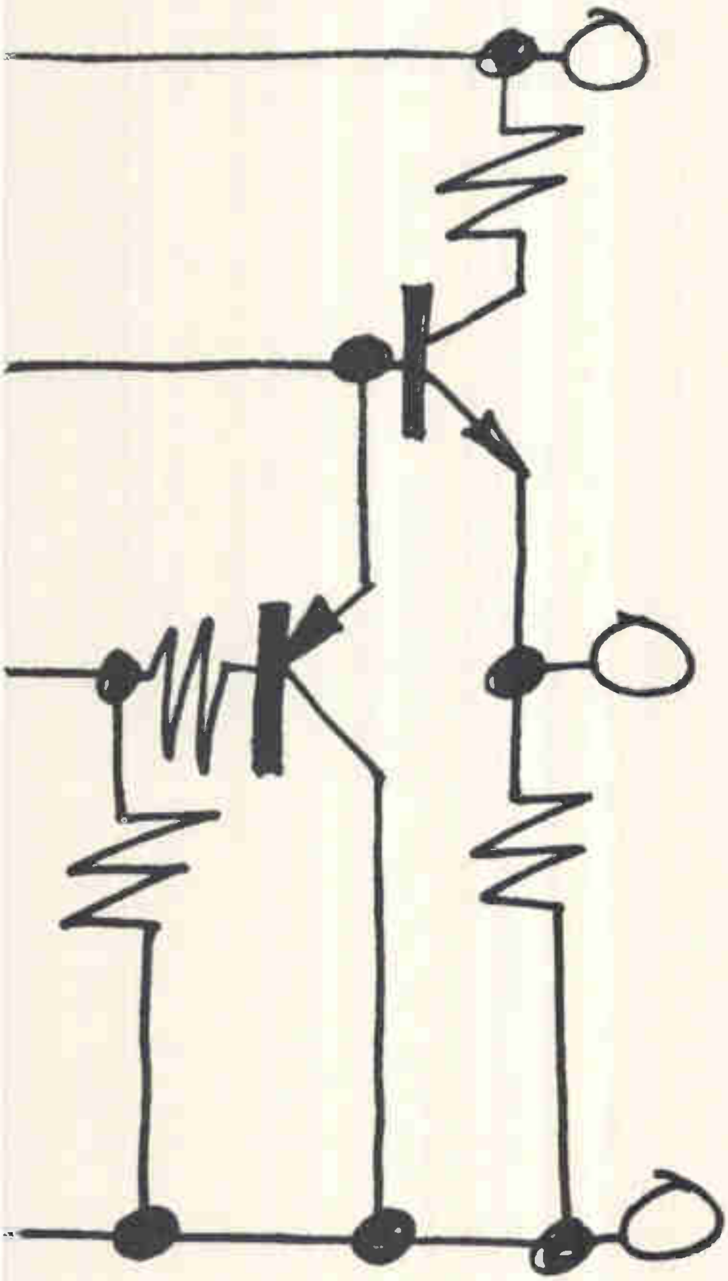

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9967 JK Flip-flop	2.00
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9971 Quad Two-input AND Gates with OR-tied pairs	1.25
9972 Quad Two-input AND Gates, one pair with OR-tie	1.25

If you want CTμL-II in sample quantities, call Fairchild. If you want standard CTμL in production quantities, call a Fairchild distributor. He has everything you need to build any computer. Even a Computer.

FAIRCHILD
SEMICONDUCTOR

Fairchild Semiconductor / A Division of Fairchild Camera and Instrument Corporation / 313 Fairchild Drive, Mountain View, Calif. 94040 (415) 962-5011 / TWX: 910-379-6435

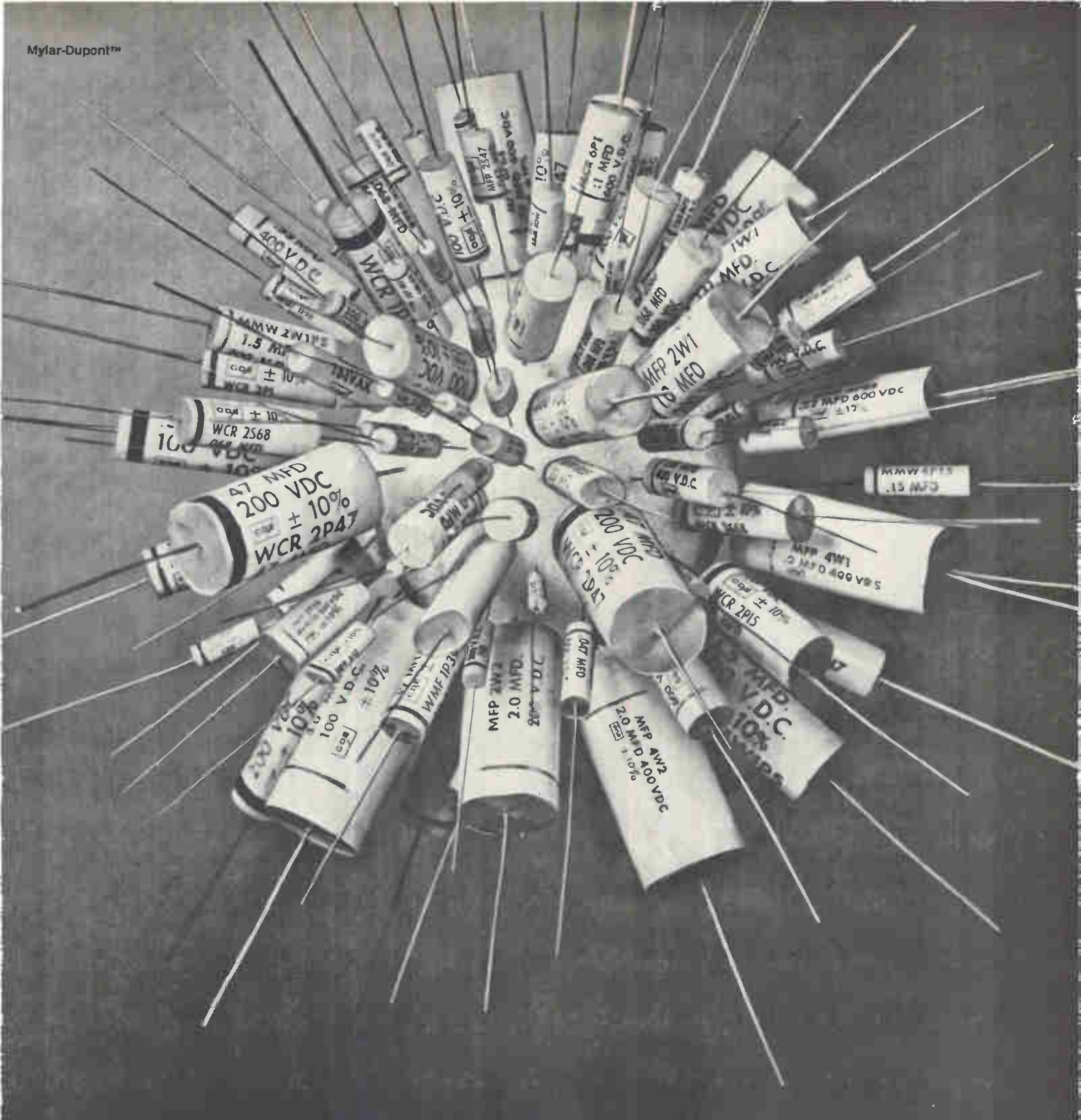
# of LSI admits there's another way:

Circle 159 on reader service card

 Circle 160 on reader service card

Circle 161 on reader service card→

Mylar-Dupont™



The wrapped tubular explosion!

When you think of wrapped mylar capacitors, you naturally think of Cornell-Dubilier. Over the years, our type WMF has become an industry standard.

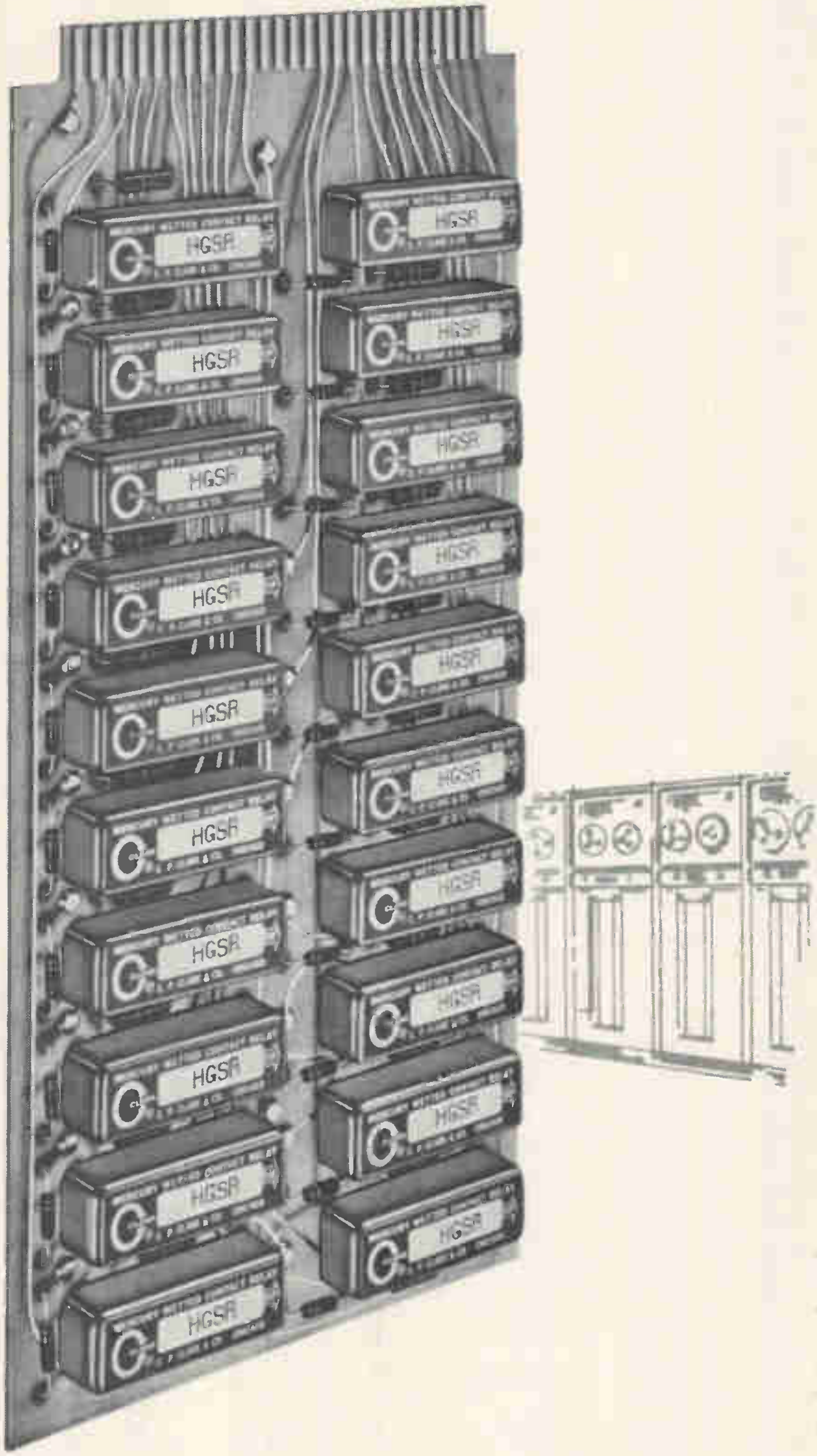
But our wrapped mylars are just a small part of the biggest selection of wrapped tubular capacitors made. The CDE line also includes type MFP pressed mylars, military grade type CTM mylars, type MMW metallized mylars and two brand new types. WCR polycarbonates and MCR metallized polycarbonates.

All are SPRINT stock standards. All are available through CDE's Authorized Industrial Distributors.

CDE CORNELL-DUBILIER

CLARE / Optimity in control

lowest profile—smallest over-all mercury-wetted contact relay



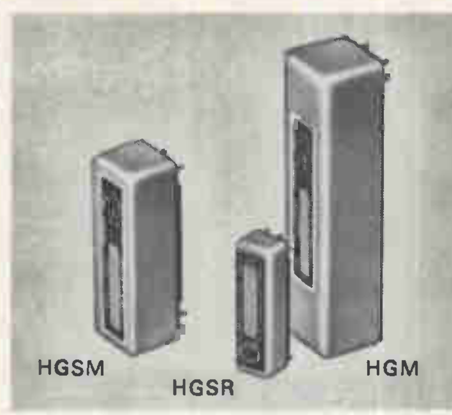
The Clare HGSR (only .33 cu. in.) puts more switching capacity on a board than ever before possible with long life mercury-wetted contacts.

It's fast and tough—serves most process control operations . . . provides over 22 billion operations without fail or falsing. And like the widely recognized Clare HGM and half-size HGSM, it provides a combination of high speed and low contact noise generation . . . the elimination of contact bounce and chatter and resulting false signalling. Advanced circuits can be designed with power gain up to 5000 . . . sensitivities as low as 20 mw. For solid state buffering, you get built-in input/output isolation . . . for measurement circuitry, minimal contact resistance, constant over billions of operations.

For complete information, circle reader service number—ask Clare for Data Sheet 855C . . . Write Group 11N8

C. P. Clare & Co., Chicago, Illinois 60645 . . . and worldwide.

a GENERAL INSTRUMENT company



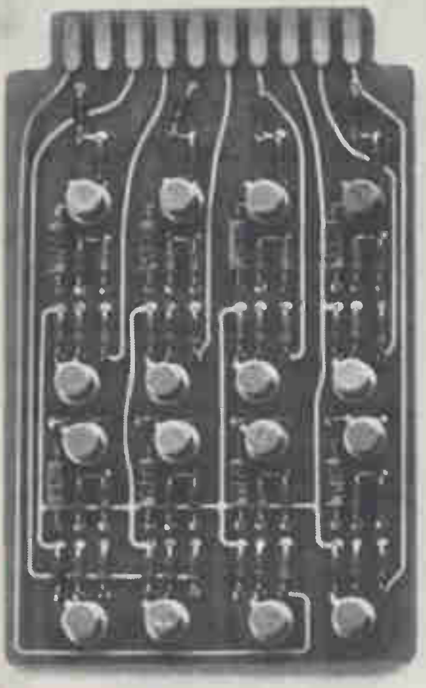
- Life: 22×10^9 operations—with no maintenance
- Low, constant contact resistance —no mechanical wear or electrical erosion
- No contact bounce
- Switching speeds to 1 ms
- Versatile contact load capabilities —low level to 250 va
- High power gain—to 5000 with no noise sensitivity
- Sensitivities as low as 20 mw

CLARE MERCURY-WETTED CONTACT RELAYS

for input analog switching, output power conversion switching, solid state input and output buffering

What is small, has stripes, and shrinks boards?

New CORNING® C3 Resistor.



16 transistors
8 capacitors
52 C3 resistors
Actual size

16 transistors
8 capacitors
52 RL07 resistors
Actual size

Now you can get 1/8 watt in a clean lead length of .150″ and diameter of .066″ maximum. That means a 35% reduction in board size for these eight Schmitt trigger circuits. Plus the proven stability of glass tin oxide film construction.

Put more circuit in the same space.
Or put the same circuit on a smaller board.

For specs and samples, write to Corning Glass Works, Electronic Products Division, Corning, N. Y. 14830.

CORNING
ELECTRONICS

Very few capital equipment requests can be accompanied with a 1½ year payback expectation. If your firm constantly strives to reduce its overhead and increase the quality and efficiency of its operation, be sure your drafting department has evaluated the Mergenthaler DIAGRAMMER—an automated push-button drafting system. Users have experienced increased output of better than 4 to 1 over manual methods—30 to 1 when drawing data is furnished in digitized form—plus receiving superior, "better-than-inked" quality that is geared to the requirements of today and tomorrow's information storage, retrieval and data transmission systems. For DIAGRAMMER details and user payback testimonials, contact Automated Drafting Systems, Mergenthaler Linotype Co., a Division of ELTRA Corporation, 300 East 42 Street, New York, N.Y. 10017. Tel.: 212-661-5615; TWX 710-581-3385.

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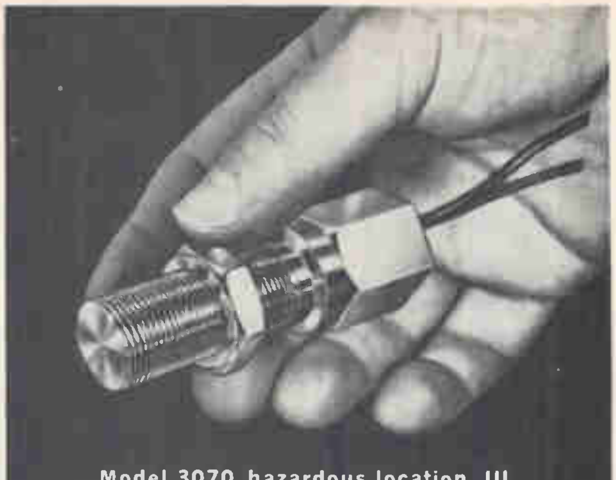
THE DIAGRAMMER by Mergenthaler

the total graphic arts company

If you have speed control or detection problems check out these versatile



Model 3070 hazardous location, UL listed magnetic pickup. Has 18" leads; mounts in ¾"—20 threaded hole.

ELECTRO Magnetic Pickups...

Take a look at the list at the right. It covers just a few of the many applications in which ELECTRO's magnetic pickups are being used. What's your problem? Positioning? Speed detection? Speed control? Timing pulses?

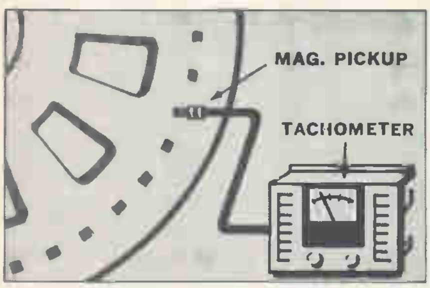
Maybe you can do it better—more economically with a magnetic pickup. Our electronic engineering specialists will help you determine if an ELECTRO magnetic pickup can supply an economical solution.

Write for a magnetic pickup data portfolio.

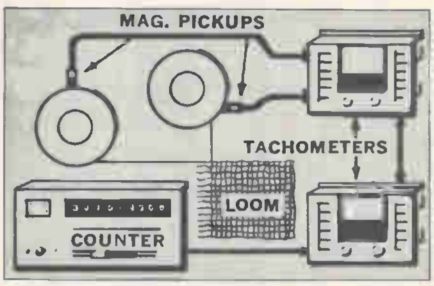
Model 3080 world's smallest standard magnetic pickup. 10-32 thread x ½" long, weighs only .05 oz. Up to 10V p-p output.

ACTUAL SIZE

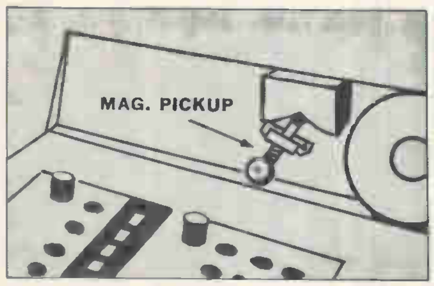
- **As a substitute for standard tachometer generator**
- **High speed printer roll sync and servo control**
- **Up-to-speed indication for drum memory**
- **Sector sync signal for disk memory**
- **Machine gun performance**
- **Analog electromechanical computer test probe**
- **Speed control servo for message tape recorder**
- **Remote water meter indicator and control**
- **Aircraft generator bearing check**
- **Diesel engine speed control**
- **Differential speed measurement**
- **Tapping machine control**
- **Molding machine speed indication**



Speed Control on Diesel Pumping Engine: Contact tachometers proved inadequate primarily because there are so few places to connect them. A magnetic pickup and Electro-tach (with the addition of a 73.163 Pulse Adaptor) sensing a series of holes on the rim of the flywheel, proved to be the solution.



Differential Speed Detection: Needed was a close check on the speed differential of two sections of a textile machine—to assure the proper stretch to the yarn. Magnetic pickups mounted to sense a gear in each section provided a direct reading of the difference in rpm and a percent of the speed differential.



Precise Position Control: A computer for desk top use demanded exceptional ingenuity in space saving simplification. A magnetic pickup sensing a ferrous set screw on a rotating 20-character print wheel provided a simple logical control of its position and eliminated the need for complex positioning apparatus.

Pioneers in Electronic Sensing and Control.
Electronic Tachometers—
Dynamic Micrometers—
DC Power Supplies—
Magnetic Pickups.
Proximity Switches.

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MAGNETIC PICKUPS

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How do most companies move a lightning-fast, long-memory, high-capacity computer?

They choose an on-time, precision-planning, big-capacity van line.

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Circle 167 on reader service card

10*
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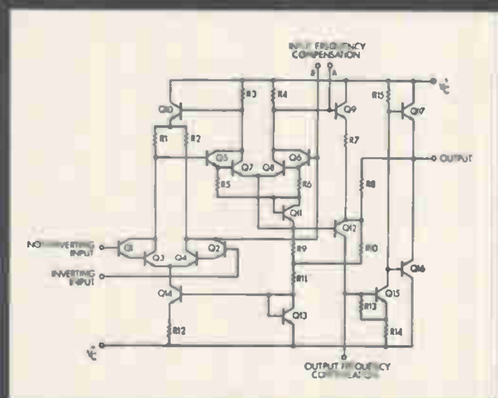

At last – an IC chip that outperforms many discrete op amps

Z_{in} = 10 megohms
I_{BIAS} = 10 nanoamps
I_{OFFSET} = 2 nanoamps
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OTHER LINEAR IC's AVAILABLE . . .
Standard 1709, 1710 and 1711 series, plus a sense amplifier series and a high sink current dual output 1711, fully compatible with HLTTL drive requirements.

***TOA7809 available with Z_{in} guaranteed as high as 50 megohms.**

You know the 709-type amplifier. Dependable. Versatile. A regular chip-of-all-trades.

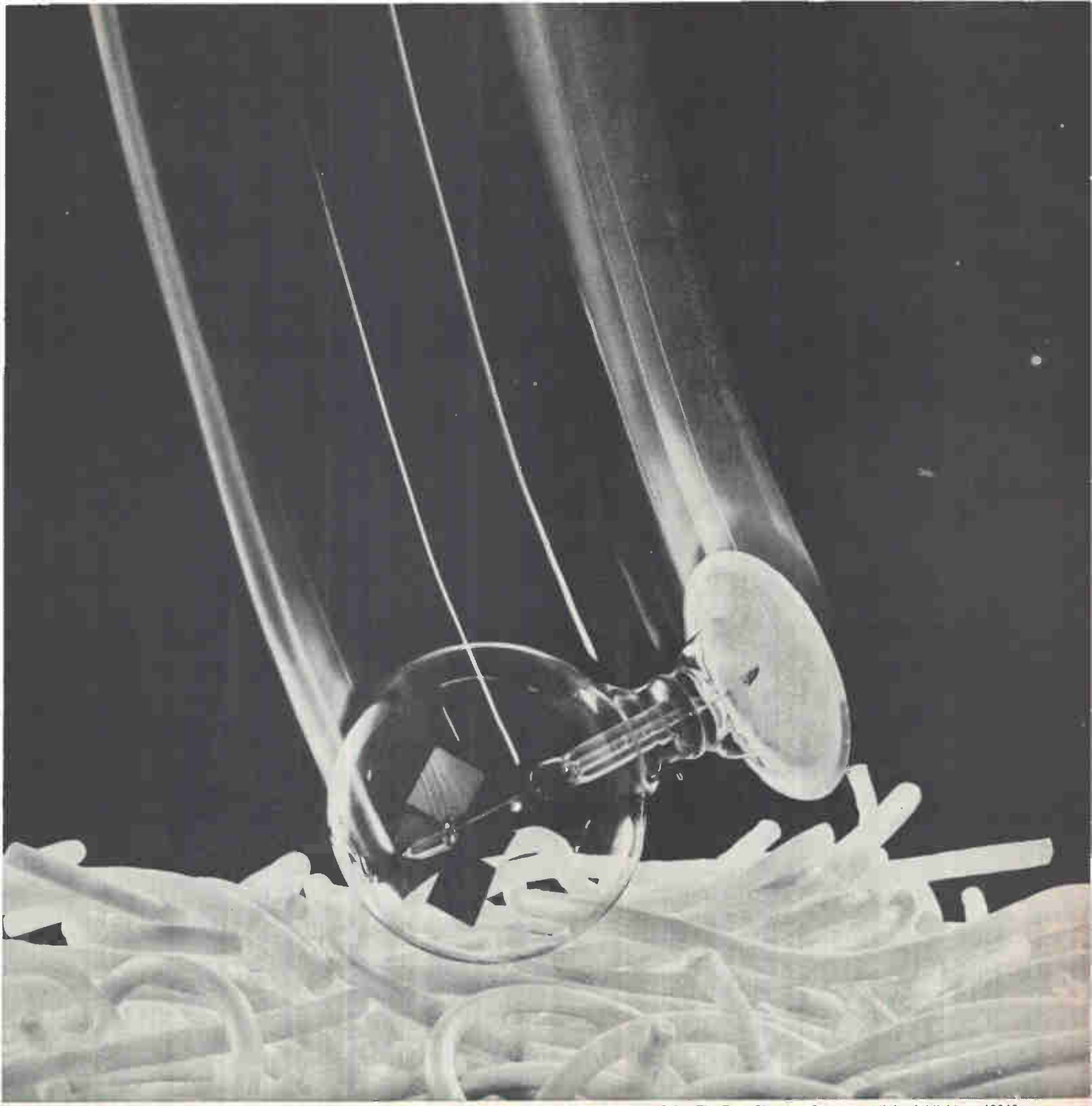
You also know its limitations.

Even while designing it into a circuit, you have probably found yourself thinking, a bit wistfully, of the input characteristics provided by a few of the more expensive discrete op amps on the market.

Now, you can get premium "discrete" performance in a 709-type chip, at a 709-type price. Here . . . today . . . on our shelves is the TOA7709 — eminently suited to direct, plug-in replacement of standard 709-type units — but with unprecedented input characteristics which can greatly simplify new-circuit design. A Darlington-connected input provides an impedance of 10 megohms, and offset and bias currents of 2 and 10 nanoamps respectively.

A commercial version, the TOA8709, provides a 3-megohm impedance, with offset and bias currents of 6 and 30 nanoamps — still a whale of a lot better than any other IC op amp around. Either unit is available in the 8-pin TO-5, 10-lead flat pack or 14-lead dual in-line package.

Transitron
electronic corporation
168 Albion Street, Wakefield, Massachusetts 01881



Packaging Sales, The Dow Chemical Company, Midland, Michigan 48640.

Try this on your fragile parts.

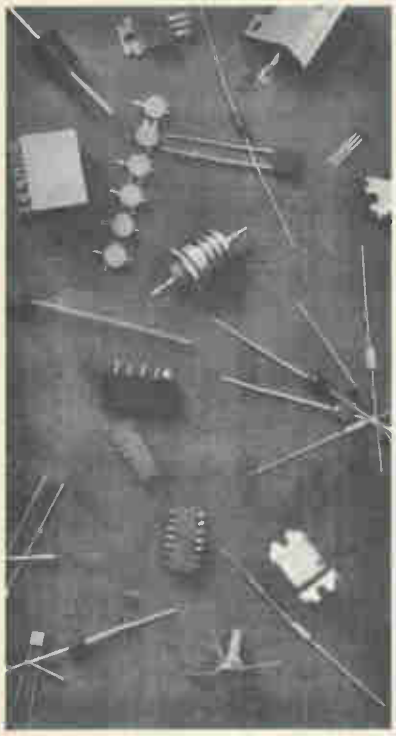
Pelaspan-Pac® loose fill packing. It weighs 3 to 6 times less than most other dunnage. It won't absorb water. It cuts shipping losses. Because it's highly shock-resistant, and it interlocks to prevent settling. It cuts cleanup, too. Because it's clean, nondusting and noncorrosive. Write for details.

DOW

Circle 169 on reader service card


NEED A SOLENOID WITH REAL MUSCLE
...OR ONE WITH VERY LITTLE PULL?

When your IC bugs out, chances are the heat's on!



Devices packaged in Dow Corning® silicone molding compound are physically and electrically stable—even after long term exposure to both high heat and humidity. Derating, a practice common with organic packaging, is not necessary. In fact, you can design for high device and component density by using silicone molding compound. One manufacturer of glass package power diodes reduced the part to 1/30th of its former volume. Sizes from 1/5th to 1/3rd smaller can be obtained by using silicone molding compound in place of other plastics.

Little moisture absorption. Silicone molding compounds when exposed for 1000 hours to 93% RH at 70 C showed an average weight increase of 0.32% with the greatest increase being 0.5% and the least being 0.17%. Five organic plastics had average weight increases ranging from 1.0 to 2.1%—an average of nearly five times greater than silicone molding compounds under the same test conditions.

No cracking. Unlike other thermal setting plastics, Dow Corning silicone molding compounds are virtually unaffected by thermal shock. For example, a power resistor molded in Dow Corning® 307 compound was cycled repeatedly from —65 to 350 C without damaging the packaging material or the component.

Will not burn. Silicone molding compounds are inherently nonburning. Thus, components and devices packaged in silicone molding compound do not constitute a fire hazard. No flame snuffers are used—a source of ionic contamination for devices packaged in organic materials.

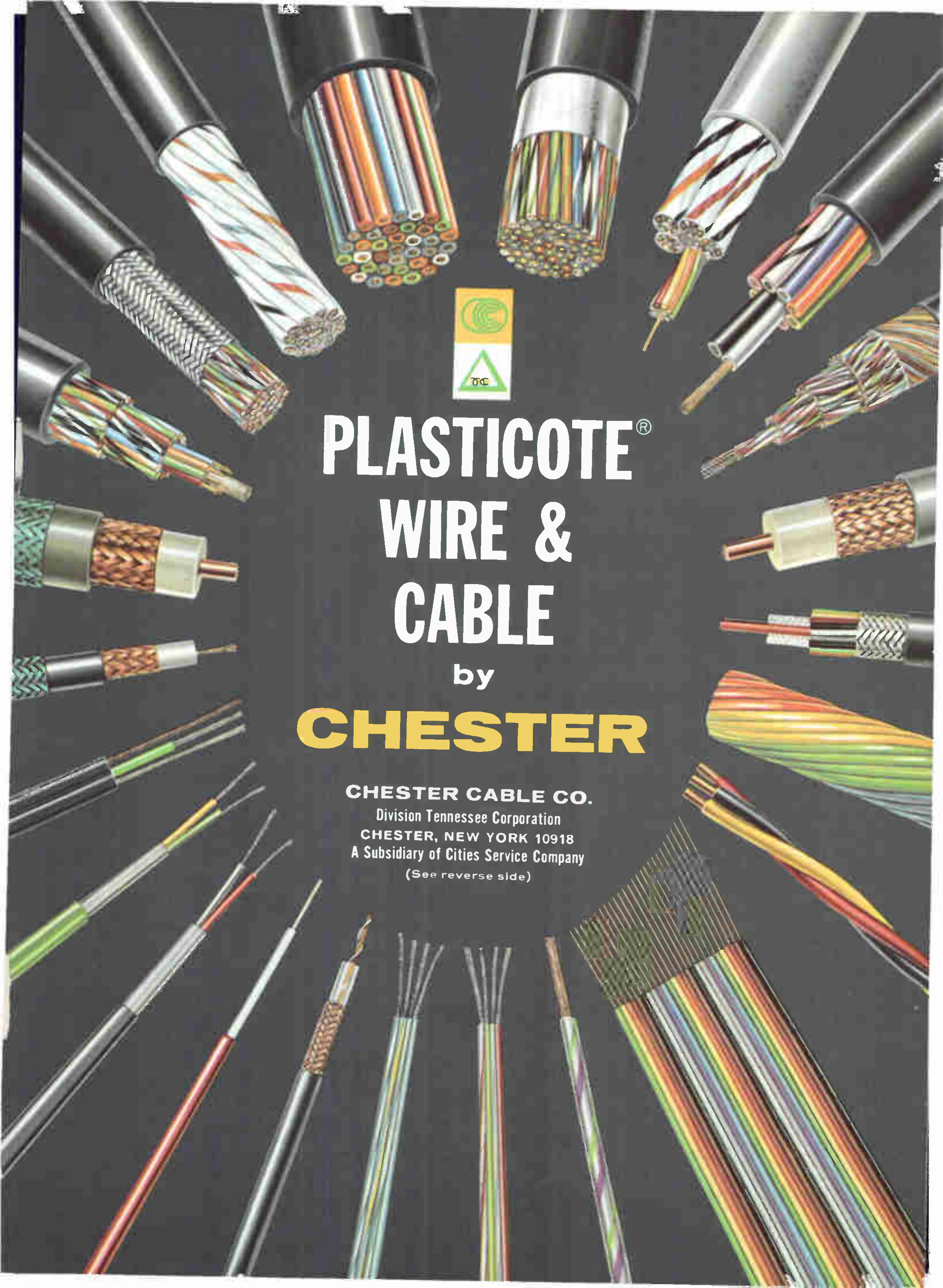
Corrosion free. These silicone molding compounds are free of ionic contaminants which may contribute to metallic corrosion when operating in high humidity and influenced by voltage bias.

Competitive price. Costing only a fraction of a cent per device, Dow Corning silicone molding compounds enjoy a substantial price advantage over metal cans . . . glass packages.

Manufacturing economies. Transfer molding enables manufacturers to package devices and components with a minimum of manual labor and supervision. Good mold release and minimum flash assure high production rates . . . reduced deflashing costs. These manufacturing advantages make silicone molding compounds totally competitive with organic plastics.

So why be bugged by device failures because of a cheap plastic package? Specify Dow Corning® brand silicone molding compound, and get the best package protection in your electronic equipment . . . lets you keep your cool. For technical data, write: Dept. A-8472, Dow Corning Corporation, Midland, Michigan 48640.

DOW CORNING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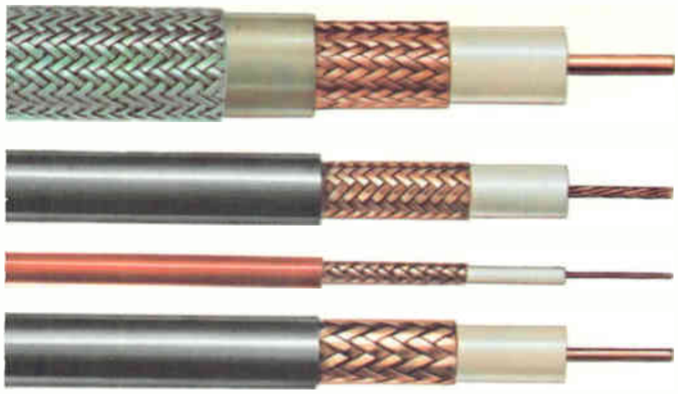
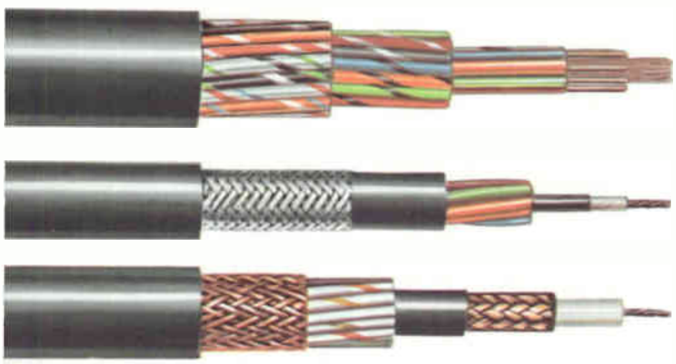
A Subsidiary of Cities Service Company
(See reverse side)



COAXIAL CABLE — Chester Cable Corp. offers a complete line of coaxial cable for military and commercial applications. Manufactured in accordance with MIL-C-17, JAN-C-17 and commercial specifications. Constructions include solid, air-spaced and foam dielectrics with conventional braid shields or flat copper tape shields, having PVC or polyethylene jackets. Custom designed constructions of triaxial cable and high frequency-high voltage cable are also available.

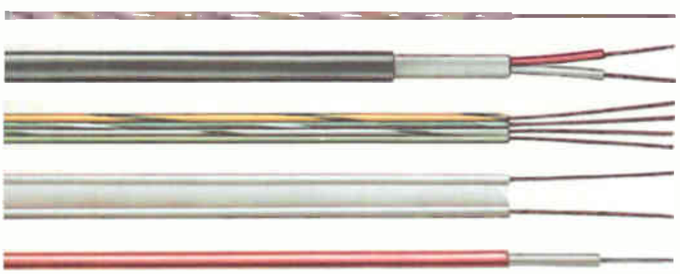


MULTI-CONDUCTOR CABLE — Wide range of custom designs available, manufactured in accordance with such industry standards as MIL specs., U/L, CSA, IPCEA, EIA, IMSA, ASTM, etc.

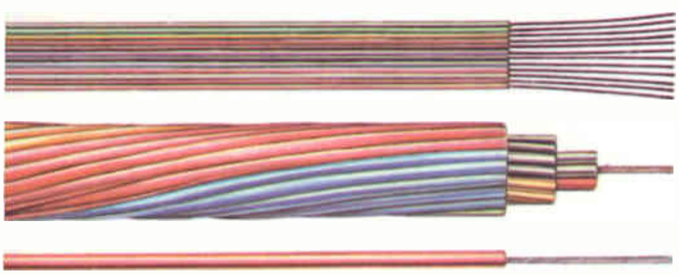
Chester Cable Corp. is a preferred source for quality electronic and electrical cable, insulated and jacketed with thermoplastic materials such as polyvinylchloride, polyethylene and nylon. Custom designs of shielded or unshielded cable include: Control Cable · TV Camera Cable · Missile Cable · Intercom Cable · Computer Cable · Special Hi-Voltage Cable and Parallel Bonded Ribbon Cable.

MIL-SPEC WIRE — Made in accordance with specifications MIL-W-16878 (Types B, C & D), MIL-W-76B (Types LW, MW & HW) and MIL-W-5086A for electronic systems. Available in single or multiple constructions, shielded or unshielded, with or without nylon or PVC jackets.

WIRE AND CORD FOR THE APPLIANCE INDUSTRY — U/L and CSA approved, 60°C — 80°C — 90°C — 105°C appliance wiring material — SVT, SJT, ST cord, SJTO & STO oil-resistant cord, SJT & ST oil-proof cord, SPT cord with or without individually insulated ground wire. Used for washers, dryers, refrigerating, air conditioning, vending, heating, X-ray and other electrical and electronic equipment.



RADIO AND TV CIRCUIT WIRE AND CABLE — U/L and CSA approved, 60°C — 80°C — 90°C — 105°C appliance and radio circuit wire, microphone cable, shielded and unshielded audio circuit wire, twin lead antenna wire, phonograph cable, parallel-bonded color convergence ckt. cable, braided hook-up wire, hi-anode wire, hot chassis lead, balun-coil wire, shielded constructions with spiral, braided, aluminum-Mylar tape and conductive materials; all available in Thrif-T-Bond® tinned over-coated conductors.



MISCELLANEOUS WIRE AND CABLE—Machine Tool Wire · Bus Drop Cable · Flexible Test Lead Wire · Municipal Signal Cable · Low Energy Circuit Control Cable · Station Control Cable · Inter-Office Communication and Signaling Cable · Deep-Well Submersible Water Pump Cable · Gas Tube Sign and Oil Burner Ignition Cable · Intercom Cable · Gasoline and Oil Resistant Wire · Computer Cable · Uninsulated Bus Wire · Parallel and Jacketed Cord · Braided Ground Strap, and special custom designed cable for your applications.

Write or phone for further information

CHESTER CABLE CO., Division Tennessee Corporation, **CHESTER, NEW YORK 10918**

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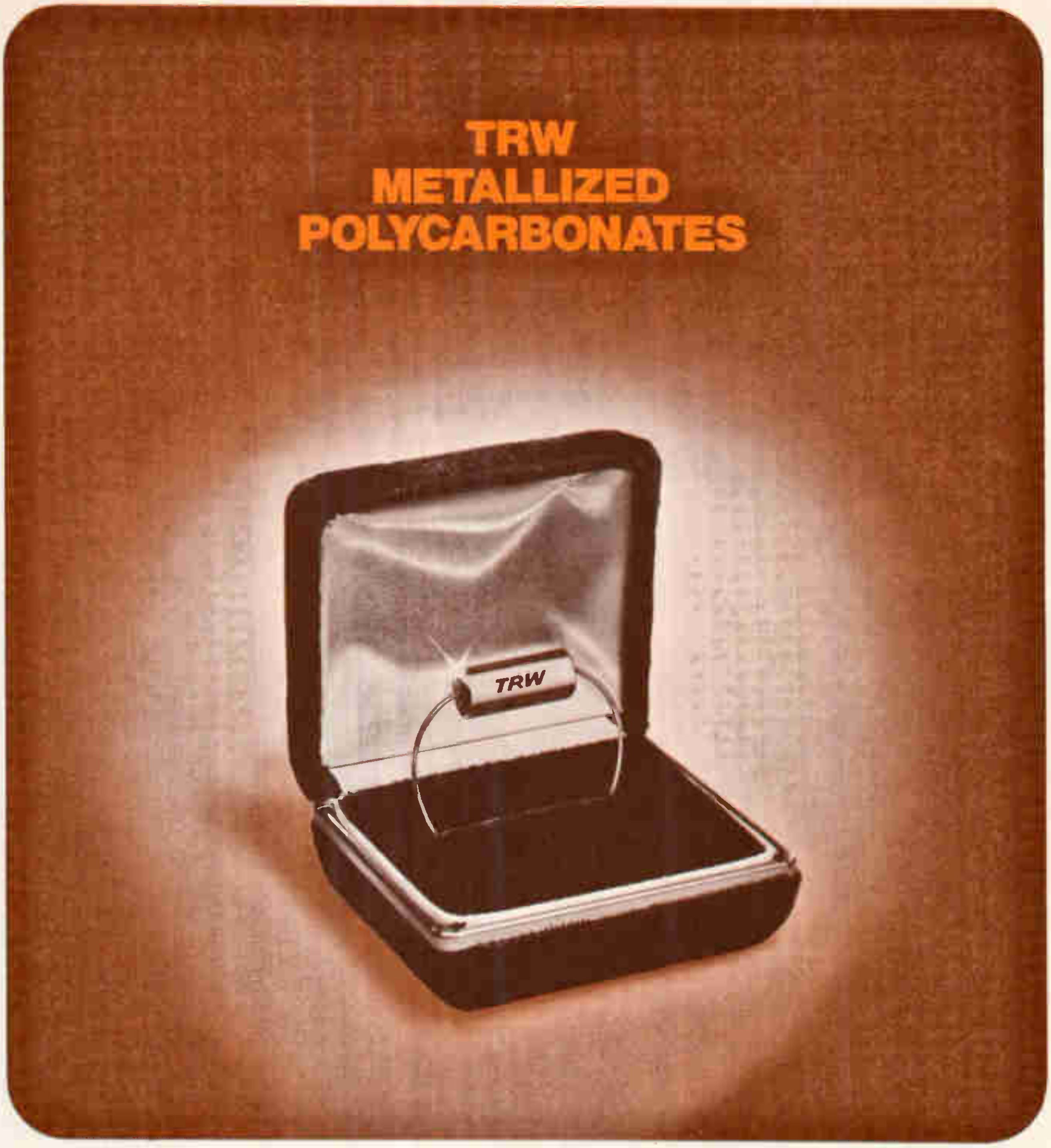

...good things come in small packages

A 10 mfd 50 volt type X483 capacitor measures a scant .670" x $1\frac{13}{16}$". It's hermetically sealed and provides outstanding temperature stability and electrical properties. Meets all MIL-C-18312 and MIL-C-19978 requirements.

Type X483 are advanced technology capacitors tailor-made for advanced technology applications. Values from .001 to 10 mfd, 50, 100, 200 and 400 volt.

Contact TRW Capacitor Division, Box 1000, Ogallala, Neb. Phone: (308) 284-3611. TWX: 910-620-0321.

TRW®

← Circle 174 on reader service card

Circle 175 on reader service card

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You could build mountains out of our logic cards... if you had to
We've got that many. And you could build different kinds of mountains, too. We've got just that product line versatility. Build T²L SUHL I mountains, or T²L SUHL II mountains, or DTL mountains, or 7400 T²L mountains. We can supply enough for you to go as high as you want. And building mountains is a nice way to look at how our micrologic circuit cards are applied. But if you don't want to think in terms of mountains, you can build mole hills, too.
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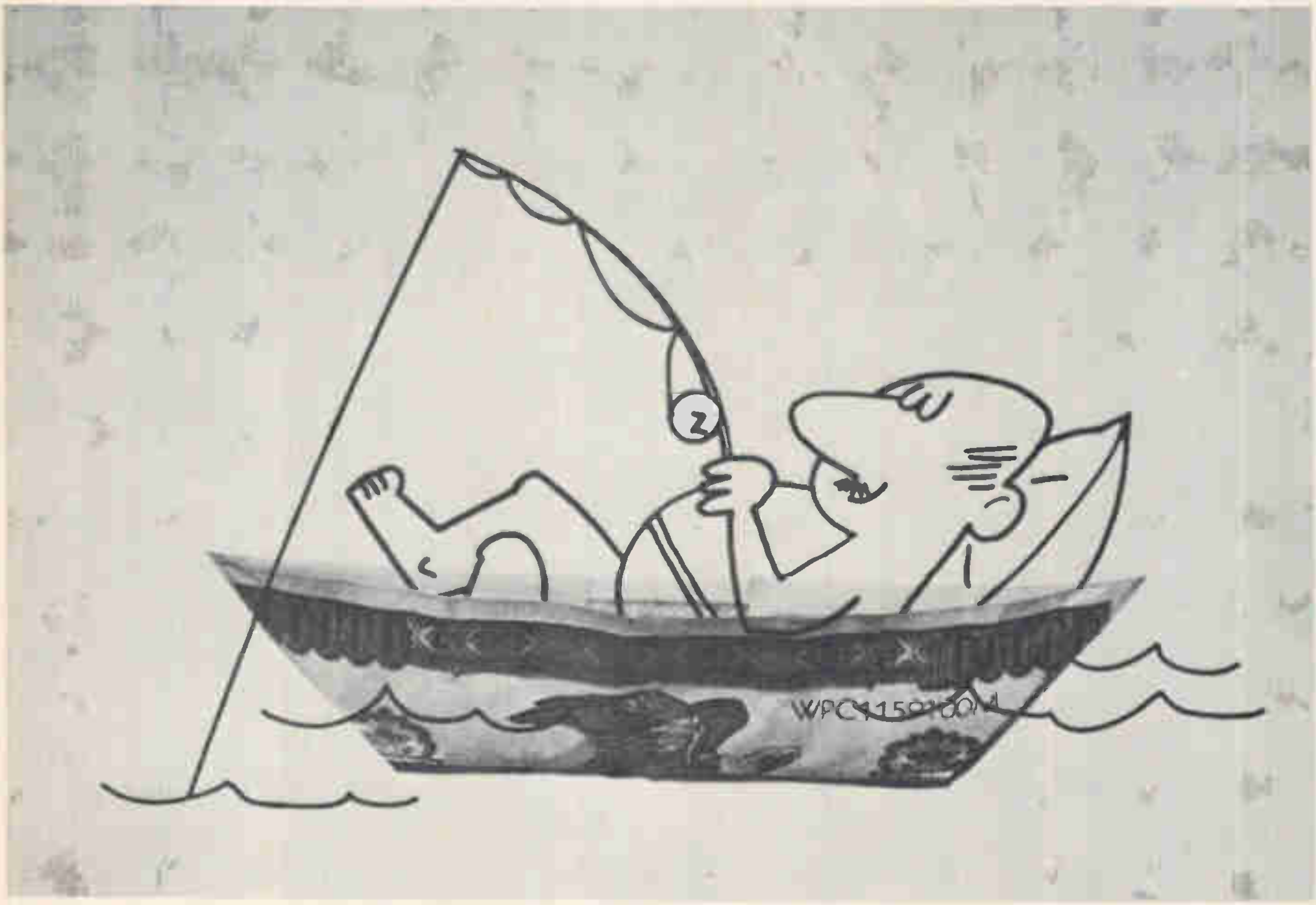
BIN/BCD COUNTER

It's nice to have enough money to retire on.



It's also nice to be around when it's time to retire.

You want to save a nest egg to retire on? Fine. All we suggest is that you be here to enjoy it. What to do? See your doctor for a thorough health checkup once a year, including a procto. And for women, also a Pap test. In short, the works.

Because most cancers are curable if spotted in time. But your doctor won't be able to spot anything—unless you give him the chance.

If you do, you'll improve your chances of enjoying your retirement. To a ripe old age.

american cancer society

THIS SPACE CONTRIBUTED BY THE PUBLISHER AS A PUBLIC SERVICE

SCIENCE/SCOPE

The world's largest communications satellite -- a two-story-high, 1600-pound experimental giant designed to provide tactical communications among military units in the field, aircraft, and ships at sea -- is being built under direction of the U.S. Air Force for the Department of Defense by Hughes.

Satellite will carry a cluster of antennas whose powerful signals can be picked up by all types of terminals, including those with antennas as small as one foot in diameter. Satellite's communications capacity is comparable to 10,000 two-way telephone channels.

The Army's TOW missile is under consideration by the U.S. Marines as a result of combat-style tests they recently gave the wire-guided antitank weapon. A Marine unit at the Twentynine Palms Marine Base fired 20 TOW missiles, blasting concrete fortifications, sandbag bunkers, tank hulls, and moving targets.

All a TOW gunner has to do is hold the crosshair of the telescopic sight on a target; the missile is automatically steered to impact on that point. After a half-hour of instruction, Marines scored bullseyes on small, distant targets.

A new radar unit to aid ballistic missile defense has been installed on Kwajalein Atoll in the Marshall Islands. The experimental system, designed to help the Defense Department develop technology for protection against ballistic missile and satellite attack, will make high-resolution measurements of various targets, both in outer space and during reentry into the atmosphere. System's 40-foot-diameter parabolic antenna and microwave subsystem were built by Hughes.

Environmental testing is now available to component subcontractors at the six-story, 17,000-square-foot Hughes test center used for Surveyor spacecraft, Intelsat and ATS satellites, and Phoenix and TOW missiles. Eight thermal vacuum chambers, ranging in size from 18x20 inches to 15x36 feet, can duplicate the radiation of sunlight in deep space and the temperatures of lunar day and night. Vibration tests are performed on two 28,000-force-pound shakers, each equipped with a separate control console.

The 30-foot parabolic antenna atop the 12-story Hughes space systems division building adjacent to Los Angeles International Airport is converting signals from two Applications Technology Satellites into pictures of cloud formations and jet streams. Photos are received as part of a research program Hughes is conducting for the Environmental Science Services Administration.

The spin-scan cameras aboard the ATS satellites take a picture of Earth every 20 minutes when weather scientists want to track a storm. Of particular interest to them have been the ATS-3 photos of the Midwest during the 1968 tornado watch. The ATS satellites were built by Hughes, their cameras by Santa Barbara Research Center, a Hughes subsidiary.

For high speed harnessing with continuous lacing...

HERE IS THE WORK SPEEDING - MONEY SAVING -

GUDEBROD SYSTEM "C"

GUDEBROD FLAT TAPE BOBBINS—This special packaging of Gudebrod Flat Braided Lacing Tape is highly popular in the harness shop. Whether used in all hand tying or with the Cable-Lacer (for which it was designed) the bobbin makes conveniently available, high quality Gudebrod Tape in most of its many types—all engineered to lie flat, tie tight.

GUDEBROD CABLE-LACER®—This unique harnessing hand tool has proved a production speeder and harness improver. Makes up to 30 knots per minute. While making firmer harnesses with tighter, more uniform knots, it eliminates wear and tear on operator's hands because special brake takes strain of knot setting. Holds bobbin of Gudebrod Tape in handle.

LONGER WIRE HOLDING PINS—They make wire threading much easier, quicker (no repeated wire redressing between pins). In harness tying they preserve the layout while using the Gudebrod Cable-Lacer. Special case hardened pins, nail better, stay straight, no nailheads.

GUDEBROD SWIVEL-TILT HARNESS BOARD MOUNT—Two dimensional balanced mobility puts every section of the cabling within easy, natural reach of the operator. Work done in this unstrained manner goes faster, is better, all day through.

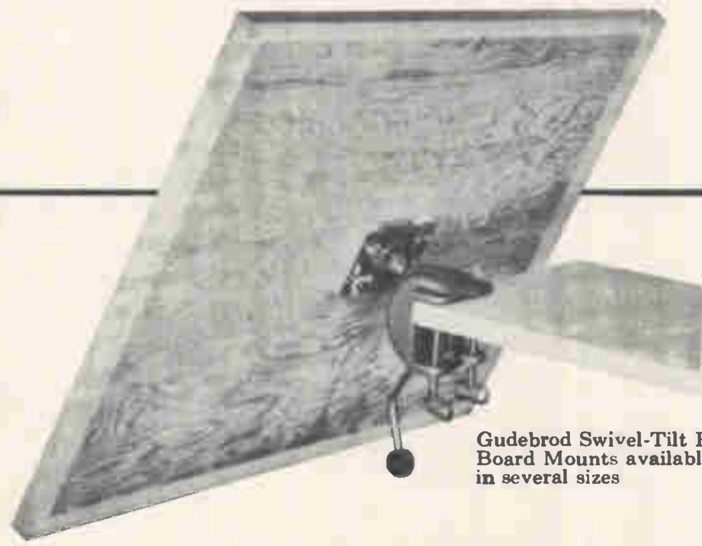
There it is, the Gudebrod System "C" solving the cable making problems in a speedy, economical, profit improving way. Ask about System "C" (If you use intermittent tying, ask about Gudebrod System "S").

Gudebrod's Special, Longer Case Hardened Pins

®T.M.—UNION SPECIAL MACHINE CO.

GUDEBROD

Electronics Division



Gudebrod Swivel-Tilt Harness Board Mounts available in several sizes

GUDEBROD BROS. SILK CO., INC. Founded 1870, 12 South 12th Street, Philadelphia, Pa. 19107

product report
digital instruments

Automate Your Measurements . . .

. . . with these NEW Tektronix products.

NEW NEW

Digital Oscilloscope

The Type 568/230 Digital Oscilloscope System provides digital readout of measurements that are displayed in analog form on the CRT. They enable the engineer, technician or production worker to make dynamic switching-time measurements with greater speed, convenience and repeatability than is possible by making measurements directly from the cathode-ray oscilloscope display. Typical measurements include pulse voltages, risetime, falltime, delay time, storage time, pulse width and many other specific measurements.

With the NEW programmable plug-in units and Sampling Heads, all of the measurement functions of the Type 568/230 can be externally programmed for use in high-speed automated measurement systems. The Type 568/230 can make more than 100 dynamic measurements per second, and data output connectors provide measurement results in convenient BCD code. Programming is easily accomplished with the use of new Tektronix Program Units.

Type 568/230/3T6/3S6/S-1/S-1 .... $7340

Automatic Measurements

NEW Type 241

Add the NEW Type 241 Programmer to the Type 568/230 Digital Oscilloscope and obtain up to 15 automatic measurements. The Type 241 will automatically sequence through 15 programs, stopping on out-of-limit measurements. Programs are easy to setup and change, enabling a person having minimum training to program the Type 241.

Type 241 .... $1950

NEW Type 240

The NEW Type 240 Program Control Unit and NEW Disc Memory program the Type 568/230 at speeds up to 100 measurements per second and provide local storage of 1600 independent measurements. Sorting, classifying and diagnostic test routines are also obtained using the Disc Memory. A Punched Tape Reader is used with the Type 240 in low-speed systems, providing a maximum of 6 measurements per second.

Type R240 .... $3800
Disc Memory $6600
Punched Tape Reader $1250

NEW Type R250

The NEW Type R250 Auxiliary Program Unit adds additional programming capabilities to the Type 240 and provides programming and buffering for pulse generators, power supplies and other equipment. System engineering and design is required with the Type R250. The NEW Type R116 MOD 703L and Type R293 MOD 703M Programmable Pulse Generators are designed specifically for use with the Type R250 in automated systems.

Type R250 .... $1400
6 Shift-Register Cards .... $ 420
Type R116 MOD 703L $2775
Type R293 MOD 703M $1300

U.S. Sales Prices FOB Beaverton, Oregon

NEW Tektronix Measurement Systems

Making the Measurement . . . . Tektronix Measurement Systems

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Electronics abroad

Mañana is today in Mexico

An amalgam of local and foreign interests, the nation's electronic industry enjoys excellent prospects in domestic markets and Latin American outlets

By Gerald Parkinson

Mexico City News Bureau

Mexico's electronics industry, with a big assist from Olympics-inspired communications projects, has established an excellent base for future growth. Right now, the field is still small by U.S. standards —1968 factory sales are estimated at $260 million, against $224 million last year—and most of its output is consumer goods. But the industry is 90% self-sufficient; television broadcasters have been transmitting in color for almost two years; the Latin American Free Trade Association (Lafta), of which Mexico is a member, has tremendous long-term potential as a market; and by the end of 1970, the country will have probably the best communications network south of the border [Electronics, April 1, p. 95].

The over-all outlook is for annual gains in the 10%-to-12% range during the period ahead as Mexico-based firms exploit not only relatively untapped domestic outlets but Lafta markets. Progress in computers, industrial products, and instrumentation will probably be slower than in other sectors because of the comparatively small local market and the high level of technology involved.

"The new communications and microwave network alone is bound to provide impetus for the electronics industry," says a local source. "There'll be a greater demand for skilled people and replacement parts that will upgrade education at all levels." The net is having other salutary effects. For one thing, a number of contractors, including Germany's Siemens AG, are studying the possibility of setting up plants in Mexico. For another, hitherto remote sections of the country are being opened up to telephone, television, and related communications services.

Consuming interest. Mexico's consumer electronics concerns, particularly tv set makers, are thriving. This year's output of television sets will probably reach 240,000—a 30% jump from the 1967 figure. Radio production will be around 1.15 million units, a 7% gain from last year's level, and some 125,000 hi-fi stereo sets will be made and sold, for a year-to-year gain of 10%.

One big reason for the dramatic growth in tv set sales is that customers had deferred purchases until color receivers came to market late in 1967. And Olympic Games broadcasts were also undoubtedly a factor. Finally, Mexico is the only Latin American nation producing color cathode-ray tubes. Sylvania set up shop there more than a year ago, and Electronica S.A., an affiliate of Holland's Philips, got started just recently. RCA and Mexico's Majestic Group also plan to open tube plants.

Their present output represents quite an improvement in set makers' fortunes. As recently as 1960, they were operating at an annual rate of under 100,000. But around that time, the Mexican government began to take an active interest in fostering the industry's development.

The government has several ways of protecting the interests of fields it would like to see flourish. When, for example, an established firm wants to make, say, a certain component, imports of that item are prohibited by the Ministry of Industry and Commerce. "As soon as someone starts a new operation here, he gets protection whether or not he asks for it," says an experienced local manufacturer of industrial goods.

The ministry also publishes

Cityscape. Microwave antennas top communications tower at Ministry of Communications in Mexico City.

periodic lists of products it feels should be produced in Mexico. The most recent compilation totals 500, including 34 electronic, electric, communications, and instrumentation items. The ministry offers incentives—tax exemptions, for example—to entrepreneurs investing in ventures to produce goods on the list.

In general, the government welcomes foreign investment. Certain industries are state-owned, others are 100% controlled by Mexican interests, and still others are encouraged to have at least majority control of the companies in the hands of nationals. So far, there are no hard-and-fast rules for electronics enterprises; each case is judged on its individual merits. Generally, however, the government enforces the policy of 51% Mexican ownership.

There is, however, no all-embracing Mexicanization law, or even a rigid policy. Most U.S. businessmen prefer it that way because it gives them bargaining room. One observer, familiar with the situation, says, "Mexicanization is a mixture of laws, decrees, and policies—shot through with exceptions—that's administered pragmatically."

Borderline cases. Another way in which the Mexican government encourages foreign investment is through its border industries program. This is not a way to develop industry integral to the economy; it's simply an arrangement whereby U.S. and other foreign companies can establish assembly plants on the Mexican side of the border. Many U.S. electronics firms have taken advantage of this program, under which parts are shipped across the border in bond, put together in the Mexican plant, then shipped out, usually as subassemblies. The output of these plants may not be sold in Mexico.

The advantage of this arrangement, from Mexico's viewpoint, is that it provides much-needed employment; for U.S. companies, it offers low-cost hand labor. In general, Mexicans are happy with the program. But Roberto Perez Rodriquez, general manager of the National Chamber of the Electronics and Electrical Communications Industry has some doubts. Perez points out that firms put plants on

Key element. Carrier signal center in communications tower is an integral part of Mexico's new microwave net.

the border largely because labor costs are low. If wages rise or conditions change, he feels, they are likely to move the plant elsewhere —perhaps to Taiwan—leaving the Mexican workers without jobs. "I think it would be more convenient for Mexico if these companies were to integrate more into the economy," he says. "Perhaps they could use some Mexican materials instead of importing everything."

The Burroughs Corp., for one, has already integrated an in-bond operation. At the same time it has built an assembly plant well away from the border in Guadalajara partly because labor costs on the border are now higher.

Burroughs may have started a trend by establishing an in-bond plant in the interior. Motorola Inc., which has one in Nogales, is now setting up another in Guadalajara.

Home cooking

Frontier plants are not exclusively U.S. operations. One all-Mexican group doing a lively components-assembly trade in Mexicali is the Majestic Group, one of Mexico's largest and most diversified organizations. Its border operation, Semiconductores California, is making integrated circuits for the Raytheon Co. and the Hughes Aircraft Co., cold cathode display tubes for the Raytheon Co., printed-circuit boards for Anaconda Electronics, and transistors for National Semiconductor.

Semiconductores California supplies these U.S. firms on a piecework basis. It also makes transistors for Majestic's Mexican plants and exports low-cost electrolytic condensers to the U.S.

Majestic, which started life as a radio assembly plant in 1947, now numbers 57 companies divided into three groups—components, assembly, and distribution. The group accounts for about 60% of Mexico's total radio production and turns out some 6,000 tv sets monthly. The current ratio is five black-and-white units for every color set, but this will narrow to two to one early next year, according to Victor Rivero, president. Annual sales are around \$32 million—comparatively large for a Mexican company. The company's tv production puts it up among the leading producers in Mexico, with Philips, GE, Philco, and Admiral.

Slow start. Majestic exports components to Lafta countries, but the trade association has been slow to get moving as far as the electronics industry is concerned. Representatives failed to ratify two proposed complementary agreements for electronic products at a recent meeting in Montevideo. Complementary agreements provide for tariff reductions on listed products in certain industries. The industries of Colombia, Peru, Chile, and Uruguay suggested a pact on 68 products, while Mexico and Brazil pushed one with 174.

The main reason for the breakdown in negotiations, according to a Mexican official, was that there was no consensus on how to deal with the "national origin" of materials used in listed products. In other words, a country might import all components at a low price from, say, Japan, then export at a low tariff rate to Lafta country where the same item is made and sold at a higher cost because local raw materials are used. The official says this problem is now being studied by member countries so that a formula can be devised.

Nevertheless, some Mexican-based companies are doing good business in Lafta countries through national lists of assorted products. Complementary agreements cover only one industry, but each Lafta country has a national list of allowable imports from other nations at agreed tariff rates. Mexico now is trading in about 60 or 70 "national list" electronics products. In fact, between a quarter and one-third of Mexico's semiconductor production is now exported to Lafta lands.

Another Mexican firm doing a brisk trade in the Lafta sphere is Electronica, 40% owned by Philips. The company is Mexico's largest semiconductor producer, making more than a million units a month. Most of this output is sold to companies outside the Philips orbit, but the firm does export to parent-company operations in Brazil and Argentina.

Something borrowed

In common with other Mexican electronics firms, Electronica imports most of its technology under licensing agreements—in this case from Philips—and does little or no research and development work. Such activities are largely confined to applications technology.

Juliano Carrillo, technical manager at Electronica, points out that the company can't apply Philips technology directly because Mexican tv set specifications and materials differ from those in Europe. In addition, the effective radiated power of broadcasting stations is much higher there than in Europe —by as much as 100 kilowatts.

Electronica pioneered a practice that other firms have since adopted —an applications laboratory to help develop new products for the market. Originally, the idea was to

Tops. Mexico uses this antenna for satellite communications; it is the largest commercial dish in the world.

Assembly. Electronics S.A., a Mexican affiliate of M.V. Philips, turns out semiconductor devices at this modern plant in Toluca.

help the components field. Thus, the company fostered outlets for stereos by designing a solid state unit and giving 20 away to manufacturers. "Before we did that, we were selling only small quantities of one of our power transistors, but now we have increased the market for that unit 20 times," Carillo says.

Fairchild Mexicana S.A. is another components firm with an applications lab. "We've had it for about a year," says Manuel Chacon, marketing manager. "It's a big help in sales. We consider ourselves a market-penetration facility as much as a component maker."

Outside outlets. The company, which started production in mid-1966, now makes about 500,000 transistors monthly and perhaps one-third that many diodes, according to Chacon. It expects to double production by the end of next year, with about half that increase going to domestic outlets and the balance to Lafta markets.

Mexican subsidiaries give their U.S. parent concerns an edge in Latin American markets. The tariff advantage for Fairchild in shipping, say, to Brazil is only 5%—a 10% impost on Mexican shipments as opposed to 15% on U.S. exports —but Both Fairchild and Electronica say the edge is sufficient. Carillo of Electronica says his firm's prices are around 10% above international levels on average. In certain cases, however, they are below. "For example, we could beat any price in the world on carbon resistors and profit," he asserts.

Integrated circuits are still used sparingly in Mexico. But Chacon feels they should start to appear in quantity in a few years—perhaps as i-f strips for tv and radio sets.

Instrumental theme

The market for test and measurement equipment in Mexico is still small—around $1.5 million to $2 million a year. But the field was practically nonexistent a few years ago. "I've been here since 1961, and when I started I had to sell components to make my living," says David Fredin, who represents Tektronix Inc. and the General Radio Co. His best prospects now, though, particularly for oscilloscopes, are tv manufacturers, research houses, owners of computer systems, and industrial houses.

The biggest share of the instrument market is held by Hewlett-Packard Mexicana S.A. The firm's largest sales are attributable to the Communications Ministry's new microwave system.

Vicente Garcia Aracil, general manager at H-P Mexicana, feels it will be a long time before the parent company's products can be made in Mexico. The reasons, he says, are a small market and the amount of technology required. At present, the quality of local components is inadequate for precision instruments. And instruments become obsolete about every five years, a situation necessitating large investments in R&D.

Receptions. Despite Garcia's pessimism, a few firms are making a go of it. Perkin-Elmer de Mexico S.A., which started manufacturing inexpensive Coleman meters a few years ago, expects sales of $150,000 in 1968. The firm has already expanded into ultraviolet spectrometers, power supplies, and flame photometers, and it will be adding more expensive spectrophotometers latter on. Manuel Maya, manager of operations, says his main outlet is Mexico's big and fast-growing chemical industry. Maya expects a 20% sales increase next year and sees a good future.

Local light. Instrumentos Electronicos de Mexico S.A., an independent national firm in Mexico City, turns out iron-core transformers for the radio, tv, and communications industries, power supplies, battery chargers, telephone gear, and specialized electronics for control systems to pinpoint equipment failures. The eight-year-old firm anticipates sales of about $750,000 this year.

Honeywell S.A. assembles potentiometers and electronic flame-failure safeguards for boilers, among other things. R.J. Holt, the general manager, estimates the industrial market's growth at an annual rate of 20%.

Computer markets

By year-end, as many as 240 computers will have been installed in Mexico, up from 200 in 1967. IBM, which—naturally—has the lion's share of the business, estimates that the market is growing by about 15% a year. Government agencies are the biggest users, says Duncan Howard, the company's promotional programs manager for the Caribbean area. Only about 5% of the installed systems are purchased, Howard says, with the rest being leased. Customers want the latest available equipment.

IBM is now installing what it claims is the first large-scale, direct digital control system in Mexico. This setup at the steel firm of Hojalata y Lamina S.A. in Monterrey will ride herd on the power consumption of blast furnaces.

Schooling. IBM has a training center in Cuernavaca for its own personnel and for customers. The company estimates that more than 1,500 programers, systems analysts, and operators have been trained there in the past three years.

Mexico's National Commission of Outer Space, created in 1962, plans to map Mexico's natural resources from an instrumented DC-6

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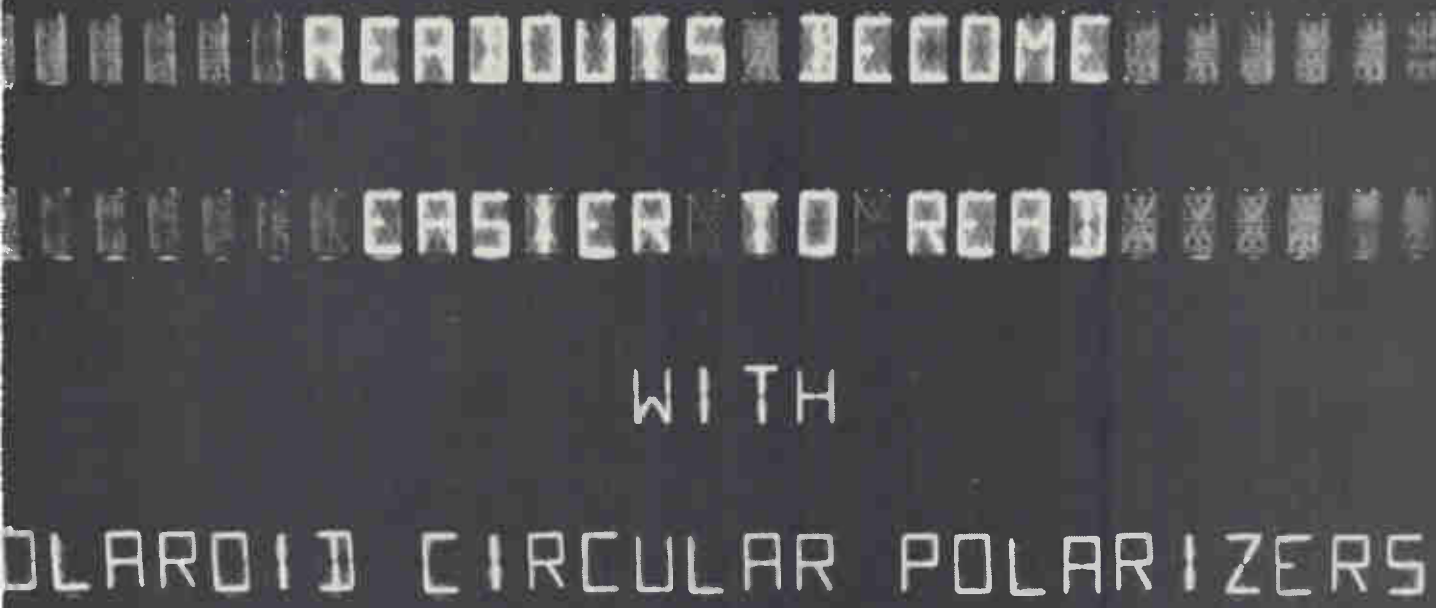

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aircraft it recently purchased. The work will start about mid-1969 and involve a variety of instruments, including an infrared radiometer, microwave equipment, multispectral cameras, and possibly side-looking radar. All this gear will be imported.

A team of 11 engineers from the commission and other national agencies attended a course in remote sensing techniques at NASA's Manned Space Flight Center in Houston. Under commission auspices, these engineers are now giving a special course to other Mexicans from concerned organizations.

Joint venture

The Mexican commission has also been testing its own rockets, which it will use to take meteorological soundings with NASA and agencies in Argentina and Brazil. Under this program, the four countries will make tests more or less simultaneously, track parachuted payloads by radar as they come down for wind profiles, and pick up temperature readings by telemetry. Each country's data will then be compared. The project is scheduled for the end of 1969. Seven Mexican engineers are now at Wallops Island, Va., training with the radar NASA will lend Mexico for the program.

The Ministry of Communications and Transport's commission for meteorology and telecommunications is installing automatic meteorological stations around the country at a cost of $5.28 million. Meteorological information will be supplied to airports, the Mexican navy, and anyone who requests it. This data will complement the output of a system currently operated for airports, and will be combined with information supplied by the Ministry of Agriculture, which runs a network of 800 manned stations.

The meteorology commission has ordered equipment for the first 20 automatic stations from a French firm, but plans to subsequently install equipment of its own design. Solid state systems will digitize data from meteorological instruments and convert it to teletype code. The gear will be programed to transmit automatically every 5 minutes via telephone, telegraph, or the new microwave network.

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2.6 - 3.95	20	1.0	1.15	20	20	S103LI
2.6 - 3.95	30	1.7	1.15	20	20	S104LI
3.3 - 4.9	25	1.0	1.15	5	5	CS110LI
3.95- 5.85	30	1.0	1.10*	20	20	C876LI
3.95- 5.85	30	1.2	1.15*	20	20	C110LIA
3.95- 5.85	40	1.0	1.15*	20	20	C111LI
5.85- 8.2	30	1.0	1.10*	20	20	Xb951LI
5.85- 8.2	30	1.0	1.15*	20	20	Xb103LIA
5.85- 8.2	40	1.2	1.15*	20	20	Xb910LI
7.05-10.0	30	1.0	1.10*	10	40	XL920LI
7.05-10.0	30	1.0	1.15*	5	20	XL103LIA
7.05-10.0	35	1.0	1.15*	5	20	XL910LI
7.05-10.0	40	1.2	1.15*	5	20	XL911LI
8.2 -12.4	30	1.0	1.10*	10	40	X956LI
8.2 -12.4	30	1.0	1.10*	5	20	X110LIA
8.2 -12.4	40	1.0	1.10	5	20	X910LI
10.0 -15.0	25	1.0	1.15	10	10	M110LI
10.0 -15.0	30	1.0	1.15*	10	10	M111LI
12.4 -18.0	30	1.0	1.10*	10	20	Ku915LI
12.4 -18.0	30	1.0	1.15*	10	10	Ku110LI
12.4 -18.0	35	1.0	1.15*	10	10	Ku910LI
12.4 -18.0	40	1.2	1.15*	10	10	Ku911LI
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†1.0- 2.0	15	1.0	1.15	L20PS
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2.0- 4.0	12	1.0	1.18	S10P
2.0- 4.0	20	1.0	1.20	S11P
†2.0- 4.0	20	1.0	1.20	S11PS
3.8-11.7	10	1.2	1.30	SCX10P
4.0- 8.0	10	1.0	1.25	C10P
†4.0- 8.0	15	1.0	1.20	C20PS
4.0-11.0	10	1.0	1.25	CX10P
7.0-11.0	15	1.0	1.25	CX11P
7.0-11.0	15	1.0	1.25	CX20PS
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LABORATORIES

Laser safety issue burning bright

Industry and the military are attempting to establish self-regulatory standards as Federal agencies and state governments come up with more restrictive measures

By Paul A. Dickson and William F. Arnold
Washington regional editors

Safety was the number one topic at the Laser Industries Association's annual meeting in Washington late last month. Everybody's for it, of course, but there's no real consensus among the various interest groups—industrial, military, and medical—about the best way to set up guidelines. To further complicate matters, the Federal Government and the states are getting into the act, passing potentially restrictive legislation.

In general, the industry professes to see no particular problems regarding laser safety. Malcolm L. Stitch, who recently joined the Korad department at the Union Carbide Corp. as assistant general manager, says that during his eight years with the Hughes Aircraft Co. he heard of no laser-connected accidents. "I am not convinced that a need exists for wide-ranging laser regulations so long as systems use is restricted to industrial and military applications," says Stitch, who heads the Electronics Industries Association's laser subdivision.

Similarly, Colin Bowness, manager of microwave devices operations at the Raytheon Co., says: "The dangers of lasers are vastly overrated. There have been rumors about people being badly hurt, but in the eight years since the invention of the ruby laser, I haven't run across any recorded examples. And I've talked to many doctors."

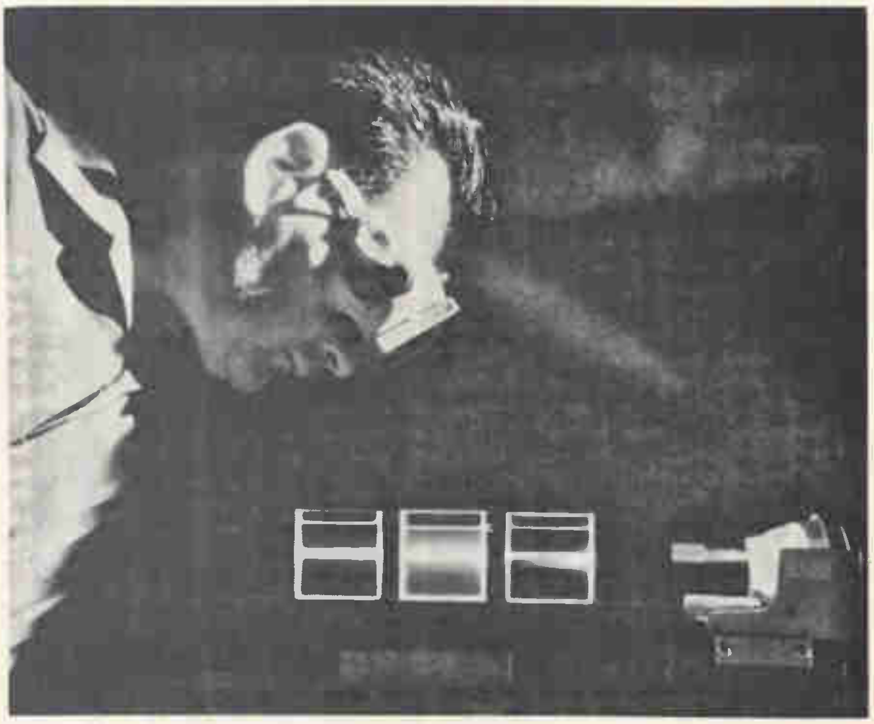
Rebuttal. As it happens, however, the Public Health Service is set to issue a three-state survey of 200 organizations using lasers; seven cases of eye damage were found, five of which were permanent. The report, which covers groups in Massachusetts, New Jersey, and California, will also point out 20 other laser-associated accidents, including electrical shock and explosions.

And many scientists and researchers investigating laser hazards warned at the LIA meeting that the dangers could not be minimized until more is known about long-term effects. Moreover, what constitutes "safe" radiation levels is still a very moot point.

Preventive maintenance

If only to protect its best interests, the laser industry is driving hard for self-regulation. Graham W. Flint, who heads the laser devices section at the Martin-Marietta Corp.'s Orlando, Fla., division, says the EIA's laser safety committee, which he heads, is drafting instructions for various classes and powers of laser systems. "These are designed to take the onus off the industry and manufacturers should an accident occur," Flint says. "A company would be liable only if damage occurred within the confines of the operating instructions."

"We're also trying to develop a closer relationship with Dr. Sam Fine, who heads the LIA's safety committee," Flint says. He hopes the two groups will be able to bring out a single document. "If we get a unified document, we can have some influence on legislation," he says. "And the guy who knows nothing about a laser's safety will have more confidence in proposals approved by both



Ounce of prevention. Upcoming Army-Navy guidelines suggest laser operators wear protective goggles though they're effective only in certain situations.

of our groups."

However, other guidelines are being issued. The American Conference of Governmental Industrial Hygienists, for example, has just published some. Among other things, the report distinguishes between laser radiation and ionizing radiation from gamma and X rays.

Corporate scene. Most companies that use lasers have safety guidelines, but the first to publicize its activities was Martin-Marietta. In 1965, it published a 24-page pamphlet with nine general safety rules for laboratory personnel and formulas for calculating safe operating conditions.

At IBM's Communications and Engineering Sciences Center, Gerald I. Farmer, a staff physicist, says all personnel working with lasers must take certain precautions. Goggles must be worn; periodic checkups with an ophthalmologist are required, and intensive training is given in the safe use of lasers. Farmer says that a guide is now being produced for internal use, which will borrow from the work done by Martin-Marietta and the hygienists.

Military maneuvers

The armed forces, as prospective volume users of laser systems for range-finding, target illumination, station-keeping, and related applications, are also concerned with safety. As it happens, the three services can't agree on just what constitutes hazard-free operation. The main reason for the apparent impasse is similar to that in the civilian world—lack of data. "We know a great deal about the eyes of rabbits and monkeys, but we don't know very much about those of human beings," says Cmdr. Charles F. Tedford, head of the radiation safety branch of the Submarine and Radiation division at the Navy's Bureau of Medicine and Surgery.

In establishing safe thresholds for eyes, the Army is the most cautious, the Air Force the most liberal, the Navy in between. The Air Force measures energy at the cornea, the Army at the retina. Since the eye magnifies light five or six times between the cornea and the retina, the Air Force approves considerably higher levels. The disparity between the two approaches stems partly from differences in mission; the Air Force rarely has to worry about ground troops in the field.

In addition, the two services use divergent samples. The top Army research organization is the Medical College of Virginia. The Air Force relies largely on the Stanford Research Institute, where "we used monkeys in lieu of rabbits," says Lt. Col. Herbert E. Bell, Biomedical Sciences Corps. "They're far better test animals than rabbits as far as the human eye is concerned. Nothing has shown up on any of the animals." The SRI experiments also included seven staff volunteers, some of whom were exposed to dosages above the thresholds with no damage apparent so far.

But perhaps the biggest factor is an honest difference of medical opinion. "Low levels of radiation exposure previously thought to be safe may be hazardous," says Col. Robert W. Niedlinger, chief of laser biology research for the Army's Medical Research and Development Command. "The Air Force has set its figures for the extreme circumstances, the exceptions," he says, "but systems may come along for which those values are no good."

Acknowledging that "there is a considerable area of disagreement" and that "we're considerably more liberal than the Army," Col. Alvin M. Burner of the Air Force's Aerospace Medical division replies: "We feel our levels are realistic for our types of operation."

Upshot. There will probably be no triservice laser document for some time. The Army and the Navy will shortly issue a joint guideline [Electronics, Aug. 5, p. 62] treating the laser as if it were a rifle and suggesting that laser operators wear goggles even though they are only effective at certain wavelengths and can shatter at high power levels.

Truly effective eye protection against lasers is a long way off, so the guidelines will also prescribe eye checkups for men about to enter laser work and periodic exams every six months or so. Men believed to have been accidentally exposed to a laser beam would be given immediate exams.

In this respect, the two services are tentatively following what's been standard Air Force practice for almost two years.

Unknowns

For all the interservice controversy, caution marks the military's approach to establishing threshold values. "You can never call a number safe if it damages one rod or cone," says Tedford. "You're born with a certain number and you don't get any more."

With lasers, permanent eye damage is always a threat because the eye is a million times more susceptible to laser burns than the skin. There is no specific treatment for such eye damage. "The only thing we can do is to reduce the inflammation with cortisone-type preparations," says Tedford. And though no one knows for sure, at least one researcher suggests that laser ionization can produce cancerous tissue over an extended period. "Some of us are scared of the long-term effects," he says.

And the Army's values, says Da-

Further fallout?

While most of the concern about laser hazards centers on damage to the human eyes and skin, there are probably other dangers. For example, Edward Klein, who is investigating laser safety at the Roswell Memorial Institute in Buffalo, N.Y. says the possibilities include "scattering of bacteria and side effects which might increase the virulence of microorganisms." James Terrill, director of the National Center for Radiological Health, is concerned about possible "synergistic effects with other forms of radiation."

Perhaps the longest list has been compiled by William McCullough, a Canadian labor official. At the National Safety Council meeting in Chicago last month he ticked off such potential hazards as: explosions set off by laser beams; atmospheric contamination from vaporized material resulting from laser welding or cutting; contamination from gas lasers or byproducts of laser reaction; ultraviolet radiation from lasers or associated flash tubes; and fire and electrical dangers involved with high-energy voltage.

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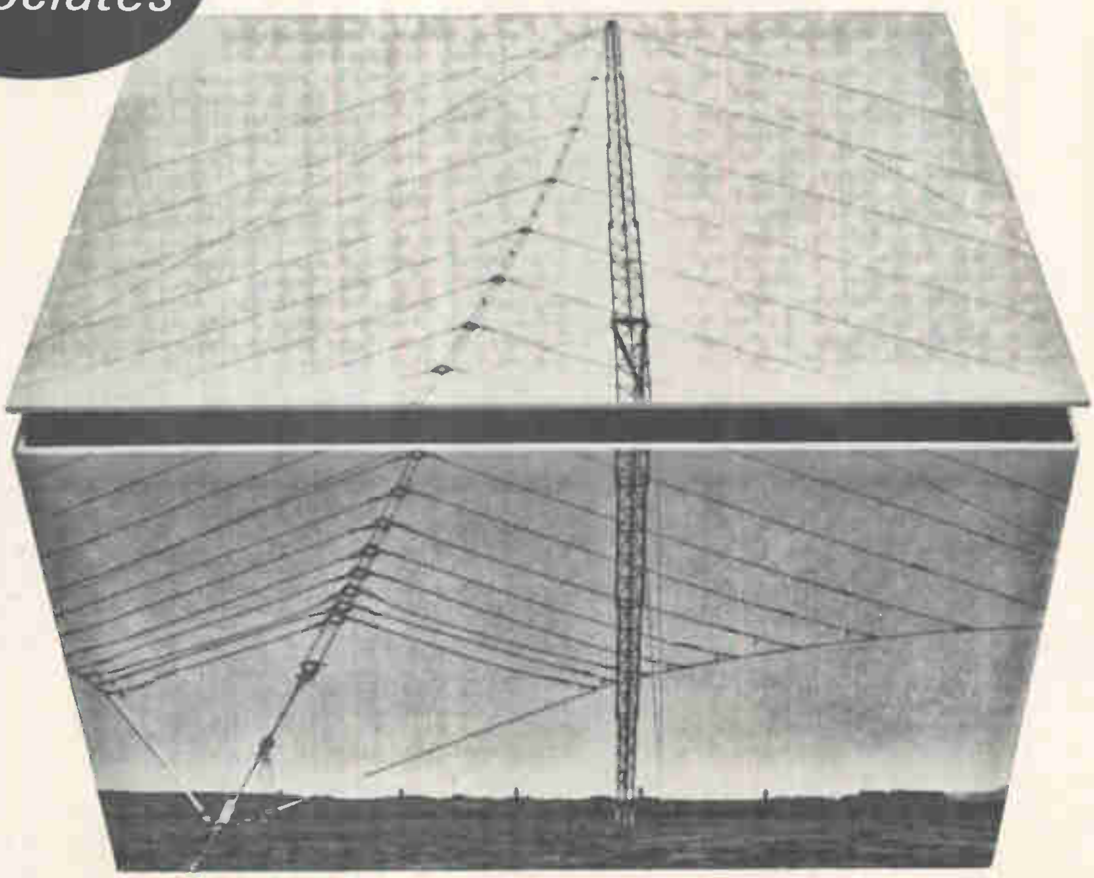
*The Delta Kit is included with antenna Model 747 CB. The Kit is also available as a retrofit for 747 CA's. CA/CB models are available for fixed installation.

Circle 195 on reader service card

Granger Associates



1601 California Ave., Palo Alto, California 94304 / Granger Corner, 1 Brooklands Rd., Weybridge, Surrey, England / 1-3 Dale St., Brookvale, NSW, Australia vid H. Sliney, a researcher with the service's Environmental Hygiene Agency, are at least 10 times under dangerous levels. Tedford predicts: "We might be able to relax the figures in time. But getting guidelines to put out to people is more important than the threshold values we're quibbling over." The services may be taking such action none too soon. Says Niedlinger: "We're starting to get proposals for experiments with provisions to expose a human eye directly to a laser. And they're often based on the wrong numbers."

Legislating lasers

Laser safety has in recent months gone beyond the domains of industry and the military to become a public issue. Four states—Illinois, Massachusetts, Pennsylvania, and Louisiana—have laser laws, and the legislatures of New Jersey and California are studying bills. The Federal Radiation Control for Health and Safety Act, passed last month, empowers the Secretary of Health, Education and Welfare to establish a control program that will include performance standards. He'll also conduct research and report back to Congress before January 1970 with a recommendation for stronger legislation. It hasn't been announced officially, but there's no doubt that the job of setting standards will be assigned to the National Center for Radiological Health.

Arthur E. Jones, a Honeywell Inc. laser expert who heads the LIA's legislative committee, says: "At this point it does not appear that the provisions of the Federal act are going to be hard for industry to live with." He points out, however, that some state laws are another question. The recently passed Louisiana law, he contends, may be the hardest, since it's essentially a rewrite of a nuclear radiation law and imposes nuclear reactor strictures on lasers. Jones, who has contacted 49 states to see what is happening in laser legislation, says that quite a few legislatures are thinking of such laws. He is worried about especially stringent bills, like the one defeated in the New York senate that would have made it difficult for anyone without a graduate degree to own or use a laser.

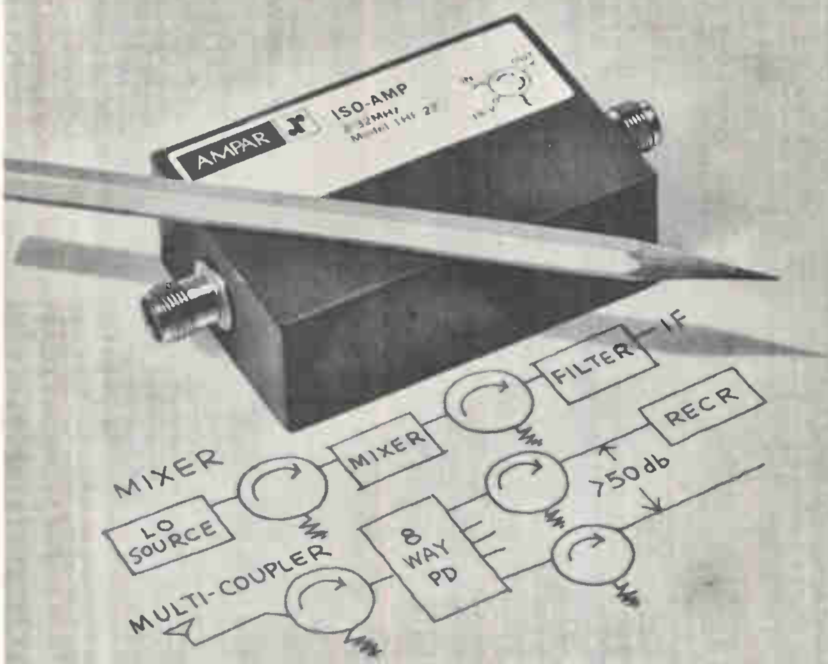
Best case. According to Jones, the most realistic of the laws is the one in Massachusetts; he considers the Illinois law relatively stiff. The recently passed Massachusetts act allows the state to adopt regulations to protect the public from hazards. Says Ronald C. MacKenzie, the senator who proposed the bill: "I had heard of the Illinois bill, which is very restrictive. The more I learned about lasers, the more I realized that the law should only be regulatory."

The Illinois law calls for the registration of all lasers, mandatory reporting of all accidents, in-plant inspection by the state, and the rejection by the state of the registration of systems it does not deem safe. Illinois officials concede that the law has thus far had little effect—primarily because another bill that was to have provided funds for enforcement was defeated.

The National Center for Radiological Health, the organization which will have the greatest impact on the laser field, was working in the safety field long before the radiation bill was passed. With its new powers, it can be expected to launch a major effort. In the next few weeks the center will issue a publication entitled "Biological Aspects of Laser Radiation," and an official at the center says that there is talk of a possible survey of lasers soon that would be much like the center's controversial check of color tv receivers.

James Terrill, the center's director, indicates that the forthcoming regulations will be tough. Terrill is clearly disturbed by the sale of lasers to schools and their use in industrial displays open to the public. He warns the industry that a black eye now could hamper the long-term success of laser applications.

Terrill's strong cautiousness may seem a bit severe to some in the industry, but he does have the backing of experts. A.M. Clark, a member of the team studying laser dangers at the Medical College of Virginia, shares Terrill's views on lasers in the classroom. Clark says, "Students and teachers approach us to check out laser science projects and it's very frightening. Some proposed experiments I have seen are very, very dangerous."



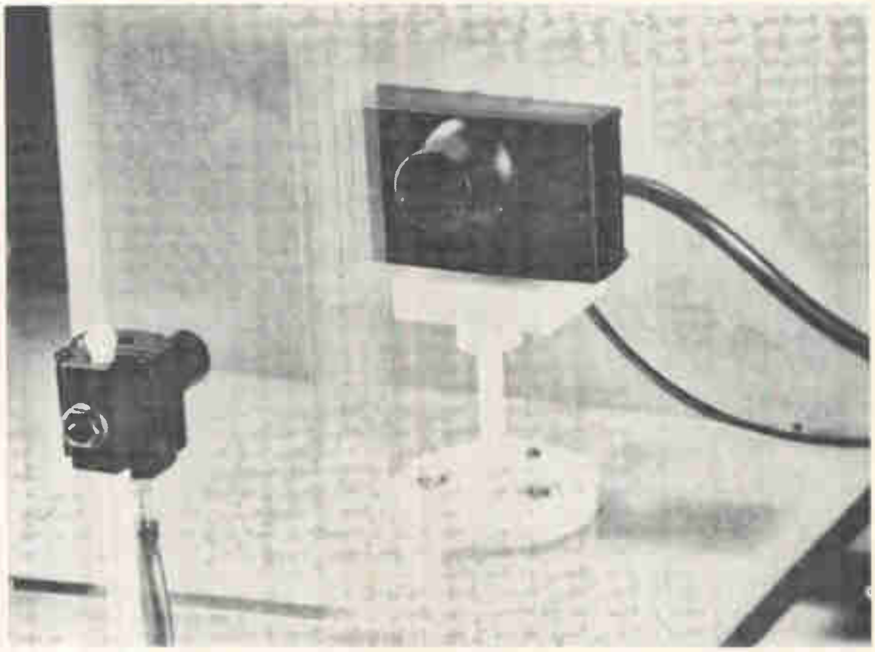
Fluidics stays barely above water

Interface problems, cut-and-try designing, and a lack of systems experience and standards are a drag on this field as it struggles to win market acceptance

It's beginning to look as if fluidics is another one of those bright ideas that just won't pan out—at least not as a significant technological threat to electronics. Despite the involvement of big-time concerns—Corning, Pitney-Bowes, Bendix, General Electric, Honeywell—the field is still short on accomplishment. As a matter of fact, the gains that have been made during the 10 years or so fluidics has been around are largely promotional in nature.

Drum-beaters have managed to assemble a fat portfolio of press clippings and even gain recognition of sorts. There was, for example, a session on fluidics at Wescon this summer [Electronics, Aug. 5, p. 137], and "the industry" is staging a road show of its own later this month in Chicago.

But a number of problems remain to be overcome if fluidics is ever to secure a foothold in the marketplace. Among them are high costs, a lack of standards and systems experience, customer disinterest, and cut-and-try designs.



Listening post. Ear arrangement from Pitney-Bowes is fluidic counterpart of an electric eye; company claims it can sense even translucent objects.

Catch phrases. Fluidic devices are built from ceramic material, etched and bonded to provide channels through which a "fluid" power input—usually clean, dry air, though water and process liquids are sometimes used—can flow to perform a function. The general attraction of fluidic systems is ruggedness and reliability. The litany of advantages includes no moving parts; unaffected by temperature extremes, radiation, corrosion, or vibration; spark-free; and operative even in grimy environments.

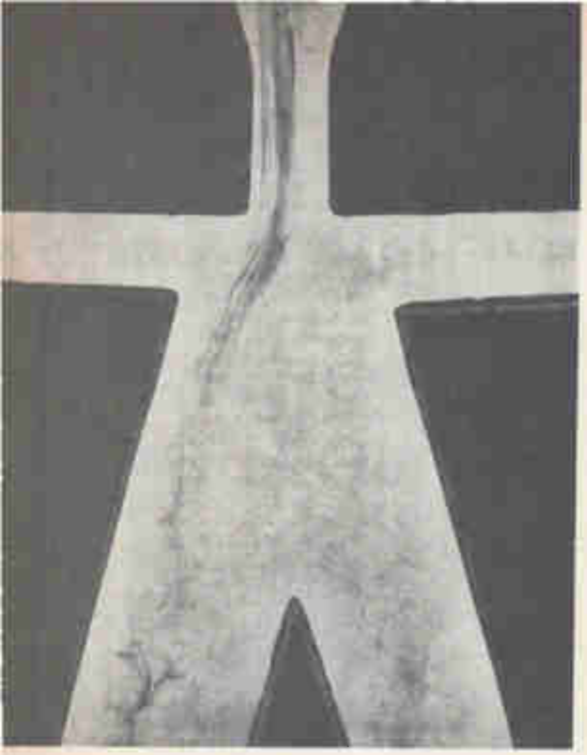
Richard A. O'Brien, manager of the Corning Glass Works' fluidic products department, likens the technology to a "practical application of a textbook explanation for electricity." In other words, the passage of fluids through tubing or pipe is often used as an analogy for the flow of electrons through wire. By controlling the direction and velocity of a liquid or gas through interconnected channels, O'Brien says, devices can be made to do almost anything of a control nature that electrical gear does.

Beyond the fact that both fields use much the same jargon—flip-flops, resistance, AND, NAND, OR, and NOR gates, and the like—fluidics and electronics part company. Fluidic devices work on two basic principles far removed from electronics: the Coanda effect—the tendency of a moving fluid to adhere to an adjacent smooth surface—and momentum transfer, by which fluid mainstreams change course in a controlled manner.

In addition, there's a tremendous speed differential between the two technologies. Electronic devices are limited only by their size and the speed of light, but fluidic assemblies operate at the slower speed of sound. As a result, such devices can't begin to keep pace in nanosecond computer systems. In theory, however, they can perform decision-making jobs in control setups where speed isn't critical. And this is precisely the area that fluidics enthusiasts have staked out for themselves.

Where it's at

Officials at the Bowles Engineering Corp., one of the relatively few firms making only fluidic devices, identify controls for machine tools as their principal commercial market. "We're after the guy who wants to automate 100 drill presses



Clinging. Warm-table demonstration illustrates wall-attachment tendency of fluid stream in a Bowles flip-flop.

in his shop," says Edwin M. Dexter, vice president for industrial controls. "He already has the air available, so investment costs are low. Electronics can't compete at this volume, and electromechanical devices are clumsy by comparison." Dexter denies, however, that fluidics is after electronics markets as such. "Our competition is with the relay people," he says. "And there's a slight possibility we might infringe on liquid-level controls."

John A. Enright, product manager at the Johnson Service Co., agrees that fluidics' niche is somewhere between electronic and mechanical controls. "But the field is in an evaluation stage," he says. "We're still trying to get our products into users' hands so they can judge what they have to gain."

Among the comparatively few commercially available pieces of equipment incorporating fluidic controls is an air-gaging system used in the machining of automobile blocks. This apparatus is now being marketed in Europe by Imperial-RIV, a joint venture of the I-T-E Imperial Corp.'s Fluidonics division and Italy's RIV-SKF. Another entry, an aerosol-can filler made by the JG Machine Works, incorporates fluidic control modules produced by Corning.

In a more exotic vein, the Howie Corp. of Norristown, Pa., makes a fluidic sensing device called a turbulence amplifier. Along with interface and input-output hardware, this assembly has been successfully used in control systems for packaging equipment and machine tools. So far, however, the company has come a cropper trying to apply it in a setup that sizes chickens before they're packaged for market. According to Kenneth Howie Jr., a vice president, the pervasive chicken dung in the processing plants hardens to a cement-like consistency, clogging ports and generally fouling up the works.

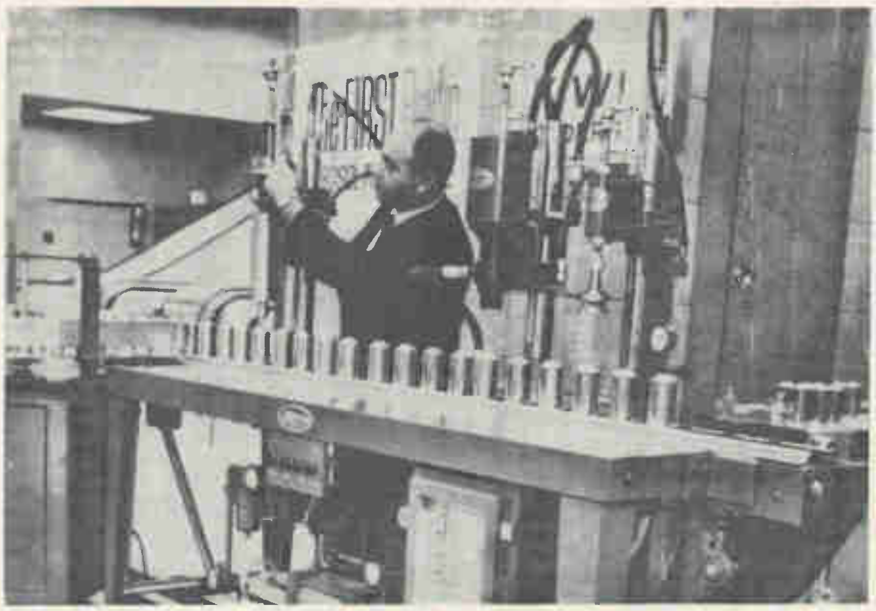
Edge of anxiety. Fluidics proponents agree that their technology has at least a psychological advantage over electronics in industrial outlets. "Among machinists, there's a fear—whether real or imaginary—of electrical shocks and worse when electronics is involved," explains one source. "In addition, maintenance must be considered. It's more expensive with electronics."

On the other side of the ledger, says Howie, is the fact that in some union shops where hybrid control systems incorporating fluidics and electronics are used, there's a problem when breakdowns occur. "You wind up having to have men from two unions in on the repairs." As a result, he claims, most prospects prefer a purely fluidic system—if for no other reason than to avoid labor difficulties.

Aerospace markets follow industrial outlets on fluidics' list of targets. The Bendix Corp.'s research laboratories in Southfield, Mich., for example, have been working on fluidic flight controls for general aviation applications under a contract from the National Aeronautics and Space Administration. Walter F. Datwiler, who heads fluidic research at the labs, notes that most of his organization's military and aerospace efforts involve interfacing with electronics, a situation that poses potential problems.

"Where size isn't critical and pulse-rate requirements don't exceed 100 per second, electropneumatic transducers can be used. But size is critical in spacecraft, and while miniaturization is possible, there are practical limits," says Datwiler. "Where space and response are at a premium, an electromagnetic system with a flapper nozzle in a pneumatic arrangement won't work. A piezoelectric-type driver circuit is necessary." Moreover, he continues, fuel consumption and purification are pretty sticky problems in aerospace applications. If a system requires hundreds of elements, fuel pressure becomes a problem since it must be kept low.

Off the ground. Honeywell Inc.'s Aerospace division has come up with a fluidic flight-control system for helicopters that's now being



Air brush. Fluidic circuit modules from Corning replace pneumatic logic in this aerosol-can filler produced by the JG Machine Works.

tested by the Navy. Powered by bleed air from the craft's jet engine compressor, the system controls the yaw, roll, and pitch axes. The craft's attitude rates are picked up by three fluidic sensors, shaped by fluidic networks, and fed as differential pressures to fluidic amplifiers. According to Walter S. Robinson, the division's director of aircraft flight systems, the pressures are then converted to drive hydrofluidic servos.

Before the system was shipped to the testing site this summer, it was flown aboard a Navy tandem-rotor CH-46A at the Minneapolis-St. Paul International Airport, where its performance was rated by the test pilot as on a par with that of electromechanical systems.

Rx for growth?

Although fluidics' potential appears to lie largely in industrial and aerospace applications, there's increasing interest in the biomedical field. Bendix, for example, is doing research with fluidics for artificial hearts. Another organization that's even more involved in this area is Fluidonics' medical instrumentation department in Salt Lake City.

"We're looking into the full spectrum," says Gale Thorne, who heads the department. "This ranges from basic assist devices through implanted artificial hearts." Some of the research is being funded by the National Heart Institute, but most of the work is financed by the company. "The body itself is a fluid system," says Thorne, "with blood flowing from organ to organ and the heart acting as a pump. What we're attempting to do is wed the electrical operation—the heartbeat—with fluidics."

Thus far, after more than 15 months of intensive research, the marriage has proved far from fruitful. The greatest difficulty still encountered by the fluidonics researchers is in the area of sensors. "The problem is to correctly match circuit functions with the physiological functions of the human body," says Thorne. Also unanswered is the question of how to power assist devices or artificial hearts over a period of, say, 20 years or so. "We're using glucose fuel cells," says Thorne. "But the answer will probably be in nuclear power. Battery sources are unlikely."

Animation. Fluidonics' medical researchers have developed a small respirator for animals. The fluidic unit helps an animal to absorb oxygen into his system and give off carbon dioxide and water.

Thorne remains optimistic about the long-range potential of fluidics in biomedical applications. Besides respirators and artificial hearts, he predicts inroads in surgical tools and instrumentation as the technology progresses. "Even intravenous feeding as we know it will probably change," says Thorne.

For all this talk of potential market, though, fluidics is still, as Johnson Service's Enright suggests, "little more than a curiosity." And already there's been at least one prominent drop-out—the Conrac Corp. Thomas Harriman, vice president for engineering and marketing there, says: "You might almost say fluidics is too late. Electronic and even mechanical systems have reached a point of refinement and sophistication where there's little left to conquer." Harriman dismisses the industry's bruited digital logic devices as "nuts and bolts," adding "you can't expect to make a living off them." He does believe a few firms can make out eventually, but says there won't be any bonanza.

Device oriented. One of the principal reasons that fluidics has made so little real headway is the preoccupation of producers with devices rather than systems. "A good 50% of our sales are in breadboarding hardware for prospective customers to try out," says Bowles' Dexter. Not that there aren't extremely interesting assemblies available. Pitney-Bowes Inc., for example, offers a line of digital logic devices, input-output items, and power supplies; only occasionally, though, does the company do systems work. Among the more intriguing items in its catalog is a fluidic ear, a digital output device that's analogous to an electric eye; it transmits a 50-kilohertz sound wave to a sound-sensitive fluidic amplifier, replacing electric eyes in hostile environments.

Similarly, other big-name concerns in the field are long on discrete devices. Corning, which produces Fotoceram, the basic material for much of the industry's output, offers 50 separate items including NOR gates, Schmitt triggers, binary counters, and pulse limiters. Only recently, however, has the company begun packaging systems for prospective customers. Corning is pointing toward an off-the-shelf capability in binary systems, says Thomas Dincher, sales manager for fluidic products.

Handicap. In the opinion of many observers, the industry's fascination with devices has impeded progress. "There's no systems approach to circuit design," says one source. "There's not going to be any real gains until producers do this and are able to predict performance, as can be done in electronics." This individual believes that the field's predilection for cut-and-try approaches, particularly in digital fluidics misses the point. "Devices aren't consistent enough for complex circuits," he asserts.

Arthur E. Maine, director of engineering at Aviation Electric Ltd., a Canadian affiliate of Bendix, agrees that output should be applications oriented. "The fluidics field has failed to address itself

A hose by any other name

For a comparatively young technology, fluidics has undergone a number of name changes. Ten years ago, when the first experimental devices were being developed, the Government used the term fluid amplification. The Martin-Marietta Corp. is generally credited with coining the word fluidics to describe work done at its Orlando, Fla., division. In 1965, the National Fluid Power Association put its stamp of approval on the term.

But that same year, the Government's Fuidics Coordinating Group decided another word was necessary to delineate the technology. Thus, fluidics, in Federal parlance at least, covers the field right up through such peripheral equipment as mechanical air pumps. The word fluerics is used to designate actual devices within a system. This distinction is the basis for the new Defense Department standard on fluidics [Electronics, Oct. 28, p. 70].

Upbeat. Honeywell developed a fluidic control system for Navy helicopters.

adequately to the applications engineers whose task is to convert the technology into effective and reliable hardware," he says. "All too often a logic diagram defining the required functions has been promptly converted into a breadboard lashup. Once the required circuit operation is obtained, the system is unceremoniously transferred to a box and put on a factory floor to do the job for which it was intended. The rationale for expecting success is that if it works in the lab, why not in the actual application? This enthusiastic but primitive approach has been instrumental in putting fluidics in a poor light."

Incompatibility

Further complicating the problem has been a lack of industrywide standards, including terms, symbols, operating characteristics, curves, air filters, power supplies and interfaces. As long as a user sticks with a single manufacturer he won't encounter too many difficulties on this score. But the moment he decides to switch vendors or use more than one, he'll have his hands full.

The standardization problem was partially solved earlier this year when the National Fluid Power Association (NFPA) in Thiensville, Wis., published a compilation of recommended symbols and terms. These standards haven't yet been adopted on an industrywide basis, but Theodore Pearce, the NFPA's executive secretary, is confident they will be. "There's no question as to the need," he says, "if the industry is going to avoid the chaos that the electronics field endured in its early years."

One of the main aims of standardization is to enhance education programs, which play a leading role in sales programs. The market isn't particularly receptive since, according to an estimate by a Corning official, there are less than 200 engineers in all of the U.S., who are skilled in applying fluidics technology. As a result, concerns are hawking their wares vigorously to overcome customers' inexperience and inertia.

Fluidonics and the Brown & Sharp Co.'s Double A Products division, for example, have developed multipurpose kits to familiarize prospective users with fluidic technology and application. Both kits are of the do-it-yourself variety, including technical manuals, circuit blocks, and hardware, as well as the necessary tubing for the assembly of fluidic circuits.

Sales pitch. Besides employing the kits as educational tools, both companies use them as sales aids. The kits are proof-positive, they feel, of the safety involved in fluidics and the ease with which controls can be maintained. Unlike electronics, a wrong connection in fluidics will only result in the system's failure to work—not a short. This, say spokesmen, cashes in on the psychological advantage fluidics holds over electronics.

But the point, as far as Aviation Electric's Maine is concerned, is that fluidics is not a panacea. "Unless we're absolutely positive an application lends itself to fluidics, we won't tackle it." He points out that during the field's formative years, enthusiasts rushed about proclaiming that "pure fluidics" was a cure-all and that other control technologies need not be considered at all. That was, and still is, pure nonsense, he says, "and is the reason why there is so little applications data, even today."

"Fluidics isn't a glamorous new technique to other technologies," he says. "Instead, it is a versatile new tool with which a control engineer can supplement the traditional tools at his command."

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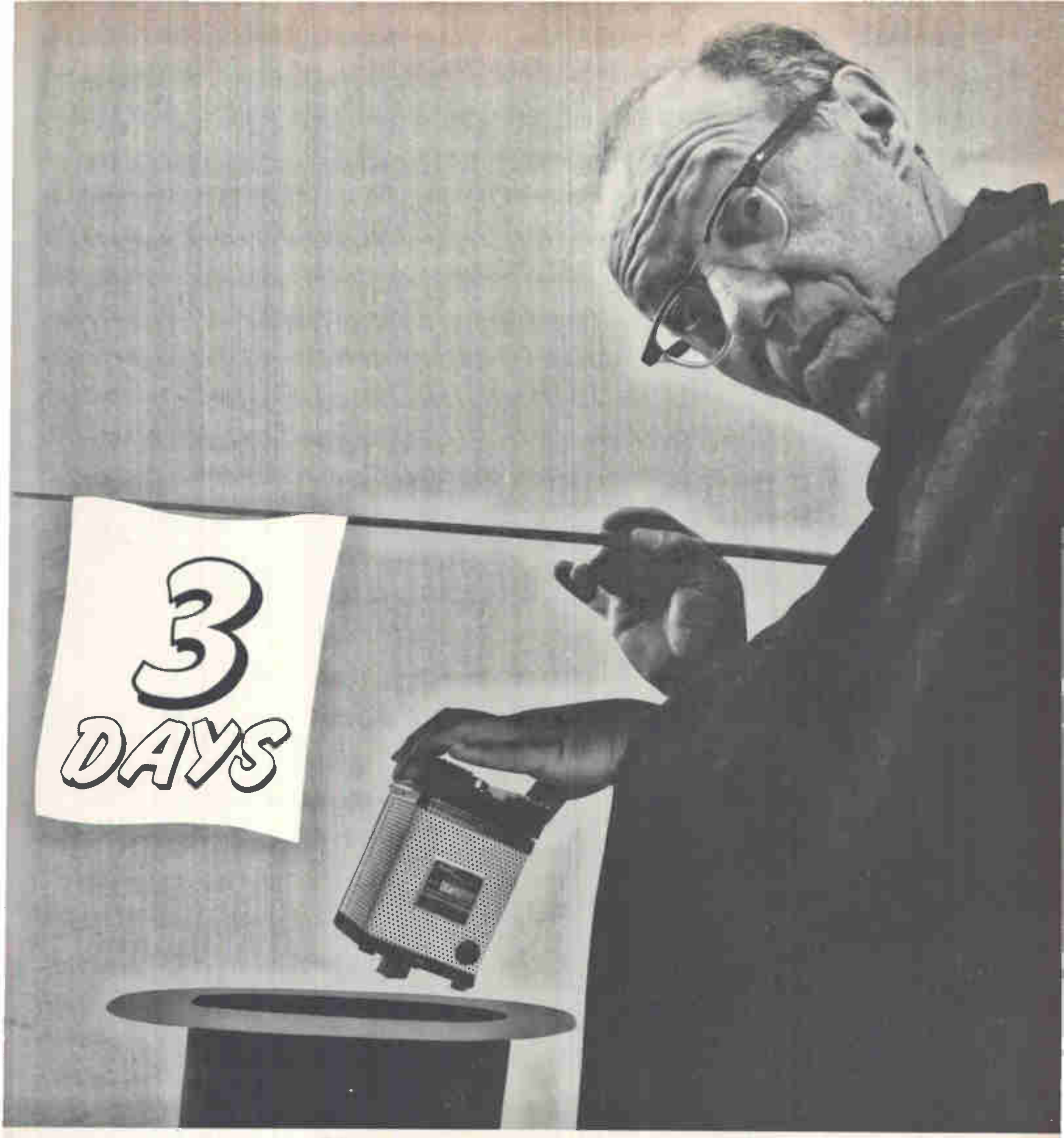
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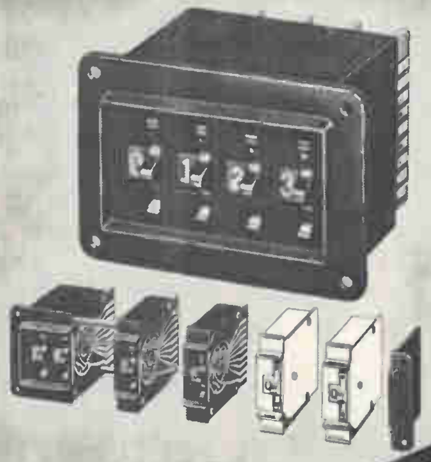

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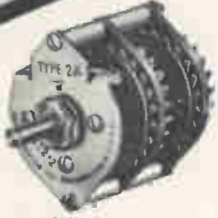

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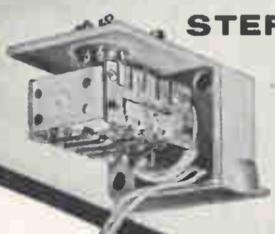

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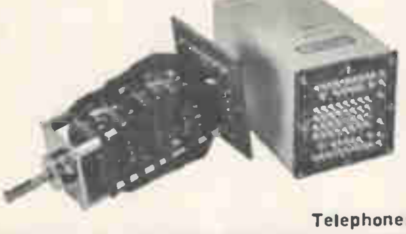

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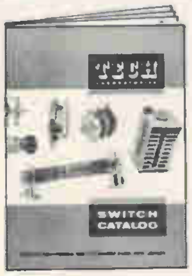

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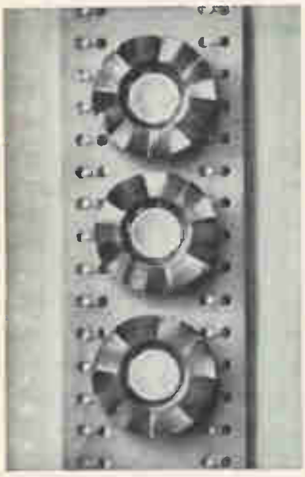
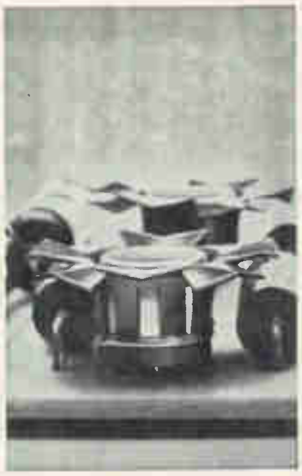

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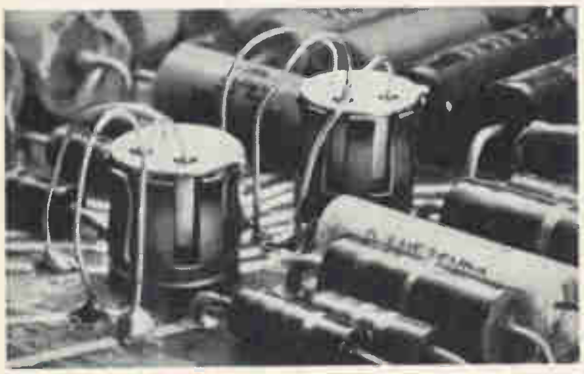

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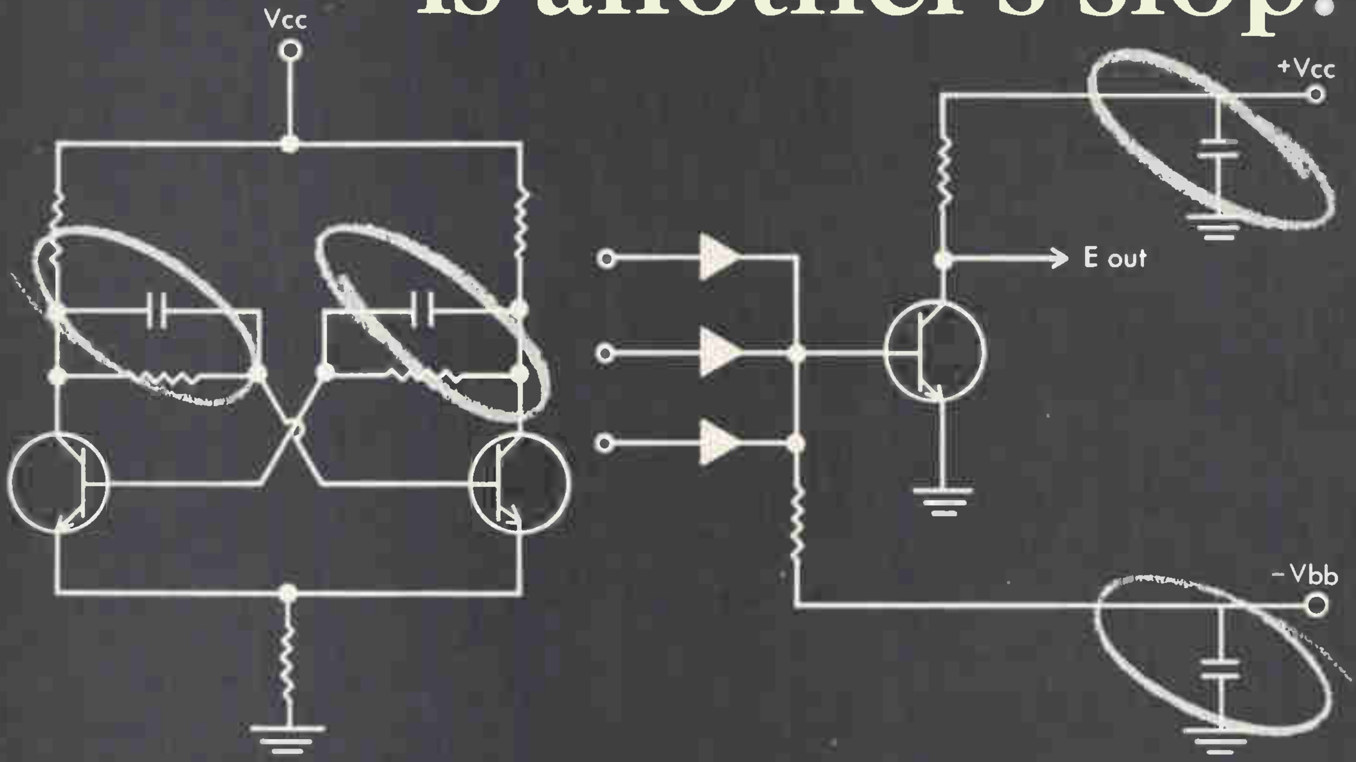

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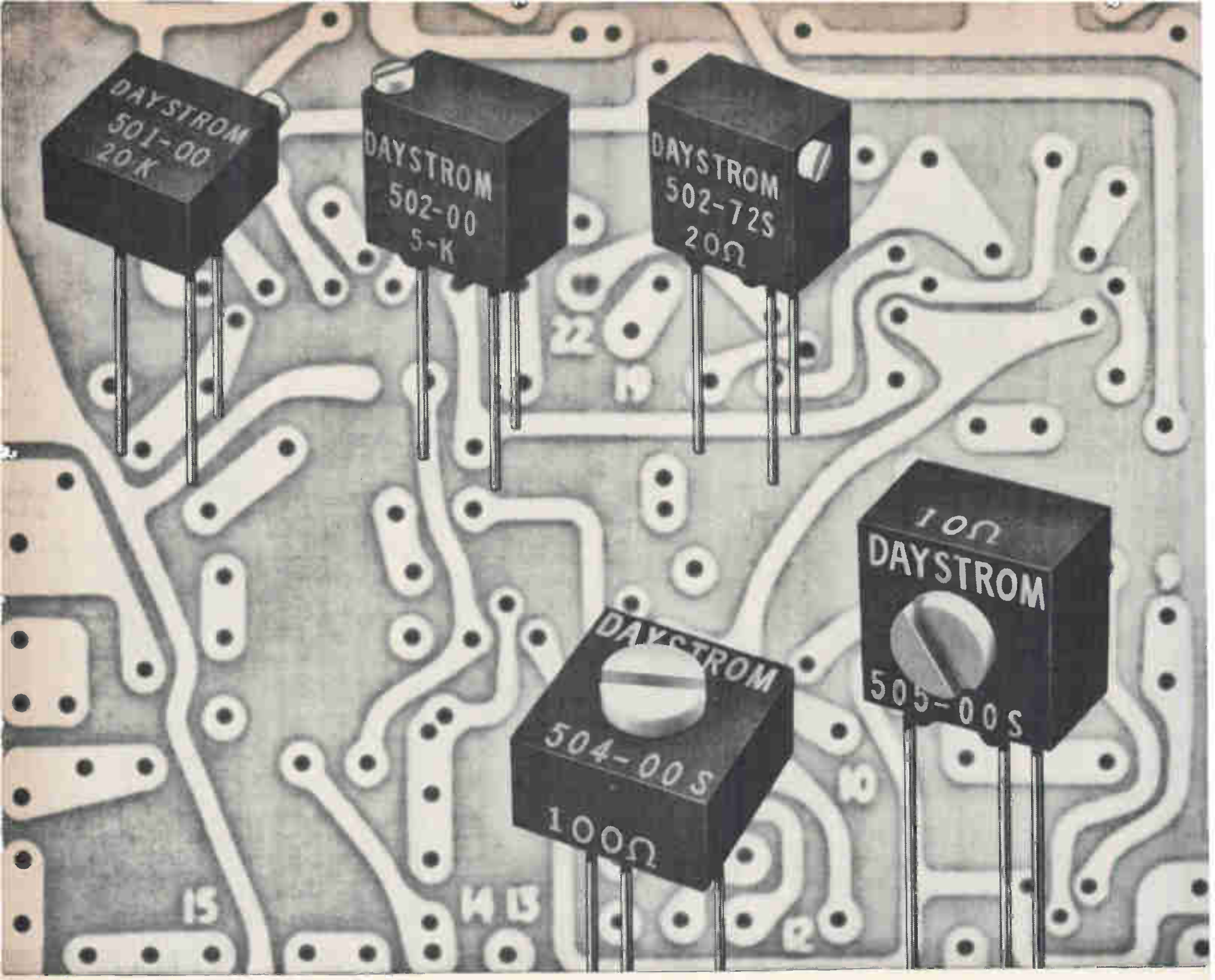
DAYSTROM
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502-72S
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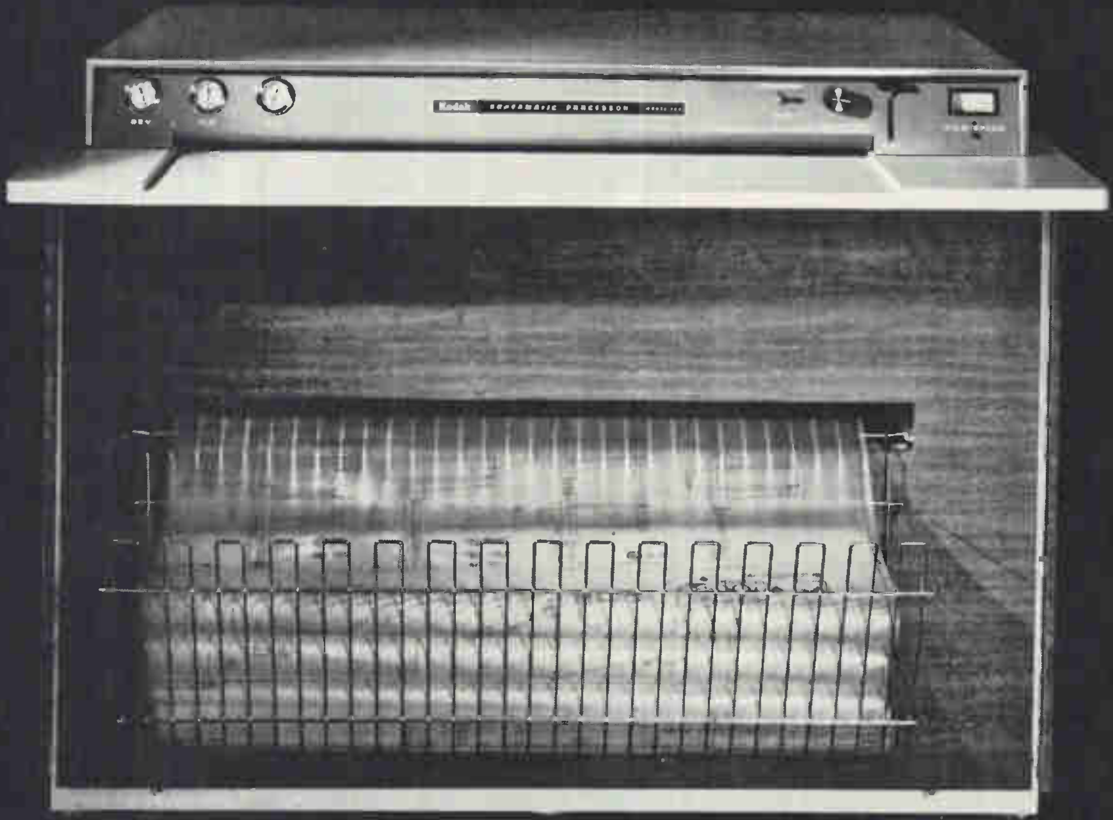
10Ω
DAYSTROM
505-00S
DAYSTROM
504-00S
100Ω

Kodak beats the clock.

The KODAK SUPERMATIC Processor, Model 242, processes exposed KODAGRAPH ESTAR Base Films up to 60 times faster than manually. And it does it more uniformly, more economically. In a minute you can have a 34″ x 44″ reproduction. The SUPERMATIC Processor does the developing, fixing, washing, and drying that formerly took skilled technicians an hour.

The SUPERMATIC Processor speeds KODAGRAPH Film processing, frees technicians for more important work, gets prints to draftsmen faster, saves countless hours and dollars. It's versatile, too: processes most ESTAR Base Film in standard A-E drawing sizes—and all the way up to 42″ wide and 15 feet long. Ask your Kodak Technical Sales Representative about *super* processing: the KODAK SUPERMATIC Processor system of compatible KODAGRAPH Films, chemicals, and equipment.

Write: Eastman Kodak Company, Business Systems Markets Division, Rochester, N.Y. 14650.



KODAK SUPERMATIC Processor

Kodak

Circle 215 on reader service card

Circle 217 on reader service card→

The Straight Line

Covered under Patent No. [illegible] and others pending.

Functional new concept in Potentiometer design

Horizontal, vertical or side mounting available.

Multiple units lock and actuate with single knob.

Preliminary adjustment with template possible.

Needs only 1/3 mounting area of standard control.

Standard solder lug, wire-wrap or printed circuit terminals supplied.

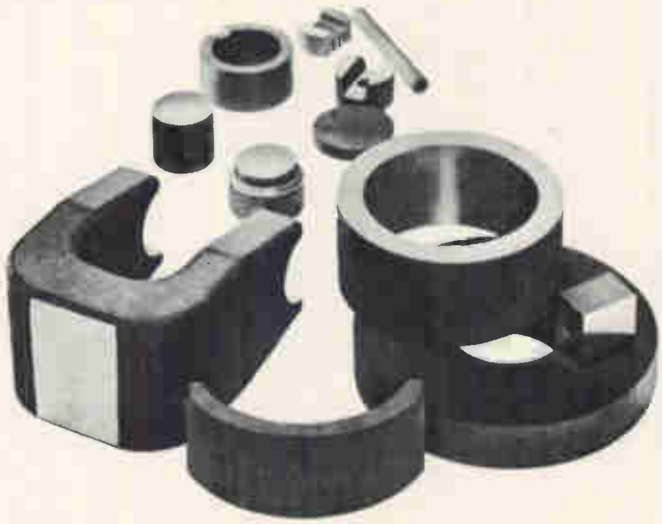
Forward or rear facing twist-tab mountings. Snap-in mounts also available.

Variable resistors have been going in circles for years. Now Stackpole straightens them out. Using linear motion, Stackpole engineers created a potentiometer that conserves circuit board and panel space and offers a host of design advantages. Stackpole calls it SLIDE-TROL®. You'll call it ingenious! Utter simplicity, yet with all the quality and features of devices costing much more. SLIDE-TROL® is available in values of 40 ohms to 15 meg. ohms and since the element is rectangular and provides more area to dissipate heat, higher wattage ratings are possible. Phenolic housings eliminate shock hazards. Low noise and low contact resistance are assured by a patented 9-point movable spring contact. Only imagination limits the applications for SLIDE-TROL®. If you're looking for performance, economy and appeal in variable resistors, get the facts on SLIDE-TROL®. Write for samples and brochure: Stackpole Components Co., P.O. Box 14466 Raleigh, N. Carolina 27610. PH: 919-828-6201 TWX: 510-928-0520

STACKPOLE
COMPONENTS COMPANY

Also a leading producer of quality slide, rocker and rotary switches.

Permanent magnets up to 13,500 Gauss and 4,400 Oersteds...



...from a production capability of a million magnets a week

Mullard can supply permanent magnets with remanent flux densities up to 13,500 Gauss or intrinsic field strengths up to 4,400 Oersteds, and they can be produced quickly to your specification. Mullard manufactures two main magnetic materials—

Ceramic 'Magnadur' offers exceptionally high coercive force and electrical resistivity (ideal for d.c. motors and generators).

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From these basic materials Mullard produces a range of variants to meet every magnet requirement in applications from meters to motors. Leading automobile manufacturers in the USA, for example, are using Mullard Magnadur segments in d.c. motors. Production capacity at the Mullard magnet factory is around a million magnets a week.

Every designer should obtain the Mullard technical information on permanent magnets. Also ask to be put on the mailing list of the Mullard Bulletin—a regular publication which gives details of new components and applications . . . the result of extensive research and development programmes in the Mullard laboratories in England. Mullard employs 1,000 qualified scientists and engineers and has six major plants, with over 3 million square feet of floor space.

Write today for information on Mullard permanent magnets and for the name of your local Representative

Mullard Limited, Mullard House, Torrington Place, London WC1, England.

USA enquiries to Mullard Inc., 100 Finn Court, Farmingdale, Long Island, New York 11735, USA. Telephone: (516) 694 8989 Telex: 961455.

Mullard

MOL 52

New, more versatile scribing . . . identical operation

Changes have been made in the new Model "C." Tempress Automatic Scribing Machine, but only where they matter . . . to increase operating flexibility and to incorporate improved components where they will contribute to the efficiency, dependability, or longevity of the machine. Follow the same set-up procedures; press "actuate," and you are scribing any rectangular or triangular pattern from .001" to .399", with incremental resolution to .001". How versatile? Choose a model to scribe either 1½" or 2" wafers, decimal or metric indexing, extended range, 50 or 60 cycle operation, without affecting price. The only option for which you pay extra is a binocular optical system. Third generation of the machine that brought low-cost, automatic scribing to the semiconductor industry, the new Model "C" meets the Tempress Standard of Excellence, your assurance of precision when you purchase any member of the growing family of Tempress miniature assembly tools and production machines.

TEMPRESS

Tempress Research Co., 566 San Xavier Ave., Sunnyvale, Calif. 94086

Circle 219 on reader service card

No other manufacturer offers as large a selection: hundreds of standard types of control knobs, more than 2,000 "specials". Almost every type, style and color combination is promptly available to you from local distributors and large factory stocks.

Turn to color with the new PANELRAMA knobs shown below...mix or match caps and body colors in almost any combination...to harmonize or contrast with every panel decor.

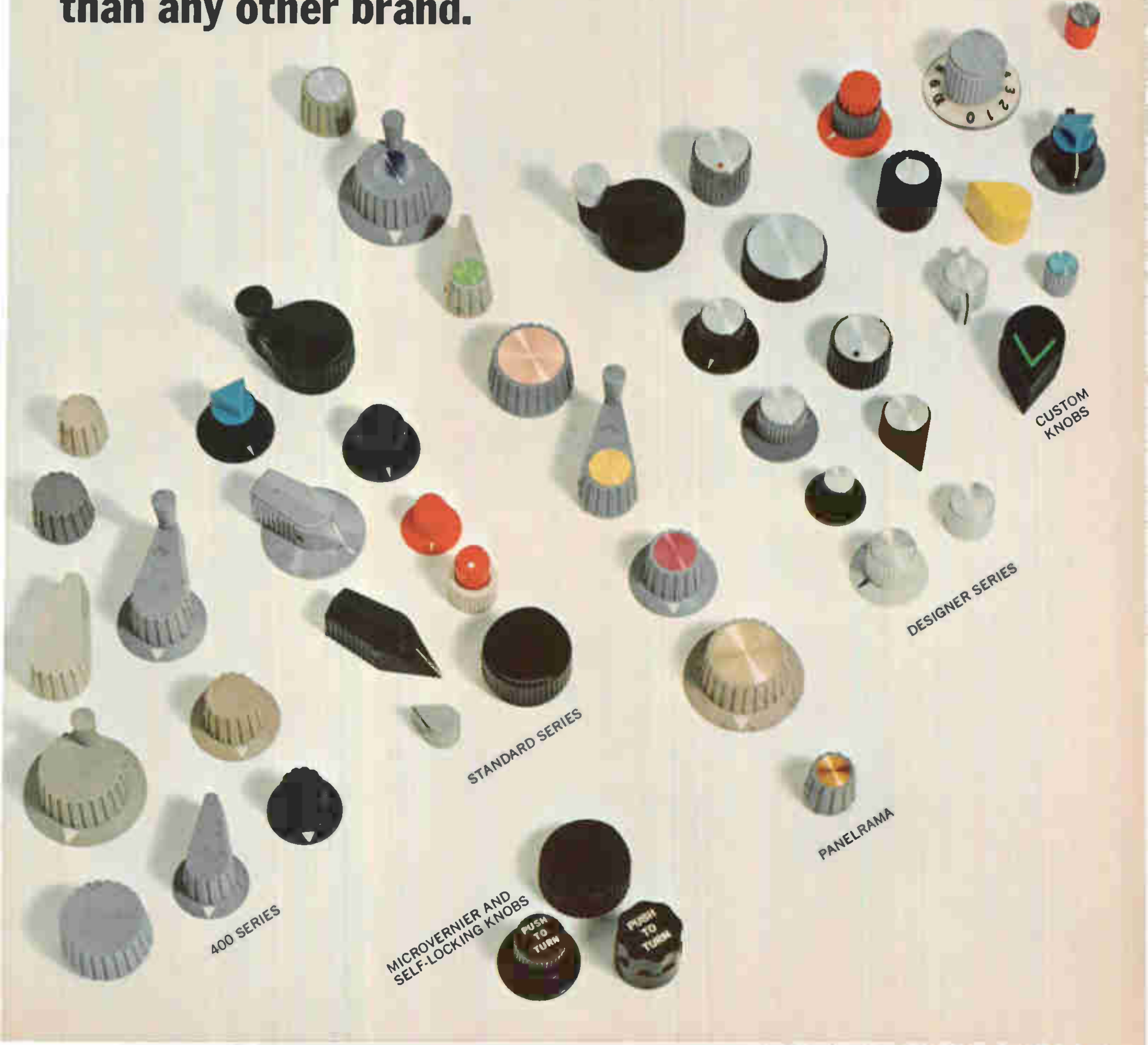
Or, you can choose elegantly-styled Designer Series knobs with spun-aluminum caps on body colors of black; light, medium, or dark grays; and off-white. When you need a solid color, select from the nine decorative colors in our 400 series.

For military applications, specify Standard Series control knobs—thousands of quality knobs that meet MS91528. Or, specify the new self-locking push-to-turn knobs and Microverniers...for accurate, precision control settings. And when you need custom-made knobs, call Raytheon first ...to get the advantages of Raytheon quality and fast delivery.

For a catalog, call your distributor or nearest Raytheon regional sales office. Or send the reader service card. *Raytheon Company, Industrial Components Operation, Quincy, Massachusetts 02169.*

RAYTHEON

Here's why Raytheon knobs control more settings than any other brand.



November 11, 1968

New roducts

Data ha

rs a numbers game

se fast IC's is smaller and cheaper
nd has much more noise immunity

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fast operators, TTL etting into new things. Its venture is a numbers game, ut a respectable one.

The game is actually a digitizer that also displays the data and passes it on to a computer or recorder. Called a reversible scaler, the Micrometric Corp. device is built almost entirely with transistor-transistor-logic integrated circuits.

According to Victor Elischer, a consultant who helped design the new scaler, using TTL enabled Micrometric to build a device that costs less than its older system, has a much higher counting speed —5 megahertz instead of 30 kilohertz—is one-third the size, and has three times the noise immunity.

And, Elischer says, things will be getting even better. "With the multifunction medium-scale-integration logic that's becoming available, we'll be able to reduce the number of components in the circuits by another 30%."

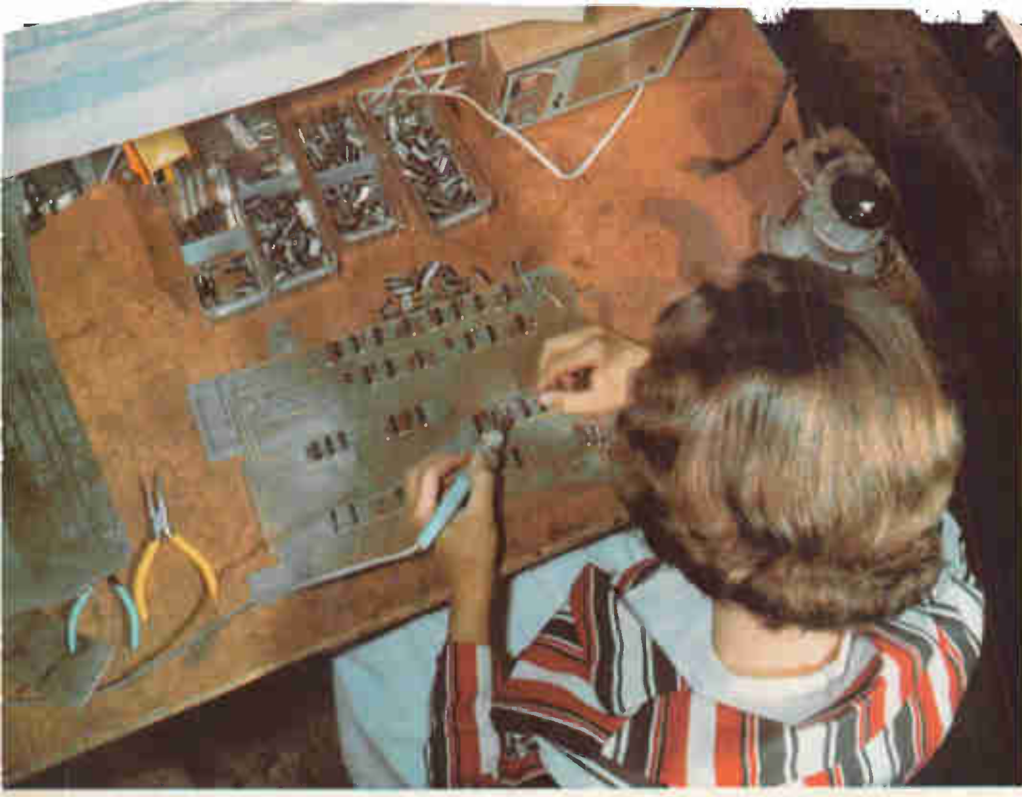
The unit, selling for $4,500, can take position data from up to three encoders (x, y, and z axes). The reversible counters can go up to 10^6, and the three sets of Nixie-tube displays have six digits each. The older scaler handles only two axes, counts up to 10^5, and costs $6,000.

The main parts of the new system are three types of printed-circuit boards, for input, scaling, and display.

Each of the three inputs comes in on two lines containing a quadrature pair of square waves. These waves pass through single-shot

Down the line. A two-axis version of the scaler can be used for laying out the artwork during the design of an integrated circuit. In this application, the system has an accuracy of 2 mils.

Digitized data from the scaler can be fed to the IBM 526 card punch (in picture) or other recorder.



On the board. The system's seven p-c boards—one of which is shown (above) being made—contain a total of 264 IC's.

multivibrators on the input board that fire on both the rising and falling edge of the waves, converting them to pulses. The quadrature waves gate the pulses to produce negative addition or subtraction pulses. These pulses toggle ADD-SUB flip-flops and feed through a gate to supply count pulses to the scaler board.

The rise time of the square waves can't be more than 2 microseconds. The normal pulse amplitude is 6 volts, but the input board can take almost any amplitude as long as the current drawn never exceeds 50 milliamps.

The input board also feeds reset and display pulses to the scaler boards and anode-gating signals to the display board. The scaler boards send cathode-drive signals to the display boards and other signals to the output board which interfaces with a recorder.

Tooling along. The Micrometric scaler can also be used as part of a larger system to control tools. However, the 5-Mhz speed is most important when the system is used as a digitizer, because it allows the instrument to work on the fly.

A user tracing out a curve needn't stop at discrete points to allow the scaler to catch up with the tracing pen, or worry about the scaler catching up when the pen changes direction.

The digitizer could be used, for example, with an interferometer or to handle topographical or bubble-chamber data.

And Micrometric predicts that designers of IC's will be interested in the system since it can measure artwork with an accuracy of 2 mils.

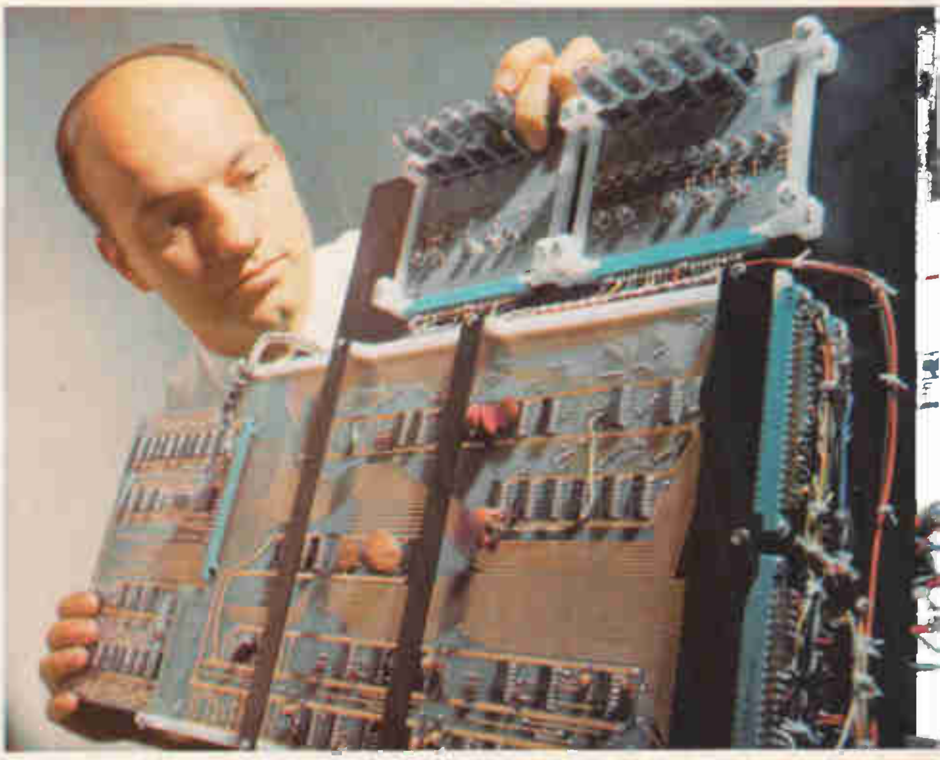
Independent trio

The board, called the S1001, of logic, scaler res tubes. This dled by a ri logic. The 9-b 39 Texas Instru a few discrete co

The scaler bo S1000, is a one-to- complete with buffer 9-by-16-inch board IC's. Separate decim coded decimal, octal, a outputs are available as

Time sharing. Six time Nixie tubes, six anode drive 10 cathode drivers are mounte each of the display boards, ca S1004's. Micrometric says it's t first to use this type of Nixie tub in a commercial system.

The cathodes of all the tubes are wired in parallel according to digit; all "0" cathodes are tied together, all "1" cathodes are tied together, and so on. The time-sharing control energizes the anode of the first display tube for about a millisecond and simultaneously



With the system. Victor Elischer, who helped design the scaler, examines the display portion, which uses time-shared Nixie tubes.

. different output p-c boards for different recorders . . .

strobes the cathodes. All other anodes are held at 0 volts. After the millisecond, the control logic energizes the anode of the second tube and strobes its cathodes. This sequence continues through all tubes and then repeats continuously. To the eye, the tubes seem to be always on.

The time-sharing plan, devised by the Burroughs Corp., reduces the number of circuits and connections in a display.

Each S1004 needs between 200 and 300 volts and draws a maximum of 60 milliamps.

Mating games

Signals from the scaler boards pass through circuit boards specifically designed to interface the system with a particular output device. For example, one board, which Micrometric calls the S1002, links the system with the IBM 526 card punch. Other available boards mate the scaler system with magnetic-tape decks, computers, and paper-tape punches.

Elischer, elaborating on the scaler's advantages, says, "This is the first time anyone has put six-decade 5-Mhz buffered and reversible scalers in such a compact system." The new unit is also lighter—25 pounds against 80 for the old one.

It hurts here. Since the new system has fewer parts and interconnections, it's more reliable. But if something does go wrong, the system itself will often tell the operator where to look for the source of trouble.

If the circuits associated with a decade display go bad, two digits are displayed simultaneously in that decade. Most malfunctions of this type can be pinpointed with a d-c voltmeter; otherwise, the operator just replaces the offending card.

Scaler malfunctions cause the transfer of superimposed data to the recording device, and the resulting gibberish sticks out like a sore digit. Buffer breakdowns turn on front-panel lights.

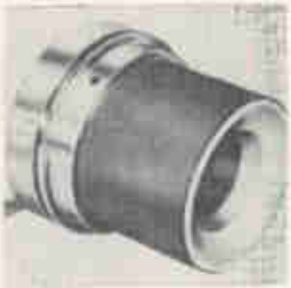
Micrometric Corp., Box 956, Berkeley, Calif. 94701 [338]

New Components Review

Low-drift metal film resistor is for high-accuracy test probes. The 1/4 watt model PME-64 is rated at 2,500 v with a resistance range of 500 ohms minimum to 20 megohms maximum. It measures 0.97 x 0.1 in. Standard temperature coefficients include ±25, ±50, and ±100 ppm/°C. This low TC helps eliminate drit. Pyrofilm Resistor Co., Cedar Knolls, N.J. [341]

Miniature, high ohm thick film resistor GE10 is a high-stability, molded device for applications such as resistor networks, FET circuits, operational amplifiers and other circuits where a high impedance is characteristic. Maximum voltage rating is 200 v and resistance range is 499 kilohms to 20 megohms. Mepco Inc., Columbia Rd., Morristown, N.J. [342]

Lumped-constant delay lines series 100 are compatible with dual in-line IC's. Sizes are from 0.385 x 0.700 in. for the 10 nsec line to 1.400 x 1.600 for the 100 nsec line. The units, at 100-ohm impedance, are designed for 125 Mhz cut-off, have typical rise times of 4 to 8 nsec, and taps are each 2.5 nsec. Engineered Components Co., Gardena, Calif. [343]

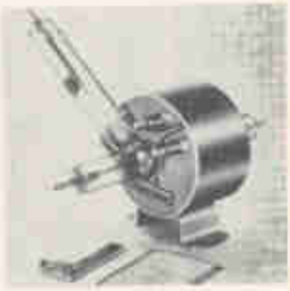


Deflection yokes type YB are designed to fill the need for a high Q yoke with high sensitivity while maintaining reasonable residual magnetism and resolution. The yokes have a d-c to over 4 Mhz bandwidth and a 100 nsec stroke capability. They may be used in direct drive, random positioning alphanumeric applications. Availability is 3 weeks. Celco, Mahwah, N.J. [344]

Rectangular trimmer type 900-20 is free from catastrophic termination failures. This is guaranteed by silver-brazed terminations. Unit is available in a resistance range from 10 ohms to 20 kilohms at a tolerance of ±10%. It has a power rating of 1 w at 40°C, derated to 0 at 125°C. Trimmer measures 3/4 x 0.16 in. IRC, Div. of TRW Inc., 401 N. Broad St., Philadelphia. [345]

Infrared sensitive Vidicon TH9890 differs from similar tube types sensitive in the visible range, only by its photoconductive layer, the threshold spectral sensitivity extending far above 2 microns. Its length is 6.25 in. and its diameter 1 in. Heater consumption is 150 ma under 6.3 v. The high voltage is about 300 v. Thomson Electric Co., 50 Rockefeller Plaza, N.Y. [346]

Screw-driver-adjust TT-75 and TT-120 Tiny Trim delay lines are variable to 75 nsec and 120 nsec and are designed to permit a wide adjustment range in a compact space with a delay resolution of 1/4 nsec. Units measure 1.75 x 0.545 x 0.275 in. Price is $15 or less in quantity; delivery, from stock. Kappa Networks Inc., 165 Roosevelt Ave., Carteret, N.J. 07008. [347]



High-voltage vacuum relay HVS-10/S8, for medical electronic uses, has broad applications in other areas where high reliability, high-voltage switching is required. It can switch up to 500 w-sec of pulse energy. The relay will switch up to 17 kv peak. It operates on a 40-v d-c coil. Price (1-9) is $65. High Vacuum Electronics Inc., 538 Mission St., S. Pasadena, Calif. [348]

New components

Photomultiplier dynode gives gain of 30

Cesium-doped gallium phosphide is used in first stage of a tube that can distinguish a single-electron event

The leap from invention to production has rarely been as dramatic as in the case of a new photomultiplier tube built by RCA's Industrial Tube division.

The discovery that properly doped gallium phosphide makes a superior secondary emitter was made in July; three months later, tubes with first-stage dynodes made of GaP were being produced in evaluation quantities. That dynode has a gain of 30, representing the most significant advance in this type of tube since 1934. The other 11 stages in the tube have beryllium-copper dynodes.

Designated the C31000D, the new tube will be a replacement for the widely used Type 8575, which has a gain of only 5 at its first stage. Gain in this context is the secondary-emission ratio—the number of electrons emitted by the dynode for each electron coming from the photocathode. With an applied field of 600 volts, the new tube's first dynode will emit 30 secondary electrons for each primary electron.

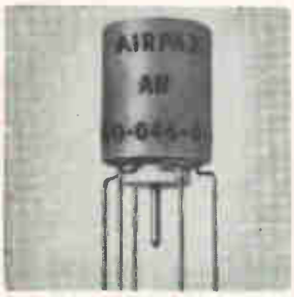
The radically improved tube is designed to detect and measure low light levels, to handle such jobs as photon and low-energy scin-

Rotary switches come in 5 series with 30, 36, 45, 60 and 90° angle of throw in 1-in.-diameter totally enclosed construction. Features include 1 to 4 poles/deck, 2 to 12 position/pole, and up to 12 decks per switch. Units are rated to switch 1 to 3 amps 115 v a-c and carry 10 amps. Life expectancy is 25,000 cycles. The ASM Corp., P.O. Box 860, Smithfield, N.C. [349]

Delay trimmer model DV1446 is designed for p-c board mounting and offers a low profile of 0.31 x 0.62 x 3.5 in. Impedance is 2,000 ohms and ripple is held to 5% or less. Delay is adjustable from 5 to 100 nsec and output rise time is 20 nsec max. Resolution is 100 psec per turn of the adjusting lead screw. Computer Devices Corp., 63 Austin Blvd., Commack, N.Y. [350]

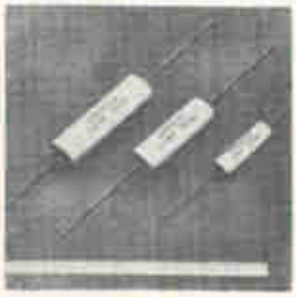
Frequency responsive switch called Fritch is preset to operate at any specified frequency between 40 hz and 50 khz. It must operate within ±2% of the selected frequency and will not operate beyond ±5% of it. Response time is 15 msec. Operating temperature is −40° to +65°C. Units are 1½ x 1½ x 2¾ in. Douglas Randall Inc., 6 Pawcatuck Ave., Westerly, R.I. [351]

Relay style 228 comes in a wide range of contact and coil options for use in a variety of industrial and commercial control functions. Contact rating is 3 amp resistive at 28 v d-c. Contact resistance is 0.10 ohm max., and contact bounce is 5 msec max. Operate time is 10 msec; release time, 5 msec. Price (1,000 lots) is 90 cents. Price Electric Corp., Frederick, Md. [352]



Subminiature relay type AR is a spdt electromagnetic unit for use in applications such as amplifier control, low impedance coaxial switching, integration and h-f/i-f switching. Nominal coil voltage is 6 v d-c. Despite its small size (0.4 x 0.48 in. case length), it accurately switches 0.150 amp resistive at 28 v d-c, 60 or 400 hz. Airpax Electronics Inc., Cambridge, Md. [353]

Voltage controlled crystal oscillator VCO-501A provides ±0.2% deviation at any fixed frequency from 5 to 25 Mhz with better than 2% linearity. Input circuit needs are simplified because the unit's high impedance, direct coupled input accepts a wide band of modulating frequencies. Standard input voltage is 26 v d-c. Hallicrafters Co., 600 Hicks Rd., Rolling Meadows, Ill. [354]



Metalized polyester-film capacitor 439P is for current-limiting or phase correction service in general purpose 60 hz a-c applications. Capacitance ratings are available from 0.047 μf to 15 μf. Typical applications for the capacitors include fan motors, tape recorder drive units, and recharging supplies for nickel cadmium cells. Sprague Electric Co., North Adams, Mass. [355]

Transistorized time delay relays series TDR are of the adjustable type, designed to overcome many of the inherent deficiencies of mechanical, pneumatic, and thermal timers. They delay on pull-in and are available in time ranges from 1 to 60 sec. Repeat accuracy is ±5%; reset time, 100 msec. Price is $8.68. Syracuse Electronics Corp., P.O. Box 566, Syracuse, N.Y. [356]

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tillation counting. The high secondary-emission ratio gives a pulse-height resolving capability that permits discrimination of single-and double-electron events.

Big help. RCA says this resolving capability could significantly advance research work in high-energy physics, astronomy, and biochemistry. The tube may help biochemists map the structure of the DNA molecule and astronomers detect light from radio stars, or be used by nuclear physicists to probe more deeply into atomic events. The device, first publicly demonstrated at last month's Nuclear Symposium in Montreal, may also increase the capability of laser range-finders and improve the performance of receivers in laser communications systems.

Key to the six-fold improvement in first-dynode gain is cesium-doped GaP deposited by vapor phase growth. Work at RCA's David Sarnoff Research Center showed that extremely high gain factors could be obtained with highly doped, p-type single crystals of GaP activated with a surface film of cesium in such a way that "negative electron affinity" is produced. As a result of band bending near the surface, the vacuum level lies below the bottom of the conduction band in the bulk of the material. Under these conditions, secondary electrons thermalized in the conduction band have enough energy for emission into the vacuum.

Other dynode materials—beryllium-copper, magnesium-silver, and cesium antimonide, for example—apparently present a substantial barrier to secondary electron emission and limit the gain per stage to from 4 to 6.

Less uncertainty. The high ratio of the first dynode in the new tube decreases the noise induced in a signal current by 18%. A photocathode itself produces a certain

Sharp-eyed. Photomultiplier can detect a light-producing nuclear event that generates only a single electron.

amount of noise, or statistical uncertainty about the occurrence of an electron event. Conventional tubes add to this uncertainty because their low secondary-emission ratios make it impossible to distinguish signals representing the emission of one or two photoelectrons from the photocathode. But the resolving capability of the new tube is such that a pulse-height analyzer can easily distinguish the electron-event peaks from the noise peaks, which occur even when no light impinges on the photocathode. The old tubes peak at a secondary-emission ratio of 7, and the curve rolls off with an increase of applied voltage. RCA engineers say the performance of the new tube is linear with increasing voltage.

There are 10 to 12 dynodes in a standard photomultiplier. But RCA is beginning work on multistage tubes with all dynodes made of gallium phosphide, and the resulting high gains may make it possible to reduce the number of stages. This would mean a shorter path for the electrons to traverse in the amplification process, which in turn would result in a shorter rise time. Rise time in the C31000D is 2 nanoseconds, but this might be reduced to around 0.5 nsec in a tube with all stages made of GaP.

Evaluation quantities of the C31000D are available, with the tubes priced at $600 each, about 2½ times the cost of conventional devices. RCA predicts that this type tube will account for a big share of the $10-million-per-year photomultiplier market.

RCA Industrial Tube Division, Lancaster, Pa. **[357]**

Corning introduces the 2½ cent bit.

In the newest CORNING® Low Cost Digital Memory Modules for serial storage.

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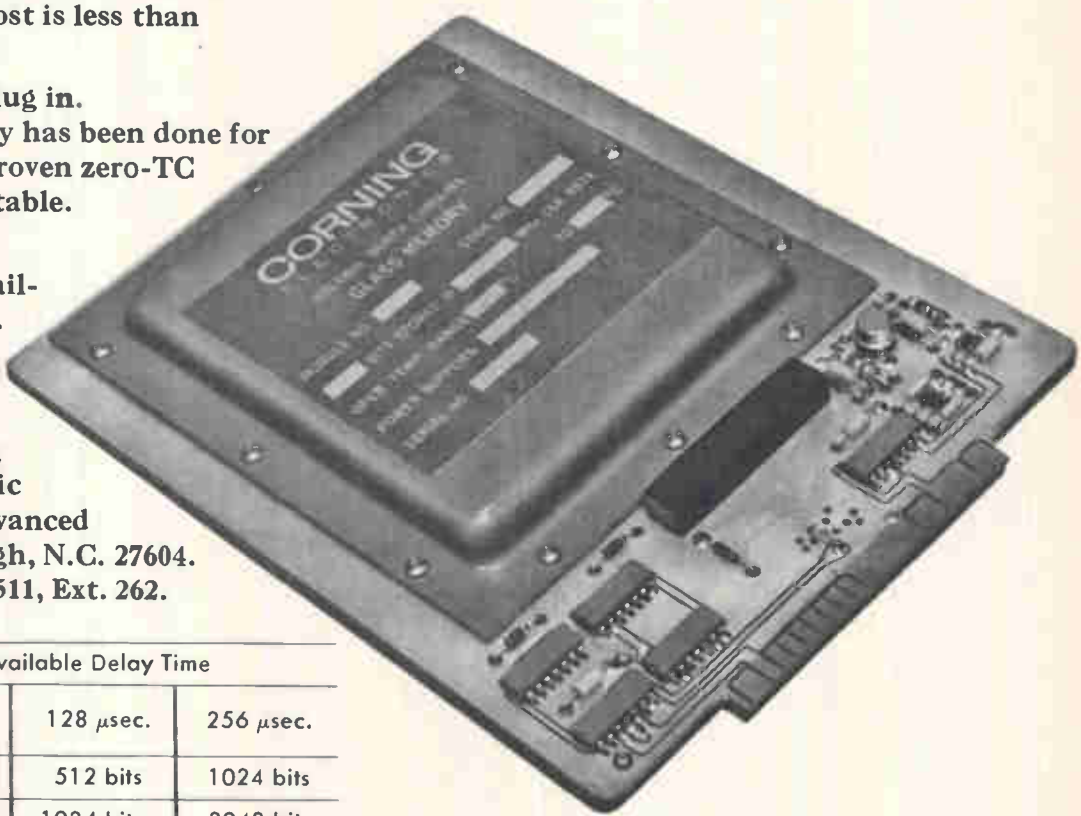


Available Frequencies	Available Delay Time: 64 μsec.	128 μsec.	256 μsec.
4 MHz	256 bits	512 bits	1024 bits
8 MHz	512 bits	1024 bits	2048 bits
16 MHz	1024 bits	2048 bits	4096 bits

CORNING
ELECTRONICS

Circle 229 on reader service card

Graphite coatings are hard and porous

They won't out-gas or flake when used on inner surface of color television tubes

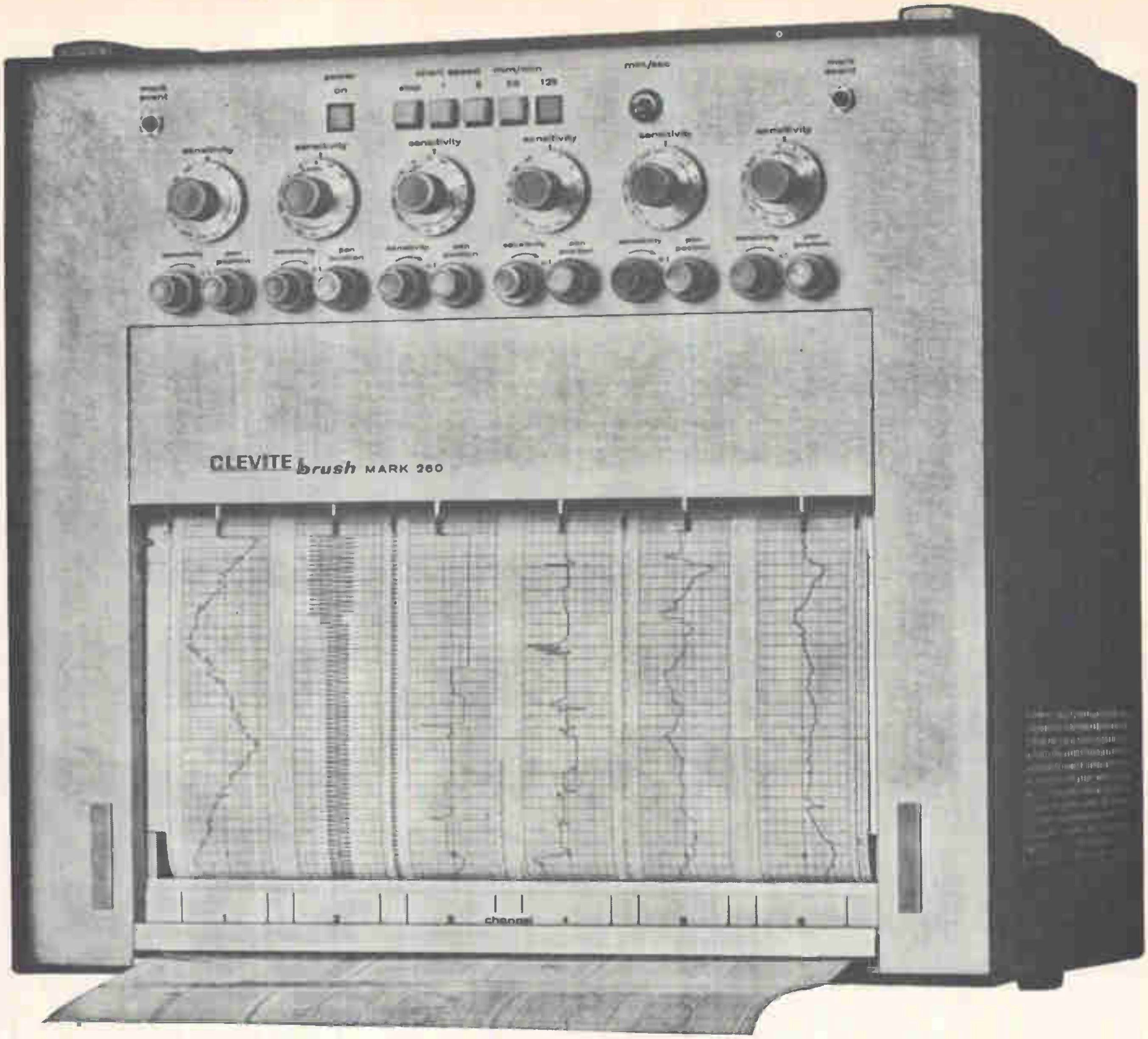
"Conductors" and "wire" have become almost synonymous, but other things besides strips of metal can carry electrons from one point to another. For example, there are the conductive coatings made by the Acheson Colloids Co. These suspensions of graphite or precious metal can be applied by brushing, dipping, spraying or screening.

The newest coatings developed by Acheson go on the insides of cathode-ray tubes, particularly the picture tubes of color television sets. The company says these coatings improve both performance and reliability.

Heat caused by electron bombardment is a problem in all crt's. The outside of a black-and-white picture tube is usually coated with a suspension of graphite in sodium silicate, and the inside with aluminum. The electrons striking the inside of the tube generate a current that flows through the aluminum to an anode button, and through the anode on out to the graphite, where heat is dissipated.

But a color tube runs so hot, that heat must be dissipated inside it. Color-tube makers first attempted to cool things off by putting a graphite coating inside the tube. This does keep the heat down and prevents a lot of the electron reflection, but the graphite suspension developed for the outside is too soft for inside work. When the electron gun is inserted into the neck of the tube during final assembly, part of the coating is chipped away, and these loose particles can get into the gun and short it.

Without additives, a hardened version of the standard coating doesn't work either because it isn't porous enough, according to Acheson. Water vapor and gas accumulated during assembly can't be



The Mark 260 tells it like it is.

That's because we've taken the fooling out of recording. This high-performance six-channel portable delivers more fact and less fiction than any other make you can buy.

The Mark 260 eliminates the things that can fool you. First, it's accurate — better than 99.5% accurate. It's the only recorder of its type with a foolproof *position feedback* system that enforces accuracy regardless of the pen's position on the chart. Second, its resolution is fully equal to its accuracy. The Brush patented pressure-fluid writing system produces thin, sharply defined traces that cannot smudge and cannot be misread. No fooling about exact reading of point-to-point values; no fooling about even the most complex wave-forms.

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Six analog channels and four event channels in a package you can carry and use anywhere. Performance that's better than many recorders twice its size . . . and twice as expensive. That's what the Mark 260 delivers.

More fact and less fooling.

We'd like to send you sample charts that "tell it like it is"— or better yet, demonstrate the Mark 260 right in your plant. Write Clevite Corporation, Brush Instruments Division, 37th and Perkins, Cleveland, Ohio 44114.

CLEVITE BRUSH

driven out before the tube is sealed, so tubes with these coatings often out-gas during operation. And when the pockets of gas crack open, large chips break away from the surface, again posing a danger to the gun.

One of the company's two new coatings, a graphite-silicate suspension, has an additive that increases porosity. Acheson says that though this coating is very hard, it can be completely out-gassed before the tube is sealed.

And the increased porosity means the coating can absorb gases when electrons bombard the tube face.

The other new suspension, graphite in lithium polysilicate, also gives a hard and porous coat. But it has the added advantage of being moisture resistant, and so eliminates the need for constant protection of the inner surfaces of partly assembled tubes.

Acheson Colloids Co., Box 288, Port Huron, Mich. 48060 **[358]**

New components

A weight saver for jumbo jets

Remote circuit breaker controlled from cockpit lightens power-cable load

As airplanes get larger, part of their extra weight comes from the electrical wiring needed to get information or energy from one end to the other.

In some new aircraft, data and communications are multiplexed and transmitted over coaxial cables to cut the weight of redundant small-gage wiring. But, until recently, no company had done much about expensive, heavy avionic power cable.

No one has yet found out how to multiplex power circuits, but Texas Instruments' Precision Circuit Breaker department has figured out how to eliminate many of the long runs of cable connecting the flight engineer's console

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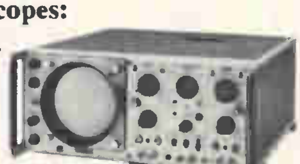
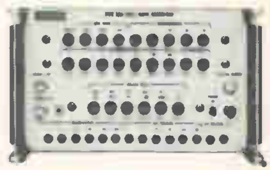


Pulse, Square Wave and Time Mark Generators

DUMONT 781A
Time Mark Generator



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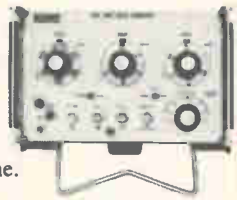
DUMONT 792A
Pulse Generator
50 Hz to 10 MHz rep rate, double or single pulse, single shot operation. Gives nanosecond rise and fall time.



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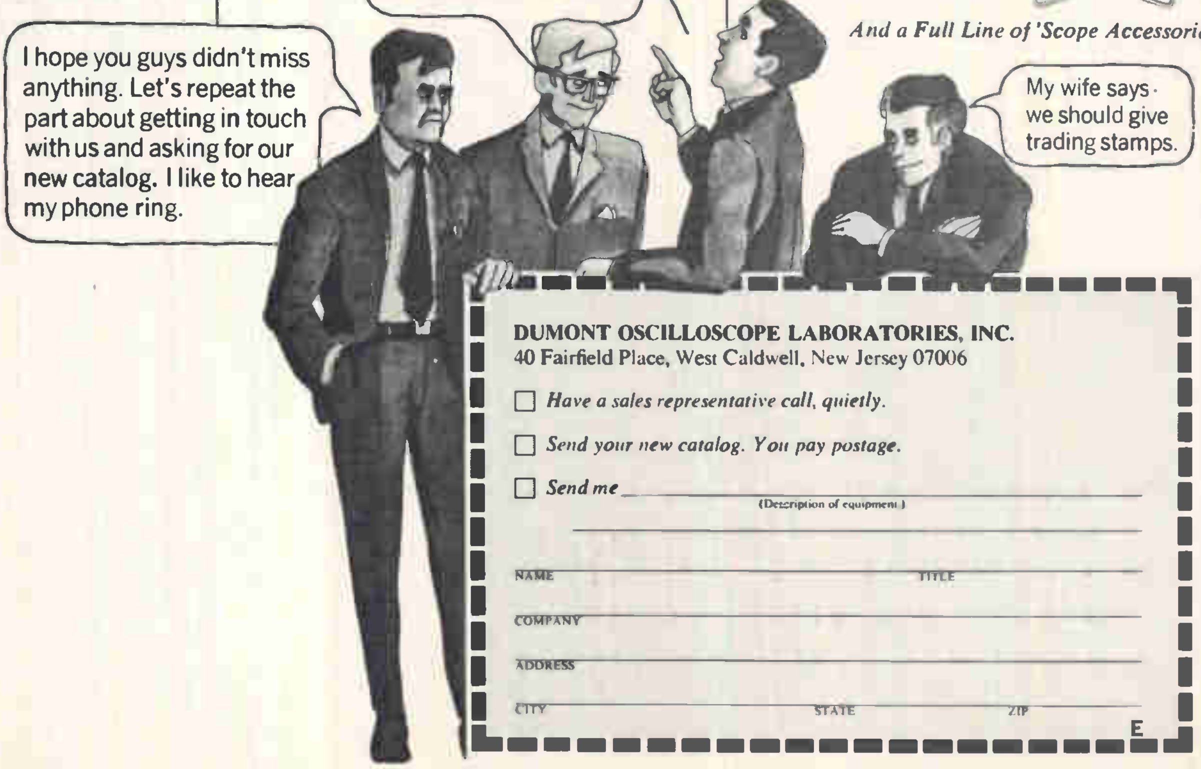

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7A

Circle 325 on reader service card

with power-generation gear.

Long loop. In today's aircraft, power leads run from generator to radar and other systems by way of a large circuit-breaker panel in the cockpit, and this additional loop might be as long as 300 feet in a plane like the Boeing 747 jumbo jet. TI would eliminate this 300 feet of heavy and costly cable by using a remote-control circuit breaker near the generator and controlling the breaker by a small low-voltage switch in the cockpit.

In a 75-amp circuit, such an installation could save tens of pounds of 6-gage wire. Substituted for it would be light, inexpensive 22-gage control wiring. The control wire would cost about 18 cents per foot, against about $1 per foot for the conventional wire, according to a TI spokesman.

Weight savings also reduce the cost of the airframe. This varies among manufacturers, but the range is from $100 to $200 per pound saved.

According to Harold R. Damberg, senior product specialist for

Sensor. The 2RC circuit breaker (above) fits into a power line and is actuated by a cockpit switch.

circuit breakers, TI foresaw the need for such a remote-control circuit breaker about two years ago.

"A jumbo jet might contain from 1,000 to 1,200 circuit breakers," says Damberg. "Of these, about 75% would be in circuits where remoting could be profitable." Damberg adds that the new breakers are expected to sell for about $75 each and will be competing with manually controlled breakers costing only about a tenth that amount. "Even so, the amount saved in heavy cable alone would offset the higher price of the re-

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Chemical Division 3M

. . . a bending bimetallic strip trips breaker . . .

mote breaker," he says. And then there's that $100 a pound.

On the buses? Early in 1968, Boeing gave TI a development contract for a remote breaker, having found that wire runs would be a weighty design problem in its 747. Damberg says that McDonnell Douglas is considering such breakers for its DC-10. Lockheed is said to be considering them for its own airbus, and it may retrofit them to the C-5A transport.

Each breaker, part of TI's Klixon line, consists of a 7274 series trip-set switch and a 2RC series circuit breaker. With the switch, the flight engineer can either open circuits at the breaker or reset breakers which have already been opened because of overload.

The 2RC is a thermally operated breaker; overload heats a bimetallic strip that releases a latched set of contacts. To reset the breaker, a 28-volt signal is sent to a solenoid in the breaker package. Another solenoid opens the power circuit with a push of the same button on the trip-set switch.

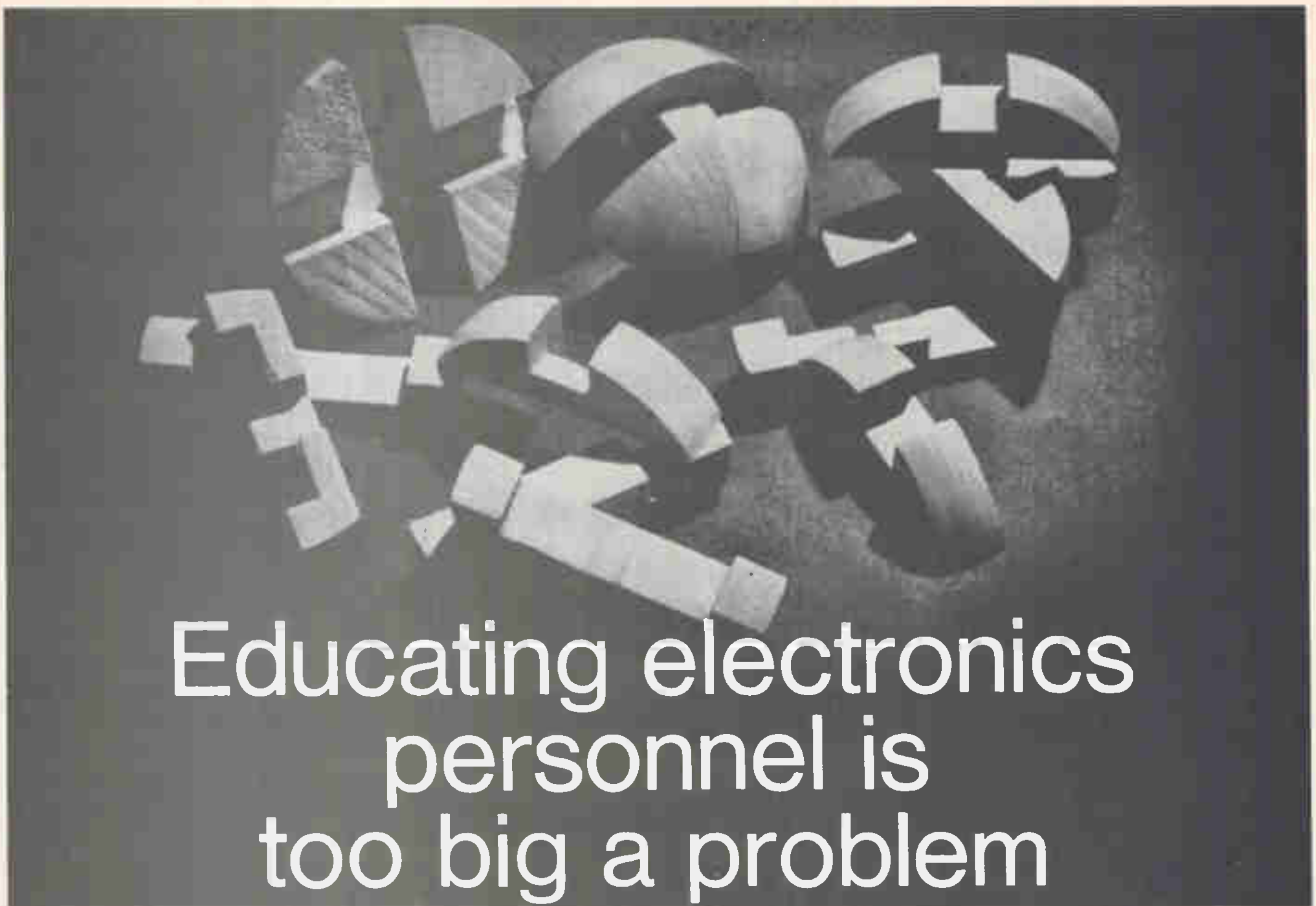
Damberg says TI will offer the remote circuit breakers in amperage ratings from less than 2.5 to 100 amperes. They would each be capable of handling either 30 volts d-c or 120 volts a-c, 60 or 400 hertz, without any sort of modification.

The new breakers might replace contactors in some applications, according to Damberg. Contactors are very high-amperage circuit breakers without current-sensing elements like the Klixon's bimetallic strip; they're usually controlled by another circuit breaker.

In its new series, TI will combine the heavy-duty contact assembly of the contactor with its thermal sensing elements in a single package.

TI plans to announce the line early in 1969 and will begin deliveries in the first quarter of the year. A delivery time of four to six weeks is scheduled after next March.

Texas Instruments Incorporated, Precision Circuit Breaker Department, 34 Forest St., Attleboro, Mass. [359]



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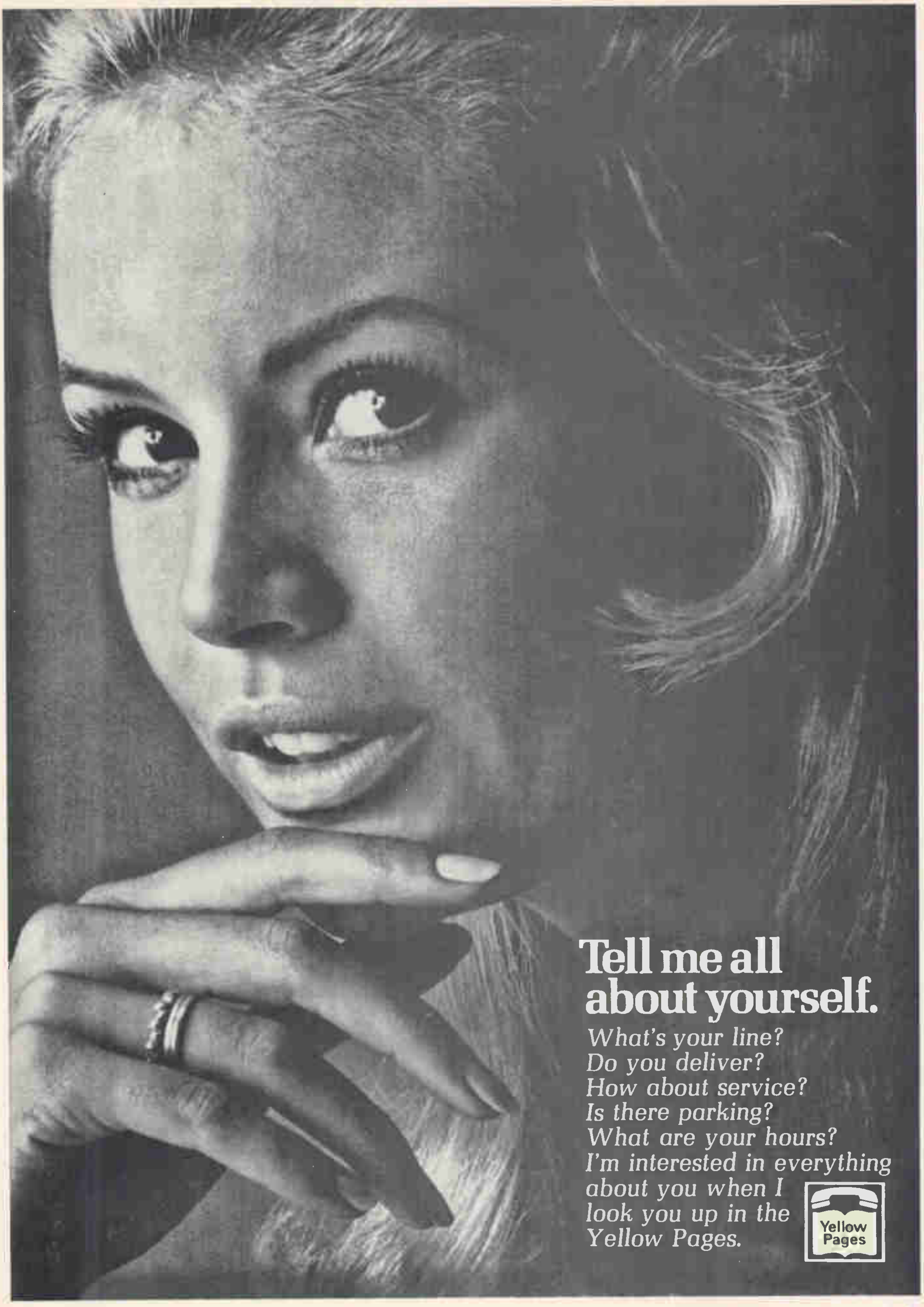
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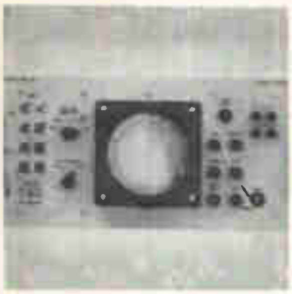
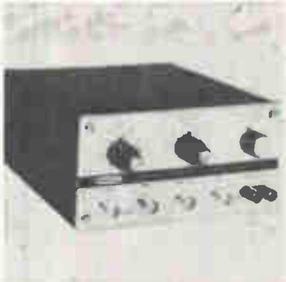
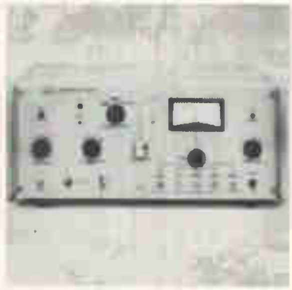
New Instruments Review



Signals detected by any 360° azimuth scan receiving system can be observed simultaneously on direction finder polar display indicator 1701. The unit is compatible with receiving systems that can supply ±1 v d-c into 680 kilohms, or 1 v d-c to 10 Mhz video into 50, 90, or 300 ohms and 60 hz synchro position data. Symetrics Engineering Corp., Satellite Beach, Fla. [361]



Pulse generator 9054 is for IC logic level compatibility. It has a frequency range of 1 hz to 10 Mhz, with controllable pulse duration. Pulse widths from 50 nsec to 50 msec are provided. The unit has two continuously adjustable signal outputs, one delivering 5-v and the other 2.5-v pulses to a 50-ohm load. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. [362]

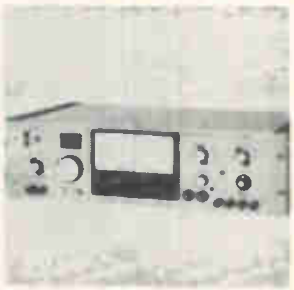


Fourier analyzer model 102 is for spectrum analysis of complex or noisy signals. It provides either the power spectrum, which is the Fourier transform of the autocorrelation or the cross power spectrum, which is the Fourier transform of the crosscorrelation. Frequency range is from 0.25 hz to 4.95 khz. Price is $12,950. Princeton Applied Research Corp., Box 565, Princeton, N.J. [363]

Six-decade log frequency to voltage converter model 1017 has an output that is a d-c voltage proportional to the logarithm of the input frequency. Output is precisely 1 v/decade and may be set to zero at any frequency. Frequency range is 10 hz to 10 Mhz with conversion accuracy of 0.5%. Price is $680. Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. [364]

X-Y recorder OEM-17 employs a low cost design usjng a d-c servo system. It offers flexibility in size and interface to accommodate various system requirements. Features include a 17 x 17 in. plotting surface, a magnetic paper-hold system, and static accuracy of ±0.2% of full scale. Price is under $700. Electronic Associates Inc., Long Branch, N.J. [365]

Solid state amplifier RF-805 is a broadband instrument from 0.05 to 80 Mhz. Ten watts are produced with better than −30 db harmonic and intermodulation distortion. No bandswitching is necessary. Gain is 47 db minimum, constant within 1 db, and full output is produced with less than 0.1 v. at 50-ohm input. RF Communications Inc., University Ave., Rochester, N.Y. [366]



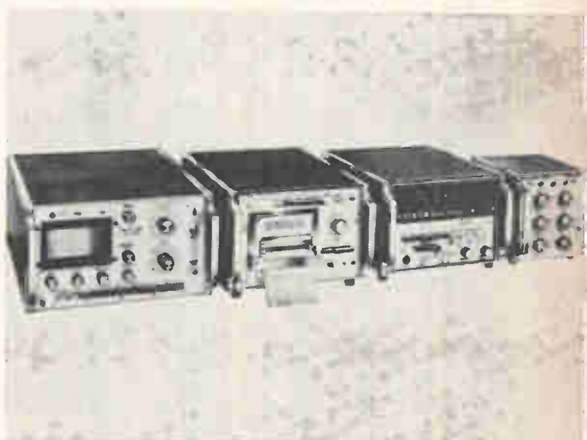
Phase sensitive voltmeter model 250 will measure phase angle, in-phase and quadrature voltages, and total voltage while sweeping frequency. For total voltage measurements, the frequency range from 10 hz to 100 khz is covered; for phase sensitive measurements, the frequency range from 30 hz to 20 khz is covered. Dytronics Co., 4800 Evanswood Drive, Columbus, Ohio. [367]

Portable ultrasonic gage NDT-110 measures thickness of metals and plastics. Using the dual-element, contact transducer, thicknesses from 0.050 in. to 2.0 in. can be read directly on the calibrated ±1% meter. Pipe or tubing as small as 5/8 inch in diameter can be measured with the gage. Northwest Technical Industries, George Washington Way, Richland, Wash. [368]

New instruments

A new 'scope—and a wider scope

Old-line instrument company introduces 25-Mhz crt display, and adds six plug-ins to its digital measuring system



Test line. 25 Mhz scope, left, is shown with one grouping of digital system.

Its introduction three years ago of a digital system capable of both counting and voltage-measuring marked the Hickok Electrical Instrument Co.'s entry into the field of laboratory and industrial test equipment.

The firm is now taking another diversification step, tackling the market for high-frequency oscilloscopes with a medium-priced unit having a bandwidth of d-c to 25 megahertz. At the same time, it's expanding its digital system, the DMS 3200, with six new plug-ins.

The compact, $650 oscilloscope

. . . plug-in extends tests to a-c voltages

"has all the important basic measurement capabilities but omits many of the more exotic and seldom-used functions often found in higher-priced models," says Kenneth F. Petersen, marketing vice president.

In the CRO 5000, response above 25 Mhz is essentially Gaussian. The scope is usable to around 50 Mhz, and trigger capability and sweep-speed ranges are consistent with this response, assuring stable displays with adequate horizontal expansion.

Display delay. A built-in vertical delay line provides nearly 50 nanoseconds of baseline prior to start of the pulse display, so the full leading edge of pulses can be viewed. Vertical sensitivity is 10 millivolts per division, with 12 calibrated steps from 10 millivolts per division through 50 volts/division. Hickok says a user can overdrive the vertical section to five times the screen height without distorting the waveshape.

The displayed waveform on the CRO 5000 can be continuously delayed up to 40 divisions by means of a multiturn horizontal position control allowing full-screen presentation of small portions of the input waveform. Sweep linearity is unaffected by this positioning. There are 24 calibrated sweep ranges, from 50 nsec per division to 2 seconds.

The scope is 11¼ inches wide, 6⅞ inches high, and 19 inches deep, and weighs 24 pounds. Delivery is from stock.

Sensitive. One of Hickok's new plug-ins for its DMS 3200, the DP110 digital microvoltmeter, provides digital display of d-c measurements from as low as 1 microvolt up to 1,000 volts when used with any of the DMS main frames. Accuracy is ±0.05% of reading ±1 digit. Push-button overranging provides full four-digit resolution for all measurements and, within the overrange capability, five-digit resolution. The price is $450.

Another plug-in extends DMS 3200 measurements to a-c voltages. The DP 130 will make a-c measurements down to 10 micro-

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Circle 330 on reader service card

. . . set-point controller added to test line . . .

volts. The unit, priced at $375, operates over a range of 22 hertz to 1 Mhz. Its accuracy up to 100 kilohertz is 0.1%.

Scalable. The DP 160 counter plug-in gives the DMS the ability to count and measure frequencies up to 80 Mhz. The functions are performed directly; heterodyning isn't needed. The plug-in, which is priced at $395 and can be used with the basic system's three-digit readout, includes scaling pushbuttons to give reading resolution up to seven digits.

A meter plug-in, the DP 210, provides digital displays of either time-interval or period measurements from 10 microseconds to 999 seconds with an accuracy of ±0.0005% of reading ± one digit. The instrument, which sells for $230, has separate start and stop inputs, each with independent adjustments of trigger level, attenuation, and slope.

Trim silhouette. The only adapter in Hickok's new line of plug-ins adds d-c current measurement to the system's capabilities. The D310, which will sell for $90, permits the DMS to measure d-c currents from 0.1 nanoampere to 10 amperes when a d-c microvoltmeter is in the main frame. Accuracy is 0.15%, and Hickok says that insertion loss is low because of the high sensitivity of the measurement plug-in. A 3,000-volt isolation from ground means the D310 can be used for in-circuit tests. And because of its thin silhouette, it can be inserted beneath the DMS main frame.

A digital set-point controller, the model 1050, can start and/or stop the operation of any peripheral function at measurement values selected by the operator. When it's used with the DMS main frame, digital values of voltage, frequency, or other measurements will activate external mechanical feeds, printouts, or feed motors. External control will be activated when a reading exceeds an upper set-point number or drops below a lower set-point.

Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 44108 [369]

Circle 243 on reader service card→

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Devices meter auto pollutants

Portable analyzers use resistance changes to measure amounts

One new idea that auto makers have had recently is to put pollution-control devices on cars and trucks. They got this idea from reading both recently enacted and proposed laws that taken together say: "Clean up automotive exhaust."

The Bacharach Instrument Corp., anticipating a demand for instruments to test these devices, has developed two: one measures the carbon-monoxide content of car exhaust; the other, the opacity of diesel engine exhaust.

Double take. As pollution legislation gets tougher, two things are going to happen, says William Milon, chief engineer in Bacharach's diesel division. First, government control agencies will need an instrument for vehicle inspection stations and roadside check points that an inspector can hook up to an exhaust pipe to get a direct reading of pollution concentration.

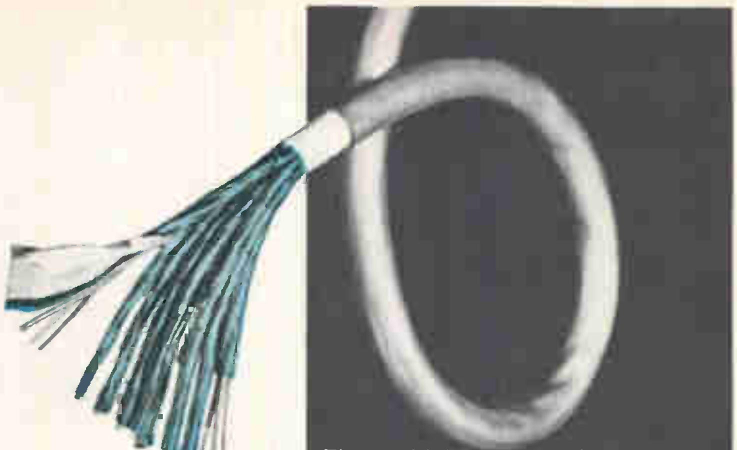
Failing such an inspection could mean a heavy fine for the driver. So, says Milon, garages are also going to need these instruments to calibrate, repair, or adjust the control devices.

So any instruments of this type have to be simple to both hook up and operate. They also should be portable and capable of running off a battery.

But they don't need the accuracy of a laboratory instrument.

Milon says both of Bacharach's instruments are rugged, easy to use, and low-cost.

The CO analyzer, called the model 7414, works on the principle of selective catalytic combustion. Exhaust gas, mostly CO and hydrogen, is pumped into a chamber that contains a catalyst-coated platinum wire. A power source outside the chamber continuously



This multiple pair, Beldfoil shielded cable is typical of the types of Belden cable used in recording critical measurements on the Goldstone tracking antenna.

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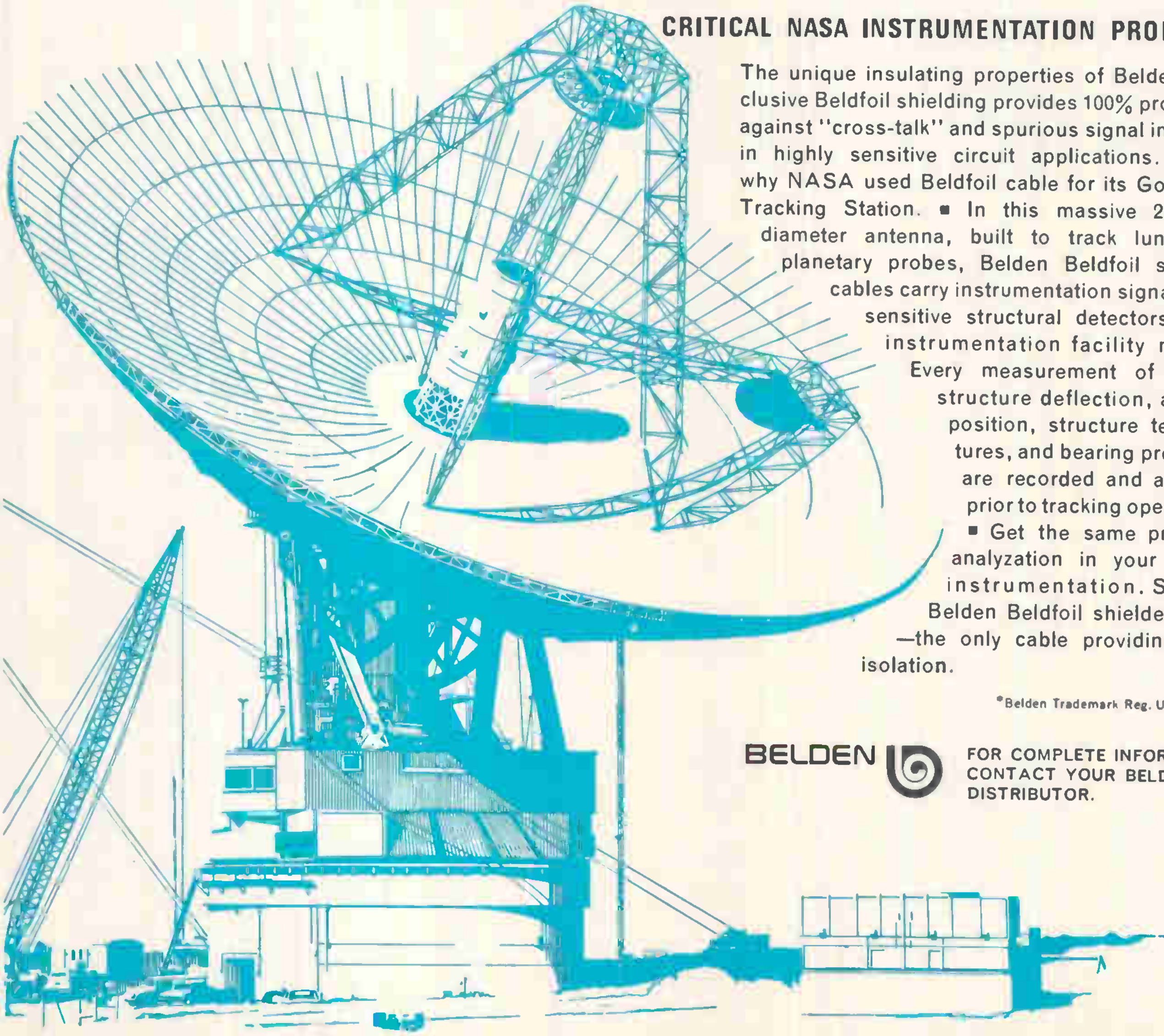
CRITICAL NASA INSTRUMENTATION PROBLEM!



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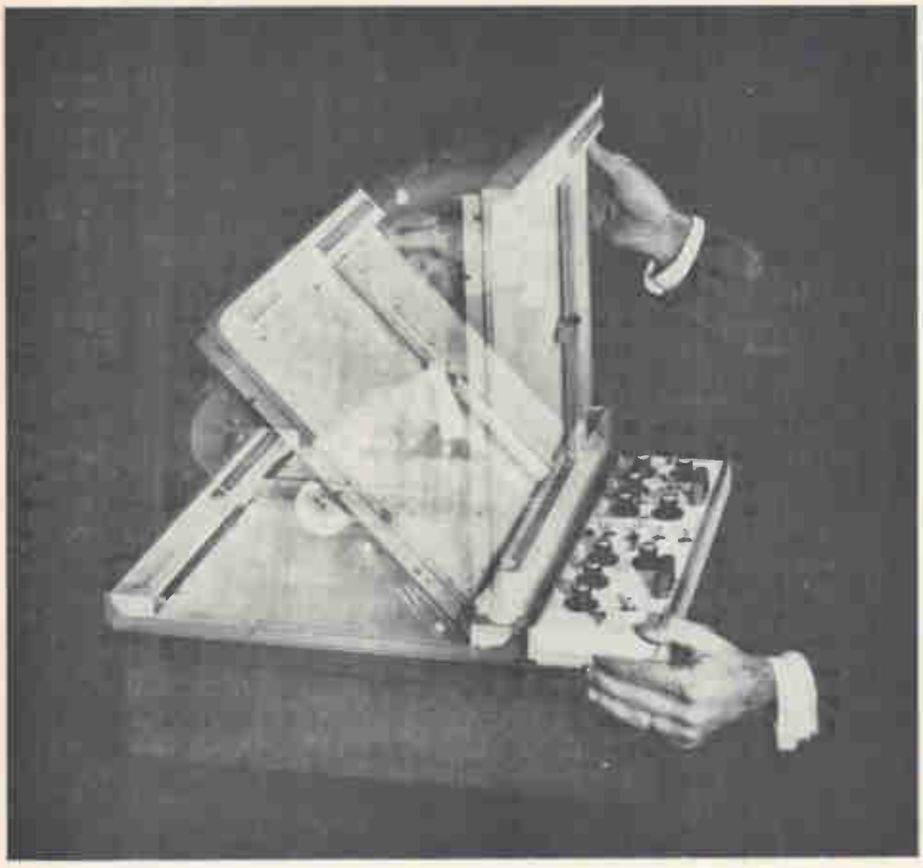

Hot . . . Exhaust is pumped into test chamber and ignited. The temperature is proportional to CO concentration.

drives current through the wire, generating enough heat to ignite the CO and the hydrogen in the presence of the catalyst.

When the exhaust ignites, the temperature in the chamber rises, increasing the wire resistance. Since the ratio of hydrogen to carbon monoxide concentrations is fairly constant, the resistance change is proportional to the amount of CO in the exhaust.

Tests in Detroit. The 7414 is accurate to within ±5%. Its meter and controls are in a 4-by-4-by-2-inch package, and the test chamber is in an 8-by-9-by-12-inch case. Packed along with the chamber is a condenser that takes hydrocarbons out of the exhaust so they

. . . and cloudy. As density of diesel exhaust increases, the amount of light reaching the photocell decreases.

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Photofab example—words photo-etched in a sheet of .001 beryllium copper.

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. . . lens needs no tanks to keep itself clean . . .

aren't burned with the CO and hydrogen.

Although intended for quick checking, the 7414 can run continuously and has a 5-second response time. The range is 0 to 5% concentration, and the instrument draws 30 watts from a 115-volt, 60-hertz input.

Milon says the 7414 is in the "advanced prototype" stage. This means Bacharach has a working instrument but is waiting for a big order before going into full production. According to Milon, the unit is now being tested by Detroit's Big Three and by the State of California.

The price isn't set, but Milon says it will be about $350.

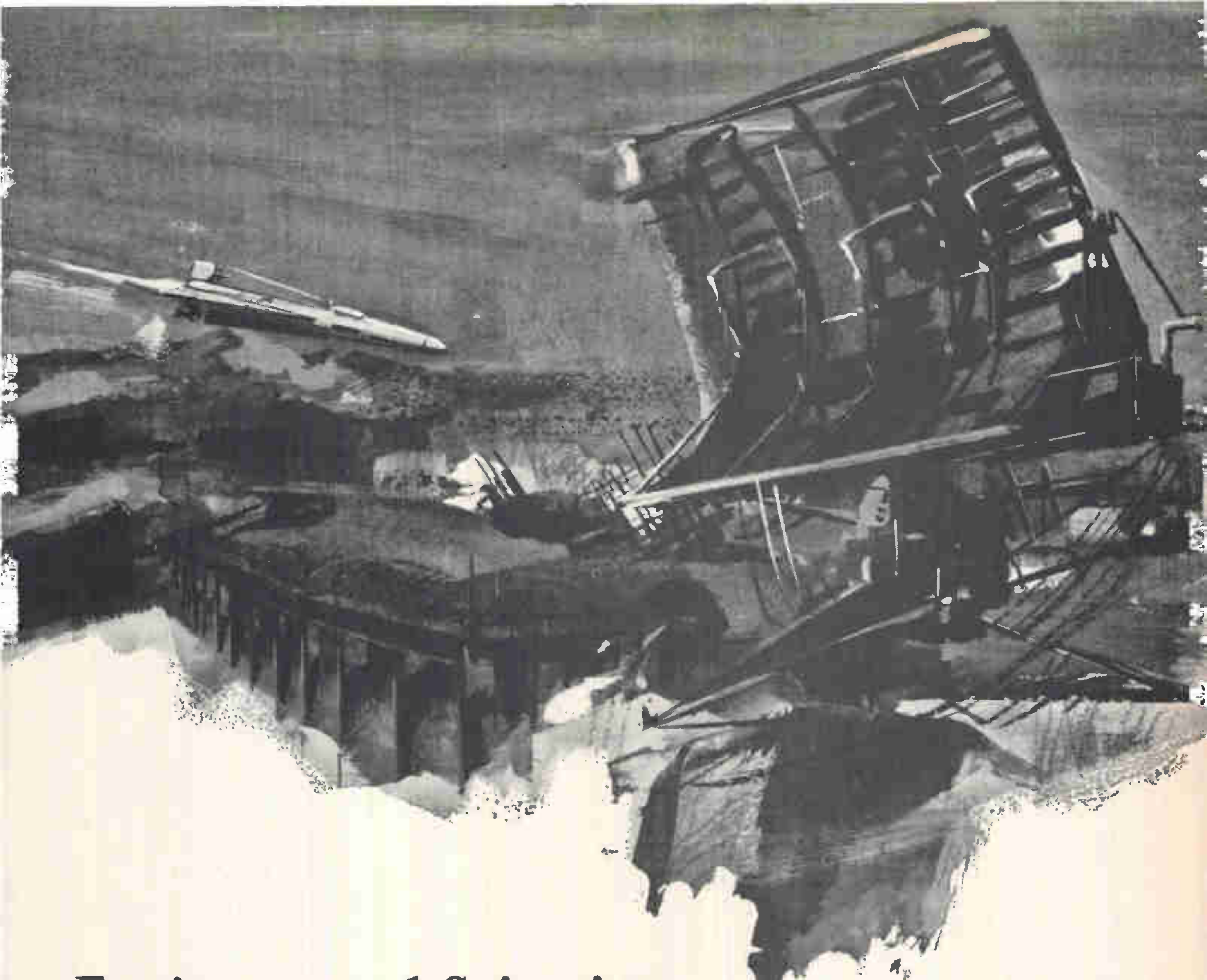
Smoke signal. The opacity meter uses a standard technique. A sensor containing a lamp and a photocell is placed at the end of the diesel engine's exhaust pipe. As the opacity of the exhaust changes, so does the amount of light reaching the cell, and the change in cell resistance is read out on a meter scaled in opacity units. The opacity is proportional to pollutant concentration.

One improvement over similar devices, says Milon, is that the Bacharach unit doesn't need compressed air to clean the lenses that focus light on the photocell, so a user doesn't have to lug air tanks around with him. Bacharach engineers built the device with the idea of selling it to New Jersey, one of the tougher states when it comes to pollution laws. Trenton hasn't decided whose meter to buy, but Milon says the Bacharach unit fills all the state's requirements.

The lenses are arranged so that the cell sees only light from the lamp; a truck won't fail a roadside inspection because a cloud passes in front of the sun.

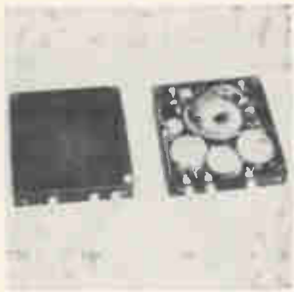
The instrument runs off a rechargeable battery pack, has ranges of either 0 to 50% or 0 to 100% opacity, is accurate to within ±2 opacity units, and costs about $400.

Bacharach Instrument Co., RIDC Industrial Park, Pittsburgh 15238 [370]



New Subassemblies Review

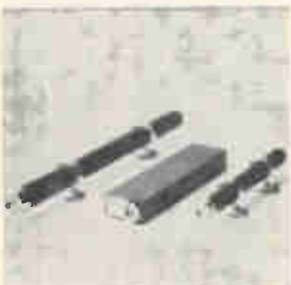
Modular triangle-averaging multiplier model 4031/25 may be used for 2-quadrant division, squaring, and square-rooting, as well as 4-quadrant multiplication with ±0.5% accuracy. Both inputs and the output are rated to ±10 v, and the module operates on standard ±15 v d-c power supplies. Unit price is $145. Burr-Brown Research Corp., 6730 S. Tucson Blvd., Tucson 85706. [381]



D-c/d-c converter type IT-322 is designed to supply accelerating voltage for a wide variety of post accelerator type crt's. Outputs of +2,200 v at 40 μa and −850 v at 2 ma are available with 1% line regulation and 3% load regulation in a 5 cu in. module. Input is 28 v d-c ±10%. Price in lots of 100 is $125. ITI Electronics Inc., 369 Lexington Ave., Clifton, N.J. [382]

Low pass transister active filter type 714 provides a 3-pole Butterworth response to attenuate undesired frequencies at a rate of 60 db per decade. Operating temperature range is 0° to 70°C. Units with −3 db cutoff frequencies in the range of 10 hz to 10 khz are offered at $45, and units down to 0.005 hz will be quoted. White Instruments Inc., Box 698, Austin, Texas. [383]

Power supply model TRP-25-0.25 is a solid state unit operating from 115 v 60 hz, delivering continuously adjustable d-c from 0.5 to 25 v at currents up to 250 ma. Housed in a cabinet 4¾ x 4½ x 4½ in. including direct reading voltmeter, it has an output regulated to ±0.1% against line variations of ±10%. Canadian Research Institute, 85 Curlew Drive, Don Mills, Ontario. [384]



Helium neon lasers models 195, 210 and 230 feature a coaxial plasma tube design and have a guaranteed output in excess of 2 mw, 4 mw and 7 mw respectively. They come in a variety of modular configurations, and can operate at wavelengths of 6,328 angstroms, 1.15 and 3.39 microns. Optics Technology Inc., 901 California Ave., Palo Alto, Calif. [385]

Power supplies series 5100 are for electrostatic applications. They are ferroresonant-transformer regulated using basic voltage multiplying circuits to attain high voltage outputs from lower voltages on the transformer. Typical output voltages would be 12.5 at 1 ma; or 6 kv at 2 to 4 ma. Sola Electric Div., Sola Basic Industries, 1717 Busse Rd., Elk Grove Village, Ill. [386]

Digital data acquisition systems of the SD-500 series are for industrial processes, laboratory, aerospace and aircraft tests. They are designed to accept d-c or a-c signals in the range from 0 to 10 khz. Full scale input ranges 2.5 v rms and 25 v rms are standard. Prices start at $25,000. Columbia Research Laboratories Inc., McDade Blvd. & Bullens Lane, Woodlyn, Pa. [387]

Magnetic tape buffer store DS-3 is for fast, accurate reception, storage and transmission of binary coded data. The basic machine provides independent read and write tape drives with associated electronics operating on a single closed loop of tape. Input and output are in 8-bit parallel format. Unit measures 5¼ x 19 x 22 in. Wiltek Inc., 59 Danbury Road, Wilton, Conn. [388]

New subassemblies

Tape memory price and package trimmed

Skew is minimized in a low-speed recording system developed for small computers and peripheral equipment

Small-computer makers and peripheral-equipment houses usually have to buy the components and make their own memory subsystems. The price tags on off-the-shelf equipment have been just too high. Ampex Corporation says it will change that situation with a tape memory system in which substantially lower costs are achieved by use of integrated circuits, simplification of mechanical features, and elimination of waste space.

The unit will be demonstrated at the Fall Joint Computer Conference in San Francisco, Dec. 9-11.

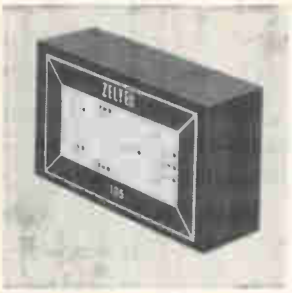
The model TM-Z, which is compatible with IBM computer systems, will sell for $3500, a figure Ampex says is 20% to 40% lower than the prices on complete tape memories of comparable size and performance.

"The emphasis is on the word 'complete'," says Eugene E. Prince, Ampex vice president and general manager of the Computer Products division. "Tape memory prices often include only the transport. Such equipment as record/reproduce heads and electronics are available at extra cost."

The TM-Z will be available in December and will be sold in mini-

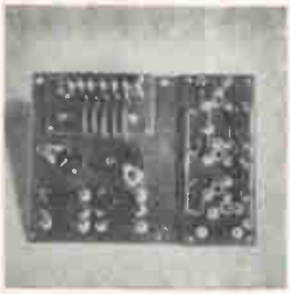
Decode/display memory module series DS-100 is designed to drive a Datecon cold-cathode tube directly from low level natural binary coded decimal input. The input count is stored in a quad latch memory and displayed on a readout tube. The display is updated upon application of a gating signal to the quad latch. Integrated Circuit Electronics Inc., Box 647, Waltham, Mass. [389]

Converter model 136 is fed audio-frequency-shift signals as received by a compatible radio receiver, or from line signals, and converts them into amplitude modulated signals suitable for photo-facsimile or teletypewriter reproduction. The converter will accept input frequencies 1,500 to 2,300 hz. International Scanatron Systems Corp., 1623 Straight Path, Wyandanch, N.Y. [390]

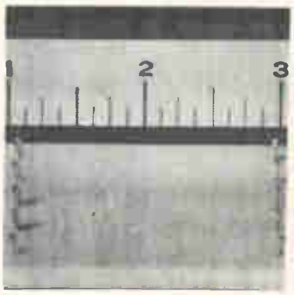


FET differential amplifier model 135 is for use in sample and hold circuits, integrators and buffers. Key specs include: common mode rejection ratio of 300,000 v/v, gain bandwidth product of 5 Mhz, and slew rate of 100 v/μsec, minimum. The unit measures 1.135 x 1.135 x 0.640 in. Price is $89 in evaluation quantities. Zeltex Inc., 1000 Chalomar Road, Concord, Calif. [391]

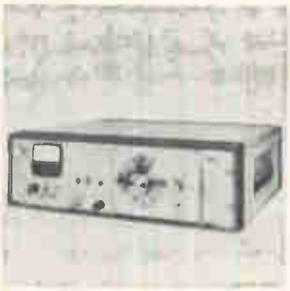
Programed digital controller model 816, with a 4,096 word 16-bit memory and over 140 basic instructions, is for a variety of control, monitoring, data logging, data communication and calculation tasks. Many standard peripherals are available including teletypewriter, magnetic and paper tape, disk, and modems. Computer Automation Inc., Newport Beach, Calif. [392]



Diode laser pulser P-110 has a pulse length adjustable over 10 nsec to 210 nsec in 25 nsec steps, permitting flexibility in choice of signal characteristics. Pulse repetition rate is variable from 1 pulse every 2 sec to 30,000 hz. Pulse amplitude is continuously variable from 0 to 100 amps at any prr up to 30 khz. Seed Electronics Corp., 9 Cypress Drive, Burlington, Mass. [393]



Hybrid IC audio amplifier BHA-0002 is capable of a sustained 15 w output. Distortion is 1% or less while operating into conventional speaker loads. Frequency response is 25 hz to 20 khz. Operating case temperature is −30° to +100°C. Price is $5.60 each in lots from 100 to 999; $9.40 each in lots from 1 to 24. Delivery is 2 weeks. Bendix Corp., South St., Holmdel, N.J. [394]



A solid state family of a-c power sources are modularly constructed and supply 130 va to 2,000 va using 19 plug-in oscillator options. Model 200-S shown features full power from 45 hz to 10 khz, regulated output settable to zero low distortion (typically 0.5%), and is short circuit proof. Price is $580. Vector Engineering Inc., 58 Brown Ave., Springfield, N.J. [395]

Compact, rugged core memory model CR-95 is available in capacities of 4,096 and 8,192 words with word lengths variable in 4 bit increments from 8 to 36 bits. Full cycle time is 1 μsec with access time less than 500 nsec. The unit is designed for application as a memory or buffer in small computers. Lockheed Electronics Co., 6201 E. Randolph St., Los Angeles. [396]

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mum quantities of 100. The company says that with this system, it will be more economical for manufacturers of small computers and peripheral equipment to purchase complete tape memories than to buy components and build their own.

The unit operates in both seven- and nine-track modes. Tape speeds run up to 24 inches per second and packing densities up to 800 bits per inch.

All in one. Both the transport unit and the memory electronics are in a single 100-pound package that takes up only 24 inches in a standard 19-inch equipment rack. The system, 19 inches deep, consists of three mechanical and electronic modules; replacement of the mechanical modules can be done by semiskilled technicians. The capstan head assembly is prealigned.

The single-capstan tape drive uses 80% fewer parts than pinch-roller machines, and this reduces maintenance, eliminates tape path adjustments, and makes for gentler tape handling, according to Ampex.

Integrated circuits are used extensively in the unit. All the read-write electronics are on a single 8- by 12-inch card, and all the mode control and servo control electronics are on another. The two fit

Compact. Tape memory system occupies 24 inches in standard rack.

... tape drive capstan is servocontrolled ...

in what would otherwise be waste space in the machine.

Doubleheader. The read-write head is in two individually adjustable pieces, each having its own gap. One of the gaps is used for writing and the other for reading; the tape first passes over the write gap and then over the read, so that the computer has a chance to read what it has just written and thus check for errors. The head sections are on the short ends of long levers with adjusting screws for very fine control—in microinches—and this control serves to reduce skew.

Most important in controlling skew—time displacement of nominally simultaneous pulses—is a technique employing special checkout and testing equipment to precisely align the gaps.

Minimum gap scatter plus separately adjustable read and write head sections hold down skew to the point that individual adjustments on the data channels aren't needed. Therefore, replacing a circuit card is simply a matter of unplugging and plugging. In some other systems, the replacement card has to be "tuned" to the skew characteristics of the particular drive into which it is being plugged.

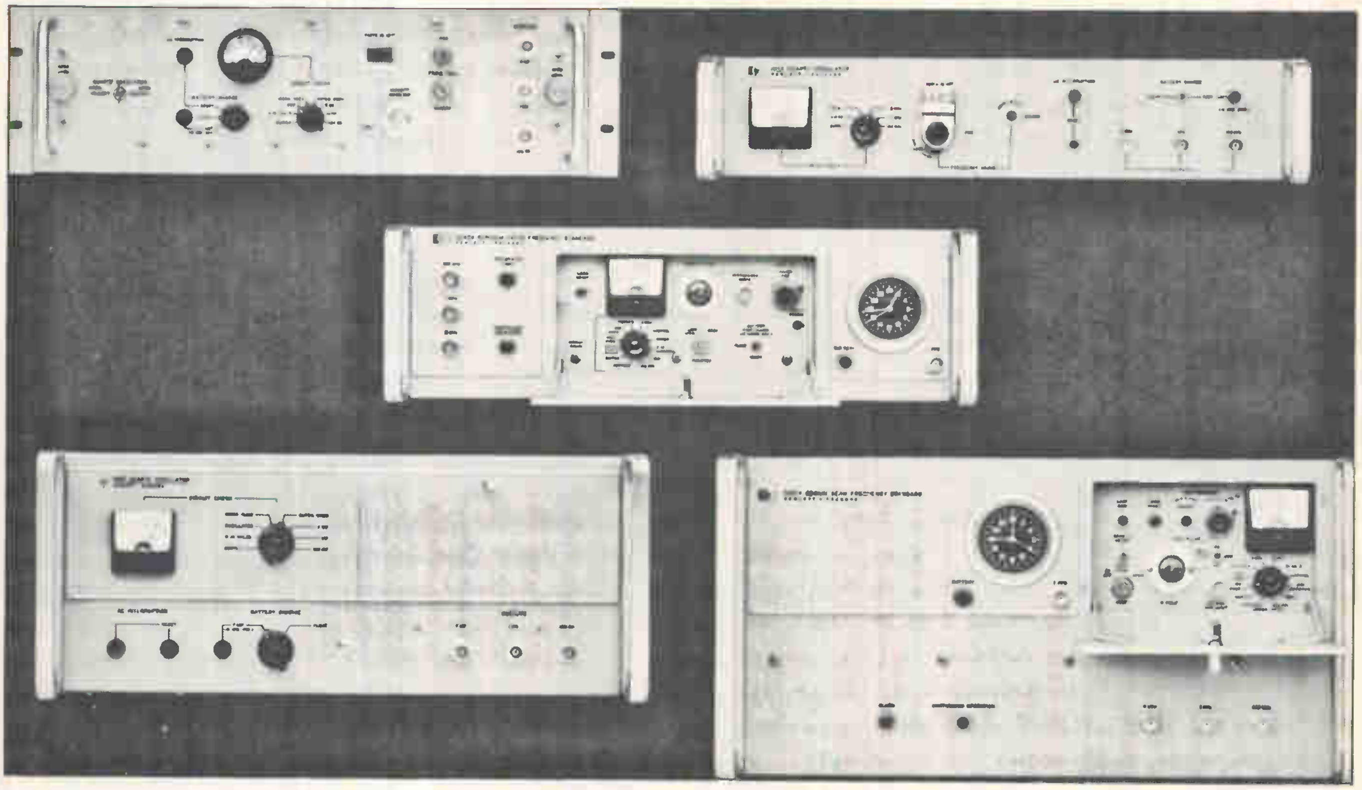
The TM-Z's relatively low tape speed contributes to its low cost, and also helps reduce skew; tape moving slowly is less inclined to flap as it moves across the head. The speed also permits the use of follower arms instead of vacuum columns to control servomotors on reels—another cost shaver.

The capstan is also servocontrolled and has a tachometer and a d-c generator whose output is proportional to speed. A variable potentiometer on it permits tape speed to be varied from 10 to 24 inches per second, depending on the application.

Servo control is usually preferred to synchronous motor drives. The latter run at fixed speed, but the speed is locked to a primary power frequency and is more susceptible to line power and frequency surges than are servocontrol devices.

Computer Products Division, Ampex Corp., Culver City, Calif. 90230 [397]

No matter which HP frequency/time standard you buy....



you're getting the best of its kind.

Hewlett-Packard Frequency & Time standards are known throughout the world for their ability to meet specific frequency and timekeeping requirements. Each type gives outstanding performance in its particular class; accuracy, precision, stability and rugged dependability.

—The HP 5061A Cesium Beam Frequency Standard has been flown around the world to coordinate international timekeeping stations within 1 microsecond. It has no long-term drift and an absolute accuracy of ± 1 part in 10^{11} for the life of its cesium beam tube. That's the equivalent of losing only one second in more than 3000 years. It costs $14,800 as a frequency standard, $16,900 as a time standard with internal standby power.

—The HP 5065A Rubidium Frequency Standard offers you superior electrical quietness over short periods of time, with short-term stability of $7\text{x}10^{-13}$ rms, 100 s. avg.; $7\text{x}10^{-12}$ rms, 1 s. avg. It's highly portable, yet rugged enough to take tough field operation. It costs $7500 as a frequency standard, $9300 as a time standard with internal standby power.

—The HP 105A Quartz Oscillator offers you the best stability available for the price. Aging rate less than 5 parts in 10^{10} per day; short-term stability $<1\text{x}10^{-11}$ rms (1 s. averaging); S-N ratio >90 dB; rapid warm-up. It costs only $1500. The 105B has built-in standby power, $1800.

—The 106A is HP's most stable quartz oscillator: aging rate $< 5\text{x}10^{-11}$ per day. Price: $3750. The 106B, with built-in standby power, is $4200.

—The 107AR is HP's most rugged quartz oscillator, and is hermetically sealed. Aging rate $<5\text{x}10^{-10}$ per day. Price: $2600. The 107BR, with built-in standby power, is $2950.

Also available from HP are the 117A VLF Comparator, for comparing frequency against NBS 60 kHz standard frequency broadcasts, $1400 (incl. loop antenna); the 115BR Digital Clock and Frequency Divider, $3000; and the highly versatile K02-5060A Standby Power Supply, $2850.

For information about all HP frequency & time standards and their various options, call your HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

FREQUENCY STANDARDS

02821

Circle 253 on reader service card

New subassemblies

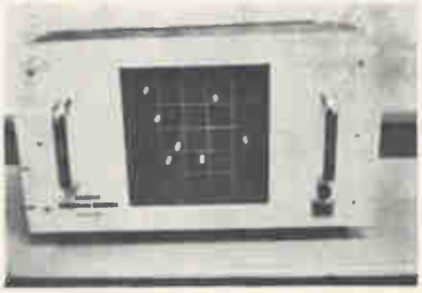
Electronic switch is a random thing

Device with 25 inputs, 25 outputs is programed through its front panel

Attracted by the reliability and compactness of solid state systems, a textile manufacturer recently asked the Agastat division of the Amerace-Esna Corp. to build a replacement for the banks of relays used to control a dye process.

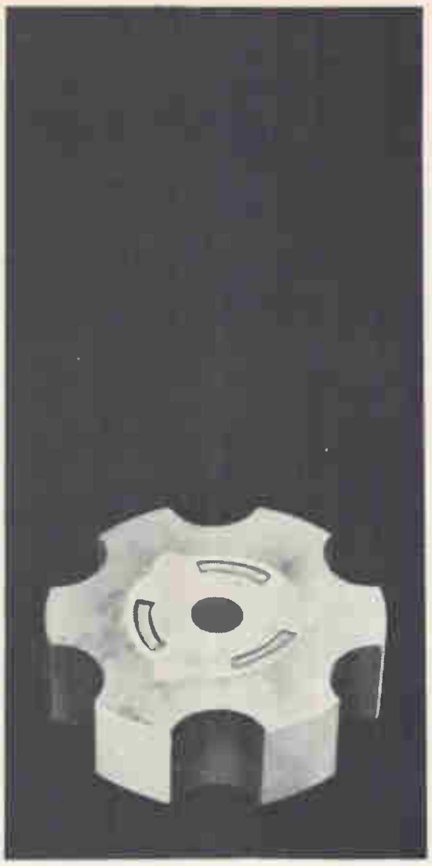
"They wanted to know if we could make an electronic switch capable of handling 25 inputs and 25 outputs on a purely random basis," recalls William Ward, Agastat's sales manager. Agastat could and did, and the textile firm bought 100 of these switches. Now the device is being offered as an off-the-shelf item.

"I don't know of anybody else selling a switch like this," says Ward. "It's completely programable and its program can be changed easily at any time. And notice I'm not calling this a stepping switch; that connotes some kind of sequential operation. This is completely random."

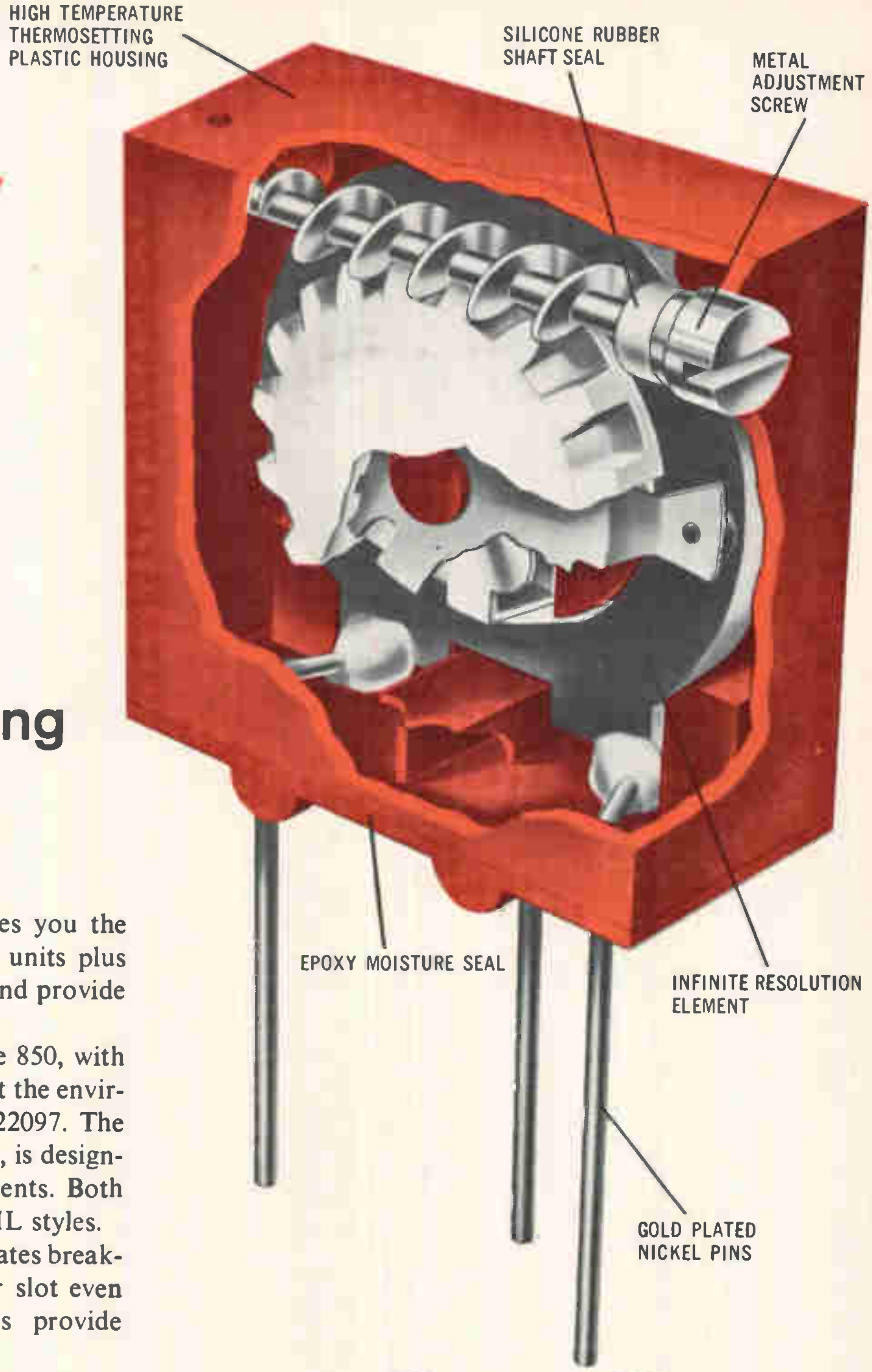


Pinpoint program. Each pin plugged into a socket connects a specific input to a specific output.

Plug-in program. On the switch's front panel is a square pegboard with 25 sockets on each side. Each row is associated with one of the inputs, and each of the columns with one of the outputs. To program the switch, the user plugs shorting pins into specific sockets. For example, if he wants input



NEW 5/16" TRIMMER PACKS TIGHTER



Saves space without sacrificing performance

IRC's new 5/16" square trimmer gives you the performance and stability of larger units plus the opportunity to save board area and provide greater packaging density.

Two types are now available. The 850, with infinite resolution, is designed to meet the environmental requirements of MIL-R-22097. The 800, a precision wirewound trimmer, is designed to meet MIL-R-27208 environments. Both are priced significantly less than MIL styles.

The metal adjustment screw eliminates breakage or distortion of the screwdriver slot even after repeated use. Staggered pins provide strength and mounting stability.

Both types are fully sealed and impervious to common industrial solvents because of a silicone rubber shaft seal and epoxy bonding at all seams. They exceed MIL humidity cycling tests. For complete data and prices see your IRC Qualified Industrial Distributor. Or, write IRC, 401 N. Broad St., Philadelphia, Pa. 19108.

Actual size
Infinite Resolution
Circuitrum 850

Actual size
Precision Wirewound
Circuitrim 800

CAPSULE SPECIFICATIONS

POWER	0.3 Watt @ 70°C (300V max.)	0.6 Watt @ 70°C
TOLERANCE	±10% or ±20%	±5%
RESISTANCE	100Ω to 1 meg.	10Ω to 20K
TEMP. RANGE	—65°C to +125°C	—65°C to +150°C
INSULATION RESISTANCE	1000 megohms @ 500V DC	1000 megohms @ 500V DC
DIELECTRIC STRENGTH	900V AC	900V AC

IRC

DIVISION OF TRW INC.

. . . if an output goes bad, just replace one card . . .

seven to trigger output 16, he plugs a pin into the socket located where row seven intersects column 16.

Any number of pins up to 625 can be plugged into the board in any arrangement.

The outputs are silicon controlled rectifiers that close when a signal is applied to an appropriate input and open when the input is removed. Each SCR can continuously handle 4 amps at 115 or 220 volts and can take surges as high as 60 amps.

The input can be almost any waveform from a d-c voltage to a pulse that's 10 milliseconds wide.

In the original model, if voltages appeared at more than one input at the same time, the output switches associated with the energized inputs closed simultaneously. However, Agastat engineers can build in logic circuits that assign priorities to the inputs.

Searching. Inside the switch, input signals cycle through a matrix of AND gates looking for paths through shorting pins to the outputs. Inside each of the inch-long, plastic-covered pins is a single diode that prevents feedback to the input circuits.

All the switch's circuitry is on printed-circuit boards. Behind the pegboard is a large p-c board with input circuits, power supplies, and interconnections mounted on one side; on the other side, output cards are stacked perpendicular to the large board. If one output circuit goes bad, the card it's on is replaced.

The original units had five of these output boards with five output circuits per board. But Ward says the new units will have 10 or 15 output cards to handle the 25 output circuits. The fewer circuits per card, the cheaper it is to replace a card when a circuit goes bad, he notes.

Replacing an output card takes but seconds, and if the main board goes bad, it only takes a few minutes to pull the whole switch out of the control system since the switch only has three cable connections—inputs, outputs, and power.

Ward expects anyone in the process-control business to be in-

These new SAMPLE/HOLD MODULES from BURR-BROWN

actual size

will help you build accurate A/D conversion systems in less time...at lower cost

Of the six Sample and Hold (or Track and Store) modules supplied by Burr-Brown, these two new units are proving to be the most popular. Why? Because they provide the type of precise, non-inverting performance that is ideally suited for highly-accurate A to D conversion systems. And, the price is reasonable. Only $110.00 for the 4034/25 . . . $125.00 for the 4035/15 . . . in single unit quantity.

Both units have excellent gain accuracy (±0.01%), low drift in the HOLD mode and a 10MΩ input impedance. Size is a convenient 1.80" x 2.40" x .60" for the Model 4034/25 . . . only 1.20" x 1.80" x .60" for the Model 4035/15. Rack mount versions are also available.

FOR DETAILED INFORMATION
on the complete line of Burr-Brown Sample/Hold Modules, simply contact your Burr-Brown Engineering Representative or use this publication's reader service card.

HIGHLIGHT SPECIFICATIONS

	4034/25	4035/15
Accuracy (0 to 60°C, 1% of f.s.)	±0.01%	±0.01%
Input Impedance	10 MΩ	10 MΩ
Aperture Time	0.05 μs	0.05 μs
Acquisition Time Settling to 0.01%	1000 μs	100 μs
HOLD Decay (at 25°C)	±0.1 mV/s	±0.25 mV/s
Power Requirements	±15V	±15V
Price, single unit quantity	$110.00	$125.00

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Circle 257 on reader service card

terested in the switch. "We'll be going after people like Foxboro and Leeds & Northrup," he says.

Packaging is decided by the customer; in a rack mount, for instance, the unit measures 18 by 10 by 12 inches. The customer also tells Agastat what the input voltage levels will be.

Delivery time is two months and price is around $1,000.

Agastat Division, Amerace-Esna Corp., Elizabeth, N.J. [398]

New subassemblies

Modulator works with hangers-on

Unit for laser Q-switching easily fitted with prisms, windows, and mirrors

"In a way, it's like an oscilloscope because it's built to take different types of plug-ins without too much adjustment," says Robert Goldstein, president of Crystalab Products Corp., describing a new light modulator for laser Q-switching.

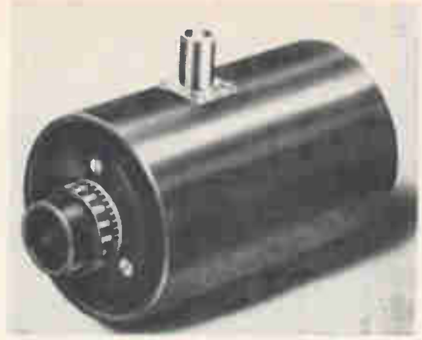
Prisms and Brewster windows, optical devices used for high-power work, can be attached to the model 3051. So can bleachable dye cells, which are used for mode-locking work and for reducing the rise time of switching pulses.

The 3051 can also be fitted with a second-harmonic crystal generator and with a totally reflective mirror. When the mirror is attached, the 3051 can be put right into one end of a laser cavity.

The 3051 is a Pockels-effect modulator—the electric field inside the device is parallel to the optical path.

Choices. Available in eight models, the price of the modulator ranges from $925 to $1,775. For all models, the optical power-density capability is 250 megawatts per square centimeter, the rise time of the switching pulse is one nanosecond, and the maximum transmission is 96%.

The bandwidth of some models is 0.25 to 1.10 microns, while others



Same road. The electric field generated by the 3051 travels parallel to the light from the laser.

work up to 1.30 microns. Depending on model, angle aperture is 0.5°, 0.6°, 0.75°, or 1.0°, and aperture diameter is 6.35, 10, 12.5, or 16 millimeters.

The crystal can be either potassium dihydrogen phosphate (KDP) or potassium dideuterium phosphate (KD*P). Multiple-crystal units, which have lower operating voltages, are also available.

The least expensive unit, the 3051-6, has a KDP crystal, 6.35-mm aperture diameter, and 1.0° angular aperture, while the $1,775 model's crystal is KD*P, aperture is 16 mm, and angular aperture is 0.5°.

Crystalab says the 3051 can resist shock and vibration. "We don't have any numbers because we don't know of any standard shock and vibration tests for lasers," says Goldstein. "But we've dropped the modulator, and thrown it against the wall, and it still worked."

Crystalab Products Corp., 19 Legion Place, Rochelle Park, N.J. [399]

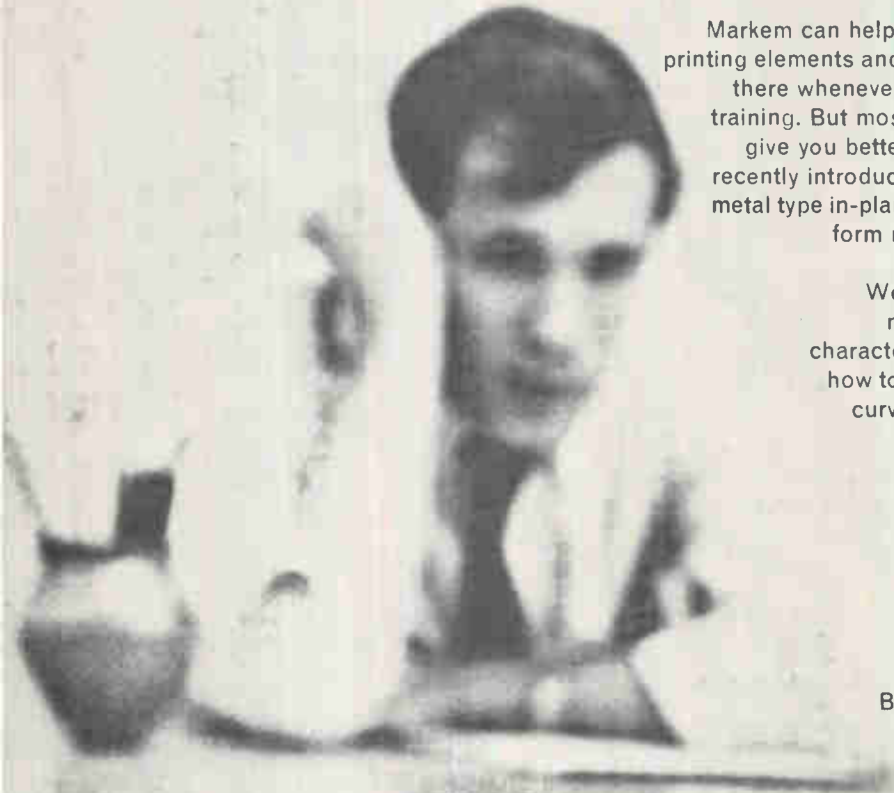
New subassemblies

Data recorder has light touch

Keyboard-to-tape unit uses single-capstan drive; left-zero fill is standard

One of the truisms of the computer business is that computers themselves are becoming too fast too soon for peripheral equipment.

Are you going to do something now about your identification problem?



If you're in the business of making things, you can't escape the business of marking things. And the business of identifying electrical and electronic components can be a messy (and costly) problem. But it doesn't have to be, with the right kind of help.

Markem can help by supplying the best machines, specialty inks, printing elements and other supplies you need. We can help by being there whenever you need service, whenever an operator needs training. But mostly we can help by coming up with new ways to give you better identification for less money. For example, we recently introduced an Instant Type Former which lets *you* make metal type in-plant, as needed. No waiting for delivery . . . you can form new type inserts in less than a minute by simply "dialing" the legend.

We can also show you how to combine sequential numbering with identification . . . how to print 14 characters plus trademark in an 0.125" diameter area . . how to produce clear imprints on recessed, irregularly-curved and other difficult surfaces . . . how to safely mark flat-pack ceramic I.C.'s either in or out of carriers . . . how to color-band axial-lead components with up to 6 different bands at high rates of speed.

It doesn't cost a dime to have one of our analysts come to your plant to discuss your particular identification problems. His ideas could save you a lot of headaches. And a lot of money. Call your local Markem Sales office or Bernie Toomey at 603-352-1130. Write for our new "Problem Solver" booklet.

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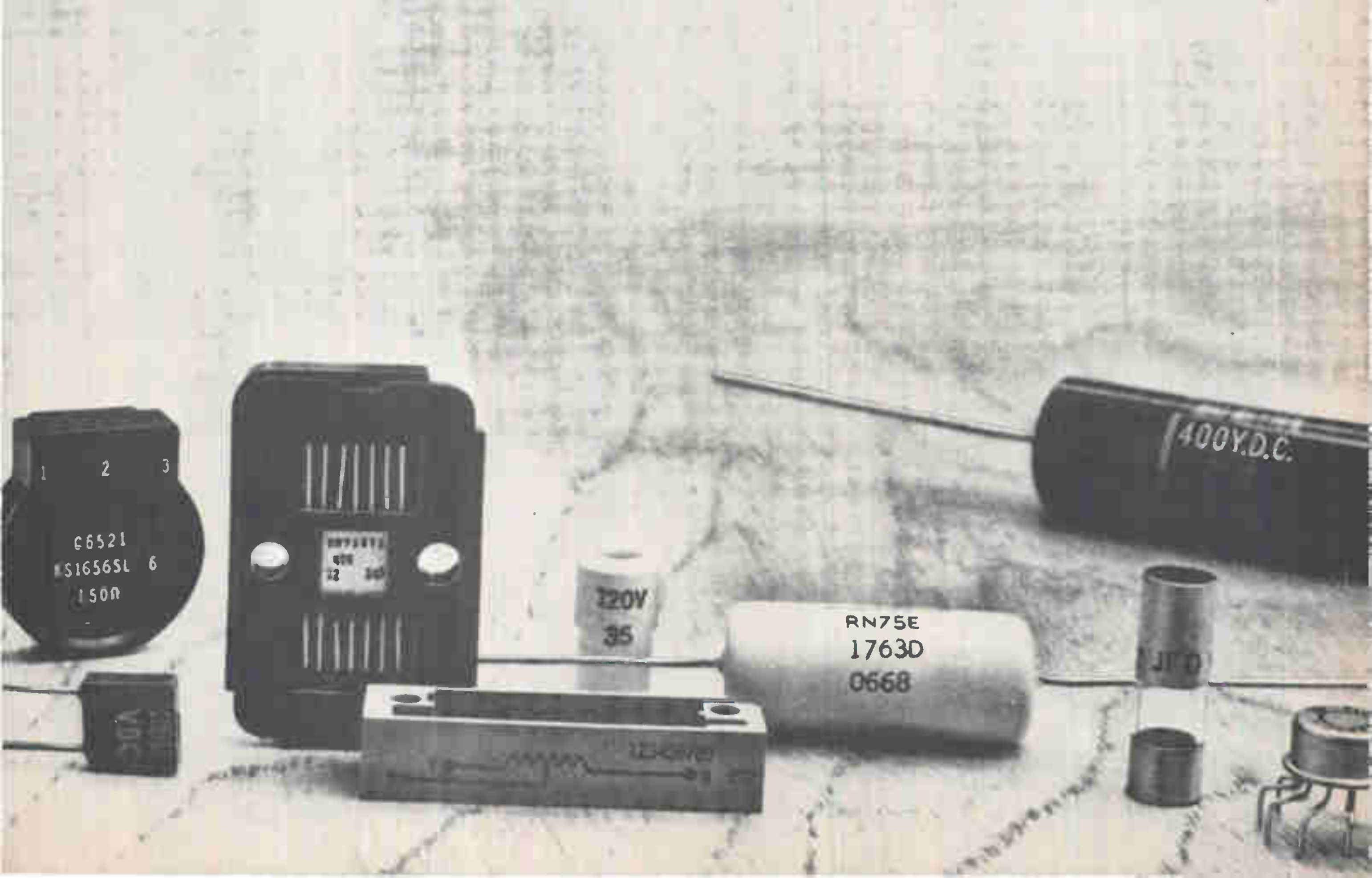

It's usually put his way: "What good is it making computers that hum along in nanoseconds if the machinery that feeds them can only chug along in milliseconds?" The obvious answer to the lag is to design faster peripherals; another, and perhaps simpler remedy, is to eliminate steps in data-handling operations.

The punched card has long been considered one of the worst slowpokes [Electronics, April 15, p. 193]. Equipment that enters information on magnetic tape directly from a keyboard, bypassing the punched card, is made by the Mohawk Data Sciences Corp., Honeywell Inc. and others. Now there's a new entry in that race; the KDR 3100 key data recorder manufactured by the Potter Instrument Co.

It comes naturally. Stephen J. Keane, the company's marketing vice president, says that the 3100

Talking to the tape. The keyboard can generate codes that have densities as high as 800 bits per inch.

is a logical extension of Potter's line of single-capstan magnetic tape drives.

The company says that the single-capstan design makes the 3100 gentler with tape than competitive devices, so breaks should be held to a minimum. All the improvements in the new machine are on that order—not necessarily advances in the state of the art, but subtle changes that enable the user to get more data on tape in less

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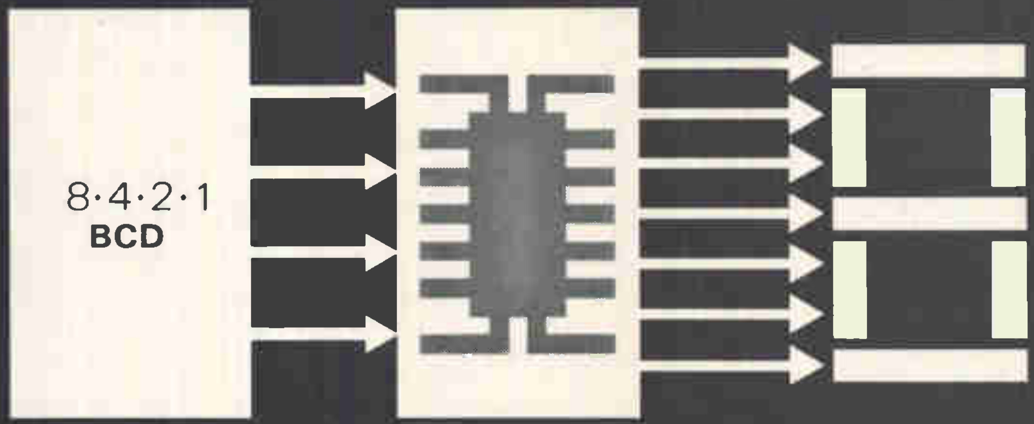

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. . . there's no destruction of the displayed data . . .

time and with less effort. As Keane puts it, "We paid a great deal of attention to such intangibles as work area, comfort and compactness. These features might not make engineers drool, but for the user they can mean money in the bank."

For example, there is more than enough leg room and work room for the operator; speedier operation is made possible by keyboard and console layout, color coding, and key sensitivity and design.

The single-capstan feature also simplifies loading and ensures accuracy and reliability of data. The recording head is a single-gap read/write type; the transport also contains an erase head. It generates codes up to 800 bits per inch in seven- or nine-channel format. Conventional half-inch computer tape is used.

Under the hood. The memory, says the company, has advantages over those in card-punch and other entry machines. Among the advantages are fast duplication, and skip and release functions. The memory also displays contents without destroying the data and allows character-error correction within any field of data. It stores its programs, holds 48 to 160 characters, and permits operation of the machine in five different modes: entry, verify, search, display, and record/read.

One feature offered as standard on the 3100 is optional on competitors' machines. That's what Potter calls the unlimited left-zero fill, which automatically fills in zeros if a two- or three-digit number should come up in a series of five-digit numbers.

The company is confident that there's a good market for its 3100. Says Keane: "While our marketing plans in this country are to sell directly to end users, we've already accepted an order for 1,000 units from one of the largest computer makers in Europe." He wouldn't identify the firm, but European sources indicated that it's Britain's International Computers Ltd.

Potter Instrument Co., E. Bethpage Rd., Plainview, N.Y. 11803 [400]

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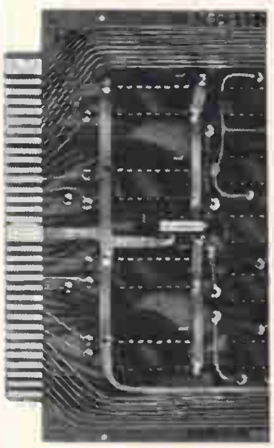

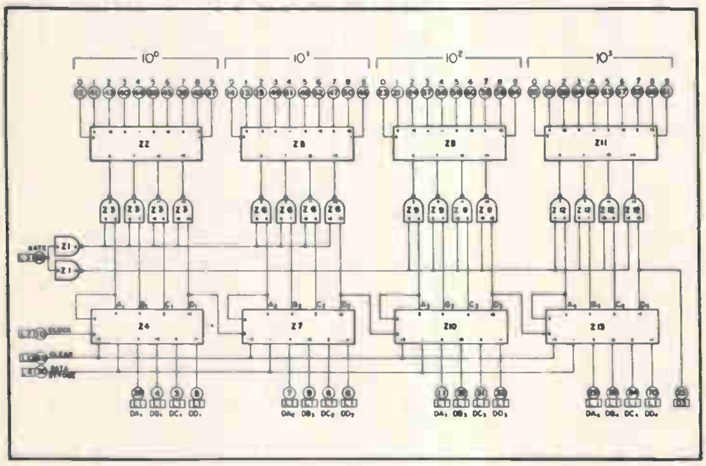

BCD counters with decoder/Nixie drivers

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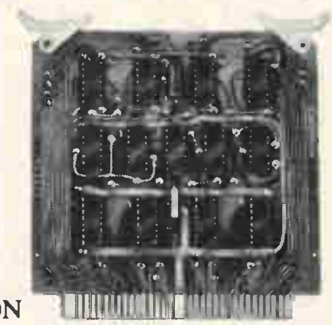

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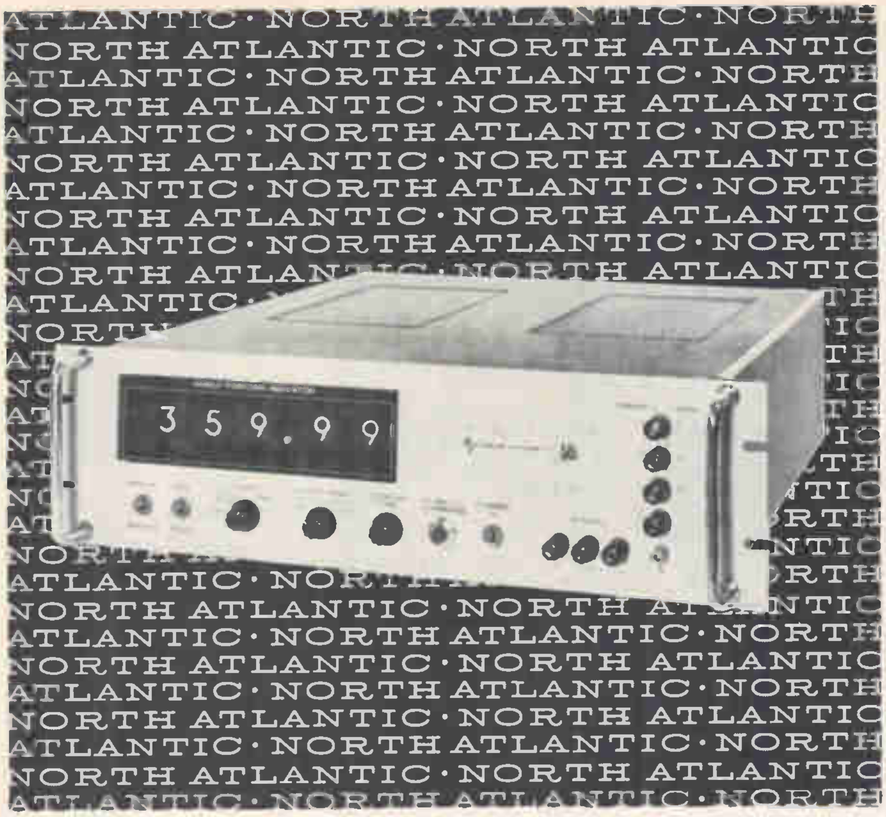
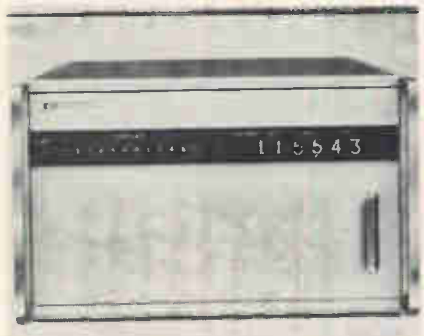


New subassemblies

Coupler makes many matches

Device gets digital data and sends it to variety of recording devices

One of the wider and more persistent communications gaps is the one between measuring and recording devices. Only rarely can a meter be plugged right into a recorder. The engineer usually has to go looking for a coupler, and his problems don't end even when he finds one; these devices have a tendency to work with only one type of meter and recorder.



Half-dozen hookups. The coupler can handle as many as six inputs.

A new coupler from the Hewlett-Packard Co. takes some of the trouble out of interfacing.

Called the model 2547, the device accepts digital data, translates it from parallel-entry code to serial form, and then transfers it to any one of eight recording devices: —a Kennedy 1406 incremental recorder, an H-P 2780A junction panel, an H-P 5050A digital recorder, a modified IBM model B output writer, an H-P 2752A teleprinter, or a Friden 2303. The coupler can be adapted to other recorders by changing logic cards.

The price depends on the recorder supplied with the coupler. A coupler and teleprinter, for example, costs $4,150.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 **[480]**

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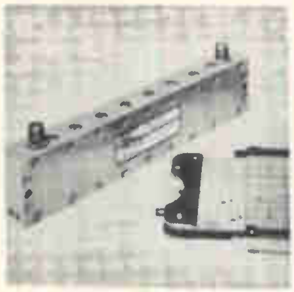
New Microwave Review

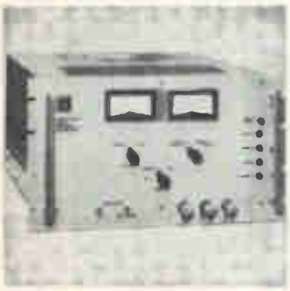
Solid state local oscillator series 6001 has afc capability and covers octave frequencies ranging from 100 Mhz to 2 Ghz. With single screw tuning it can also be used as a multiplier pump, low power transmitter and the signal source for broad-tuning-range test equipment. Power output ranges from 20 mw to 100 mw. Trak Microwave Corp., Tampa, Fla. 33614. [401]

Slotted blade, linearly polarized antenna model 803L was developed as part of an L-band radar transponder system for use in drone application. The antenna's stainless steel body construction offers high dependability in missile environments. Linear radiation coverage is provided with minimum aerodynamic drag. Vega Precision Labs, Vienna, Va. [402]



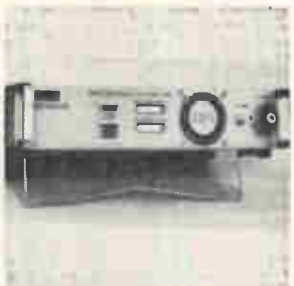
Bandpass filter TSJ2250-100-8SS for use from 2.2 to 2.3 Ghz is designed for airborne telemetry applications. A typical unit measures 5 in. long with a cross section of 1 1/8 x ½ in., and weighs less than 4 oz. Insertion loss is 1.5 db max. at center frequency. Average power rating is 60 w. Price is $380. Telonic Engineering Co., Laguna Beach, Calif. [403]

Broad band stub antenna 01-24-03444 covers 2 to 10 Ghz. Vertically polarized with a quarter-wave monopole pattern, the radome-enclosed antenna has a vswr of under 2 to 1 over 96% of the band. It has a 90% efficiency and can handle 100 w average power. It weighs 3 oz. Temperature range is −65° to +250° F. Electronic Specialty Co., Los Angeles. [404]



Two-stage r-f power amplifier model 03-63-00 provides greater than 17 db of gain from 1.725 to 1.775 Ghz. It is a completely self-contained instrument including all necessary power supplies and control circuitry. R-f input is 1 watt; impedance (input and output), 50 ohms; vswr (input and output), 1.5:1. Applied Microwave Laboratory Inc., Andover St., Andover, Mass. [405]

Multioctave YIG filter model 212MS, available with OSM or N-type connectors, shows a high performance, two-stage bandpass from 1.0 to 12.4 Ghz. Tuning power required is less than 6 w at 12.4 Ghz. The unit has application as a test component for lab measurements. Size is 1.4 in. cube. Price is $880. Ryka Scientific, North Pastoria Ave., Sunnyvale, Calif. [406]



TWT amplifier 1177H covers 2 to 18 Ghz with a minimum power output of 10 w c-w. Each amplifier consists of a ppm traveling-wave tube, an all solid state regulated power supply and a complete air cooling system. Units are suited for applications in rfi testing, antenna measurements and general laboratory use. Hughes Aircraft Co., Torrance, Calif. [407]

P-i-n diode attenuator/modulator model N172AL incorporates a driver module with a logarithmic transfer function which permits the attenuation level to be controlled with a single d-c voltage at the rate of 10 db/v. The unit operates over the frequency range from 0.05 to 8.0 Ghz. Price is $525. General Microwave Corp., 155 Marine St., Farmingdale, N.Y. [408]

New microwave

Double cavity widens Gunn range

Two-resonator design combats mode jumping in oscillator; initial X- and K-band units put out 32 to 87 milliwatts

Complexity can sometimes be a good way to simplify things. The Nippon Electric Co. added a second cavity in its new Gunn oscillators, and it says the double-cavity models give a tuning range of about 10% of the center frequency by a simple adjustment of a single screw; one needn't change the applied voltage. The power output over the tuning range varies by less than a decibel from the maximum.

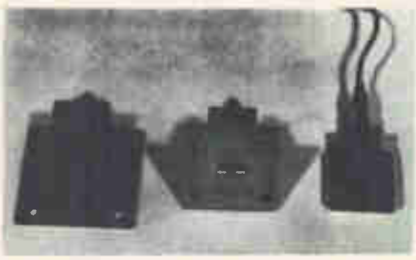
By changing the iris between the cavities and adjusting the applied voltage, the same oscillator can be set to operate at any frequency over a range of an octave.

One reason for the wider tuning, Nippon Electric says, is the absence of unwanted modes and mode jumping within the tuning range. Mode jumping refers to sudden changes in frequency and power output of the oscillator because of changes in the pattern of electric and magnetic fields in a single cavity, usually tuned with a variable-position plunger.

Sizing it up. At lower frequencies, the Japanese company says, a tunable single-cavity oscillator operating in the fundamental mode is not greatly susceptible to mode jumping. But at X and K bands, where the new oscillators work, a fundamental-mode cavity becomes too small for convenient fabrication of a tunable cavity, so the designer has to go to a larger cavity and operate it in a higher-order mode. This increases the probability that it will jump to neighboring modes.

With the double-cavity configuration, there is no tuning in the diode oscillator cavity, which thus can be made small enough to operate in the fundamental mode. Adjustment of the capacitance at the iris and the coupling between the two cavities make the double-cavity circuit lossy at neighboring modes, effectively suppressing them.

The smaller cavity contains the Gunn diode. The supplementary cavity is tuned by a plunger attached to a screw. The two cavities, with the iris between them,



Band trio. Gunn oscillators, left to right, operate at 10, 15, and 22 Ghz. Flanges fit standard waveguides.

can be considered a resonator consisting of a transmission line shorted at both ends and having capacitive loading.

Nippon Electric points out that it borrowed an idea from the designers of reflex klystrons—the tubes, which, it is hoped, will be replaced by solid state sources. In some of the latest klystrons, a supplementary cavity is electrically coupled to the internal cavity but is itself outside the evacuated portion of the tube for mechanical convenience and superior electrical performance.

Power play. Standard units of the double-cavity Gunn oscillators are available for the 10, 15, and 22-gigahertz ranges. The 10- and 15-Ghz devices can be tuned over a range of more than 10%, and the 22-Ghz units are tunable over a range of about 1.9 Ghz. The maxi-

E-Cell* Integrator/Readout System Measures, Stores, and Retrieves the "Area Under the Curve"

Something New!

"Area under the curve" is a phrase that first enters an engineer's working vocabulary in high school calculus and stays with him throughout his career. Yet, even with today's sophisticated technologies, actually *measuring* the area under the curve has until now been a lot easier said than done.

So we see good engineers and scientists resorting to the old brute force method of doing it – plotting the curve and calculating the area under it.

In a field use situation, even if basic engineering sense points to building an on-line, real time integration function into the problem solution, the researcher or designer is likely to seek another alternative approach. Why? Simply because the only tools previously available to do the job were bulky, complicated, and expensive.

But as every engineer knows intuitively, there's always got to be a "better way." Our "better way" is . . .

The E-CELL Integrator

Bissett-Berman's E-CELL integrator looks like a simple circuit element but does the work of a complex assembly. It can be simply connected across the output leads of a sensor unit responsive to the phenomenon to be integrated. Examples: a photoelectric cell sensing the accumulated sunlight falling on a satellite during a several months' mission: or the accumulation of RF energy output of several radars to give a warning when the total becomes dangerous to humans.

Physically, an E-CELL integrator is the size of a discrete electronic component. Inside the cell is a center electrode, which is surrounded by an electrolyte, with the case itself serving as the second electrode.

When connected in a circuit, the E-CELL integrator plates silver atoms onto either the center electrode or the case electrode, depending on the polarity of the integrator in the circuit and the operational mode.

The E-CELL Transform

The simple beauty of this arrangement lies in the fact that the plating process is perfectly precise. For every electron impressed on one of the electrodes, exactly one atom is plated onto the other.

The information stored in the E-CELL integrator as atoms is non-volatile, and doesn't have to be retrieved in the same way or at the same rate that it was generated in the E-CELL integrator. This means that the *input* curve can be highly irregular, have simultaneous multiple sources, and extend over a very long time period, but the transformed integrator *output* can be represented as a convenient flat curve at any chosen level of time or current.

The E-CELL integrator action is reversible, i.e. you can count up from zero or count from a predetermined total down to zero. In the "Countup" mode you start with a bare center electrode on the integrator and accumulate a charge on it as the action proceeds. In the "Countdown" mode you start with an E-CELL integrator whose center electrode is plated with an amount of silver representing the integral in your problem solution. Then you let the integrator run until all of the silver has been transferred from the center electrode to the case. When this has occurred, the E-CELL integrator delivers a sharp voltage rise which can trigger a solid state-actuated light, alarm, or switch.

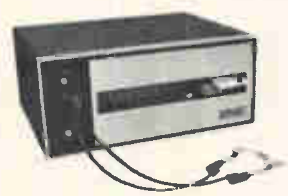
The Integrator/Readout System

Bissett-Berman has just completed development of the Model 300 EDR E-CELL Digital Readout. An E-CELL integrator together with a Model 300 EDR Readout comprise a *data collection system* capable of measuring the "area under the curve" on-line in real time, and over periods from seconds to months.

The Model 300 EDR Readout is specifically designed to measure and digitally display total charge accumulated on the center electrode of an E-CELL integrator used in the "Countup" mode. In addition, the Model 300 EDR provides for manually pre-setting an E-CELL integrator with a precisc amount of plating for operation in the "Countdown" mode.

The E-CELL Integrator/ Readout system is ideally suited for: physical, medical, and agricultural research; product field testing; collection of use data, and evaluation; process monitoring and control; warranty validation – or wherever an analyst desires to measure a phenomenon that can be represented by the "area under the curve."

*Patents applied for.



For technical information on Bissett-Berman E-CELL integrators and our new Model 300 EDR Digital Readout, please send in the coupon below.

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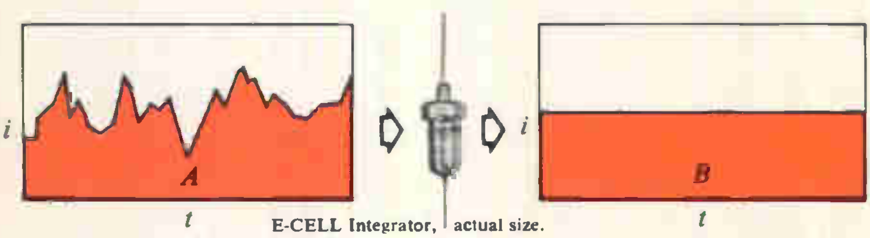

E-CELL integrator transforms irregular input signal into average integral. Area under curve A equals curve B area. Countup Mode → measures unknown input integral. Countdown Mode ← gives signal when unknown input equals pre-set value.

. . . 100 mw Gunn units now being planned . . .

mum power outputs are 56 milliwatts for the 10-Ghz units, 87 mw for the 15-Ghz, and 32 mw for the 22-Ghz models. The devices sell for about $550 in Japan.

The company expects to design oscillators with outputs of more than 100 mw soon. It will not try to go much above this because its engineers expect that Gunn oscillators will be solid state sources for low-power, low-noise applications and that avalanche-diode oscillators will be more suitable for higher-power jobs. In the avalanche field, Nippon Electric expects to offer an X-band unit for transmitter applications that will put out more than a watt.

The Gunn diodes for the oscillators now available have an n^+, n^{++} structure, formed by epitaxial growth of n and then n^{++} material on the original n^+ substrate. The diodes are given a mesa etch so that only the substrate remains large and the diameter of the active epitaxial portion is greatly reduced. The diode is mounted with the n^{++} region bonded to the heat sink, for the most efficient heat removal. The other end is attached by a bonded gold ribbon. The diode for the 10-Ghz oscillator is in a pill case, and those for the higher-frequency units are directly mounted to the cavity interior.

Nippon Electric expects the devices to be used in receiver local oscillators, test equipment and signal generators.

In portable equipment, the oscillators can operate from the same low-voltage power supplies needed for transistor equipment, without a voltage converter. They are also suitable for use in telephone repeaters.

The company says that some of the Gunn diodes selected at random have withstood operating life tests beyond 10,000 hours. A large number selected at random have passed environmental tests which included temperature cycling between —65 and +150°C, variable frequency vibration, and acceleration to 2,000 g's.

Nippon Electric Co., 33-7, Shiba 5-chome, Minato-ku, Tokyo [409]

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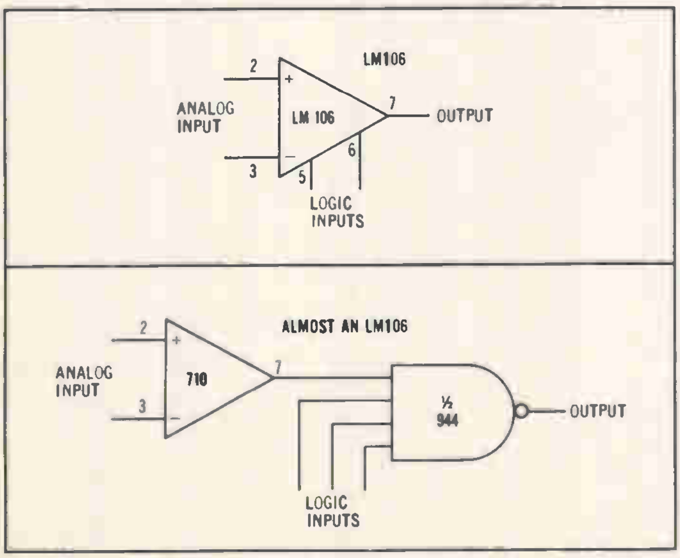
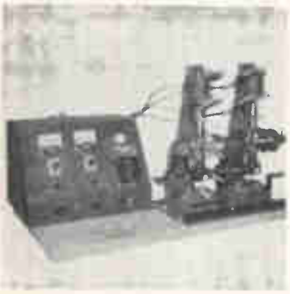
Our new LM106 is the 710 and then some.



Our LM106 is a clever brute. It's a high-speed voltage comparator that is a direct plug-in replacement for the 710 in practically every application. What's more, on two pins the 710 doesn't even use, the LM106 accepts logic signals to strobe an output that drives up to 10 DTL or TTL loads. Or it switches up to 18V at 100mA to drive relays or lamps directly. The 25,000 gain makes gain error insignificant compared to the 2mV maximum offset. And it operates over a wide range of supply voltages even with symmetrical supplies. In quantities of 100 to 999, the military version LM-106 is $18.00, the LM206 for instrumentation (—25 to +85°C) is $11.50, and the LM306 for industrial uses (0 to +70°C) is $6.80. Write us for other clever things about the LM106. National Semiconductor, 2975 San Ysidro Way, Santa Clara, California 95051. (408) 245-4320.

National Semiconductor

New Production Equipment Review

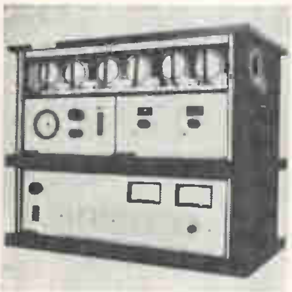


Roll leaf wire-marking machine model 2A2 has individually heated, twin imprint heads. One section is adjustable so that spacing between each marking can range from 5 to 10 inches. Roll leaf is fed into the marking machine automatically on spools where a hot type then imprints and marks the wire. Ackerman-Gould Co., 10 Neil Court, Oceanside, N.Y. 11572. [421]

Dancer winder tension controller DLC-100 is applicable to any type of dancer mechanism and is adaptable to new or existing winders. It offers constant and adjustable taper tension capability.. By utilizing this capability, winder horsepower can be reduced by a factor equal to the taper ratio. Lower horsepower reduces costs. Louis Allis Co., 427 E. Stewart St., Milwaukee. [422]

Leak detector MS-90UFT is for fast, high-sensitivity, low memory production leak testing of hermetically sealed IC's, semiconductors and components. Capable of detecting leaks as small as 1 x 10^{-10} atm cc/sec at slower speeds, it still detects leaks as small as 6 x 10^{-10} atm cc/sec at its full rated production speed. Veeco Instruments Inc., Terminal Dr., Plainview, N.Y. [423]

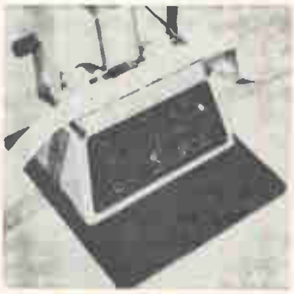
Console type machine tests and calibrates large scale integrated arrays, including universal LSI devices. It is for use where different arrays will be tested, and solves the problem encountered with short runs of different circuits, each requiring special word drivers. It incorporates a large programable word generator. North American Electronic Systems, Sicklerville, N.J. [424]



Plasma machines models 1101 and 2101 use the electrodeless plasma dry chemical process to remove photoresist and clean semiconductor substrates. They require less than 5 minutes to remove photoresist from 100 wafers. The machines generate 1,000 w output of r-f power at a frequency of 13.56 Mhz. International Plasma Corp., 25222 Cypress Ave., Hayward, Calif. [425]

Production centrifuge meets all requirements of MIL-STD-883 for both destruct and screen testing of semiconductors and IC's. A fast cycle time for screening 14-lead devices allows testing of approximately 800 pieces every 4 minutes. The machine will complete a 4-minute cycle to 25,000 g's Trio-Tech Inc. of California, 2435 North Naomi St., Burbank, Calif. 91504 [426]

Wire locating and terminating machine called Wirecenter W/C1 blends numerical control and manual techniques. It is designed to handle a wide variety of wire types and gauges, and can accommodate any size panel up to 30 x 72 in. The table operates at a traverse speed of 360 ipm with a resolution of 0.001 in. Hughes Aircraft Co., 5261 W. Imperial Highway, Los Angeles. [427]



Paper-tape slicer called Thermopress offers 4-sec average splicing time and strong bonds. Individual controls for heat, pressure, and timing allows 5-, 7-, or 8-channel tape to be spliced accurately, quickly and economically, with a minimal overlap and increase of thickness. A "winking eye" timer blinks at 1-sec intervals. Jay Smith Inc., 292 State St. East, Westport, Conn. [428]

New production equipment

Probe lights up to verify IC logic state

Hand-held instrument detects DTL or TTL pulses, eliminates need to monitor oscilloscope or voltmeter

Visual aid. Presence of logic pulse is indicated by lighted band near tip.

Techniques for verifying the logic states of integrated circuits mounted on printed-circuit boards have been extremely cumbersome, usually requiring the use of an oscilloscope—often with a viewing hood—or a voltmeter. In either case, the engineer has to move his eyes from the workpiece, slowing the operation and increasing the probability of error.

A hand-held probe being announced this month by the Hewlett-Packard Co. detects the steady-state logic level, checks repetitive pulses and fast nonrepetitive

. . . works with positive or negative logic . . .

pulses, and displays these variables.

The designer, Gary Gordon, says he and other H-P engineers got tired of looking for traces on an oscilloscope or fooling around with analog voltmeters to determine logic states. "The engineer," he says, "needs to be free to think about what the circuit should be doing and not about how to read a signal."

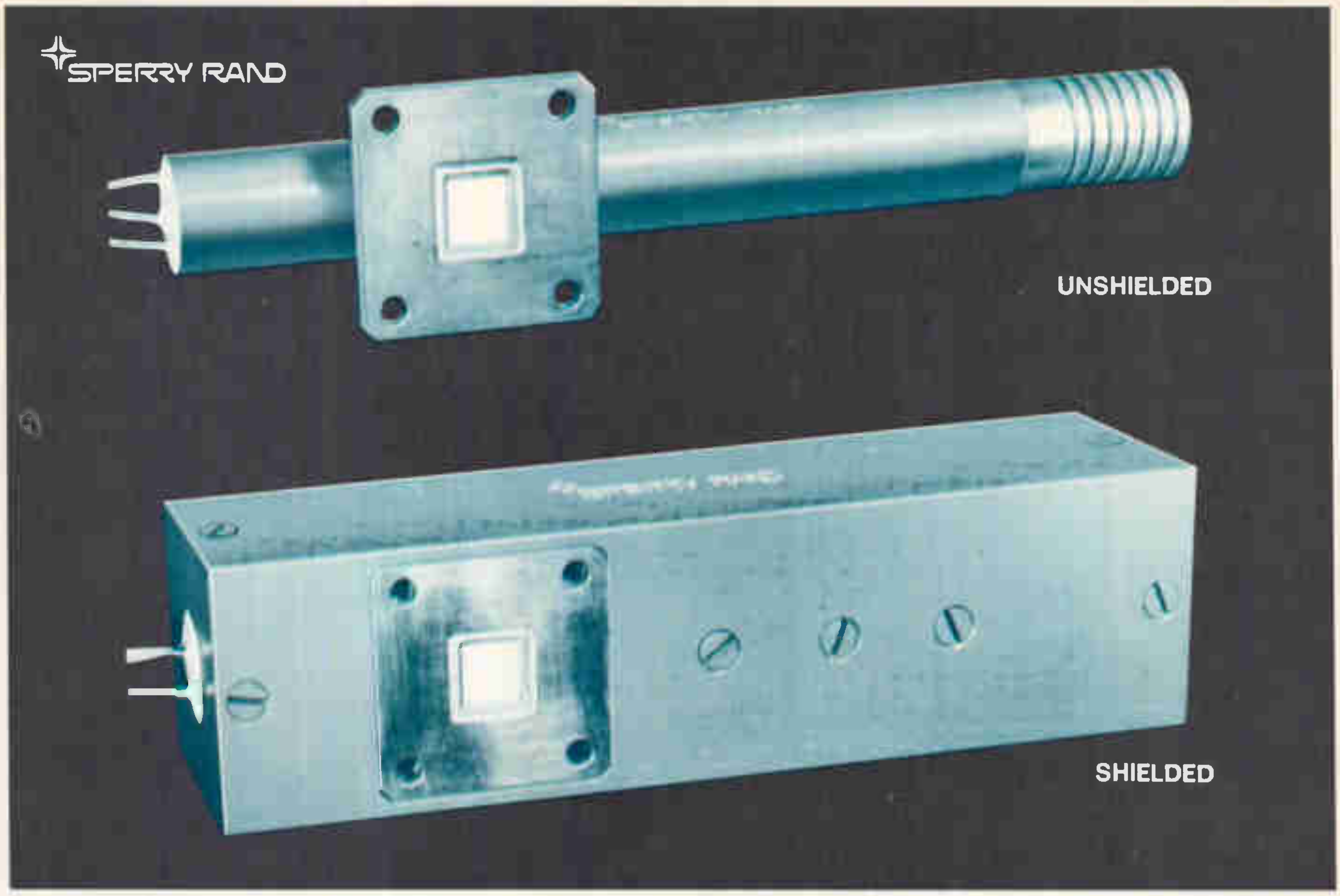
The 10525A logic probe emits a bright circle of light from a translucent band about an inch from the probe tip; the light goes on or off to indicate the presence or absence of logical highs or lows for conventional diode-transistor or transistor-transistor logic levels. The indicator, unlike other rudimentary probes on the market, operates equally well for either positive or negative logic. And it responds to pulses as brief as 30 nanoseconds and stretches the duration of the illuminated indicator to 0.1 second for easy viewing. For pulse trains, the indicator light glows at half intensity.

The following table shows how the probe indicates various test conditions:

Condition	Indicator
Positive reference	
No pulse	Bright
Pulse	Out momentarily
Repetitive pulse	Partial brightness
Negative reference	
No pulse	Out
Pulse	Bright momentarily
Repetitive pulse	Partial brightness

Linger a little. The probe's incandescent lamp, says Gordon, will indicate any change in voltage level out to its overload limit as long as the on-off voltage spans a ±0.4-volt swing through the preset 1.4-volt triggering point of the probe input. This threshold-level discriminator and amplifier activates a quad NAND gate, especially designed for H-P by Texas Instruments, which stretches a short pulse into a lingering illumination of the probe.

In operation, the logic probe is moved from point to point on a circuit run at normal speed; this process detects the presence of pulses such as clock, reset, start, shift, and transfer. The circuit can also be stepped one pulse at a time



Who needs Sperry's new 5 ounce Ku band backward wave oscillator?

You do, if you're working on radar systems, ECM systems or test equipment with a premium on size and weight.

Sperry's remarkable new device, the SBU-4531 will give you 20 mW or more of output from 14 to 16 GHz. In the 14.5 to 15.5 GHz area, it produces 60 mW.

The SBU-4531 also features a modulating electrode that permits flexible programming of the BWO output.

The tube is PPM focused and forced air or conduction cooled. It is available with or without an integral power supply. In its unshielded version, it weighs only 5 ounces and is approximately 6 inches long. Its low external magnetic field makes it suitable for many applications that formerly demanded shielded tubes. It is also available, as the SBU-4532, in a magnetically shielded package which weighs only 12 ounces.

Find out how the SBU-4531 and SBU-4532 can help you cut size and weight out of your Ku band system — contact your Cain & Co. representative or write Sperry Electronic Tube Division, Gainesville, Florida.

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Circle 277 on reader service card

and a comparison made between the logic levels of the IC package and corresponding truth tables. Using several logic probes simultaneously, timing pulses and following state transitions can be detected to identify function operations.

In addition to simple troubleshooting and maintenance checks, the probe can be used for analysis of breadboard designs; complete digital systems and data acquisition systems can also be analyzed and checked.

The probe operates from any positive 5-volt source and is supplied with a BNC bulkhead connector to be plugged into the power bus of the unit under test, a BNC-to-banana adapter for use with a laboratory power supply, a BNC-to-miniature-alligator connector to clip onto p-c boards, and a ground cable assembly.

The price will be $95 each, with quantity discounts available.

Specifications

Impedance	10 kohm
Trigger threshold	+1.4 v, nominal
Pulse-width sensitivity	30 nsec for ±2 v referenced symmetrically about ± 1.4 v
Overload protection	−50 v to +200 v continuous −200 v to +200 v transient 120 v a-c for 10 sec
Power requirements	5 v ±10% at 75 ma, BNC power connector. Internal overload protection to ±7 v supply
Temperature	0 to 55°C

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94303 [429]

New production equipment

Climate for growth is inside cathode

System for making crystals has a hollow electron gun and handles many materials

Crystal growing systems are usually specialized; they handle three or four materials and that's it. But a unit built by engineers at the Materials Research Corp. makes

. . . method may produce new laser materials . . .

single crystals out of almost anything—yag, Y_2O_3, $YAlO_3$, Er_2O_3, $ErAlO_3$, NiAl, Cu, Si, Ge. The company says the system, called the PBZ-99, handles most dielectrics, metals, and rare-earth oxides.

The PBZ-99's versatility can be traced to use of a plasma-beam technique for transferring energy to the source material. Materials Research's approach was developed by Walter Class, manager of the Ceramic Products division.

Key to this method is the heat source, a hollow-cathode gun. which makes it possible to melt float zones on highly reactive and refractive materials. Application of a high d-c voltage to low-pressure gas in a bell jar causes glow discharge. Electrons come off the surface of the cathode and converge at its center, producing a high energy-density heat source.

According to Class, the plasma-beam technique lets the operator choose from a wide variety of gases and run the system over a broad temperature range.

Amateur growers. Class notes that the beam can be given a much sharper focus than is possible with radio-frequency growers. "There are a few people around, real pros, who can grow copper crystal with a radio-frequency system. But we brought technicians and even sales engineers into the lab and taught them to grow copper crystals without any problems."

Another use for the system is purification. Most rare-earth oxides come with a high-purity tag, says Class, but these percentages are calculated relative to the purity of other rare-earth oxides. In all these oxides there are metallic contaminants whose presence isn't indicated by the purity figures and which are very difficult to get out. "But our system will get rid of a lot of these metals," Class declares.

Materials Research expects the system to find use of research and production laboratories.

Priced at $21,000, the PBZ-99 has a delivery time of eight weeks.

Materials Research Corp., Orangeburg, N.Y. 10962 [430]

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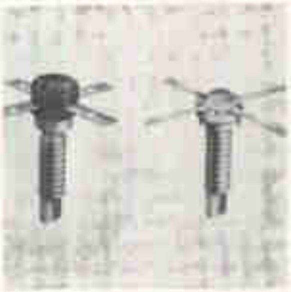
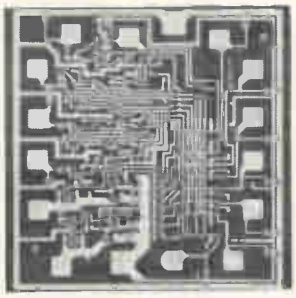
New Semiconductors Review

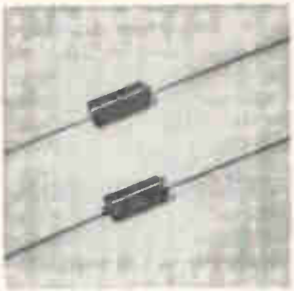
Silicon diffused photodiodes 671 and 663 feature low leakage current. They offer high quantum efficiency and/or sensitivity, and high detectivity throughout the visible range and to 1.1 microns. Active areas measure 10 mm diameter for the 671 and 5 mm for the 663. Units are surface passivated. Electro-Nuclear Laboratories Inc., 115 Independence Dr., Menlo Park, Calif. [436]



High power 2 Ghz microwave transistors come in a hermetically sealed ultraceramic stripline package. Type 2N5483 provides 5 w output from a 28 v source with 4 db gain. Type 2N5482 furnishes 2.5 w r-f output from a 28 v source with 5 db gain; and the 2N5481 delivers 1 w from a 28 v source with 6 db gain. TRW Semiconductors Inc., Aviation Blvd. Lawndale, Calif. [437]



Eight-input digital multiplexer 9312 is a medium scale integration circuit featuring on-chip select decoding and input enabling, with fully buffered complementary pull-up outputs. A 25-nsec through delay allows this monolithic device to be used in a wide variety of multiplexing and switching uses. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. [438]



Miniature molded zener diodes feature internally the Amerseal process for protection against vibration and shock. They are for use on compact p-c boards in commercial applications. They are offered in ratings up to 200 v. Standard tolerance is 20%, but tolerances of 10%, 5% and closer are available. American Semiconductor Corp., 4 N. Hickory Ave., Arlington Heights, Ill. [439]

Gallium-arsenide laser diode arrays LD200 are for room temperature operation. Emitting coherent, infrared radiation at 9040 angstroms when pulsed in the forward biased region, the magnitude of their light output is a function of the magnitude of the forward current in the array. Prices are $78 to $207 in 1,000 lots. Laser Diode Laboratories Inc., Metuchen, N.J. [440]

Monolithic operational amplifier model 9308 provides full output swing of ±10 v from d-c to 500 khz minimum. Features include: 80 db minimum open loop gain, ±30 v/μsec minimum slewing rate, 80 Mhz minimum gain bandwidth product, and 150 nsec settling time to 0.01%. Price in lots of 100 to 299 is $25 each. Optical Electronics Inc., P.O. Box 11140, Tucson 8576. [441]

Three-phase silicon rectifier bridge PBT 05 is a 50 piv device that carries 30 amps at 100° case temperature. Dimensions are 2 x 1½ x 1 in. including terminal. Units are suitable for motor controls, computer power supplies, transistor circuitry and instrumentation. Price is $3.70 each in quantities of 1,000. Electronic Devices Inc., 21 Gray Oakes Ave., Yonkers, N.Y. 10710. [442]

Two PNP, high-voltage silicon transistors are for power switching applications. The 2N5345 is a 1 amp device that can handle 300 v, while the 2N5344 is rated at 250 v. Both have a maximum total run-on time of 200 nsec at 500 ma and 100 v. Price (100-999) of the 2N5344 is $12 and the 2N5345 is $15. Motorola Semiconductor Products Inc., Box 20924, Phoenix. [443]

New semiconductors

Added terminal lets SCR turn on a crowd

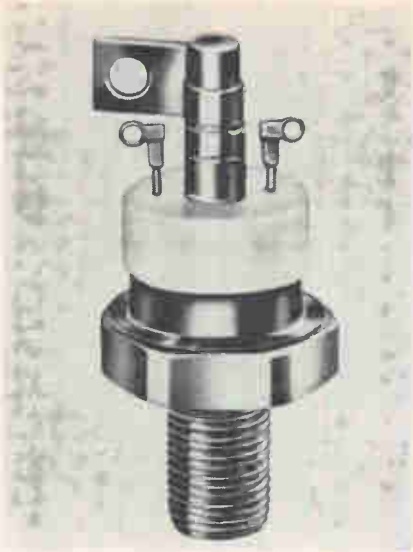
Rectifier has a lead connected to its regenerative gate, which puts out enough voltage to fire parallel devices

As far as specs go, the NL-F silicon controlled rectifier National Electronics, Inc. developed last spring [Electronics, June 10, p. 207] and the NL-H, the company's new SCR, are identical. Voltage and current ranges, anode current change (di/dt), size, weight, and other parameters have the same value for both rectifiers.

The difference is that the NL-H is more of a team player than its older brother. Besides the normal cathode, anode and initiating-gate leads, the NL-H has a fourth terminal whose signal can be used to trigger other rectifiers. So in high-power work where it's necessary to run SCR's in parallel, using an NL-H as one of those SCR's enables a single driving circuit to turn on all the rectifiers.

When National—a subsidiary of Varian Associates—introduced the NL-F, it stressed the device's high di/dt, 600 amps per microsecond. National got this quick current change by putting conductive spokes into the rectifier. Called a regenerative gate, these spokes are bedded in the emitter lip, that part of the n-layer cathode not under the metal terminal.

The signal from the driving cir-



Spiked. The output of the regenerative gate is a voltage spike that can turn on other rectifiers or sync a circuit

cuit comes in through the initiating gate, then travels across the cathode to the regenerative gate and out along the spokes. The entire region near the spokes thus turns on right away. The added gate lets more of the cathode see the turn-on signal faster, resulting in a high di/dt and less chance of inrush current burning out the center of the cathode.

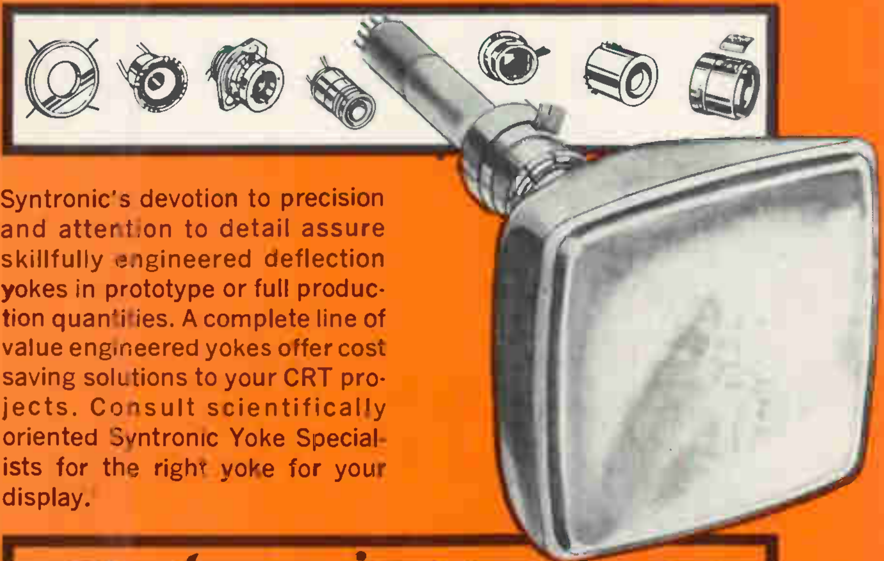
Getting the gate. Discussing regenerative-gate SCR's, National design engineer Donald I. Gray has said, "Paralleling these devices is a simple matter; the regenerative signal of one device can be used to trigger others" [Electronics, Sept. 30, p. 100].

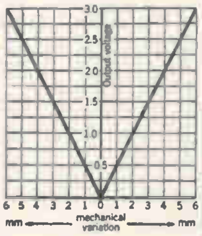
National engineers took care of this simple matter in the NL-H by connecting the fourth lead internally to the regenerative gate. The regenerative signal—the potential between the regenerative gate and the center of the cathode—appears when the SCR starts to turn on. It's a spike whose amplitude can go as high as 50 volts.

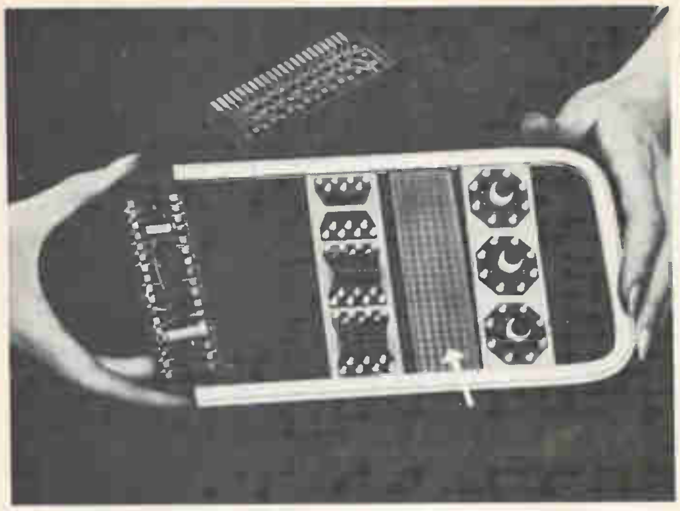
When SCR's are paralleled, the drive circuit is connected to the NL-H's initiating gate, and the initiating gates of all the other SCR's are tied to the NL-H's regenerative gate. The NL-H can drive as many as five NL-F's.

The price depends mainly on the voltage rating, up to 1,000 volts, and ranges from $120 to $275. Delivery is from stock.

National Electronics Inc., Geneva, Ill. 60134 [444]







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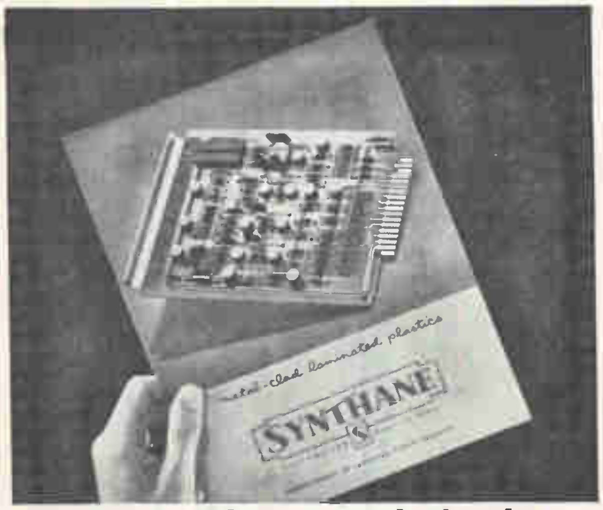

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Meetings

(Continued from p. 26)

Short courses

Modern small digital computers, University of Wisconsin's Department of Engineering, Madison, Wis., **Nov. 14-15; $70 fee.**

Maintainability—engineering and management, George Washington University's School of Engineering and Applied Science, Washington, **Dec. 2-6; $275 fee.**

Computer Systems: applications, University of Wisconsin's Department of Engineering, Madison, Wis., **Dec. 6-7; $70 fee.**

Standards and calibration laboratories, George Washington University's School of Engineering and Applied Science, Washington, **Dec. 9-13; $275 fee.**

Reliability—failure analysis, George Washington University's School of Engineering and Applied Science, Washington, **Dec. 9-13; $275 fee.**

Call for papers

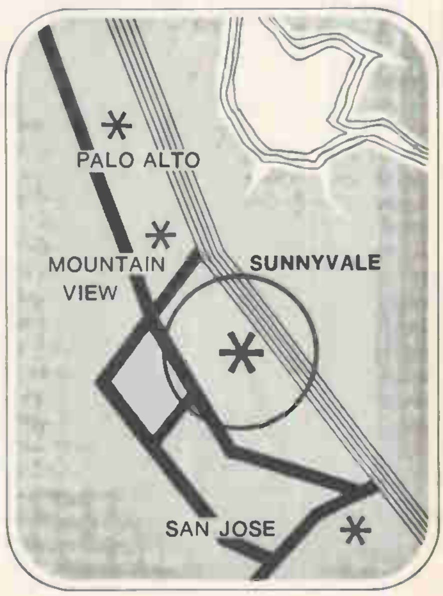
G-MTT International Microwave Symposium, IEEE; Dallas, Texas, May 5-8. **January 10** is deadline for submission of abstracts to IEEE at 345 East 47th Street, New York, N.Y. 10017

Southwestern Convention & Exhibition (Swieeeco), IEEE; San Antonio, Texas, April 23-25. **December 1** is deadline for submission of abstracts to Dr. William H. Hartwig, Department of Electrical Engineering, Engineering Science Building 439, University of Texas, Austin, Texas 78712

International Joint Conference on Artificial Intelligence, Association for Computing Machinery; Statler-Hilton Hotel, Washington, D.C., May 7-9. **January 15** is deadline for submission of manuscripts to Dr. Donald E. Walker, IJCAI program chairman, The Mitre Corp., Bedford, Mass. 01730

Biennial Joint Materials Handling Conference, IEEE; Portland, Ore., October 26-29. **May 1** is deadline for submission for abstracts to Max Frey, conference program chairman, project engineer, Cascade Corp., P.O. Box 7587, Portland, Ore. 97220

International Symposium on Man-Machine Systems, IEEE; Cambridge, England, September 8-12. Information will be circulated to individuals who request it from Robert C. McLane, G-MMS meetings chairman, Honeywell Inc. 2345 Walnut Street, St. Paul, Minn. 55113



Maxwell meets Einstein

Electromagnetic Waves and
Radiating Systems
Edward C. Jordan and Keith G. Balmain
Prentice Hall Inc.
753 pp., $14.95

Advances in electromagnetic technology over the past 18 years have prompted Prof. Jordan of the University of Illinois to revise his popular textbook, originally published in 1950. The new edition, prepared with the help of Balmain of the University of Toronto, is as clear and comprehensive in its treatment of today's technology as its predecessor was in its day. And though intended primarily for undergraduate honors students, the book will profit many design engineers with its chapters on waveguides and antennas.

Practical engineering examples are interspersed throughout, but the text is aimed at comprehension of the subject and is not meant to be a designer's reference book. Disappointingly, though, the bibliography isn't as updated as the subject matter.

The book begins with the usual approach—vector analysis, electrostatics, magnetic fields, Maxwell's equations, and configurations of waves reflected off surfaces or transmitted through various waveguides. But then the authors, believing that engineers nowadays should know how materials behave, devote a lengthy chapter to the interaction of fields and matter. Covered are such subjects as oscillations of hot, gaseous plasma, the interaction of a wave with a plasma, and the frequency response in a dielectric material.

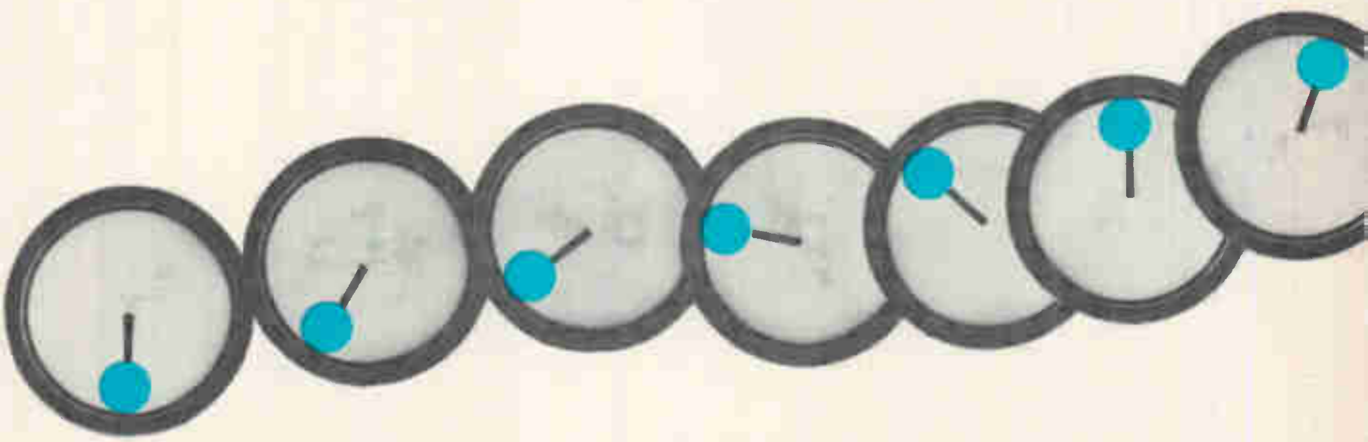
Coverage of developments in space communications, radio astronomy, and holography bring the text into the 1960's; major innovations in antenna design, particularly the frequency-independent and log-periodic structures, are also discussed.

Another addition is a chapter on the relation of Maxwell's electromagnetic theory to Einstein's special theory of relativity. The authors speculate that "there may come a time when electromagnetic theory is introduced to the electrical engineer using Coulomb's law and special relativity as a starting point."

Linking two worlds

Analog-to-Digital/
Digital-to-Analog
Conversion Techniques
David F. Hoeschele Jr.
John Wiley & Sons Inc.
455 pp., $15.95

Engineering is full of ideal laws, but their application often suffers from errors introduced by the equipment itself and by how it works. A classic example is the conversion of signals from analog to digital form and vice versa. Even with precise construction of a con-



verter, the discrete nature of its conversion technique usually generates errors.

This volume acknowledges that conversion error can be tolerated in some systems. As usual, the smaller the tolerable error, the more the converter costs. The reader is given an understanding of the conversion methods and their relative performance.

The author comprehensively discusses the design and operation of all major methods of conversion, from shaft-position converters to successive-approximation ladder networks. A review of conversion logic is also included. Other major parts of the book include detailed discussions of reference voltages, analog voltage comparators, and the switching of analog voltages.

Bipolar transistor switches and field effect transistor comparators also get complete treatment.

The text is excellently complemented by lists of symbols and by appendices. Among the latter are a table of binary-decimal equivalents and a review of the network theorems that form the bases of the design and operation of many types of converters.

Winning the pot

Computer Process Control
Modeling and Optimization
T.H. Lee, G.E. Adams, and W.M. Gaines
John Wiley & Sons Inc.
386 pp., $14.95

Taking on a computer control project is like playing high-stakes poker. The smartest players make money and become confident enough to sit down for more rounds. Winning means a continuing return of hundreds of thousands of dollars—perhaps more. Losing means a sterile investment of several hundred thousand dollars, with more going into the pot to get the system to work—just like trying to fill an inside straight. In computer control, as in poker, it's brains and experience that win. This excellent book is bound to become the "How to win in computer control." It's packed with clear, valuable knowledge.

Computer control differs from conventional closed-loop control in many ways, but an essential distinction is that while conventional control is concerned mainly with plant regulation, computer control can continually adjust the plant to meet stated production demands. Key phases in computer control are defining the objectives, modeling the controlled operation, and implementing an optimization procedure. The book handles these extremely complex subjects with exceptional skill and clarity.

Each of the many broad subjects is segmented to let the reader grasp the over-all subject piece by piece and make him aware of how these pieces fit into a total project.

Model is a word usually tossed

New Books

around rather glibly in industry, sometimes to the point that real projects go awry because the engineer didn't realize which kind of a model he needed. The authors settle this matter nicely. They distinguish between functional, physical, and economic models, and spend several chapters detailing each type. For example, the authors point out that there is a difference between an economic model for planning the computer control project and an economic model for operating the controlled process. A realistic numerical example is worked out for many kinds of models.

The book also discusses the optimization problem, a subject that must be accompanied by advanced mathematics to be comprehensible. The authors don't shy away from the math, but skillfully blend ideas and equations—and examples—to let the reader learn without getting bogged down in mathematical obfuscation. The book thus very ably presents chapters on steady-state and dynamic optimization for processes that can be properly defined, and on evolutionary operation for poorly defined processes.

If you're going into the computer-control game, read this book of instruction first.

Recently published

Algebraic Coding Theory, Edwyn R. Berlekamp, McGraw-Hill Book Co., 466 pp. $17.50

Discusses the best error-correcting codes proposed to date, stressing topics most relevant to the design of decoders. It covers the structure of finite fields and presents new results likely to have applications in discrete system theory. For graduate students and engineers.

Optimum Systems Control, Andrew P. Sage, Prentice-Hall Inc., 562 pp., $14.50

Covers optimal control with deterministic inputs, state estimation, combined estimation and control, sensitivity analysis, and computational techniques. Included are deterministic control and stochastic problems. Aimed at graduate students and systems engineers, it emphasizes basic concepts.

High-Voltage Technology, Edited by L.L. Alston, Oxford University Press, 408 pp., $14.40

Aimed at graduate engineers and scientists, this text covers the basic concepts of electric stress and strength, and surveys associated phenomena and techniques. It also comprehensively discusses electrical breakdown in gases, vacuums, liquids, and solids under laboratory and practical conditions. In covering high-voltage equipment it emphasizes practical application of basic principles.

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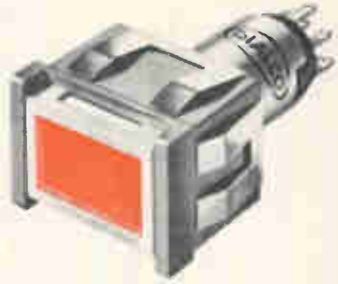

and a

legend presentation that's positive (like this one) or negative (like the one below) or just plain (like the one above) . . . one that's white when "off" and red, green, yellow (amber), blue or light yellow when "on" . . . or colored both "on" and "off."

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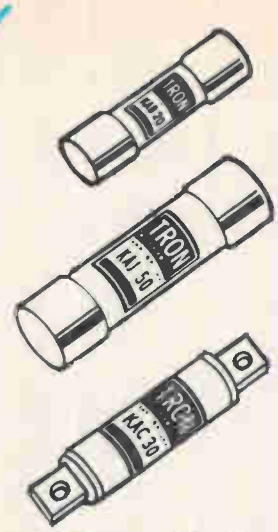

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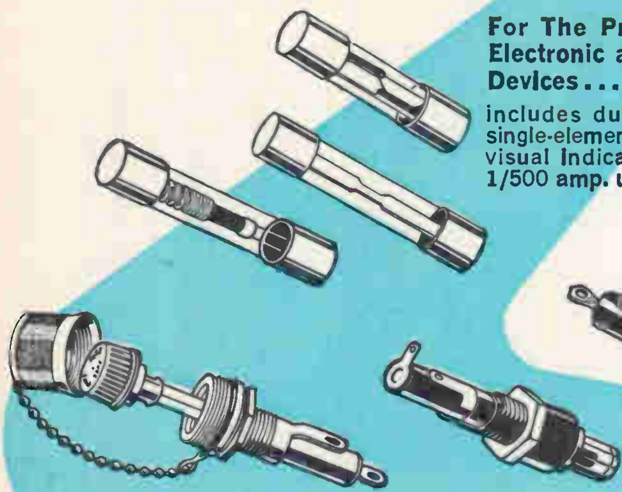

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Film puzzlers

Thin-film microwave components
Martin Caulton
RCA Laboratories, Princeton, N.J.

What are microwave integrated circuits? Just metal put on top of a dielectric substrate and etched? Many manufacturers wish they were that simple.

The job of fabricating precise and reproducible thin-film microwave components, either lumped or distributed, on ceramic substrates involves a host of considerations. These include the value of the dielectric constant of the substrate and its surface finish; the adherence of the metal to the substrate and the kind of r-f conductor it will make; and the thickness of the conductor. In addition, there's the question of how compatible the substrate will be with the metal conductor.

Regardless of the type of microwave integrated circuitry to be fabricated, materials are judged as much on their compatibility as on their electrical parameters. The thermal expansion coefficients of the dielectric and conductor and the etchants that can be used are part of the picture, as is the possibility that troublesome alloys may develop.

Thin-film microwave IC's have been built with distributed or lumped elements for use at the lower frequencies, but microstrip is used for circuits operating at X band and higher. The same basic metal and dielectric deposition techniques are used in making either type of IC, but there are differences.

If a lumped-constant high-frequency inductor is to have a high Q, for example, the thickness of the conductor must be equal to several skin depths at the operating frequency. Also, the surface finish must be smooth and only the better conductors such as gold, silver, and copper should be used.

Presented at Nerem, Boston, Nov. 6-8.

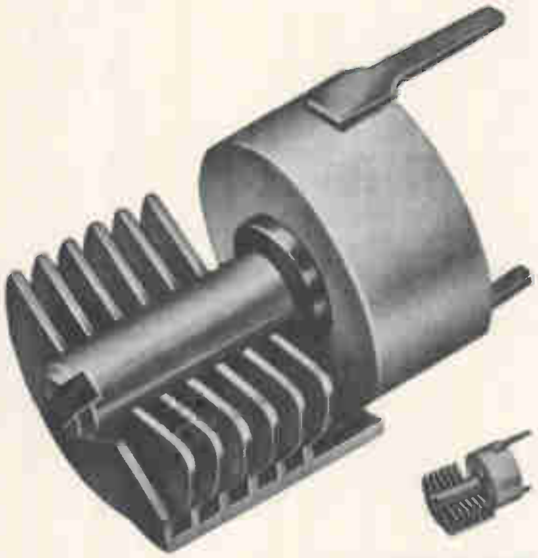
Simple setup

The gyrator—a miniature ferrite device
R.W. Roberts
Microwave Associates (West) Inc.
Sunnyvale, Calif.

The microwave gyrator is a passive, nonreciprocal ferrite device that can be used as a circulator, isolator, or impedance inverter. It consists of the same basic ferrite element found in a circulator, but it comes without the impedance-matching networks, transmission lines, and connectors usually associated with a circulator.

The gyrator is smaller, cheaper, and easier to put into integrated circuits than the circulator. The disadvantage of the gyrator is its generally complex characteristic

New, smaller air variable capacitor



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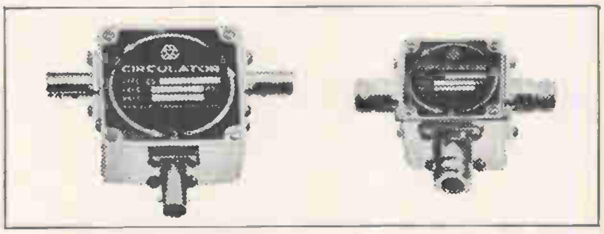

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impedance, which requires fairly sophisticated matching networks.

A typical junction circulator for conventional microwave applications may be roughly 2½ inches square and an inch thick. Connectors may extend out for another inch or so. In a typical IC application, most of the networks and connectors aren't needed.

For example, there is no need to use a 50-ohm transmission line in an IC, because the components are so close together. Also, connectors aren't needed, and impedance-matching networks can be absorbed within other components of the IC.

Thus, if all these parts are stripped away from a typical junction circulator, the central ferrite element alone is left. This is roughly only 0.4 inch in diameter and 0.125 inch thick.

A gyrator consists of this single ferrite disk with three windings wound around it and returned to ground. The windings are coupled to each other both through a reciprocal leakage term and through a nonreciprocal off-diagonal susceptibility term. A bias field is supplied by a permanent magnet. This field is chosen as the best compromise between low loss, which requires a high field, and maximum nonreciprocity, which requires a lower field. Leakage inductance is a primary bandwidth-limiting element and must be considered in designing the impedance-matching network. Bandwidths may range from 4 to 20%, depending on the network's complexity.

A typical gyrator for the uhf band is about ⅝ inch in diameter and ⅝ inch thick. In S band, projections show that the size could be reduced to ¼ inch in diameter and ¼ inch in thickness. These dimensions are much smaller than those possible even with circulators built on microstrip. They're quite compatible with the size of other components used in IC's.

Presented at Nerem, Boston, Nov. 6-8.

Print hints

Printed thick-film microwave integrated circuits

Charles Greenwald and
R.K. Barcklow Jr
ITT Defense Communications Inc., Nutley, N.J.
Edwin Zaratkiewic
ITT Avionics Inc., Nutley, N.J.

Studies of nonmicrowave microcircuits have shown thick-film types to be 20% to 40% cheaper than the thin-film versions. Similar cost savings may apply to microwave circuits, especially when they're printed.

A high-resolution screen-printing process yields acceptable pattern resolution for most microwave integrated-circuit geometries. Resolution is now 100 to 150 lines per inch—with equal line width and spacing, and with line-edge varia-

tions less than 20% of line width. Process refinements can, however, improve resolution.

A finer mesh stainless-steel screen is required. A 325 mesh was used in the present system. High-viscosity inks will minimize pattern settling after screening. Du Pont 8115 thixotropic gold ink, with a 1,000-poise viscosity, was found to print better than higher-conductivity silver-based inks.

Indirect screen-pattern preparation, where the emulsion pattern is photo-formed on a Mylar carrier sheet and then adhesively transferred to the screen, is recommended. Substrates should be very flat, with a 1-mil maximum camber. Patterns should be air-dried before firing because rapid drying with a heat lamp will distort the pattern.

One component that's been printed is a 50-ohm termination that dissipates 50 milliwatts (less than 1/50 wavelength) and has a vswr of less than 1.2:1 over a 16% bandwidth at 4 gigahertz. A 100-ohm-per-square palladium-silver resistor ink is used, printed to a 1-mil thickness.

A microwave transistor oscillator was printed on a 1-by-1.5-by-0.25-inch alumina substrate. It develops a 10-milliwatt fundamental at 4 Ghz. The circuit includes a 10-decibel directional coupler (with a 5-mil gap) to provide an auxiliary output to feed an external phase detector. Three d-c bias resistors are printed, as are three 100-picofarad bypass capacitors, which provide low-frequency stability. These two components are decoupled from the r-f circuitry by series-choke/shunt-stub microstrip sections.

Another component is a printed thick-film mixer-preamplifier with an X-band balanced mixer and a 70-megahertz i-f preamplifier. It fits on a 1-by-3-by-.025-inch alumina substrate. Microstrip lines, d-c bias and i-f pad resistors, and i-f bypass and coupling capacitors are printed as well. Schottky mixer diodes, a leadless, inverted, device-mounted (LID) i-f input transistor, a flatpack monolithic IC, and a toroidal transformer are appliqued.

Presented at Nerem, Boston, Nov. 6-8.

New Literature

Control, telemetry, conversion. Raven Electronics Inc., 101 W. Alameda Ave., Burbank, Calif. 91502, has published an eight-page catalog on its control, telemetry and power conversion components.
Circle **446** on reader service card.

Digital spectrogram recorder. Conrac Corp., 1600 S. Mountain Ave., Duarte, Calif. 91010. An eight-page brochure describes a system for converting analog data from potentiometric recorders into digital form for computer analysis. **[447]**

Digital data monitors. Lear Siegler Inc., 1152 Morena Blvd., San Diego, Calif. 92110, offers a two-page data sheet describing a new generation of digital data monitors. **[448]**

Power supply modules. Power/Mate Corp., 163 Clay St., Hackensack, N.J. 07601, has released a 16-page general catalog covering a broad line of regulated power supply modules. **[449]**

Vacuum components. Granville-Phillips Co., 5675 E. Arapahoe Ave., Boulder, Colo. 80302. A 12-page brochure describes more than 200 standard components to assist in building or modifying vacuum systems. **[450]**

Solid state relays. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. 60076. Catalog 750 describes features of the SSA solid state relays, such as inherent contact isolation and universal operating voltage range. **[451]**

Laser trimming system. Spacerays Inc., Northwest Industrial Park, Burlington, Mass. 01803. A four-page data sheet covers the factors involved in mass producing precision-trimmed cermet resistors with an automatic laser trimming system. **[452]**

Polycarbonate capacitors. San Fernando Electric Mfg. Co., 1501 First St., San Fernando, Calif. 91341. A 12-page brochure details operating characteristics of West-Cap polycarbonate capacitors for application in precision RC circuits, high-Q tuned circuits, a-c circuitry, or capacitance standards. **[453]**

Pulse instrumentation. Datapulse Inc., 10150 W. Jefferson Blvd., Culver City, Calif. 90230, offers a condensed catalog describing its complete line of general purpose pulse generators and digital data generators. **[454]**

Ultrasonic degreasers. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15230. Ultrasonic degreasers for rapidly cleaning delicate components and pieces with difficult-to-reach crevices are described and illustrated in a four-page bulletin. **[455]**

Stepping motors. Heinemann Electric Co., 252 Magnetic Dr., Trenton, N.J. 08602. Bulletin 702 covers the Roto-Netic line of inexpensive stepping motors. **[456]**

Frequency response tracer. B&K Instruments Inc., 5111 W. 164th St., Cleveland 44142. Model 4712 frequency response tracer is described in a product data bulletin. **[457]**

Transducer/strain indicator. Strainsert Co., 24 Summit Grove Ave., Bryn Mawr, Pa. 19010, offers bulletin 102 describing a portable transducer/strain indicator, which permits reading of eight separate strain sensors. **[458]**

Strain gage pressure transducers. Astra Corp., 2428 Wyandotte Road, Willow

New Literature

Grove, Pa. 19090. A line of patented strain gage pressure transducers is described in technical bulletin 60-5. **[459]**

Microwave test lab system. Genesys Systems Inc., 1479 Plymouth St., Mountain View, Calif. 94040, has available a data sheet on the model 4030 microwave test lab system. **[460]**

Analog building blocks. Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664. Series 2600 analog building blocks for high-performance instrumentation and data-processing systems are described in bulletin 894. **[461]**

Microwave tube stabilization. Micro-Now Instrument Co., 6124 N. Pulaski Rd., Chicago 60646. Stabilization of microwave oscillators in the 40- to 100-gigahertz region is described in engineering application bulletin No. 3. **[462]**

Serial character generator. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051. Application Note 14 describes the MM420/MM520, a 256-bit serial character generator. **[463]**

Assured reliability relays. Hi-G Inc., Spring St. and Route 75, Windsor Locks, Conn. 06096, has available a brochure for relay specifiers and buyers requiring exceptional reliability in crystal can relays. **[464]**

Microwave loadings. Solitron-Microwave, 37-11 47th Ave., Long Island City, N.Y. 11101. A six-page brochure provides a reference source to design-in terminations, attenuations, and other loadings as required in a particular system. **[465]**

Count-display module. Integrated Circuit Electronics Inc., P.O. Box 647, Waltham, Mass. 02154. A data sheet describes the C-101 count-display module that accepts 4-line or 8-line BCD for display with decimal point on a cold-cathode tube. **[466]**

Automated instrumentation. Julie Research Laboratories Inc., 211 W. 61st St., New York 10023. Catalog CC-6 highlights automated instrumentation and precise components for production, test, and calibration. **[467]**

Hybrid IC's. WEMS Inc., 4650 W. Rosecrans Ave., Hawthorne, Calif. 90251, offers a brochure outlining the manufacturing process of a hybrid IC from the engineer's drawing to the finished package. **[468]**

Rack-and-panel connectors. Elco Corp., Willow Grove, Pa. 19090. A 28-page guide describes a wide range of low-cost rack-and-panel connectors. **[469]**

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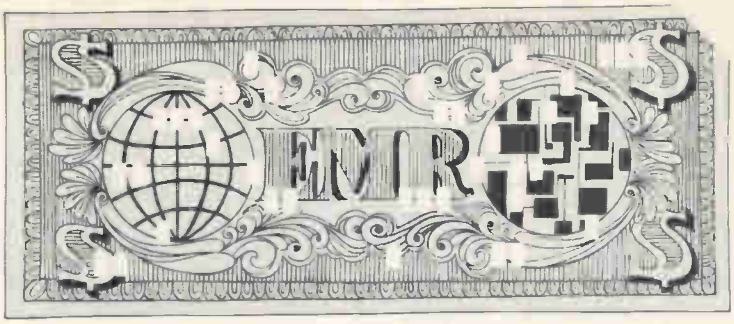

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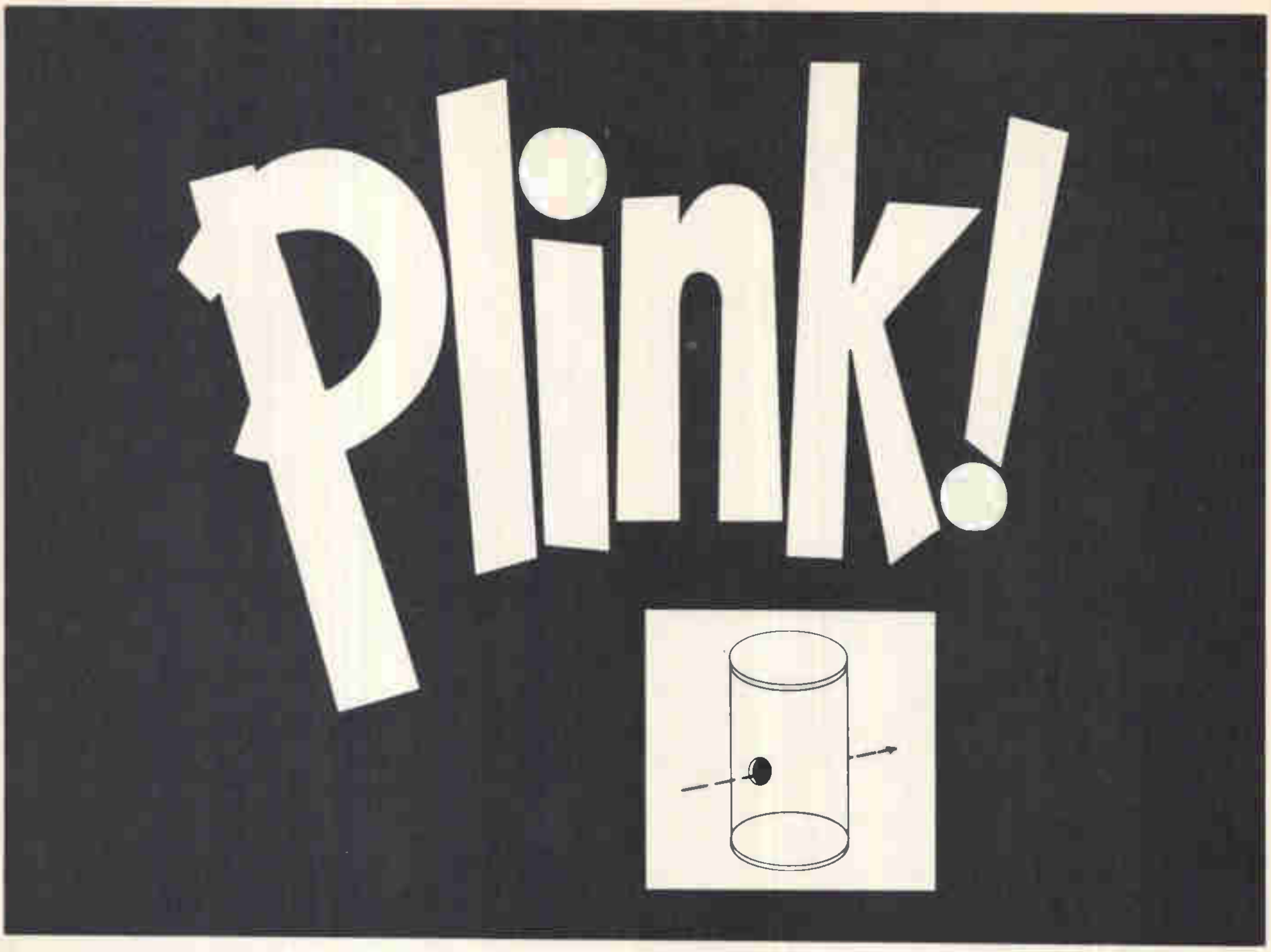

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International Newsletter

November 11, 1968

French claim NASA will agree to launch Symphonie satellite

French space sources are jubilantly passing the word that NASA will soon agree to launch the Franco-German Symphonie communications satellite. NASA officials refuse to confirm or deny the report. Though the U.S. has refused in the past to launch satellites that could compete with Intelsat, it apparently has decided to accept the argument that Symphonie is an experimental project, not a commercial system. The French point out, though, that Early Bird was launched as an experiment but has since become a useful communications link.

NASA's acquiescence could be a fatal blow to the financially troubled European Launcher Development Organization, which had hoped to get the Symphonie job for its Europa 2 rocket [Electronics, Oct. 28, p. 201].

Britain's withdrawal from the project has left ELDO's members with the prospect of chipping in an extra $49 million to keep Europa 2 on schedule—an outlay that will receive a lot of study this week from European space ministers meeting in Bonn.

Nippon Telegraph developing repeater

A solid state microwave repeater, using a high-power impatt diode and a low-noise Gunn oscillator, is being developed at the Electrical Communication laboratory of the Nippon Telegraph and Telephone Public Corp. It features an 11-gigahertz transmitter and puts out an f-m signal.

Nippon's researchers say that the signal-to-noise ratio is about 70 decibels, slightly lower than a klystron's but more than enough for the 960-channel telephone repeater the equipment is being developed for. For longer range, though, an impatt avalanche diode with higher output power will be used. For short-haul systems, the diodes are presently available off the shelf.

Grundig: more time for the consumer

Behind the $50 million sale of the Grundig Group's six office-equipment manufacturing and distributing subsidiaries to Litton Industries is Max Grundig's belief that his firm has no future in that business. The West German magnate is convinced that the problems of software supply—even for small computers—will become increasingly knotty and that they're better left to the giants in the field. The six firms involved make typewriters, small accounting machines, and desktop calculators.

Instead, Grundig plans to concentrate on consumer electronics. Most of his profit from the Litton deal will be used to expand his company's already far-flung consumer operations. For example, $40 million is earmarked for additional facilities in Ireland, Portugal, France, Italy, and at home.

What Grundig isn't saying, though, is that he must lay out that kind of money to meet increasingly stiff competition from European companies controlled by U.S. firms that have introduced streamlined mass-production techniques. Among them are Saba GmbH, controlled by General Telephone and Electronics, and Kuba-Imperial, with General Electric. Also, Grundig must take into account the surging demand for color television sets in West Germany and elsewhere in Europe.

As for Litton's plans for the former Grundig properties, the American firm will combine their small-computer operations and continue to produce typewriters.

British firm delays IC amplifier's debut

Britain's Sinclair Radionics Ltd., the first company to announce a 5-watt monolithic integrated-circuit audio amplifier, won't be the first to sell one. **General Electric is getting set to unveil its PA240 [see p. 33], but Sinclair says its already-advertised IC-10 is "several months" away from production.** Designers, Sinclair concedes, have not solved all the technical problems. Sinclair says the IC-10 will have ±1-decibel response from 5 hertz to 100 kilohertz, 1% distortion at full output, 110-db gain, and 5-millivolt sensitivity.

U.S. nears decision on dumping charges against Japanese

The Bureau of Customs, winding up its year-long inquiry into charges of Japanese dumping of receiving tubes and resistors, will make its recommendations to the Treasury by the end of the year. The bureau isn't giving any hints as to its recommendations.

If Customs finds evidence of dumping, and the Treasury agrees, the Tariff Commission must then determine if U.S. industry has been hurt. If so, a dumping duty can be applied to these products. **The bureau's findings in this case might be a clue to what it will conclude from investigations, started within the past few months, covering a broad range of electronic components and products from Japan.** Investigations were begun after complaints from the parts division of the Electronic Industries Association.

Dutch plan to buy 400 German tanks

West Germany may be considered Europe's biggest importer of arms, but when it comes to tanks she's quite an exporter. Now that Belgium has received the first 100 of the 334 Leopard tanks ordered last year [Electronics, July 24, 1967, p. 224], **the Dutch government is dickering with the Germans about a similar deal, with the stipulation that electronics be installed in the Netherlands.** The Dutch have decided to buy about 400 Leopards worth about $125 million. Details on the manner of payment are still being worked out with Krauss-Maffei AG, producer of the tank. Krauss-Maffei says deliveries would start during the second half of next year.

The order will be part of a compensation deal calling for Germans to order products worth about the same amount from the Netherlands. The Dutch will probably also insist on putting some hardware other than electronics into the tanks.

Also, negotiations with Norway for 75 Leopards worth about $25 million dollars are still in progress [Electronics, May 27, p. 236]. Contracts might be signed at any time.

Nippon Electric mulls U.S. prospects for 1240 computer

The Nippon Electric Co. may take a fling at the U.S. computer market. **The company, which has a close working arrangement with Honeywell Inc., is gauging the U.S. prospects for its NEAC 1240, a machine in much the same class as the Digital Equipment Corp.'s PDP-8,** a small-sized computer.

The Japanese firm plans to put the 1240 through its paces for Honeywell's computer people in Boston soon. If their reaction is favorable, Nippon Electric will presumably begin setting up an American sales network. Although the mainstays of the company's computer line are Honeywell designs built under license, **the 1240 is a Nippon Electric development and has been selling well in Japan since its introduction there three years ago.**

Electronics International

Japan

Put it on the line

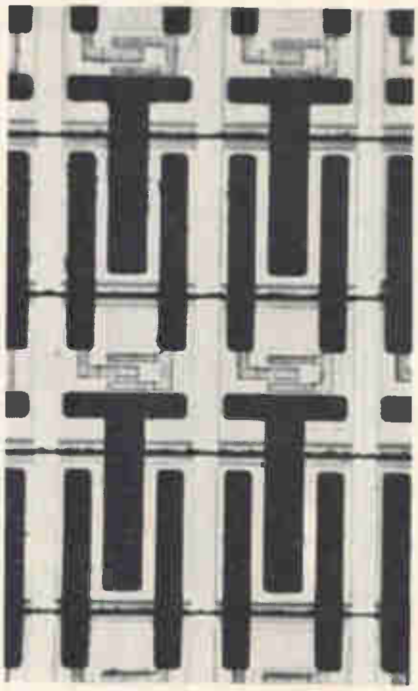
The beam-lead technique offers economies in packaging integrated circuits—and packaging can cost more than the chip itself. Still, it's a difficult way to make IC's, because of the ticklish etching required to provide separated chips with cantilevered leads.

A small Japanese company, Kyodo Electronic Laboratories, has developed what it calls a scribe fabrication technique that eliminates the need for etching after electrochemical formation of the beam leads and prevents the accompanying loss of silicon. And because there is no concern over the corrosive action of silicon etchants, limitations on the selection of metals are relaxed. What's more, say the three engineers who perfected the process—Heishichi Ikeda, Yoshio Enosawa, and Takoshi Yamaoka—the method yields the same number of devices per wafer as wire bonding.

More than 1,000 hours of life tests promise reliability exceeding that of conventional devices. Bonded wire leads, says the company, can be peeled away from the chip by a 3-gram force; the figures for the Kyodo beam-lead diode, for example, are 12 grams for a wide lead and 8 grams for a narrower version. For the new Kyodo IC's, peel strength is 10 grams.

Do it first. The major innovation is to scribe wafers before beam leads are formed; this permits easy separation. Portions of the beams are fabricated over, but not attached to, the neighboring chip. Polycrystalline isolation keeps beam lead-to-substrate capacitance low. The final result is cantilevered beam leads extending beyond the edge of the chip.

After the completed wafer is etched to remove silicon dioxide over the contact areas and photoresist is stripped away, the wafer is scribed. Then another photoresist coating is applied over the entire wafer, exposed through a mask, and developed. This gives a coating over the area between the contact and the edge of the chip where the beam lead will be anchored to the silicon dioxide passivation layer. Also, the scribed line is filled with photoresist material to provide a smooth surface.



Togetherness. Beam-lead transistors, shown before dicing, made by the Kyodo scribe fabrication technique. Final etch step is eliminated.

Aluminum film 0.8 micron thick and nickel film 0.1 micron thick are vacuum-evaporated onto the wafer. Then a second photoresist coating is applied above the nickel film, exposed, and developed. The nickel is now completely covered except for the regions where beam leads are to be formed by electrically plating gold onto the uncovered portions of the nickel surface to a thickness of 10 to 15 microns.

Take it off. All excess material is then stripped, starting with the second photoresist layer, which is the uppermost layer surrounding the beam leads. Next, using the gold beams as a mask, the unneeded nickel and aluminum layers that don't lie under the beams are stripped. This leaves the beam leads firmly attached to contacts and anchor points beside the contacts, freeing them and leaving them cantilevered over the wafer where they cross the boundary between chips and extend over the adjacent chip.

Finally, the wafer is diced in a manner identical to that used for transistors: the wafer is attached to adhesive-backed flexible material and bent to break at the scribed lines.

Even with its new development, the company is reluctant to compete head-on with larger firms for a share of the standard monolithic IC business. Instead, it will use the process for its line of hybrids, where higher unit prices make competition more attractive.

But because portions of the hybrids are similar to standard monolithics, Kyodo hasn't ruled out eventual entry into that area. For example, a core driver might consist of a standard transistor-transistor-logic gate chip, followed by an amplifier consisting of a power transistor chip and cermet resistors, in a single assembly.

LSI calculator

Backed by a government subsidy, the Hayakawa Electric Co. has put together a small experimental electronic desk calculator incorporating large-scale integration. The machine contains 11 MOS integrated circuits with 300 to 400 elements, three bipolar hybrid IC's, four bipolar transistors, four display tubes, a six-layer p-c board, and assorted hardware. The project was undertaken to show that the Japanese industry could accomplish such miniaturization; a commercial prototype is due next March.

The machine is 2.8 inches high, 6.3 wide, and 8.7 deep. It has an average calculation time of 0.6 second and uses 4.5 watts of power from an a-c line.

The Hayakawa approach was to place all logic circuits in a small number of LSI packages, which were designed as functional blocks; it's thus possible to change the calculator's design by adding or subtracting a block or two. Application of LSI—plus the use of custom-made components—adds reliability.

Also, the LSI circuits and multilayer board mean fewer manufacturing operations and simpler servicing.

But there are several obstacles between laboratory and market, as Hayakawa has discovered with some other experimental calculators. For one thing, the machine displayed in Japan is designed for only four operations—addition, subtraction, multiplication, and division—and provides no roots or other complex functions. There are just eight digits and a floating decimal point.

The project has been expensive. Hayakawa received $42,000 for R&D, and will get another $130,000 to design a commercial version. Component makers such as Mitsubishi, which is developing the MOS IC's, claim they're spending more than the subcontracts are bringing in. Hayakawa must still come up with a design that's commercially viable.

West Germany

A sad Red Baron

West Germany's troubled aircraft and avionics industries, stunned by the government's decision to fill the Luftwaffe's reconnaissance gap with McDonnell Douglas RF-4E Phantoms, expect things to get even worse.

For the reasons, it's necessary to go back about a year to the beginning of a debate over which of two aircraft to buy—the Phantom or Lockheed's RTF-104, which is a beefed-up version of the F-104G Starfighter the Luftwaffe already flies. The 104 would have been built under license in Germany, giving the ailing industries a shot in the arm. But the generals wanted the Phantom, and Bonn's defense committee went along to the tune of 88 planes at a cost of $500 million.

A little balm. Even the belief that the U.S. has promised to get McDonnell Douglas to invite German bids on $100 million worth of subcontracts has failed to dispel the clouds. The German aircraft industry association figures its members are in a poor competitive position on price and know-how, because the Americans have been supplying Phantom parts right along. And it's unlikely that the American firms would step aside in favor of the Germans.

Furthermore, a spokesman for a large U.S. company in Germany points out that "because of the so-called Buy American regulation, it'll be tough for foreign firms to compete in the U.S." Even if the ruling is waived, he says, it will be difficult for German firms to meet prices.

What it all boils down to is that there isn't much work left in the German aircraft houses. Since the end of the big licensing deals for Lockheed and Fiat fighters three years ago, the outlook has been bleak. True, the industry has been reasonably busy lately with the Transall, a Franco-German transport, and with some helicopter license deals. But these can't begin to fill the vacuum left when the 700 F-104's and 400 Fiat G-91's were completed. And unless more big contracts are signed soon—the British-German-French airbus is a possibility – the industry faces harder times in the early 1970's.

The industry also fears that the half-billion-dollar outlay might hurt NKF, the proposed Starfighter replacement. The government could delay action or be less inclined to commit as much money as the industry wants. And a decision to buy the Lockheed reconnaissance plane would have given the industry further design, production, and system-management know-how that could have been applied to the NKF.

Quick recovery

When the West German electronics industry slumped in 1967—sales up only 3% from the previous year after a 7% growth in 1966—it was feared that the industry might be sick. However, the current version of Electronica, the big biannual components show at Munich that ends this week, indicates that those fears were groundless.

Judging from experts' comments at the show, 1968 industry sales growth will bounce back to 7%. Not only that, they say, but 1969 may see an increase of 10%.

Coming up rosy. The industry-wide optimism has generated a lot of bullishness in the components sector. The 900 exhibitors at Electronica (there were 780 in 1966) are predicting an $800 million components market next year, up almost 20% from the estimated total of $670 million for this year. That would be the biggest leap for components in recent years.

The major impetus for the quick comeback has come from the rising production of color and monochrome television sets, the opening of markets, and stable prices. For example, predictions are that next year 450,000 color receivers will be turned out, up from 280,000 this year. And with each cathode-ray tube costing an average of $125, crt's alone will account for a sizable chunk of the components market. Add to that the expected 2.2 million black-and-white sets and the result is a lot of business for device makers.

Also contributing to the upsurge in component sales is the automobile industry. For example, a big break was made last year when Volkswagen put an electronic fuel injection system into its 1968 beetle exported to the U.S.; other companies may soon follow suit. One large firm, Robert Bosch GmbH, has come out with a line of accessories—windshield wiper systems, regulators, signaling equipment—using passive and active devices.

Hold the line. Still another factor is that prices for most components have stopped tumbling. "With many electronics firms now beginning to hit bottlenecks in production, ours has become a seller's market," one large component manufacturer says. "We can pretty much ask for what we want." The production difficulties, especially in consumer electronics, will probably get worse next year as a result of rising demand and the continuing shortage of labor. Integrated-circuit prices will keep falling, however, but not as drastically as in the past. Says Fritz Hoehne of Texas Instruments Deutschland GmbH, "Electronica-goers are interested in IC applications. Price has become a secondary consideration." IC exhibitors report that radio and tv manufacturers are increasingly turning to IC's.

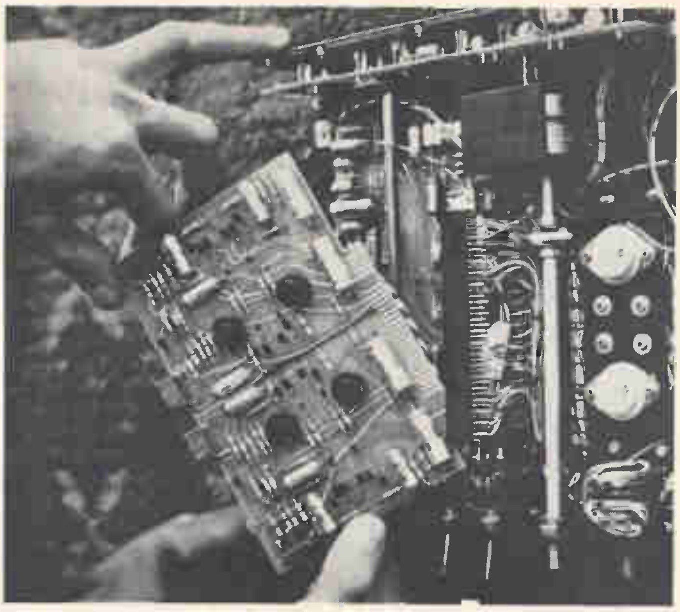
The consumer sector alone will account for about a third of the 1969 IC market, estimated at $105 million to $110 million, up about 10%. Even so, the move toward IC's in consumer goods is just beginning, and it will be another year or two before all of West Germany's tv producers put IC's in their sets.

Great Britain

Sound thought

If a hi-fi enthusiast wants to heighten the fi of his equipment, one of the things he might tend to do is plug in a high-gain cartridge, right? Wrong. Because if the cartridge's gain is too high for the input preamplifier, it will overload the amplifier and distort the sound.

To avoid the overload, an operational-amplifier circuit between the cartridge and the hi-fi set's amplifier can adjust the gain. In the U.S., H.H. Scott has built an op amp into an f-m stereo music system [Electronics, Dec 11, 1967, p. 50]. Now a British company—Cambridge Audio Laboratories, a subsidiary of Cambridge Consultants—has turned the trick.



Innards. The p-c boards of Cambridge Audio's new preamplifier carry an op-amp circuit that prevents amplifier overload.

Sweet and low. Cambridge has used an essentially grounded, low-noise op amp operated by the gain control to optimize preamp performance the way an op amp handles input for an analog computer. So long as the gain is set so that the total volume doesn't exceed the rated power of the amplifier, the preamp will be able to handle without distortion any signal level likely to be fed into it from the cartridge pickup. If the selected gain level and the top end of the record's dynamic range result in overload distortion from the speakers, the gain control is tuned down. This simultaneously increases the signal level the preamp can handle until the distortion is eliminated.

With this technique, says Cambridge, the input stage can handle 3 volts through a 3-millivolt input, or an overload of 1,000 times—10 times the overload claimed for any other equipment known to the company.

Cambridge has made two models. The smaller gives 40 watts rms output and 80 watts peak into 8 ohms, the larger 80 watts rms and 60 watts peak into 8 ohms. Prices in Britain are $155 for the smaller model and approximately $222 for the larger version.

Indonesia

East is east—and cheaper

Gordon Ness bristles at the suggestion that he's running a country club in the Far East. But try as they may, neither he nor Frank Bailey, president of the new subsidiary that Ness Industries Inc. has formed to manufacture electronic subassemblies in Indonesia, can come up with a more descriptive phrase for the operation.

Ness Industries is a conglomerate whose component companies offer a variety of marketing, manufacturing, and consulting services. P.T. IndoNess (the initials stand for "Perseroan Terbatas," the Indonesian equivalent of "societe anonyme," or "persons undisclosed") is the country club; for a fee of $50,000, its members will be permitted to exploit the agreement that IndoNess has negotiated with the Suharto regime in Djarkata.

Key to the door. That agreement has given IndoNess practically exclusive access, so far as small manufacturers are concerned, to the cheap labor pool in Indonesia—where unemployment is at the 15% level and where the basic rate for unskilled workers is 3 cents an hour (5 cents with fringe benefits). IndoNess and its members will enjoy a three-year tax holiday (four years, if they sign up during 1968), will be exempt from duties on imported materials that are to be made into articles for export, and will be given a guaranteed exchange rate for reconverting Indonesian rupiahs into dollars.

Most important, IndoNess has been given exclusive rights to its type of operation in Indonesia for three years. Other companies may manufacture subassemblies; but no other consortium (the way IndoNess describes itself when it's not using "country club") may be formed to do so. Since the research and capital investments needed to start a manufacturing facility in the Far East are considerable, IndoNess figures it has a head start on the competition. Phillips Gloeilampenfabrieken of the Netherlands does have a radio manufacturing plant in the country; but it's the small- and medium-sized manufacturer that IndoNess hopes to attract.

For his $50,000, IndoNess will provide the investor with a plant and a labor force, and will generally smooth his way in Indonesia.

John I. Hermann, who for a time ran Philco-Ford's Taiwan semiconductor assembly plant, will be the resident manager, though members can send over their own managers. IndoNess can also keep air-freight costs down to approximately 65 cents a pound by pooling freight operations.

A membership runs for four years, and it may be sold like a seat on the stock exchange or a taxi medallion.

Dealer's choice. By no coincidence, the first member of IndoNess is the Pacific Assemblers Co. (Pasco), a Ness subsidiary that manufactures subassemblies on a contract basis in Hong Kong. Last year's Hong Kong riots scared off some of Pasco's customers. Ness, pursuing cheap labor and stable political conditions, began dickering with Indonesia, where the military has maintained iron control since the bloody anti-Communist revolt.

Then as now, Indonesia required foreign investors to commit $2.5 million to an Indonesian manufacturing venture. However, Ness was able to get this requirement reduced to $50,000—provided that the investor did not manufacture finished products. That's why IndoNess is limited to the manufacture of subassemblies, though neither Ness nor the Indonesians are anxious to define just what a subassembly is. The first product—printed circuit boards—qualifies no matter what the definition.

Regarding other members, Bailey says that "we're looking for medium-sized electronics companies—perhaps 200 to 500 employees—that are beginning to feel the competitive pinch from larger companies already having offshore assembly operations." The club needs two members besides Pasco to begin operations, Bailey says; he expects to sign them up within a month. IndoNess wants five to 10 members eventually.

Soviet Union

Getting a ruble's worth

Soviet scientists and engineers are about to find out that Lenin wasn't just playing with platitudes when he wrote: "Political institutions are a superstructure resting on an economic foundation." Those words must have been echoing through the corridors of the Kremlin late last month when the Central Committee of the Communist Party and the Council of Ministers decreed that all the money being poured into pure research had better generate some results pretty fast. Apparently, Russian officials, like their American counterparts, have been finding it more and more difficult to justify expenditures that lead only to more expenditures.

Shape up. The double imprimatur on the decree, and the fact that it was spread over the front page of Pravda, is evidence enough that the government means business. But in case there was a lingering doubt, a system of periodic evaluations of the work of individuals and research organizations has been instituted with punishment specified for malefactors. Also, certain programs have been given high-priority tags.

Visiting Western scientists have long noted that the gulf between research and production men is often wider in the Soviet Union than in their own countries. The prevailing Russian attitude is expressed by a researcher in the intellectual hothouse of Akademgorod: "We have our problems and the factories have theirs." This division isn't universal, though. One large electronics research institute outside Moscow has its own instrument-making department turning out equipment that is patented and sold elsewhere.

The reforms were probably spurred principally by dissatisfaction with the nation's recent growth in productivity. Just published economic statistics for the third quarter of 1968 show a production increase of only 5%, a rate sufficient to please some countries but disappointing when compared with Russia's past performance and its long-range goals. The decree also reflects the findings of the State Committee of Science and Technology, which has been assessing the country's research efforts over the past two years.

The inspection and penalty system calls for at least one evaluation every three years based on five criteria:

- Novelty of the research.
- The promise of an application.
- The number of scientific and technological proposals generated.
- Their over-all economic effect.
- Fulfillment of contracted research obligations—not only to Soviet enterprises but those of all other East-bloc countries.

Or ship out. These appraisals, says the decree, "will be taken as the basis for the decisions on material incentives to staff members and the further development of the institutes." In other words, they will affect employee bonuses and fringe benefits, capital investments, and outlays for new equipment, housing, recreational facilities, and the like. Finally, an accreditation system has been established to determine whether individuals should be promoted, demoted, or even fired.

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