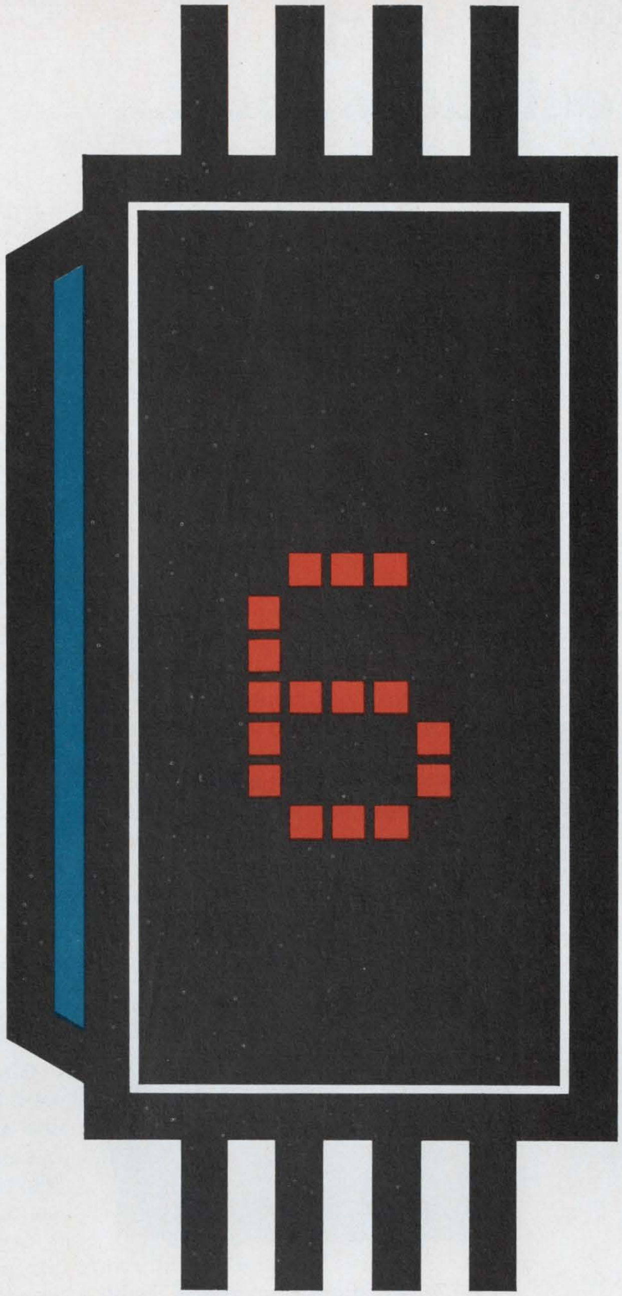
Electronics

Using preleaded semiconductors: page 88
Op amps in active filters: page 98
Assessing the Russian market: page 126

December 9, 1968
$1.00
A McGraw-Hill Publication

Jumbo meets his match in this minicomputer that never forgets page 76



Surprise package
(1″ x ½″ x 1/10″)

It's a completely new way to display digital information. The Hewlett-Packard solid state numeric display packs everything in one, small unit only 1″x 0.5″x 0.16″. Gallium arsenide phosphide diodes and an IC driver/decoder chip deliver bright red numerals—bigger than life, visible for yards.

This new "total package" also gives you the edge on cost. You don't have to buy driver elements, or anything else. No special interfacing is needed. Only four line 8-4-2-1 BCD input and less than five volts to drive it. The modules are available in three-character packages, too.

The Hewlett-Packard solid state numeric display is ideal for instruments requiring smaller, tighter display panels. Or any application demanding either low power or resistance to shock and vibration, without catastrophic failures.

Get more information about the new technology for numeric indicators. Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SOLID STATE DEVICES

01810

The Engineering World Is Full Of Great Ideas, But...

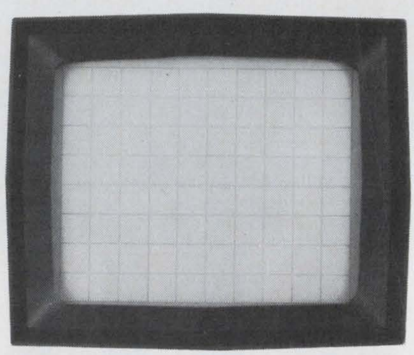
What you do with your ideas is a measure of your progress. Getting an idea is not always easy. Transforming that idea into reality – and proving it – that's where the work really begins!

At HP, we're using the best of our ideas and years of experience in design and production of measurement instrumentation to make the job of turning your ideas into realities easier and faster.

Take the HP 180 Scope System as a case-in-point. It now has a sampling system that allows you to see 12.4 GHz. This sampling system circuitry contains step recovery diodes which produce nanosecond rise times with high power. Dr. Frank Boff was using the first practical gigahertz sampling scope—the HP 185—to analyze the effects of different combinations of "p" and "n" material when he discovered the step recovery diode. Other research by Hewlett-Packard Associates produced the hot carrier diode that made the 12.4 GHz system practical, provided an extremely fast sampling gate, simplified circuitry and gave greater reliability.

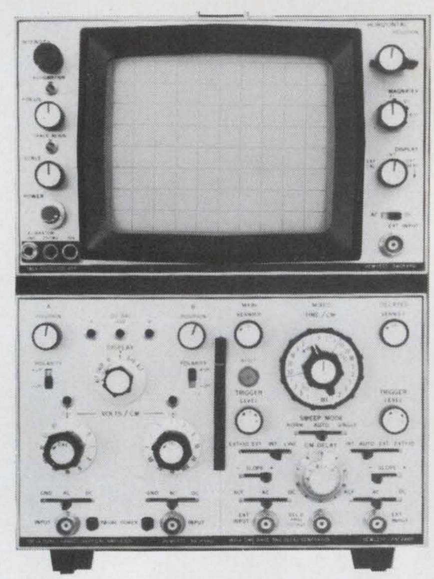
The engineering world has been plagued for years with inaccuracies caused by capacitance when measuring high frequencies and nanosecond rise times. We fought this problem, also. HP Microwave Division's experience with high frequency 50 Ω transmission systems led to development of the 50 Ω input system for the 100 MHz 180 scope, so you have a near-perfect termination – regardless of your signal frequencies.

A few years back, to design connectors, circuits, antennas, strip lines, and similar component parts, you had to measure all around the problem. Then to get where you needed to be—to find out what, where, and how much, you had to interpolate or extrapolate to find your answer. Now all you need for a direct measurement is the 180 and the TDR plug-in—another HP idea that came from experimentation with microwave circuitry.



CRT size is another example. Early scopes—and even some of the modern scopes—had CRT's that were so small you had to squint to see them. We took the post-accelerator technique and the mesh dome technique ideas and combined them to produce larger, easier-to-read and more accurate CRT's. This combination requires lower driving potentials so the CRT can be driven directly by the plug-in. Driving the CRT from the plug-in gives you a mainframe that is not limited by its internal components and allows a choice of 50 MHz, 100 MHz, four channels, differential offset...

Vacuum tube scopes have a difficult time settling down to the point where accurate measurements can be made consistently – time after time. Signals often drift all over the face of the CRT! All-solid-state components (which reach operating level almost immediately) and field effect transistors in the 180 scope system amplifier plug-ins virtually eliminate drift in both ac and dc measurements!



Speed your great ideas into realities. Step forward with the state-of-the-art new-idea-packed 180 scope system! It's no johnny-come-lately. It's been proven by more than two years in the field.

Consult your Hewlett-Packard Instrumentation Catalog for specifications and prices on the 180 Scope System mainframes and plug-ins, then contact your nearest HP field engineer. (He's an instrumentation specialist who can furnish information on a *complete* measurement system using the HP 180 as the core.) Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

089/3

STEP FORWARD

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

Electronics

Volume 41, Number 25 December 9, 1968

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Electronics International

New Products

Technical Articles

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Readers Comment

Blood and thunder

To the Editor:

Concerning your article about an impedance cardiograph to measure blood flow [Sept. 2, p. 46], there have been no new electronic methods advanced in this field since Jan Nybor's early days. As coauthors of a paper critical of the assumptions made by many researchers, we find the expenditure of masses of money on electrical impedance plethysmography highly wasteful.

Of all electrode configurations, the system described in the article would be the one most prone to error signals. There must be a less expensive and cumbersome way to prove that the heart is beating.

Jerold C. Jansen
James L. Fling
Custom Systems Associates Inc.
Portland, Ore.
R.V. Hill, M.D.

▪ The developer of the instrument in question, William G. Kubicek of the University of Minnesota Medical School, replies: "Such a harsh attack seems out of proportion when none of the three critics has ever taken a look at our technique. Moreover, it implies that no one at NASA knows what he's doing. Even Nybor is satisfied. He spent more than a day scrutinizing our work, and remarked to me that he wished he had the kind of engineering support I have."

Same league

To the Editor:

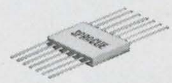
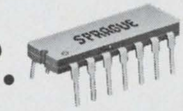
You announced that an oscilloscope with a bandwidth extending to 300 megahertz will soon be introduced by the Matsushita Communications Industrial Co. [May 13, p. 192]. You omitted to mention that an oscilloscope with similar features made its appearance at the Salon des Composants in Paris in April of this year.

This scope, the OCT 590 manufactured by my firm, is a solid state instrument with a bandwidth of 250 Mhz at 3 decibels. It has interchangeable plug-in units and a

Two new Series 54/74 AND gates.

The 54/7408—a Quad 2-input AND.

The 54/7411—a Triple 3-input AND.

Choice of flat pack  or DIP. 

Full of features.....

- High Speed—t_{pd} = 13 nsec.
- Low Power—25 mW/gate
- Full Fan-out of 10
- Input Diode Clamping
- Reduce Package Count

Available now from Sprague— the broad line Series 54/74 supplier.

SERIES 74N	FUNCTION	SPRAGUE PART NO.*
SN7400N	Quad 2-Input NAND	USN-7400A
SN7401N	Quad 2-Input NAND (No Collector Load)	USN-7401A
SN7402N	Quad 2-Input NOR	USN-7402A
—	Quad 2-Input AND	USN-7408A
SN7410N	Triple 3-Input NAND	USN-7410A
—	Triple 3-Input AND	USN-7411A
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
SN7472N	J-K Master Slave Flip Flop	USN-7472A

SERIES 74N	FUNCTION	SPRAGUE PART NO.*
	Dual J-K Master Slave Flip Flop:	
SN7473N	Single chip, pin 11 GND	USN-7473A
—	Single chip, pin 7 GND	USN-74107A
SN7474N	Dual D-Type Edge-Triggered Flip Flop	USN-7474A
—	Dual J-K MS Flip Flop with Preset and Clear	USN-7476B
—	Dual AC Clocked J-K Flip Flop	USN-7479A
	COMPLEX ARRAYS	
SN7441N	BCD-To-Decimal Decoder/Driver	USN-7441B
SN7475N	Quadruple Bistable Latch	USN-7475B
SN7480N	Gated Full Adder	USN-7480A
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

*0 to 70 C dual in-line circuits. Standard devices also available in flat pack, as well as Series 5400 full-temperature-range equivalents in flat pack or DIP.

For complete technical data on Series 54/74 circuits, write to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Mass. 01247

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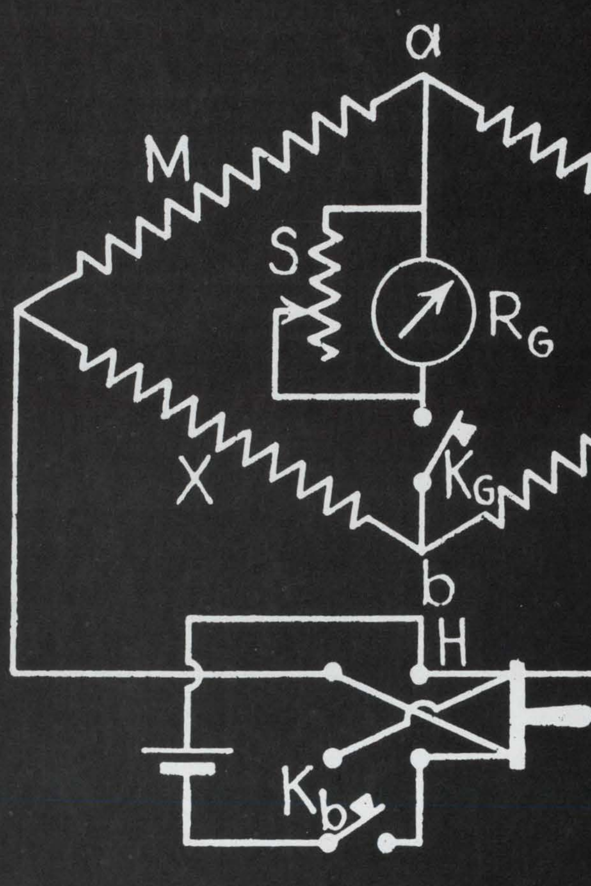
SPRAGUE®
THE MARK OF RELIABILITY

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS



A new bridge?

Redesigning something as basic as an R-L-C Bridge is like reinventing the wheel. What more can be done beyond just a face-lifting? A lot. You can always improve on basic old concepts by adapting them to meet today's needs. This is what happened to the new GR1650-B Impedance Bridge. After all, what did Wheatstone, Maxwell, and Hay know about transistors?

Oh sure, we're guilty of face-lifting too — we gave the 1650-B a new, light look; but we also added features that adapt the bridge to today's and tomorrow's needs. For example:

Access has been provided to the bridge arm opposite the unknown. An external capacitance decade may be connected here to make a reactive balance of inductive resistors. This is often useful when measuring an amplifier's input impedance.

A conductance bridge has been added. It permits direct readout in micromhos of parameters such as h_{oe}. A simple test jig allows you to measure all the transistor h parameters including input and output capacitance.*

A convenient external DQ jack simplifies inserting a dc blocking capacitor for incremental inductance measurements of inductors carrying direct current.

A slow-motion dial drive has been added to ensure fine accurate balances. The drive comes into use during the final stages of balance.

DC sensitivity for low resistance has been improved and the bridge transformer has been redesigned to permit low-frequency measurement with less drive power.

With all these additions, you probably wonder about subtractions. There is one and it's in the price. The 1650-B sells for $450 in the USA. That's $25 less than the price of its predecessor, the 1650-A.

*See General Radio Experimenter.

Circle 6 on reader service card

What's old about this new bridge?

The features that made the 1650-A Bridge so versatile have been maintained and strengthened:

- Wide measuring ranges: C from 1pF to 1100μF, series or parallel; L from 1μH to 1100H, series or parallel; R from 1 mΩ to 1.1 MΩ, ac or dc; G from 1 nanomho to 1.1 mhos, ac or dc; D (at 1 kHz) for C_s from 0.001 to 1, for C_p from 0.1 to 50; Q (at 1 kHz) for L_s from 0.02 to 10, for L_p from 1 to 1000.
- $\pm 1\%$ accuracy for G, C, R, and L measurements holds on all ranges, is not reduced at range extremes, and holds from 20 Hz to 20 kHz. Accuracy is only slightly reduced at 100 kHz.
- Exclusive Orthonull® balance finder avoids false nulls when measuring lossy components. The bridge's DQ dial has now been color coded to indicate when Orthonull should be switched in.
- High DQ resolution and accuracy make for accurate determinations of equivalent circuits and network modeling for computer analysis. You could almost call the 1650-B "computer software".
- Battery operation for portability and isolation from the power line . . . Solid state 1-kHz oscillator and selective null detector . . . External biasing provision . . . Useful for both two- and three-terminal measurements . . . Flip-tilt case provides protection and doubles as an adjustable stand.

For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH 8034 Zurich 34, Switzerland.

GENERAL RADIO

helical deflection tube. And we are now developing a double-beam oscilloscope with the same characteristics.

Jean Toutain
Constructions Radioelectriques
et Electroniques du Centre
Saint-Etienne, France

Paper pileup

To the Editor:

Regarding your editorial on the Mansfield amendment [Oct. 28, p. 31], which would have limited overhead charges on Government research contracts to 25%, that ceiling is historically too low and 150% is almost certainly too high. In 1948, when I monitored some R&D contracts as a Navy engineering employee, 100% overhead was common. In 1966, the industrial firm for which I was working charged 125% overhead, some of this for bookkeeping and record-keeping that would have been unnecessary but for formal Government requirements. The rest of it went for managerial and other "service" costs, some of them also unnecessary.

There has been a tendency at both industrial and Government organizations for overhead costs to increase at the expense of the engineering work done. Much of the work covered by these costs—management, marketing, accounting, and administration—does not contribute to results. In industry, the cost of just getting the contract—formulating proposals and such—is very high because of Government usages and regulations.

There is a growth in what we might call "concealed" overhead—requirements that force working engineers and scientists to spend more and more of their time on paperwork. This condition is brought about by dividing a project into smaller and smaller pieces that have to be performed by more and more organizations—both Government groups and contractors. Each such division creates another interface, and each interface calls for more documentation. Both industry and Government have fostered this kind of fragmentation over the years. And it has run up the costs of R&D.

L. Fleming
President
Innes Instruments
Pasadena, Calif.

Added touches

To the Editor:

The cover of your Sept. 30 issue features a picture of an IBM input-output terminal display. It has been retouched, however, and suggests that the IBM 2550 is capable of handling color displays. It is not.

Walter Keeshen Jr.
International Business
Machines Corp.
White Plains, N.Y.

■ Electronics overlaid two additional colors to brighten its own product. We had no intention of distorting IBM's image.

Circle 7 on reader service card

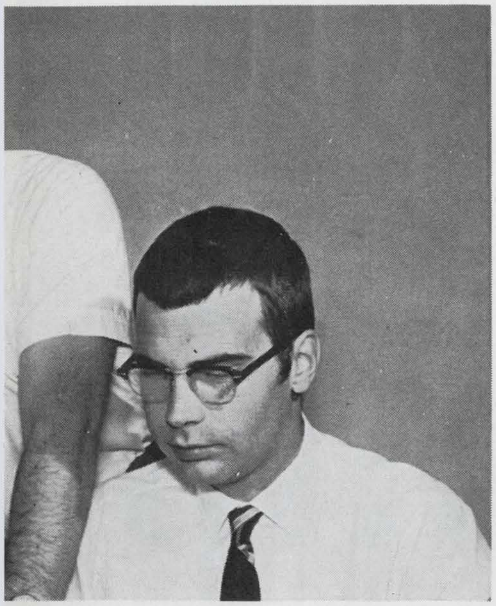
Who's Who in this issue

Burkhardt de Castro

The founders of the Data General Corp. have a lot of experience in designing small computers; they're all ex-employees of the Digital Equipment Corp. The president of the new company, Edson D. de Castro, and his vice presidents, Henry Burkhardt and Richard G. Sogge, are co-authors of the article

The brain drain, that one-way transatlantic current, numbers George S. Moschytz among its passengers. The European-born engineer, co-author of the article on active filters on page 98, received his schooling in Switzerland, earning a doctorate in 1960 from the Institute of Technology in Zurich. In 1963 he was attracted to the U.S. by Bell Labs, where he's now

Wyndrum



Sogge

on page 76 about the firm's first computer. As head of small-computer design at DEC, de Castro developed the PDP-5, -8, -8/I, and -8/S. Burkhardt was in charge of small-computer applications programing and Sogge was in charge of DEC's memory and circuit development.

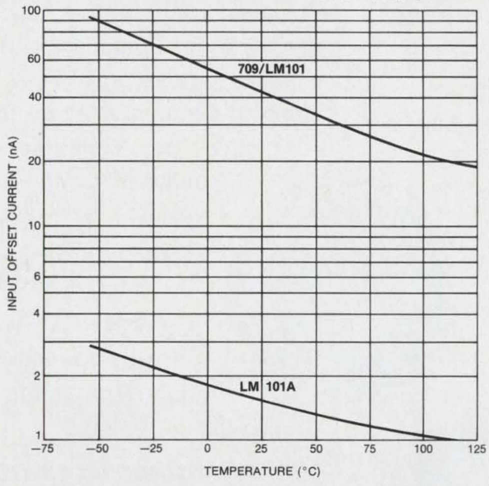
a supervisor of the data systems and circuits group.

Ralph W. Wyndrum Jr., the other author, is a native of New York. He received his Sc.D. degree in 1963 from New York University and joined Bell Labs the same year. He is now supervisor of exploratory circuit applications and has investigated thin-film circuit development, including active RC filters.

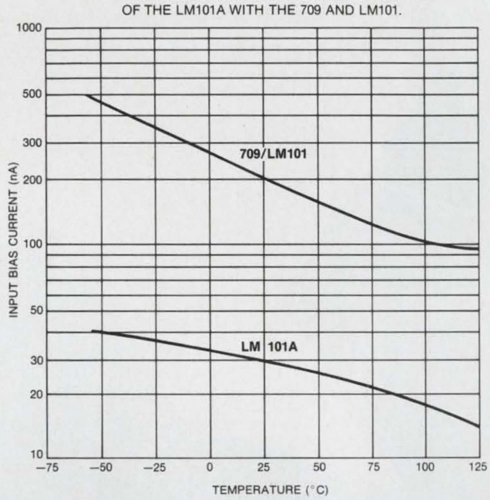
Moschytz

How do you improve on an Op Amp like the LM 101?

COMPARISON OF THE TYPICAL INPUT OFFSET CURRENT OF THE LM101A WITH THE 709 AND LM101.



COMPARISON OF THE TYPICAL INPUT BIAS CURRENT OF THE LM101A WITH THE 709 AND LM101.



An order of magnitude improvement. The LM 101A has every advantage of the LM 101, but with 20 nA offset current and 100 nA bias current guaranteed over a −55° to 125°C temperature range.

With this device, we also guarantee offset voltages of 3 mV, offset voltage drifts of 15μV/°C and offset current drifts of 0.2 nA/°C. Again over the −55° to 125°C mil range. The offsets are specified over the common mode range and both the common mode and supply rejection have been improved. A new processing technique gives the LM 101A lower noise and input currents, and the input stage biasing has been changed to reduce temperature drift.

None of the other 101 basics have changed. You still get frequency compensation with just one 30 pF capacitor. Insensitivity to oscillations with capacitive loads or loose supply by-passing. Overload protection on the input and output. No latch up modes. All the good things. Completely interchangeable with old LM 101.

The price is right, too. $30.00 from 100 pieces. And $12.00 in the commercial/industrial version, LM 201A.

Write for the details. National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 (408) 245-4320.

National Semiconductor

the LM 101A

HP 3450A Multi-Function Meter:

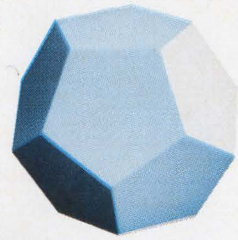
The basic HP 3450A digital multi-function meter measures dc voltage and **true four-terminal** dc ratio. From there you make up your own unit with options to fit your needs now—then add other field-installable capabilities later to make your unit a complete "dodecameter" with five digit plus overrange digit readout for dc, ac and ohms measurements. Full autoranging capability for all functions is standard.

Add the AC Option and you can make **true RMS** ac measurements from 45 Hz to 1 MHz—and true four-terminal ac ratio. Add the OHMS Option for six four-wire ohms ranges including a 100 Ω range and ohms ratio. Put in the LIMIT TEST Option and you have HI GO LO and digital readout with two preselected limits for dc, ac and ohms – and ratio limit tests for ac, dc and ohms. That gives you a total of twelve measurement functions. But, that's not all! Add the DIGITAL OUTPUT Option for nine columns of digital output to a printer. With the addition of the REMOTE CONTROL Option, you have added full programmability for systems use. The only option that must be factory-installed is the REAR INPUT Option for isolated front and rear input capability! All this capability is contained in a rack-mountable cabinet only 3½ inches high. All-solid-state construction—including more than 220 integrated circuits—gives you increased reliability and lower maintenance. Turn the instrument on, and in seconds it's ready to operate.

Call your nearest HP Sales and Service Office to learn how you can save time and reduce bench clutter with the one multi-function meter with twelve measurement capabilities. For full specifications, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

DC VOLTAGE and DC RATIO

DC voltage and dc ratio capabilities are contained in the basic unit. The 3450A uses a dual-slope integration technique and is fully guarded for excellent noise immunity at 15 readings per second on all five dc voltage ranges (100 mV to 1000 V). Input resistance is $>10^{10}\,\Omega$ on the lower three ranges and $10^{7}\,\Omega$ on upper ranges to minimize the effects of resistive loading of your sources. The four-terminal ratio on the 3450A gives you complete isolation between X and Y inputs so you can measure the ratio of two independent dc voltages. Four ranges (1:1 to 1000:1) of true four-terminal dc ratio are provided. Price of basic 3450A, $3150.



AC VOLTAGE and AC RATIO (Option 001)

The 3450A with ac option is the only true RMS digital voltmeter with five-digit resolution for ac measurements

from 45 Hz to 1 MHz. This greatly increases the capability previously available in a digital meter. You get true RMS responding measurements on four ranges (1 V to 1000 V). And the 3450A has a ±0.05% midband accuracy!

Adding the ac converter (Option 001) to your basic 3450A provides ac voltage and true four-terminal ac ratio. Price Option 001, $1250.

OHMS and OHMS RATIO (Option 002)

Six ranges (100 Ω to 10000 kΩ) of four-wire ohms measurements at 15 readings/sec are available when you add the ohms converter to the 3450A basic unit. A maximum of 1 mA signal current reduces self-heating in the resistor under test. The ohms converter also adds four ranges of ohms ratio. Price Option 002, $400.

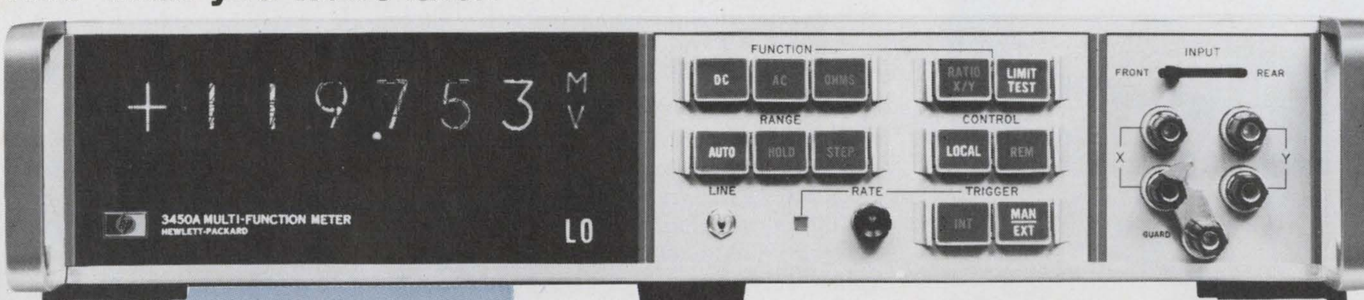
LIMIT TEST (Option 003), DIGITAL OUTPUT (Option 004)

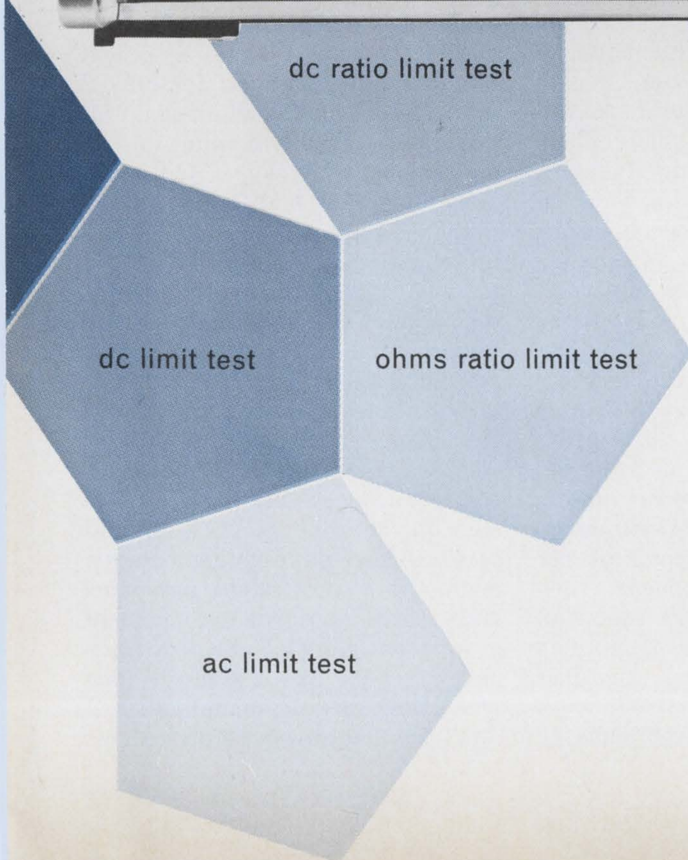
Install the limit test converter in your 3450A. Then you can use contact-closures-to-ground to preset two four-digit limits (with an additional digit for 20% overranging) and polarity for dc and dc ratio limit tests. When your 3450A has ac and ohms capability, plus the limit test option, you have ac limit and ac ratio limit tests, ohms limit and ohms ratio limit tests. HI, GO, LO front panel lights clearly indicate results of a test.

With the digital output (Option 004), you get 9 columns of information including HI, GO, LO limit test decisions in 1-2-4-8 "1" state positive BCD form. Buffered BCD output stores previous reading until printer can record it and allows DVM to immediately make another reading. Price Option 003, $350; Option 004, $175.

THE INCREDIBLE DODECAMETER

Start with the basic meter...Order what you *need* now... Add what you *want* later!





REMOTE CONTROL (Option 005)

For systems applications, remote control option installed in the 3450A allows full programmability. All programmable front panel controls can be locked out in remote operation. Price Option 005, $225.

REAR INPUT TERMINALS (Option 006)

Addition of this option provides a set of rear input terminals and a FRONT/REAR INPUT selector switch on the front panel. Price Option 006, $50.

098/9

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

Who's who in electronics

O'Connor

One of the first actions that Douglas J. O'Connor took upon becoming group director of marketing at Fairchild Semiconductor was to lay down the law to the sales staff: in the future, Fairchild personnel will be known as professionals who help the customer solve his problems. Those present at the meeting say that O'Connor and Joseph Van Poppelen, corporate vice president of marketing, were severe in their evaluation of Fairchild's present marketing image. O'Connor, who'll discuss only the positive aspects of his talk, says there will be no major change in his department.

But O'Connor himself is certainly a change from the ebullient supersalesman, W. Jerry Sanders, who was his predecessor. Sanders, colorful of dress and speech, during one period sported a Mississippi riverboat gambler's mustache. O'Connor likes dark suits, wears black shoes and socks, a plain tie, and a buttondown shirt, and has mannerisms to match this quiet fashion. Yet at 37, he has been a paratroop officer (82nd Airborne) and has served as director general of Texas Instruments Deutschland and as marketing director of TI's Semiconductor Components division. And the Fairchild sales staff can testify that there is nothing quiet about the way he does business.

'Sock it to 'em.' Ever since C. Lester Hogan & Co. took charge of Fairchild in August, there had been speculation that Sanders' days as marketing director were numbered. Sanders himself said later that Hogan clearly wanted to change Fairchild's marketing image and that bringing in a new man was the easiest way. Still, O'Connor's arrival was something of a surprise because it was so sudden: Sanders was reportedly informed of the change at a luncheon with Van Poppellen and Hogan only an hour before Fairchild made the announcement. Sanders was offered a post as assistant vice president of marketing under Van Poppelen and said he would accept it, but he hasn't yet taken up his duties.

O'Connor manages to talk about how he plans to run Fairchild's marketing without ever conceding that there will be a change in the old "sock it to 'em" style. "Today we can solve the customer's design problems," he says, "but we can't deliver on some high-volume standard products. We will have to ask for indulgence and patience until we get into a position to meet volume demands."

'Unique team.' O'Connor notes that integrated-circuit technology has shortened a product's lifetime considerably. "In 1960, the life cycle of a transistor was 4 to 7 years," he says. "Now, DTL and TTL have been around for only 2 or 2½ years and medium-scale integration is already coming in as a replacement technology." O'Connor feels that Fairchild is in an extremely strong position in DTL and linear circuits and thus ready to reap the high profits that come at the end of a product's lifetime. And he adds that it will make a strong effort for deep market penetration in MSI and memory products.

O'Connor concedes that Motorola dominates the domestic semiconductor market and TI the foreign market but says, "Fairchild seems to have put together a unique team—the old Fairchild personnel and technology plus a management group consisting of the top business executive and a group of men who know how to manufacture. I don't see that anywhere else; that's

why there is an opportunity for us to become the dominant worldwide supplier." That's Hogan's goal; the timetable is 3 to 5 years, and with the addition of O'Connor, the team seems to be shaping up.

Beaton

Paradoxically, General Electric's Electronic Systems division has been anything but systems oriented: it's neither produced systems nor used a systems-engineering approach. But this is changing, according to Roy H. Beaton, who recently became general manager of the division and a GE vice president.

Beaton, 52, is no stranger to systems engineering; he was formerly general manager of GE's Apollo Systems division in Daytona Beach, Fla. Beaton says his mission at the Syracuse, N.Y., facility "is to integrate a large number of separate entities within the division to produce total systems from a systems-engineering viewpoint, especially in the military sector."

"Before this," Beaton explains, "the division was primarily a supplier of military equipment and subsystems. Now we're trying to bring in systems engineering at the division level and work down from there." He cites the military trend toward total-systems procurement as a reason for the approach.

Study group. Among the innovations already under way is the creation of an advanced systems and requirements operations group, which will study coordination of the division's diverse activities and report directly to Beaton.

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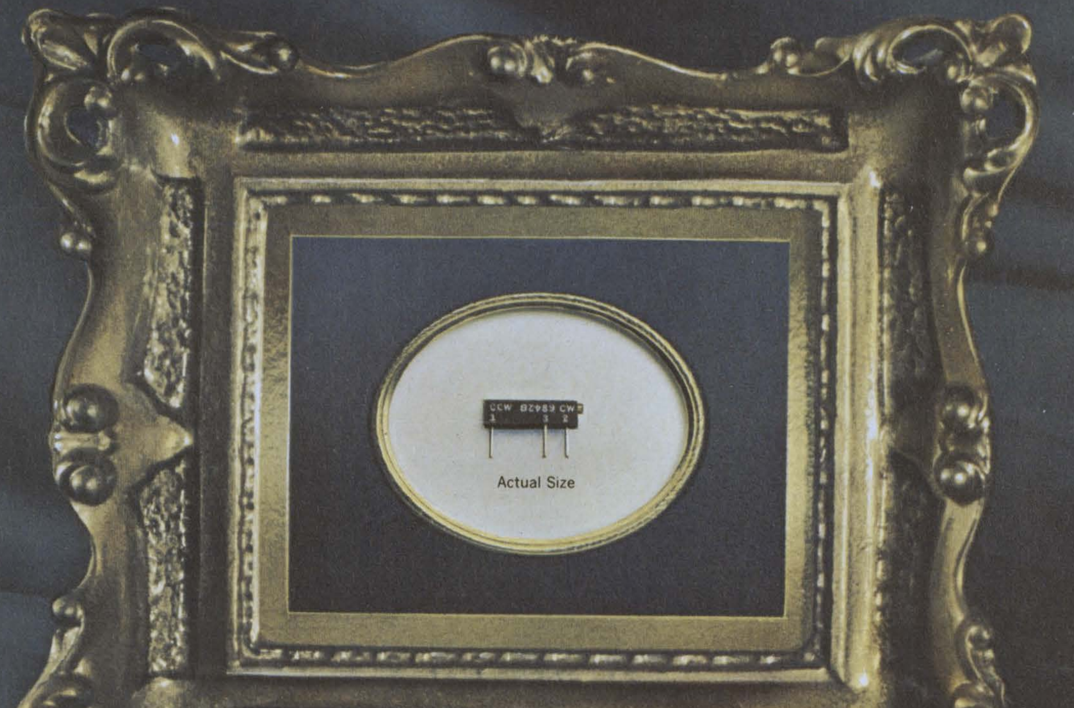

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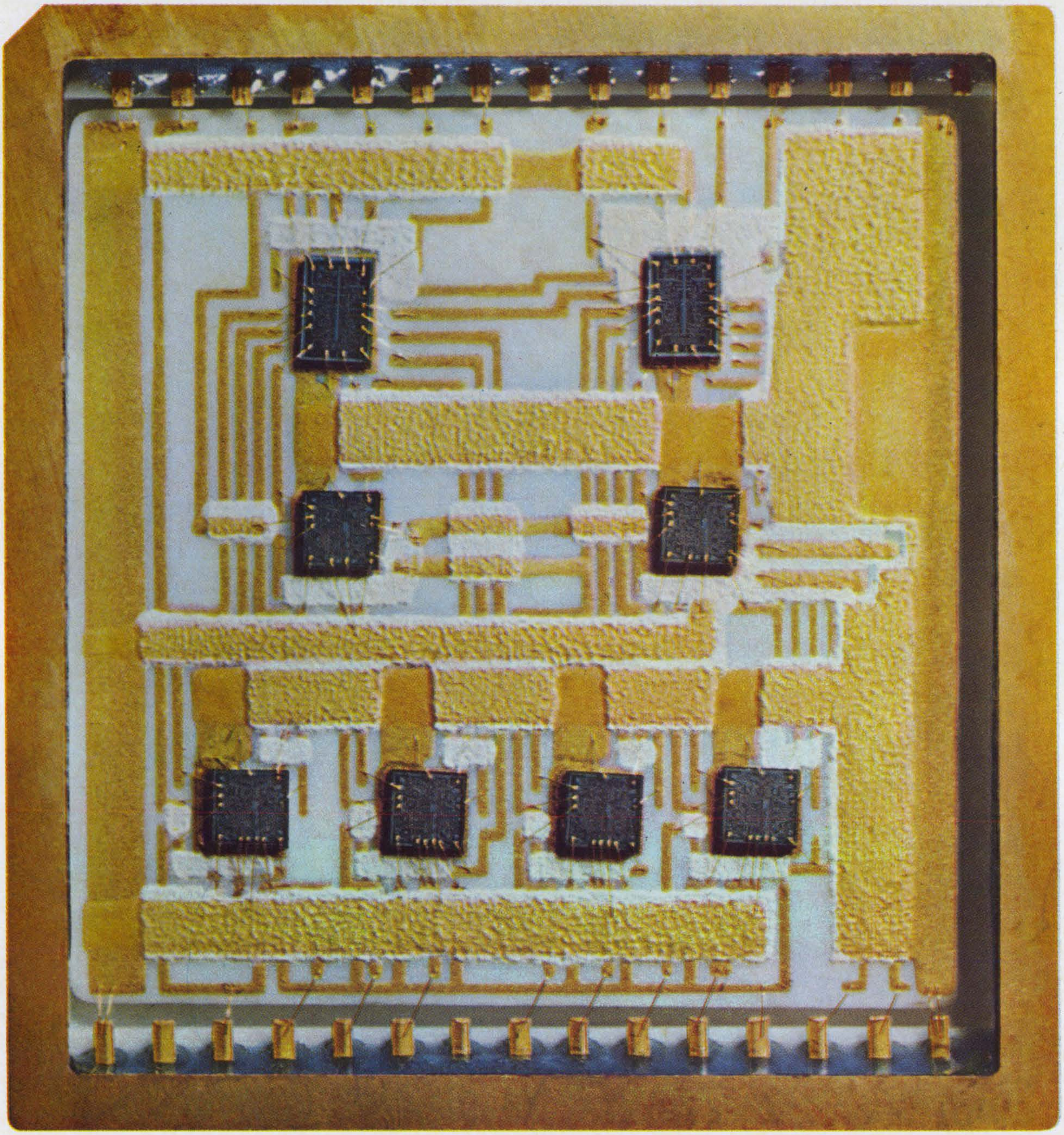
Fairchild can make more hybrids in



How to select the best DVM in the medium price range:

	HP 3440 SERIES	FAIRCHILD 7000 SERIES
TO MEASURE DC VOLTS		
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)		
price	$1775	$1725
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
$2230	$1795
dc, ac, mV, ohms, current, ratio	dc, ac, mV, ohms
#002 - 6/67	catalog - 1968

The rest of the series 4400 specs are in our new brochure along with those on all the Dana DVM's. A letterhead request will get you a copy. Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664.

DANA

Circle 21 on reader service card

Meetings

Reliability symposium

The formal trappings of the reliability business—manuals, specifications, standards—have been a feature of military and space electronics programs for the past decade. And they're now being applied to the non-Government field. This extension of reliability technology will be the theme of the 15th Annual Symposium on Reliability, to be held in Chicago, Jan. 21 to 23.

An indication of the theme is that the two keynote addresses will be given by consumer-industrial men—Thomas Morrow, vice president of Chrysler, and Thomas Wands, vice president of Sears, Roebuck.

Included in the range of reliability topics on the agenda: marine products, consumer electronics, manufacturing, welding and soldering, lasers, software, and, of course, military and space systems.

Broad view. Nondestructive electronic testing is included in the symposium for the first time. In the one-day session on nondestructive testing the topics again reflect diversity: shipbuilding, bridges, and building construction will be included.

Another session included for the first time is on medical instrumentation. Among the papers: safety and reliability in medical electronics by Prof. Jesse Crump of the Polytechnic Institute of Brooklyn and "Hazards in Hospital Instrumentation" by J. A. Hopps of the National Research Council of Canada. Other items on the agenda for the first time are a panel on reliability and cost and a panel on reliability in consumer electronics.

One session that has always proved controversial in past years and gives every indication of remaining true to form is on math and prediction techniques. For example, R. E. Myers of Honeywell in his paper "How Meaningful Are Reliability Predictions?" will assert that most of them are based on premises which are suspect.

For further information write 1969 Annual Symposium on Reliability, c/o C.M. Bird, registration vice chairman, 26 Yawl Dr., Cocoa Beach, Fla. 32931.

(Continued on p. 24)

first at the SUMMIT

Allen-Bradley hot-molded resistors are the *first* resistors to meet the requirements at the *S level* of the new MIL-R-39008A specification, which covers the general requirements for established reliability for Insulated Fixed Carbon Composition Resistors. ■ And Allen-Bradley provides this "peak" performance in *all three ratings*—the 1 watt, 1/2 watt, and 1/4 watt—and over the *complete resistance range* from 2.7 ohms to 22 megohms! ■ This conclusively demonstrates the superiority of Allen-Bradley's exclusive hot-molding technique. Completely automatic machines developed, built, and used only by Allen-Bradley produce such uniformity from resistor to resistor—billion after billion—that long-term performance can be accurately predicted. And Allen-Bradley hot-molded resistors have no known incident of catastrophic failure. ■ For complete specifications on this quality line of resistors that afford tops in performance, please write to Henry G. Rosenkranz and request Technical Bulletin 5000. Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017. In Canada: Allen-Bradley Canada Ltd.

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

Meetings

(Continued from p. 22)

Calendar

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; Gainesville, **Dec. 17-21.**

American Association for the Advancement of Sciences; Dallas, **Dec. 26-31.**

Symposium on Reliability, IEEE; Palmer House, Chicago, **Jan. 21-23.**

Second Hawaii International Conference, Department of Electrical Engineering, University of Hawaii, Honolulu, **Jan. 22-24.**

Winter Power Meeting, IEEE; New York, **Jan. 26-31.**

International Symposium on Information Theory, IEEE; Nevele Country Club, Ellenville, N.Y., **Jan. 28-31.**

PMA Meteorology Conference, Precision Measurements Association; The Ambassador, Los Angeles, **Feb. 3-5.**

Winter Convention on Aerospace and Electronics Systems (Wincon), IEEE; Biltmore Hotel, Los Angeles, **Feb. 11-13.**

International Solid State Circuits Conference, IEEE; University of Pennsylvania and the Sheraton Hotel, Philadelphia, **Feb. 19-21.**

Particle Accelerator Conference, IEEE; Shoreham Hotel, Washington, **March 5-7.**

International Convention & Exhibition, IEEE; Coliseum and Hilton Hotel, New York, **March 24-27.**

Conference on Lasers & Optoelectronics, IEEE; Southampton, England, **March 25-27.**

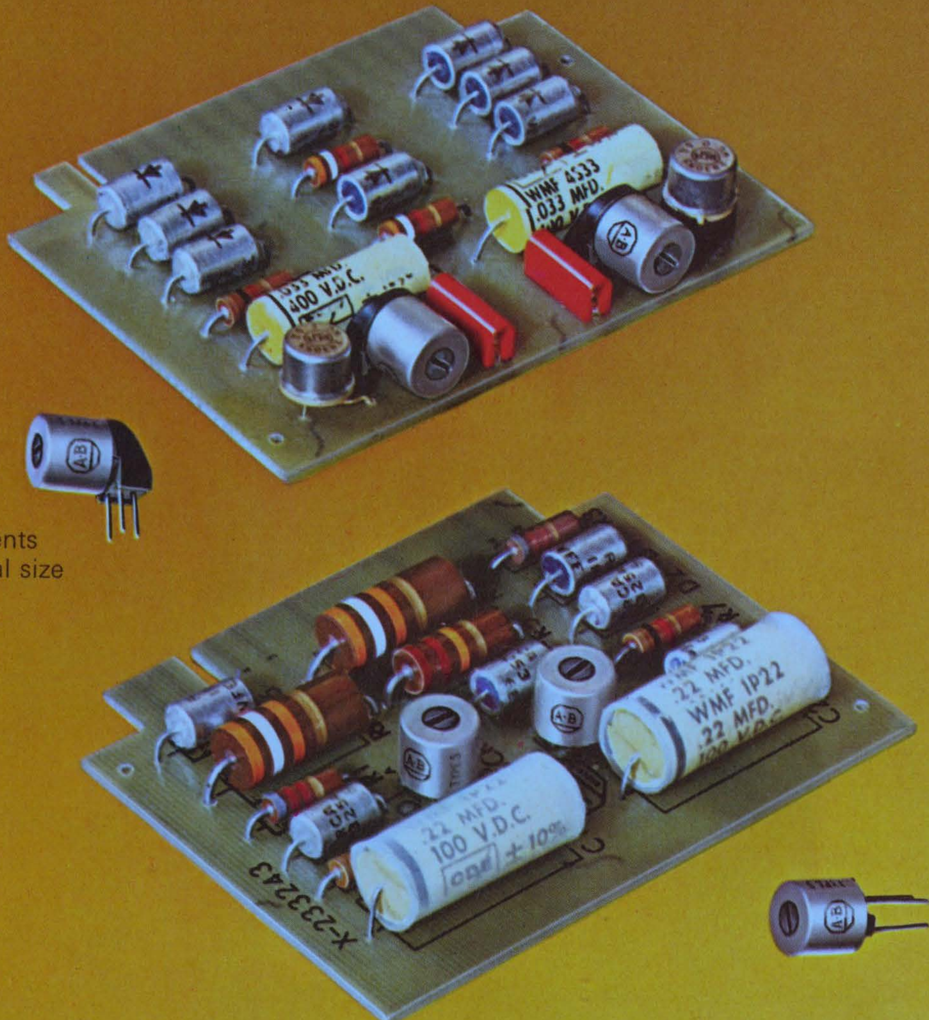
Semiconductor Device Research Conference, IEEE; Munich, West Germany, **April 11-14.**

Joint Railroad Conference, IEEE; Queen Elizabeth Hotel, Montreal, **April 15-16.**

International Magnetics Conference (Intermag), IEEE; RAI Building, Amsterdam, Holland, **April 15-18.**

International Geoscience Electronics Meeting, IEEE; Twin Bridges Marriott Hotel, Washington, **April 16-18.**

(Continued on p. 26)



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Type S
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A-B QUALITY

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

Meetings

(Continued from p. 24)

Conference on Switching Techniques for Telecommunications Networks, IEEE; London, **April 21-25.**

Southwestern Conference & Exhibition, IEEE; Convention & Exhibition Center, San Antonio, **April 23-25.**

Electrical & Electronic Measurement and Test Instrument Conference, Instrumentation & Measurement Symposium, IEEE; Skyline Hotel, Ottawa, Canada, **May 5-7.**

Rocky Mountain Bioengineering Symposium; University of Wyoming, Laramie, **May 5-6.**

Frequency Control Symposium, Electric Components Laboratory, Army Electronics Command, Shelburne Hotel, Atlantic City, N.J. **May 6-8.**

Short courses

Modern on-line process analysis and control, University of Wisconsin, Madison, Wis., **Dec. 12-13;** $70 fee.

Evaluation technology, University of Calif., Los Angeles, **Jan. 20-24;** $285 fee.

Winter institute in computer and information sciences, University of Florida, Gainesville, Fla., **Dec. 17-21;** $250 fee.

Call for papers

Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, D.C., April 16-18. **Jan. 1** is deadline for submission of abstracts to M.E. Ringenbach, director, Equipment Development Lab, U.S. Weather Bureau, Room 201, Gramax Building, 8060 13th St., Silver Spring, Md. 20910.

Electrical and Electronic Measurement and Test Instrument Conference, IEEE; Skyline Hotel, Ottawa. **Jan. 15** is deadline for submission of abstracts to Dr. George E. Schafer, Institute for Basic Standards, National Bureau of Standards, Boulder, Colo. 80302.

Conference on Laser Engineering and Applications, IEEE; Washington Hilton Hotel, Washington, D.C., May 26-28. **Jan. 17** is deadline for submission of abstracts and summary to Dr. William B. Bridges, Hughes Research Laboratories, 3011 Malibu Canyon Rd., Malibu, Calif. 90265.

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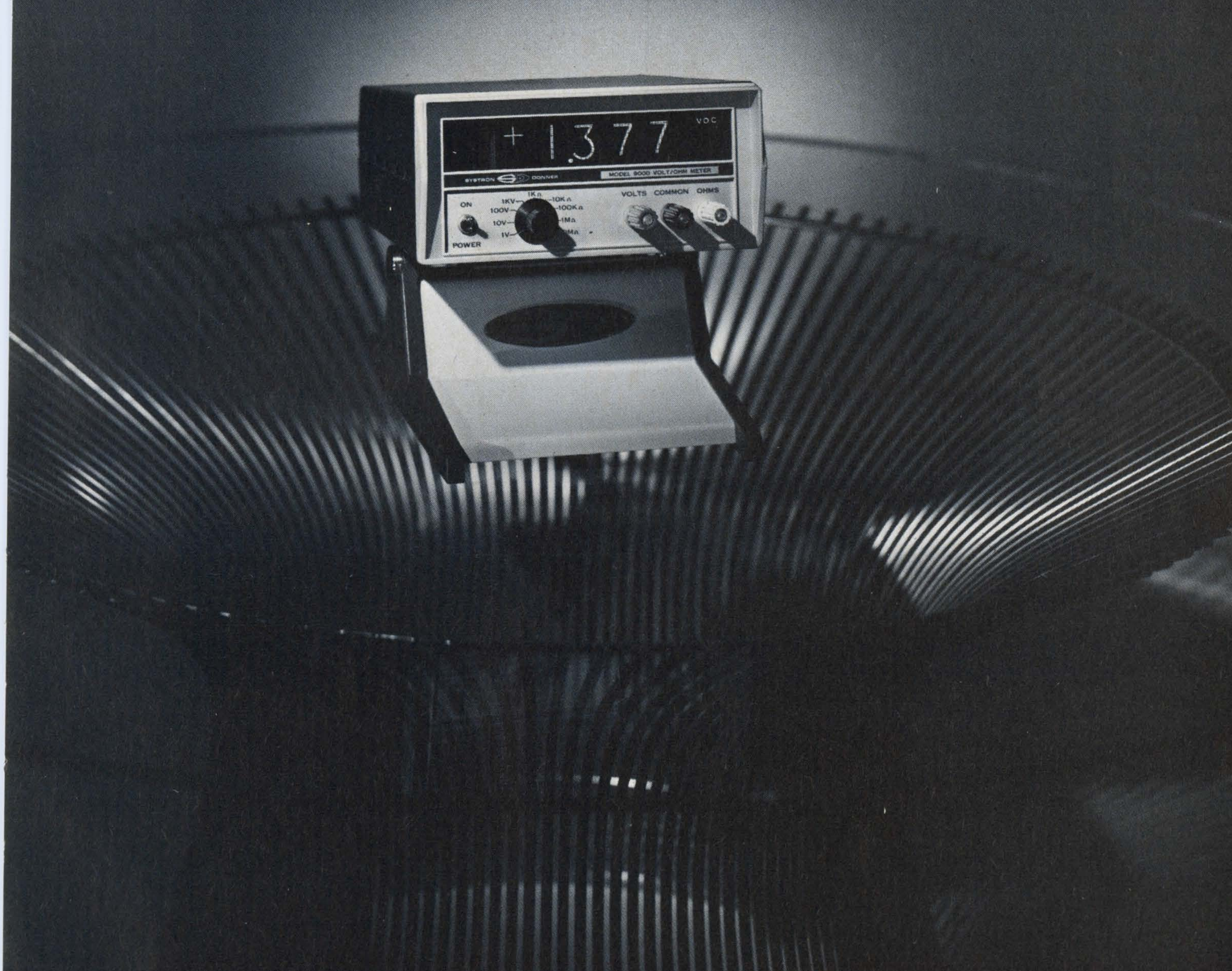

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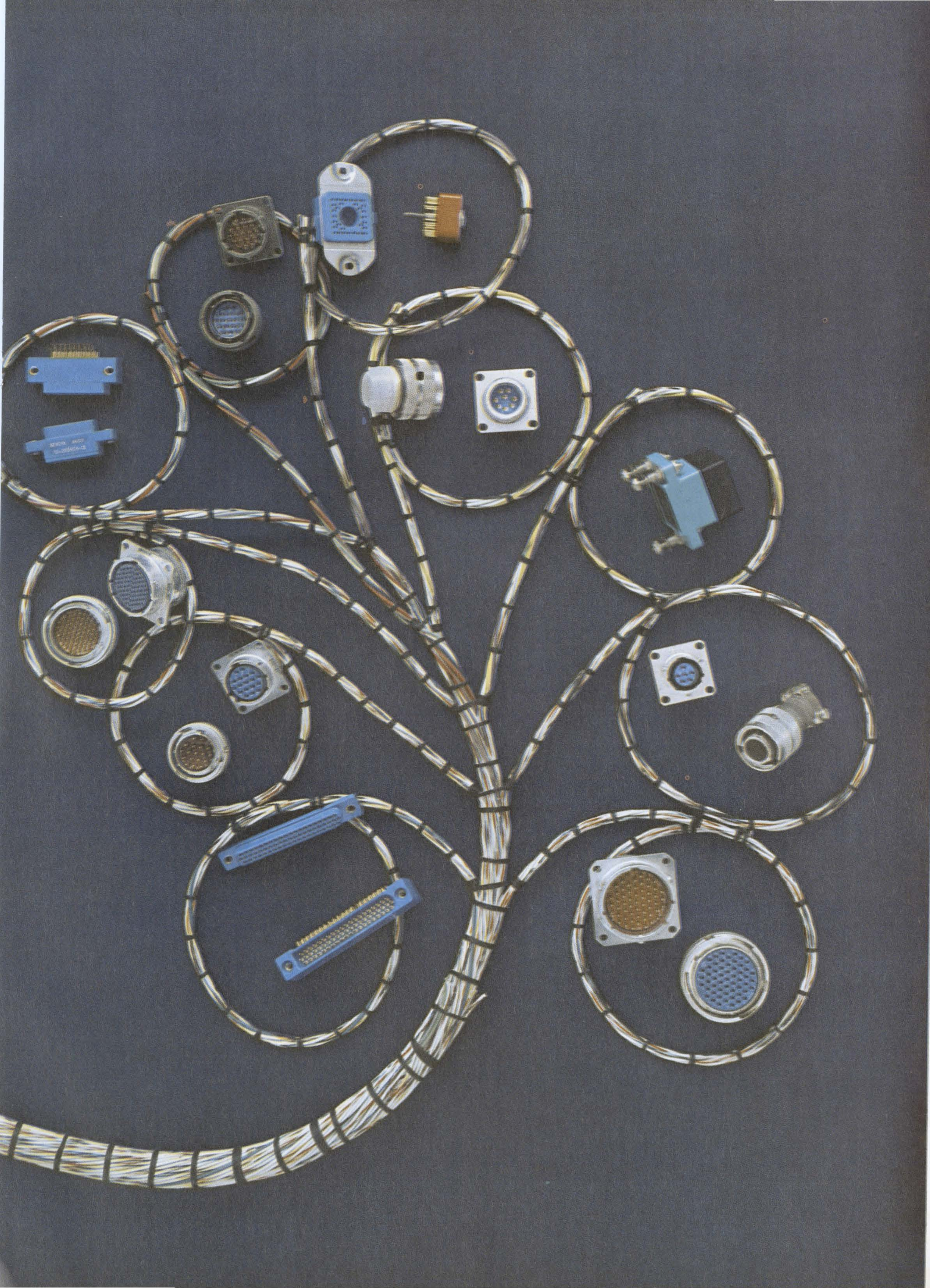

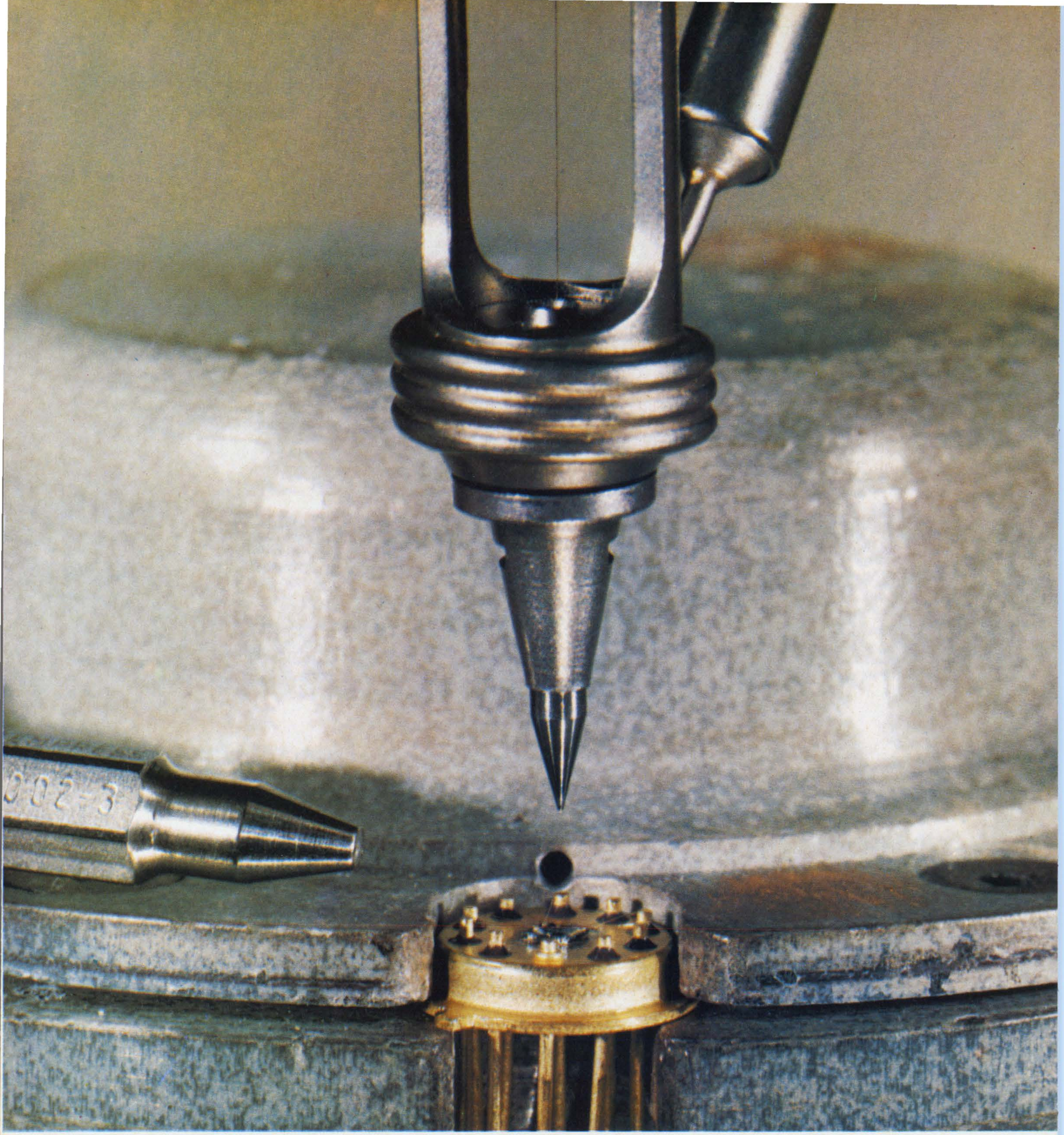

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Circle 30 on reader service card

Editorial comment

Vintage year in Europe?

It may seem foolhardy to predict how electronics in Europe will fare during the coming year. The repercussions of last month's international monetary crisis have hardly subsided and the experts are far from agreed that the steps taken to stabilize the world's currencies will work. Added to this uncertainty is the chance of strikes and political unrest.

Nevertheless, it's possible to make some predictions based on the situation in three European countries: West Germany, France, and Britain. Together they account for the bulk of Europe's total electronics output. And with these nations as indicators, the outlook is favorable.

West Germany. If the crisis involving the mark and the franc did nothing else, it confirmed that the dominant economy in Western Europe is West Germany's. While financial specialists fretted, the mark grew steadily stronger, attracting speculators' francs in anticipation of a revaluation of the mark that hasn't materialized. Instead the German government has held fast, agreeing to a 4% to 6% indirect revaluation through import-export tax modifications.

Just how did Germany reach its current position of national strength and prosperity? Much of the credit must go to the industrialists who a year ago laid careful plans to pull the economy back from its 1967 doldrums. They anticipated an expanding economy this year and invested heavily in new plant. Much of the money went for equipment aimed at boosting productivity, an investment that was reflected in more demand for instrumentation and industrial electronics gear. Unemployment dropped to virtually zero and a labor shortage sharpened the need for even more automation. The installation of process-control computers alone is expected to jump next year by 25% to 50%.

The prosperous German consumer is expected to continue to spend more on electronics, a trend that began in this year's second quarter. The more optimistic forecasters are predicting sales of 400,000 color tv sets in 1969. And the industry expects to sell another 1.5 million black-and-white sets as well.

Meanwhile, the German post office intends to continue its massive spending for communications gear. During the next year it will evaluate four competitive pulse-code-modulation systems that have been installed in local exchanges.

The rosy outlook in West Germany is reflected by optimism in Holland, Belgium, and Luxembourg —all of whom look to Germany as an important outlet for their electronics wares.

France. While Germany prospers, France hopes to recover from lost opportunities and economic setbacks. Most damaging were last spring's strikes, which cost the country $3 billion in lost output and brought a wave of inflationary wage increases. President de Gaulle has opted for austerity rather than devaluation to protect the faltering franc. To slash the expected deficit, there'll be a cutback in government spending, so that a number of formerly sacrosanct defense projects will be stretched out during 1969. But although the government is holding down its direct expenditures, it will encourage plant expansion and improved productivity through tax incentives. French process-control and industrial electronics firms could profit handsomely.

The wage rises may have slowed the French economy as de Gaulle says they did, but they've also put the French worker in a spending mood. Despite austerity, consumer electronics firms could have a good year.

Britain. The British are generally optimistic about the prospects for the year ahead. The government, through its Industrial Reorganization Corp., has encouraged mergers to create companies that can compete favorably with U.S. electronics firms. In addition, there's a trend to develop those markets in which Britain holds an advantage over its U.S. competition—Russia and Eastern Europe, for instance. Like its German counterpart, the British post office will spend money to enhance its communications system and will evaluate pcm system installed by four firms.

Unfortunately, the British consumer may adopt a more conservative stance next year. Deliveries of items such as color tv sets are expected to slow in the wake of government actions to freeze wages and restrict consumer credit. The Briton who intends to buy will find prices high. Color tv sets average $700 (and most are rented); tape recorders, previously tax free, are now subject to a sales levy of about 20%.

If the bellwether countries are any indication, electronics in Europe should enjoy a profitable year. In the next issue, Electronics will publish a comprehensive country-by-country analysis of Europe's 1969 electronics markets. ▪ ▪

Electronics Newsletter

December 9, 1968

Autonetics unveils all-MOS computer

The D-200 general-purpose avionics computer Autonetics will show at this week's Fall Joint Computer Conference is a mockup of **the first such machine to use only metal oxide semiconductor large-scale integrated arrays in its central processor, control unit, and memory.** MOS has heretofore been limited to a few special-purpose computers.

A breadboard of the Autonetics design is operating now. **The prototype will measure 5 by 6 by 7 inches, and will be ready in March.** It will be suitable for aircraft navigation applications, although officials say it could also handle such other functions as fuel management in jet engines.

The computer, which consumes 10 watts, has been proposed to at least one of the military services. Its central processor has 24 arrays of eight different types, ranging in complexity from 142 MOS field effect transistors to 1,053. The unit has a 108-microsecond multiply time, a 112-μsec divide time, and a 4-μsec memory cycle. Most other instructions take 8 μsec. A 1-μsec memory cycle time is in the offing when the present 250-kilohertz clock rate is boosted to 1 megahertz.

Electronics makers woo phone concerns

Electronics firms, especially those producing communications gear and semiconductors, **have flocked to the annual meeting of the Independent Telephone Association in Miami this week.** The reason: with the Carterphone decision opening the way for independent firms to produce phone equipment, **electronics companies are eagerly wooing their potential customers.** Currently, most phone gear is produced by the Bell System's Western Electric Co. or its licensees.

One-tube tv camera for medicine draws military attention

A one-tube color tv camera developed for the medical market is being considered by the Navy and Air Force for reconnaissance and remote-control operations. Military experience with color tv systems has been none too good, but **the two services want to take a look at the CBS Laboratories' camera because it weighs only 12 pounds and is considerably less complex than three-tube units.** And while the conventional cameras require a high ambient light level, the CBS camera uses a secondary electron conduction vidicon that **can record pictures at levels as low as starlight.**

The tube, operating with a synchronous color filter wheel, utilizes the field sequential video principle developed years ago. In reconnaissance applications, camouflaged or man-made objects could be easily detected if the primary-color filters were replaced by those of other colors.

A prototype of the medical system is now being field tested at the Army's Fitzsimmons Hospital in Denver. CBS plans to market the unit next spring for $15,000.

CBS presses EVR on tv set producers

For the past several months, executives have been trying to get television set producers around the country to design CBS's electronic video recording (EVR) units into their receivers [Electronics, Sept. 4, 1967, p. 25]. Most of the set makers confirm that talks have been held, but they decline to say whether any accords have been reached. **It's understood, however, that at least one U.S. set producer has already agreed to build**

←Circle 32 on reader service card

the CBS equipment into some of its sets. It's estimated that EVR would add $120 or less to the price of a receiver. CBS marketing plans are to be disclosed this week in New York.

Technical details of EVR haven't yet been disclosed by CBS, but this much is known: the system will be able to play back up to an hour of black-and-white programing directly on the set, and the recording film will fit into a small cartridge that's plugged into the set.

The current EVR design is limited to black-and-white pictures, **but CBS is understood to be working on a color system.**

Government may make Navy's Cains an in-house project

Industry reports indicate that the Navy hasn't come up with sufficient funds to have a contractor build its Carrier Aircraft Inertial Navigation System (Cains), a ship-borne unit that would quickly align, via radio link, the inertial systems of carrier-based planes using the ship's inertial navigation system [Electronics, Oct. 30, 1967, p. 44]. **One source says the system could wind up being furnished by the Government itself by modifying existing equipment.**

Specs for the fast-reaction system have been sent to potential builders of both the VSX antisubmarine-warfare aircraft and the VFX fleet defense fighter to serve as a guide to navigation requirements. For the VSX, the fast-alignment inertial system is clearly labeled an industry-furnished item. For the VFX, Cains was originally spelled out as Government-furnished, but an amendment to that specification calls for an alternative bid from industry.

"It's still up in the air," says one observer, who believes that if industry is called upon to build the Cains equipment, **the leading contenders will be AC Electronics, General Precision, and Litton Industries.** Eight firms answered the Navy's request for proposals for six prototypes [Electronics, Sept. 30, p. 63].

DuBridge will back more science funding

Lee A. DuBridge, who is retiring as president of California Institute of Technology to become Nixon's science adviser, **will probably push for increased Federal funding of scientific research, particularly at universities.** He can also be expected to oppose any moves to combine civilian and military space efforts. His attitude towards an expansion of the antiballistic-missile program isn't known, but there's some speculation that he may oppose it on scientific grounds.

Addenda

Control Data's new giant computer, the 7600, is expected to cost about $5 million (for details, see page 45). However, a source at Lawrence Radiation Labs says that facility is buying two machines for about $3.8 million each. . . . **Two impending airline decisions are being eagerly awaited by AC Electronics and Litton, who both have commercial inertial navigation systems.** United Air Lines is expected to decide early next year—probably in March—whether it will retrofit the stretched-out DC-8's on its Hawaiian run. And Eastern Airlines is also considering a retrofit for its big jets, according to industry sources. United would want its DC-8 systems by June. . . . **Indiana General is about to start selling quantities of plated wire for computer memories.** Currently, firms producing plated-wire memories—including Univac, Honeywell, and Electronic Memories [Electronics, Oct. 14, p. 216]—have to make the wire themselves.

Circle 35 on reader service card→

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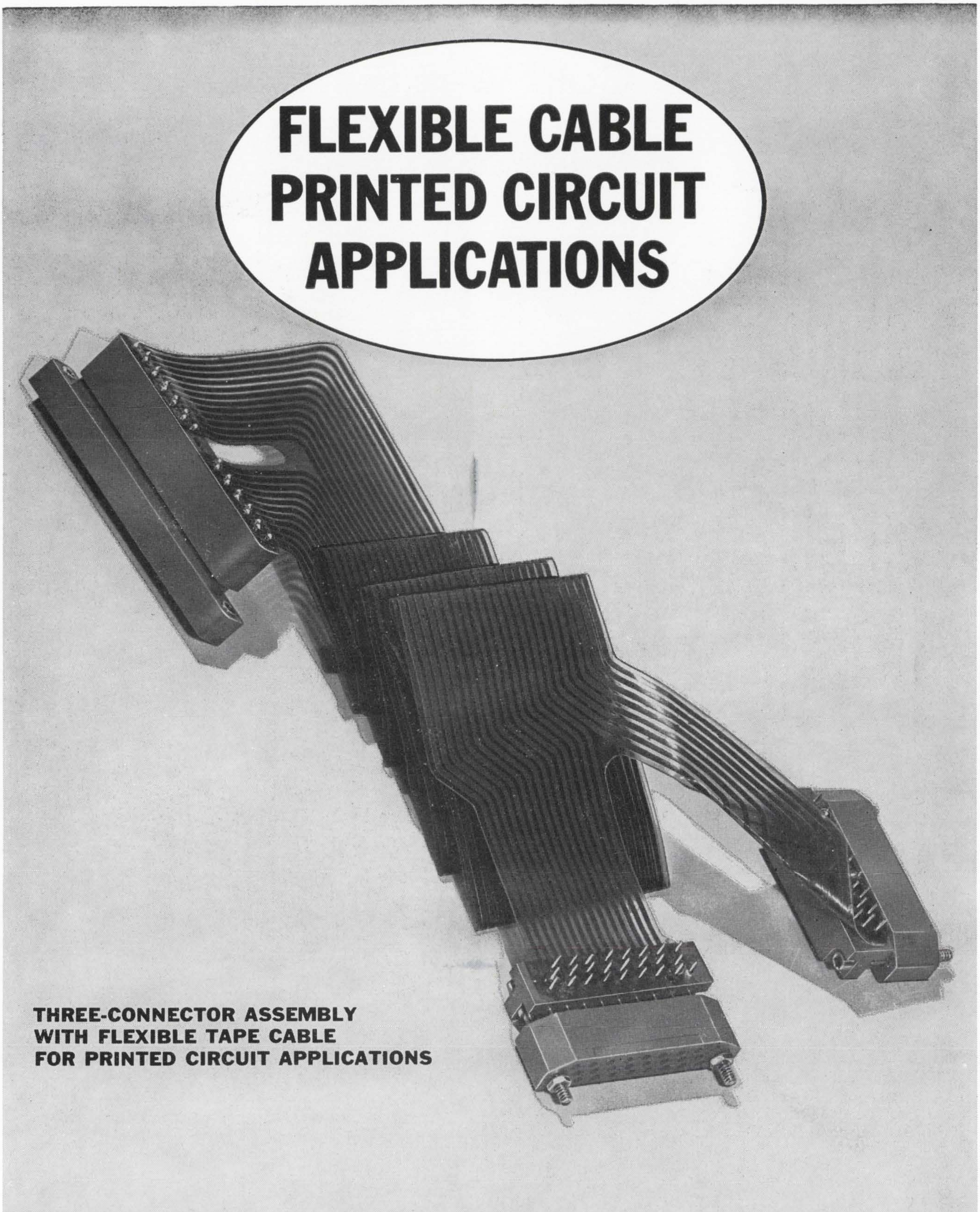
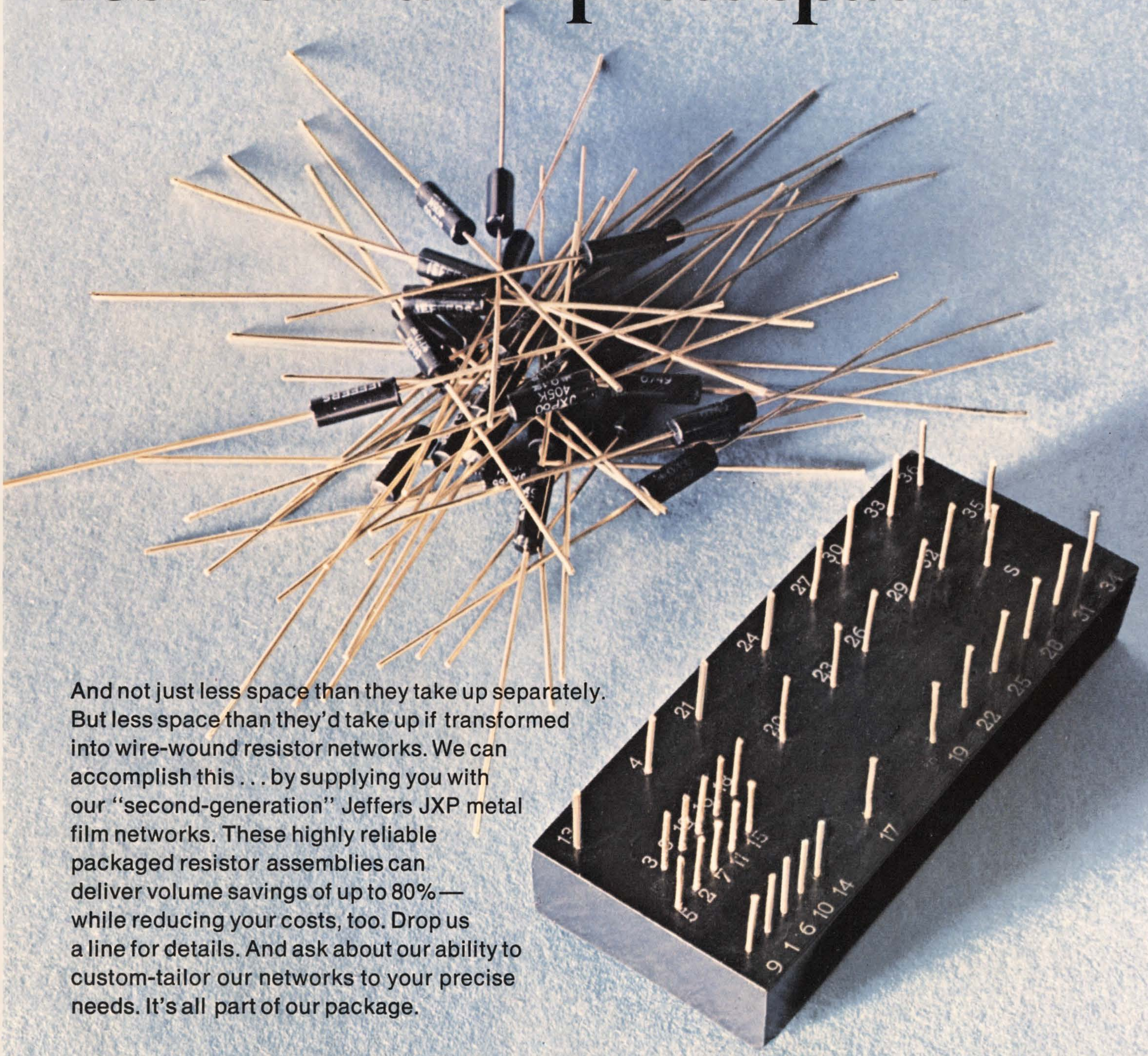


Circle 37 on reader service card→

Who can make your precision resistors take up less space?



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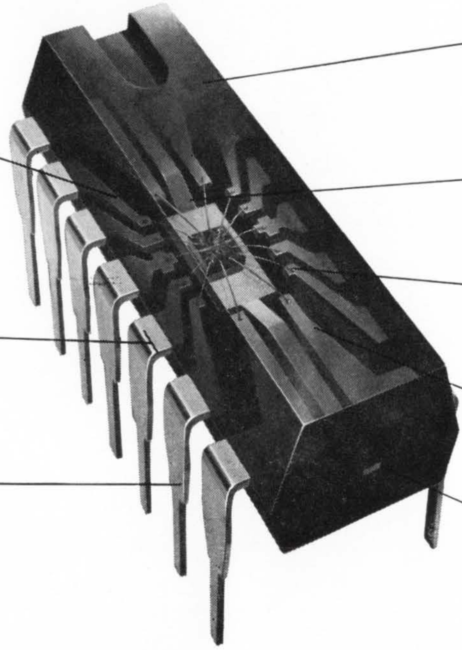

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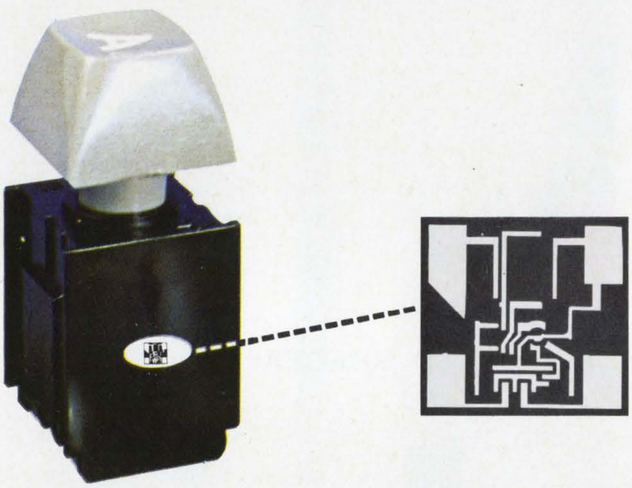

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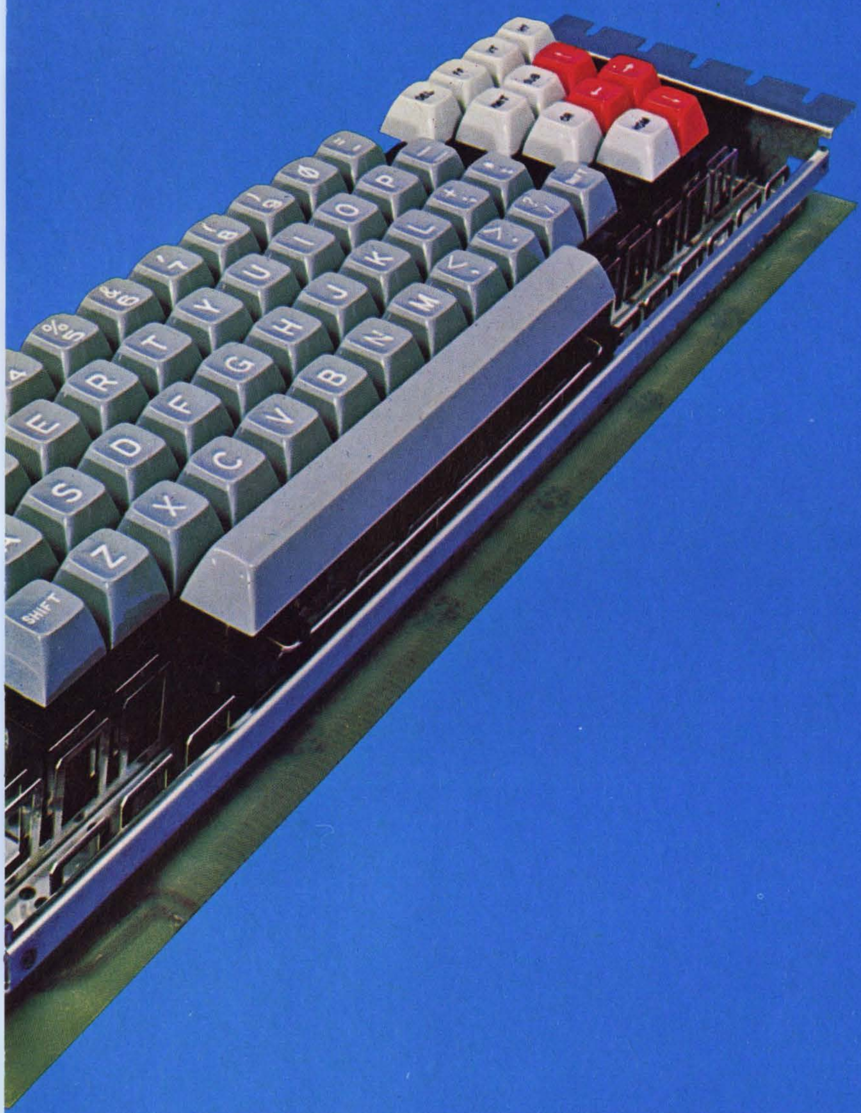

Circle 42 on reader service card

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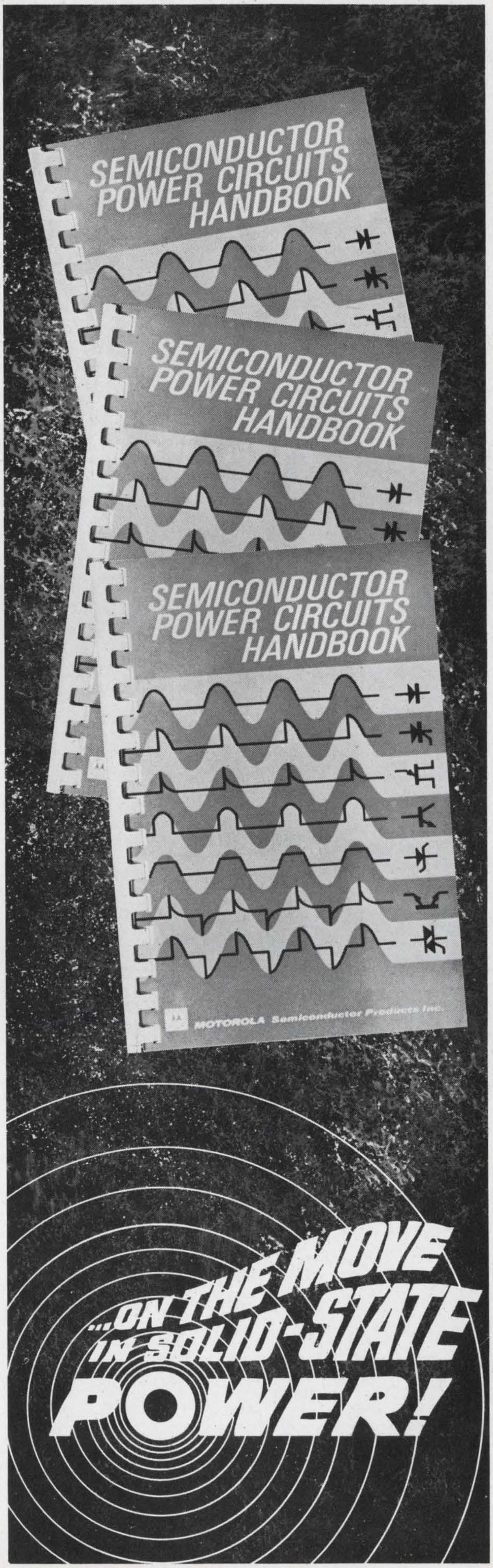


Electronics Review

Volume 41
Number 25

Computers

Walk-in model

Not since 1951, when Univac 1 was built, has anyone designed a computer big enough for a man to walk into. Univac's 1's performance is far surpassed today by a small unit sitting on a desk top, but its shape has been resurrected by the Control Data Corp., which bills itself as the builder of the world's largest computers. The new machine [Electronics, Sept. 30, p. 34], the CDC 7600, exceeds the performance of even the biggest machines previously built by the company.

The most important hardware features in the new machine are the small core memory that serves as a buffer between the large main memory and the processor, the maintenance control unit, and discrete circuits. The small core memory consists of 32 banks of 2,048 words each. Each bank—a conventional 3-dimensional, 4-wire unit—can cycle in 275 nanoseconds, storing or fetching one 60-bit word in that time.

The banks are capable of 10-way overlapping; in other words, independent cycles can be initiated in each one at 27.5-nsec cycle time. This 27.5-nsec interval matches the cycle time of the circuits in the machine.

Simple arithmetic. Even so, its 275-nsec cycle is fast for a core memory—especially a coincident-current unit. Control Data uses hand-wired arrays of 16-mil toroidal cores—instead of today's standard 20- to 22-mil cores—in the small memory because they can switch faster. The memory banks also dissipate quite a lot of power for their size—exact figures aren't yet available—suggesting that the cores may be made of a new type of ferrite material that requires more wallop to switch. It's understood that the cores are also only partially switched—a high-speed technique that switches only the material around the hole, instead of the entire core. Noise problems usually preclude partial switching in 3-D arrays, but a new material or an unusual sense winding pattern could reduce these problems to a manageable level.

Big and small. Control Data's new computer, the 7600, is big enough for a man to step inside. And it uses tiny (16-mil) hand-wired arrays of toroidal cores in its memory. Despite its use of cores, the machine has a 275-nsec cycle speed.

The main memory contains eight banks of 65,536 words each and operates at 1.76 microseconds. Words, usually instructions, can be individually fetched from the large memory for use in the central processor, or large blocks, usually data, can be transferred into the small memory.

The 7600's central processor contains nine independent arithmetic units, each for a narrowly restricted class of operations and therefore relatively simple in design. These nine units, being separate, can operate in parallel, thus speeding up the system's throughput. A similar approach was used in the CDC 6600, announced in 1964.

Connected to the central processor are a number of peripheral processing units, which control input-output equipment. Each peripheral processor has a self-contained memory of 4,096 words of 12 bits each and eight data channels for connecting input-output devices—either local or remote—or additional peripheral processors. This approach permits an indefinitely large number of input-output units to be connected to a given central processor; the penalty is only in the number of times data has to be transferred from memory to memory through a string of peripheral processors.

Unique unit. The 7600 is the first computer with a maintenance control unit. This is a specialized processor that monitors the other components of the system without interfering with the system's performance and permits engineers to diagnose and exercise some components of the system off-line while other components continue running normally. To the system, the maintenance control unit has the same characteristics as a peripheral processor. The maintenance and diagnostic hardware that is sometimes distributed throughout other systems is pulled together into a single unit in the 7600.

Strange as it may seem, the 7600 attains its extraordinary level of performance even with discrete components. Cordwood packaging of the components achieves the extreme packing density that the machine's high speed requires, while still retaining what CDC designers feel is the reliability that integrated circuits haven't quite achieved yet.

And stranger still, Control Data won't disclose the price of its new machine. It was formally introduced last week, and at that time the company declined to say why it kept the price secret. But it is known that the first machine is to be delivered in January to the Lawrence Radiation Labs.

Space electronics

Drawn to magnetics

Researchers at the Ampex Corp. in Redwood City, Calif., under a NASA contract, have revived the dream of attaining completely reliable, low-power magnetic logic structures.

Ampex has produced a multistage logic structure that can be wired to an identical structure to act as a four-stage shift register or an eight-stage ring counter. The key to the company's work is a proprietary process that permits the fusion of two ferrite materials.

Magnetic logic circuits can resume operation after a power shutdown without starting a job over. This minimizes power requirements, since circuits need not be kept on to preserve logic states, and maximizes reliability. NASA thus viewed such circuits as especially suited to three- to five-year space shots.

Uncompetitive. Herbert Heckler Jr., Ampex materials-devices section engineer, notes that industry interest in magnetic logic peaked in the 1950's, diminishing with the advent of the transistor and almost dying after the development of fast integrated circuits, which magnetic logic could never compete with.

Magnetic-logic speed reaches its maximum at 100-kilohertz clock rates. However, for specialized functions, such as long space shots, where reliability and power rather than size and speed are prime considerations, magnetic logic may be the solution, the engineers believe.

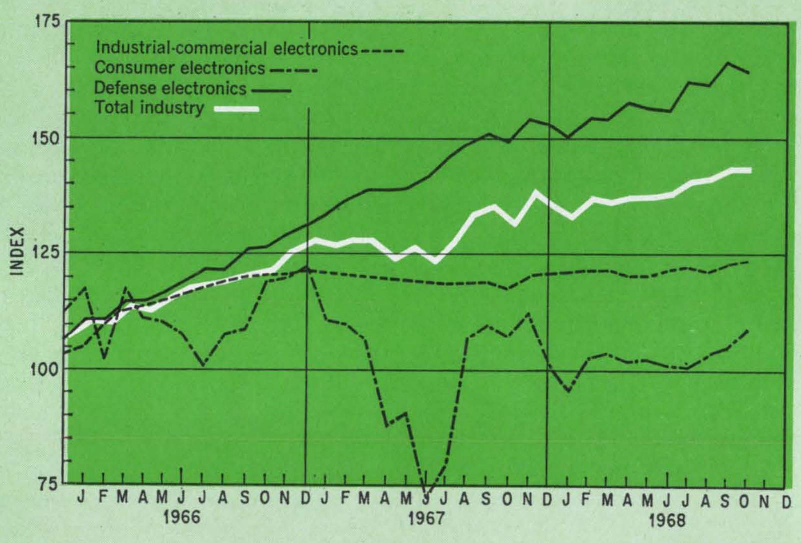
The real stumbling block to developing magnetic logic structures, says Heckler, was that most work has been done with ferrite materials developed for magnetic core memories, and most magnetic structures have used only one ferrite material. The ideal device, he adds, would have different coercive forces for various magnetic paths so that the magnetomotive force ratio would be equal to the product of the ratio of path lengths and the ratio of coercive forces.

Cut into sheets. The addition of regions of high coercive force would allow high ratios of magnetomotive force for a structure of a given size. The ratios of magnetomotive force are vital in obtaining controlled switching of specific amounts of flux around the various paths—the fundamental consideration for the procession of binary logic states through the circuit. Two flux conditions are equivalent to binary 1 and binary 0.

The Ampex logic structures are formed, basically, of magnesium-manganese and cadmium-magnesium-manganese, each of which is "doctor-bladed" into small sheets; after drying, each material is punched into specific shapes, which are then compression-bonded in patterns that determine the relative placement of low and high coercive

Electronics Index of Activity

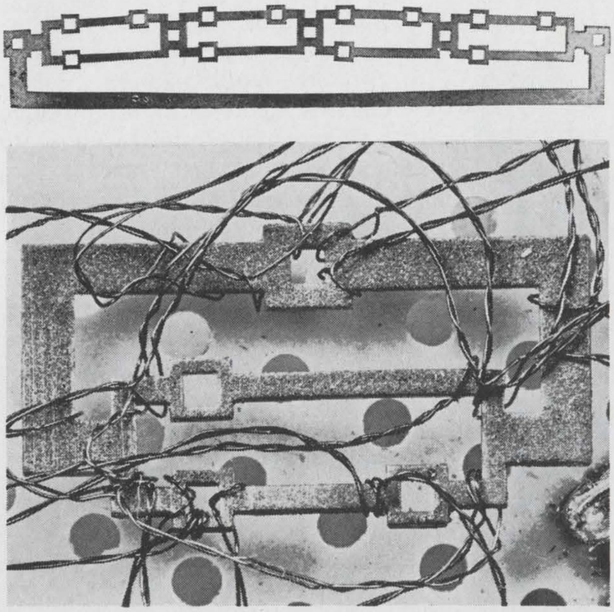
December 9, 1968



	Oct. 1968	Sept. 1968*	Oct. 1967
Consumer electronics	109.8	105.3	107.3
Defense electronics	1164.5	166.1	149.4
Industrial-commercial electronics	123.9	122.9	116.7
TOTAL INDUSTRY	143.3	143.1	132.7

Electronics production edged up 0.2 point in October from September but was up 10.6 points from October 1967. The consumer electronics index climbed 4.5 points in the month and 2.5 points in the year, while industrial electronics output rose 1 point in the month and 7.2 points in the year. Defense electronics slipped 1.6 points from the previous month but was still 15.1 points above the year-earlier level.

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



Magnetic logic. Four-stage logic structure (top) is building block of magnetic memory being developed for NASA. Lower photo shows how structure is wound.

force regions. This final structure is then sintered at high temperature, typically 1,300°C, to make the ferrite denser and develop the desired magnetic properties.

The present multistage structure, which is about 2½ inches long, offers the possibility of mass production, and such techniques are now being developed at Ampex. Efforts to halve the size of the structure without altering the circuit parameters are also under way.

Industrial electronics

One-tube color camera

A sizable share of the educational, industrial, and cable-television markets eludes color tv because the cameras and associated equipment cost too much. And camera makers haven't been able to lower their prices much because they've had to use three pickup tubes, one for each primary color.

Last month, however, RCA introduced a single-tube color camera that considerably enhances the outlook for those markets. Priced between $6,500 and $10,000, the camera systems cost from a third to a half less than competitive cameras.

Resolution of the new color systems is about 200 lines, adequate for most educational purposes but far short of the 525-line broadcast quality. RCA engineers think higher-resolution systems may be developed within five years, however. This would probably also reduce prices of broadcast-quality equipment. To improve resolution for broadcast quality, RCA could take a number of approaches, among them bigger vidicon tubes or different tubes altogether.

Primary principle. In developing the one-tube color camera, RCA focused on a principle developed in the 1950's but then discarded. Nobody worked on it because the electronics—considering the state-of-the-art at that time—was unwieldy. The idea was resurrected a few years ago, when semiconductor technology seemed to permit an inexpensive, compact design.

Since primary colors leave a signature even on black-and-white patterns, RCA's Commercial Electronics Systems division began working on methods to extract the values of two of the primary colors from a black-and-white picture. By subtracting the known two, the third can be derived.

They devised a basic design whereby dichroic optical filters in a sandwich configuration identify the red and blue before the light reaches the vidicon. The red-blue-green image is then carried whole to the tube, where it is converted

Two down. RCA's new color television camera has one pickup tube instead of the conventional three.

into electrical signals.

These signals go from the camera to a control console in which a proprietary arrangement of integrated circuits and discrete transistors on a 5-by-12 inch printed-circuit board identifies the primaries and enhances them. Standard colorplexing techniques fuse them into NTSC color signals. One control console can handle three cameras.

The beauty of the system is that "it's basically a standard black-and-white camera," says Henry Ball, chief engineer. "The tube doesn't see color. All it sees are black and white values." Also, the basic image is never taken apart, he explains, so there are no registration problems of bringing together three pictures as there are with three-tube cameras. This is the chief cost-cutting factor.

Fewer controls. Another is the use of an ordinary $130 1-inch 8507A vidicon. Since the average user will be a nontechnical person, RCA was able to eliminate many of the fine adjustment controls a studio technician would require. The color filters automatically set the color values, for example.

The studio camera, with viewfinder, costs $9,850. It's 10 inches high, 11 inches wide, and about 25 inches long, and it weighs about 45 pounds. A camera without viewfinder for static uses will cost $6,500, and a complete tv color-film system will go for the same price as the studio camera.

Once it knew it could produce the system, RCA quickly chose to announce it at last month's National Association of Educational Broadcasters convention in Washington, the first convenient showcase. It seems Japanese companies have also been experimenting with single-tube color tv. "We don't know what they're going to do," says one RCA executive. "So we decided to announce first and get as many orders as we can."

Instrumentation

Energetic identification

Two researchers at Varian Associates have applied a technique used for studying radioactive decay to the analysis of chemical compounds, and in doing so have developed a new type of spectrometer. Varian says the unit, called an induced electron emission spectrometer, is 10 times more sensitive than present analytical instruments, and will complement or supplant infrared, ultraviolet, X-ray emission, mass, and nuclear magnetic resonance spectrometers.

The new technique uses low-energy X-rays to knock electrons loose from the inner shells of the atoms in the compound. The energy required to shake the electrons free depends on the element and is determined by sending the electrons through an electrostatic field, where they're dispersed according to their energy levels. They then enter a detector slit and pass through a 15-stage dynode that multiplies the number of electrons 100,000 to 1 million times.

Taking the pulse. Which electrons are entering the detector slit is determined by sweeping the strength of the electrostatic field. In addition, the electron multiplier produces a series of electrical pulses, which, when counted, indicate the number of electrons knocked loose at each energy level, and hence the amount of each ele-

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ment that is present.

John Helmer and Norbert Weichert, the developers of the new spectrometer, report that binding energy varies with an element's structural environment, so that carbon in a methyl group exhibits a slightly different binding energy than carbon in a carboxyl group. Identification and measurement of these chemical shifts will provide a new body of chemical information.

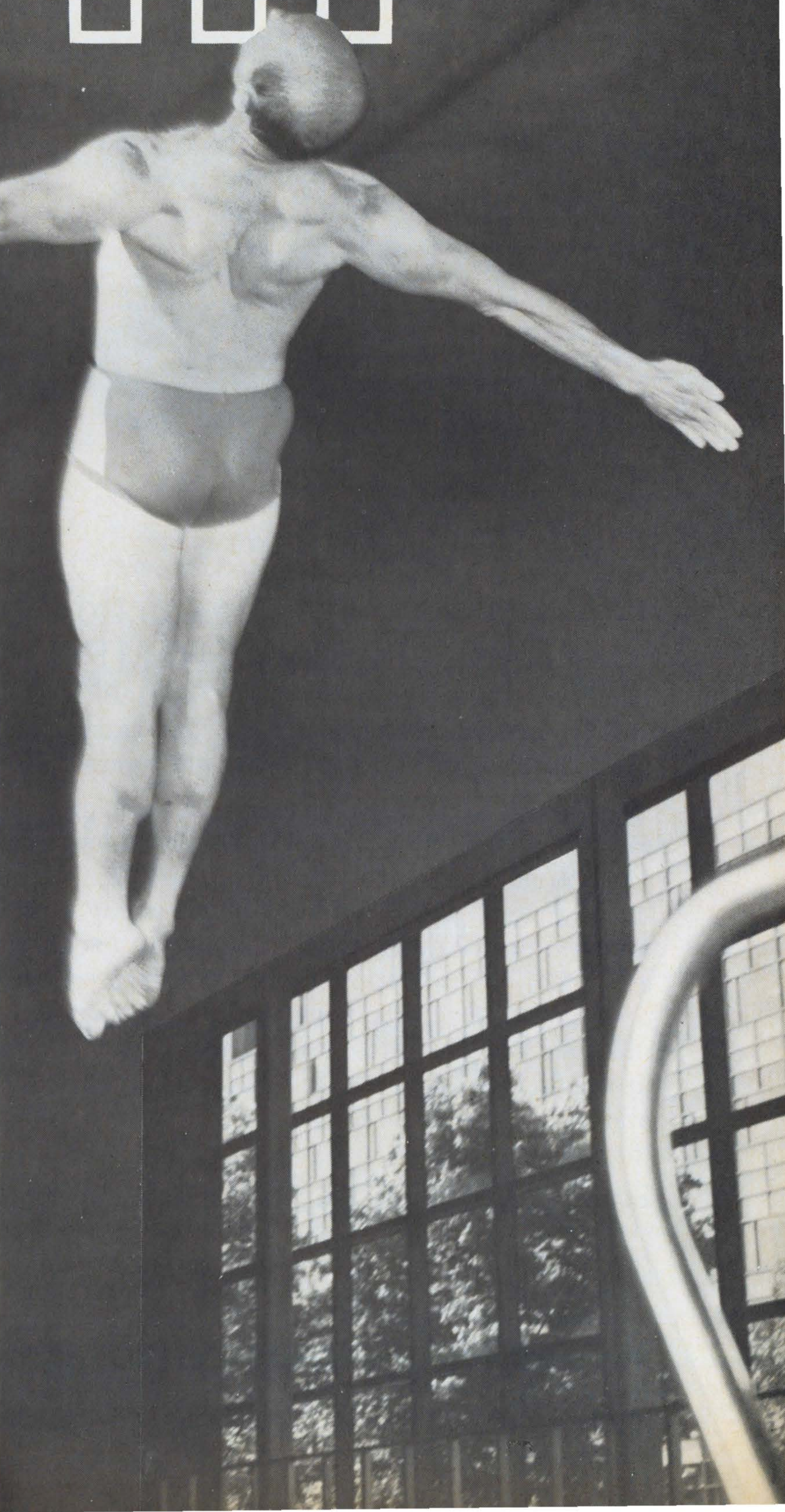
Induced electron emission was pioneered by Kai Siegbahn, a professor at the University of Uppsala, Sweden. But Siegbahn needed large magnetic fields to detect fast electrons; he had to use huge coils to create a magnetic field equal and opposite to the earth's to prevent magnetic perturbations. The equipment was housed in a nonmagnetic building containing no steel. Similar gear built at other universities requires several rooms full of equipment.

Siegbahn used magnetic fields because he couldn't get electrostatic fields of sufficient energy in a vacuum to operate with fast particles. But high energy isn't a requirement for spectroscopy, and so Weichert and Helmer were able to design an electrostatic analyzer and shield it in a double-walled Mu-metal cylinder only 4 feet tall and a foot in diameter. And this has enabled Varian to produce a desk-size instrument.

The spectrometer accepts samples in their natural form—solid, liquid, or gas. When the chamber has been evacuated to a pressure of 1×10^{-7} torr, the sample is bombarded with soft X-rays at an energy level of 1,500 electron-volts. The electronic energies are resolved to 0.1 ev, or one part in 10,000.

In-house rivals. Announcement of the spectrometer was made last month at the Pacific Conference on Chemistry and Spectroscopy in San Francisco, and Varian plans to start selling the instrument in mid-1969 at a price of $60,000. Once on the market, it will compete with Varian's own mass and nuclear magnetic resonance spectrometers, but the company figures it's time to act on the new technology. "In the first place, the technology will need acceptance in the marketplace,"

winning form



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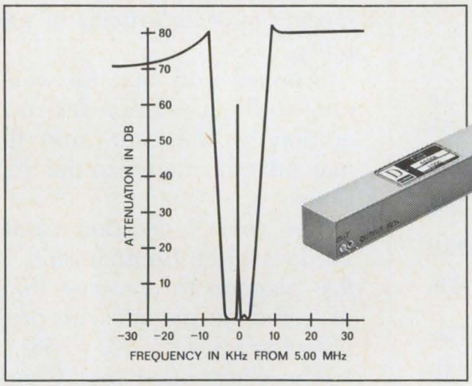

When it comes to rejecting clutter in a Doppler radar system, or the carrier in a suppressed-carrier communications system, the **Damon Model 5200A Bandpass-Notch Filter** gives you a double edge. It provides at least 50 db of clutter or carrier rejection — plus crystal bandpass filtering to eliminate unwanted sidebands.

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DAMON

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says Jerome Holcomb of the Analytical Instruments division. "In the second place, we have a strong feeling that we're not the only instrument company that's been working on it."

Patents

Upsetting decision

The Patent Office, which ruled in October that computer programs aren't patentable, was reversed last month when the Court of Customs and Patent Appeals overturned an examiner's ruling that prohibited a patent for a device using a program.

The Patent Office, however, hasn't conceded defeat. Patent Commissioner Edward J. Brenner said he interprets the decision as meaning that programs are patentable subject matter and that patents should be granted if the software meets the other criteria of patentability.

Brenner said that he was planning to file a petition for reconsideration by the court and that he may take the matter to the Supreme Court.

The court's decision came only 29 days after Brenner said his office planned to continue its policy of refusing patents on programs [Electronics, Oct. 28, p. 58].

The court ruled that Charles D. Prater and James Wei of Mobil Oil's computer center in Princeton, N.J., were entitled to a patent on a device used for spectrographic analysis of gases. The device requires an analog computer and its associated software.

Wait a minute. Two days before the court announced its decision Brenner petitioned the court for a delay, saying the appeal "involves broad fundamental questions of whether certain process claims fall within the statutory definition of a process."

Brenner further warned the court that "important legal issues are involved, which may affect the business community active in a new field of technology." He said the decision "will undoubtedly be


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treated as a precedent for a number of other appeals" currently before the court involving the same or similar issues.

Components

Reluctant inductance

It's not often that an R&D contract is the result of a chance meeting between two men. But that's just what happened with Philip R. Geffe, a Westinghouse research engineer, and Charles E. Holland, a senior engineer in the Naval Electronics Systems Command.

Holland has been convinced that integrated-circuit gyrators promise a breakthrough in achieving inexpensive, versatile filters for communications networks and systems. This would include teletypewriters, sonar filter banks, and extremely-low and very-low frequency receivers.

However, there just aren't any such inexpensive off-the-shelf filters because semiconductor manufacturers, uncertain of the market, haven't invested in their development.

It turned out that while Holland was considering a gyrator contract, Geffe was tinkering with the gyrator problem during his work on active filters for Westinghouse. He had even built a few rough ones on his own but couldn't get any in-house money to pursue the problem.

Small stuff. One result of the chance meeting, then, was that—to spur commercial interest—the command awarded Westinghouse's Defense & Space Center a small (a little more than $100,000) 18-month contract to develop a monolithic IC gyrator [Electronics, Oct. 28, p. 69]. Of course, the development could eventually give all the services cheap, small, mass-produced filters.

Filters are the largest subassemblies in communications equipment because they use bulky and expensive inductors. IC gyrators would lead to filters 100 times smaller than present ones. But this

You can't tell from this picture that these are the only monolithic fused-in-glass JAN TX type 1N4942 fast recovery controlled avalanche rectifiers in the business.

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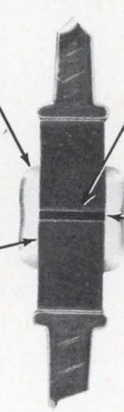

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is far from the only reason the Navy is looking at such components. Since a gyrator with a capacitor acts like an inductor, a designer can connect a communications circuit with his present knowledge of inductors. With other approaches to active filters, such as amplifiers, the designer would have to learn a new technology. What's more, IC gyrators mounted on printed-circuit boards could also lead to modular equipment assembly, making maintenance much easier. And large-scale integration promises further benefits.

Other devices. Although the Navy sees the contract as the start of an "evolutionary type of development which will eventually evolve into a wide range of devices," according to Holland, it also wants Westinghouse to devise filters that can be readily made mass produced.

The Navy also wants high Q and stability. "We would like to have the maximum possible Q of thousands," Holland says. "We'll probably get 400," Holland adds, and it seems he would be happy with that.

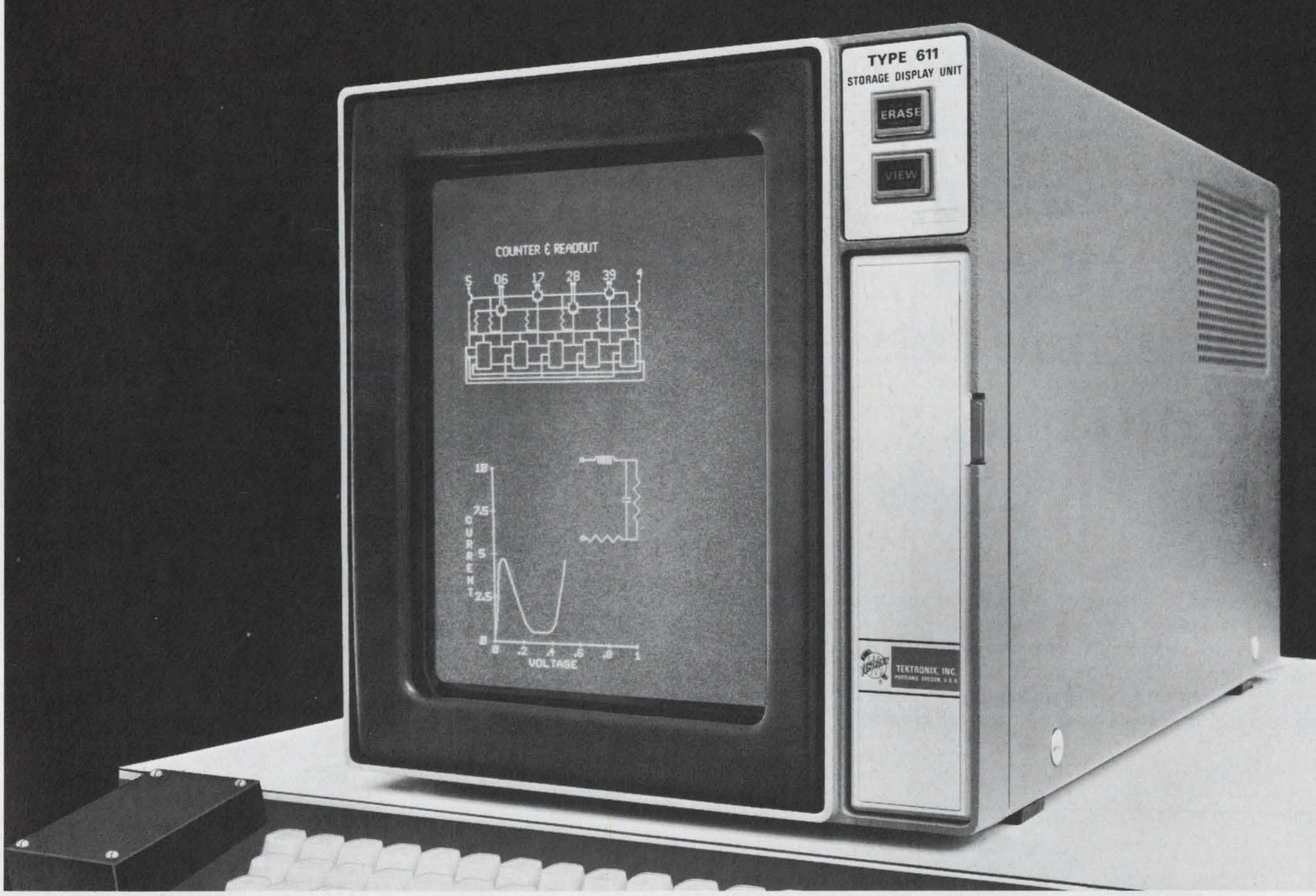
For the record

Top man. The IEEE has elected F. Karl Willenbrock president for 1969. Willenbrock, a provost at the State University of New York, succeeds Seymour Herwald.

Light music. Hughes Aircraft has been awarded a $12 million contract by McDonnell Douglas to develop a multiplexed entertainment system that will eliminate 400 pounds of wiring from the DC-10 airliner [Electronics, June 10, p. 25].

Purchase. The Data Automation Co., a computer service firm, has bought a 45% interest in the Carterphone Communications Corp. of Dallas. Carterphone successfully challenged AT&T's ban on attaching customer-owned equipment to phone lines [Electronics, Sept. 16, p. 55].

Flicker-Free CRT Storage



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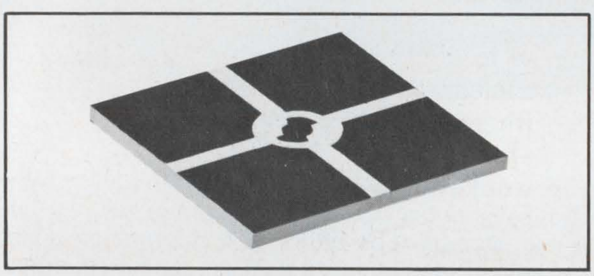
MICROWAVE IC
PROGRESS
REPORT #5

PACT proves microstrip is compatible for MIC mixers, filters, hybrids

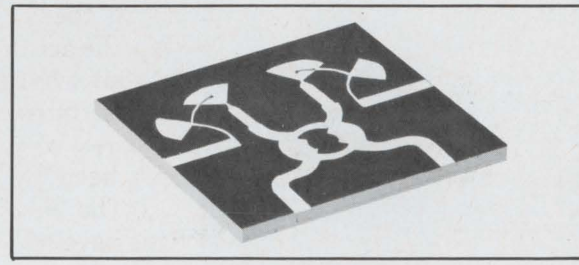
Before microwave integrated circuits can become a reality this important question must be answered — can present stripline technology be converted to microstrip without a prohibitive performance penalty? Engineers and scientists engaged in Sperry's PACT (Progress in Advanced Component Technology) Program have found the answer, and the answer is yes!



TWO-BRANCH MICROSTRIP 3 DB COUPLER

PACT investigations have already produced couplers, balanced mixers and a number of hybrid circuits, all utilizing the basic microstrip technology. Performance penalties have been negligible, and all indicators point to production availability of entire subsystems deposited on a single substrate.

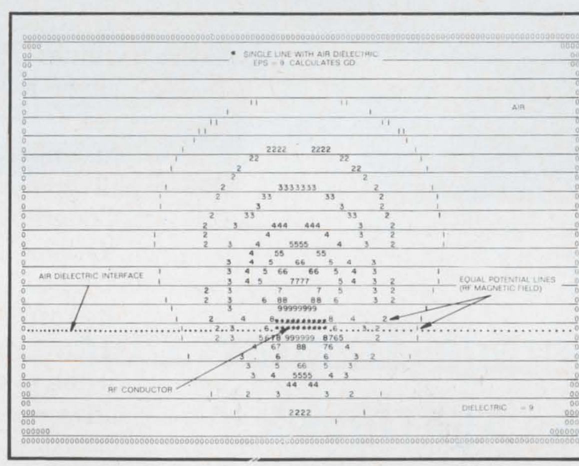
Like other PACT activities, this effort has depended heavily on the proper selection of materials. For multi-function substrates, such as those capable of carrying entire subsystems, Sperry's choice is a composite of ferrimagnetic and alumina substrates. In some cases all-ferrimagnetic substrates are recommended.



MICROSTRIP BALANCED MIXER CIRCUIT

This approach provides maximum size, weight and cost savings, along with significant increases in thermal and mechanical stability.

PACT has also benefited from the use of the computer as a design aid. For example, the computer was programmed to calculate the electrostatic potentials around a microstrip circuit and determine its impedance. Options were then added to the program to obtain a print-out of actual potentials around the microstrip and to plot equal potential lines.



COMPUTER PLOT OF EQUAL-POTENTIAL SURFACES (RF MAGNETIC FIELD) AROUND MICROSTRIP LINE WITH $\varepsilon' = 9$

The result is optimum configuration for microstrip circuits prior to their fabrication.

To learn more about Sperry progress in design and fabrication of multi-function MICs for your applications, ask your Cain & Co. representative or write Sperry Microwave Electronics Division, Sperry Rand Corporation, Clearwater, Florida.

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Washington Newsletter

December 9, 1968

House unit says agencies withhold data despite law

A freer flow of information from Government agencies in such areas as procurement—details on contractor evaluations and unclassified bids, for example—was expected to result from the Freedom of Information Act. **But this isn't happening,** according to the House subcommittee on foreign operations and Government information. It's finding that many agencies, including the armed forces and intelligence gathering groups, aren't obeying the act. **The subcommittee plans to schedule hearings next spring to find out why and force compliance with the law,** which has been on the books since July 1967.

One area of concern to the subcommittee staff: the armed forces haven't been making contractor evaluation reports available to the public. The Army is currently revising its procedures, but the other services have not yet done anything to alleviate the situation. Something else irritating the subcommittee is that the armed services are still using procurement rules that the panel says are inconsistent with the law. For example, **information on unclassified bids has been repeatedly withheld.**

Post Office alliance with Western Union will be recommended

The Post Office may eventually get involved in facsimile mail transmission—conceivably in partnership with Western Union—if a proposal by the President's Task Force on Telecommunications is adopted. The task force, which is still applying final touches to its report, will recommend that a deal be worked out to allow Western Union to use Post Office facilities and personnel. For example, special delivery mailmen would deliver telegrams and Western Union would open windows at Post Offices.

Western Union would also like to offer a new cooperative service it calls "mail gram"—an overnight telegram delivered with the morning mail. **If Congress goes along with such a service, the next step could easily be facsimile mail services—handled jointly by the Post Office and Western Union.** This obviously would open up a large market for such equipment. Post Office researchers have long followed facsimile developments but have hesitated to recommend their use by the Post Office because of the many legal and political objections that would be raised. A cooperative effort with Western Union might sidestep these hurdles.

LBJ may hand GOP sharply pared budget

President Johnson may be cooking up a hot potato to pass on to the incoming Nixon Administration—**a very tight and balanced Federal budget to be sent to Congress in January.** By chopping the budget requests of Government departments, the present Administration would be leaving it up to the Republicans to restore projects cut in its fiscal 1970 budget.

One Congressman who sees evidence of this is Rep. Melvin Laird (R., Wis.). After getting a rare glimpse of the budget, which is now going through its final appeals in the Budget Bureau, he reports that the Consumer Protection and Environmental Health Service, for example, is down for only a \$9 million increase from its present \$222.3 million outlay—a rise of less than 5% and not even enough to cover increasing costs due to inflation.

Budget Bureau officials who have been pulling together the 1970 budget see similar patterns elsewhere. William D. Carey, assistant director of the bureau, says R&D is in "a holding pattern that is probably going to last for a while."

Government plans computer-based education system

The Office of Education's research bureau is moving ahead with a computer-based education system that will cost only a projected $12 to $15 per student annually. **The system will do administrative work and teach students how to work with computers, but will not include computer-aided instruction.** Called Cues (for Computer Utilities for Education Systems), it is an outgrowth of studies performed by IBM and the General Learning Corp. [Electronics, May 29, 1967, p. 59].

Within the next few months, the Office of Education will ask for industry proposals for Cues software and curricula. **The research bureau is currently drawing up specifications for hardware, but it won't ask quotes from computer firms for about a year.** The system will be built around a large time-shared computer.

Though the location hasn't yet been decided, Cues may be installed in the Washington area to serve 200,000 high school and junior college students at 100 schools in a 100-mile radius. **The cost per student is low because there will be only one or two terminals at each school.** These terminals will include moderate-speed card readers and printers. The students, who'll be offline, will either mark or punch cards, which will then be batch processed.

Figures on midair near misses could spur work on CAS

Congress may step up or even expand work on pilot warning indicators and collision avoidance systems (CAS) after it sees the FAA's report on the number of near midair collisions in 1968.

If reports of near misses continue to come in at the present rate, the number of instances rated "hazardous" this year will total at least 1,000, with more than 700 of them in the area of terminals. During January and February—considered "slow" months because flights are frequently grounded by poor weather conditions—**the agency got reports of 436 near misses; of the 186 deemed hazardous, 117 were in terminal areas.**

NASA to ask funds for Mariner-Mars 'soft landers' in '70

NASA has decided to ask for money in its fiscal 1970 budget to build "soft landers" for its two Mariner-Mars 1973 missions. The soft lander would be ejected from the mother craft as it passes Mars, and would be designed to send back data from the Martian surface. **Still undecided, however, is the number and complexity of experiments on the missions.** The space agency would like to have eight, and it is currently fighting with the Budget Bureau to include all of them in its budget. The battle may result in a compromise. One NASA insider says, "We may end up with six experiments or with eight scaled-down ones."

Outlook dimmer for aeronautical services satellite

The proposed vhf aeronautical services satellite, which has always had shaky prospects [Electronics, Oct. 28, p. 33], has suffered another setback. At last month's closed-door meeting of the International Civil Aviation Organization's Astra (for applications of space techniques relative to aviation) panel in Montreal, **foreign delegates refused to discuss, let alone endorse, the U.S. plan for satellite relay of aircraft-to-ground communications.** Though the U.S. didn't expect other members to foot part of the bill, it had hoped for some international support.

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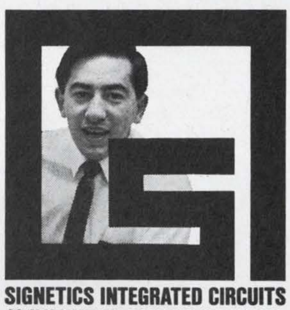

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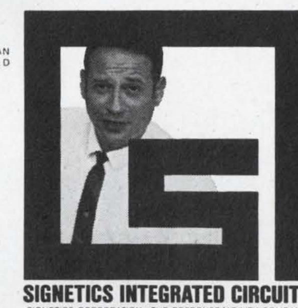

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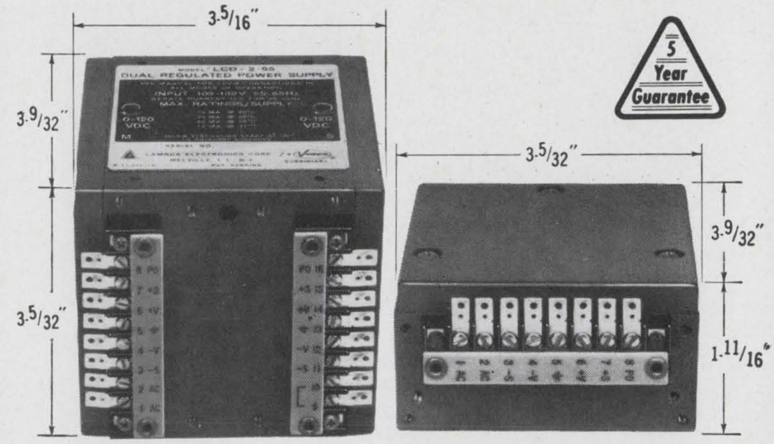

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3 5/32" x 3 9/32" x 3 5/16"

Model	VOLTAGE RANGE (EACH SIDE)	MAXIMUM CURRENT (MA) AT AMBIENT TEMPERATURE (1)				Price (2)
		40°C	50°C	60°C	71°C	
LCD-2-11	0-7 VDC 0-7 VDC	300ma 300ma	240ma 240ma	175ma 175ma	115ma 115ma	$155
LCD-2-12	0-18 VDC 0-7 VDC	160ma 300ma	130ma 240ma	100ma 175ma	65ma 115ma	155
LCD-2-13	0-32 VDC 0-7 VDC	120ma 300ma	95ma 240ma	70ma 175ma	45ma 115ma	155
LCD-2-22	0-18 VDC 0-18 VDC	160ma 160ma	130ma 130ma	100ma 100ma	65ma 65ma	155
LCD-2-23	0-32 VDC 0-18 VDC	120ma 160ma	95ma 130ma	70ma 100ma	45ma 65ma	155
LCD-2-33	0-32 VDC 0-32 VDC	120ma 120ma	95ma 95ma	70ma 70ma	45ma 45ma	155
LCD-2-44	0-60 VDC 0-60 VDC	65ma 65ma	52ma 52ma	37ma 37ma	23ma 23ma	170
LCD-2-55	0-120 VDC 0-120 VDC	30ma 30ma	30ma 30ma	22ma 22ma	14ma 14ma	170

LCS-2 SINGLE OUTPUT MODELS
3 5/32" x 3 9/32" x 3 5/16"

Model	VOLTAGE RANGE	MAXIMUM CURRENT (MA) AT AMBIENT TEMPERATURE (1)				Price (2)
		40°C	50°C	60°C	71°C	
LCS-2-01	0-7 VDC	550ma	455ma	350ma	240ma	$90
LCS-2-02	0-18 VDC	330ma	275ma	210ma	140ma	90
LCS-2-03	0-32 VDC	240ma	205ma	155ma	95ma	90
LCS-2-04	0-60 VDC	145ma	115ma	87ma	57ma	100
LCS-2-05	0-120 VDC	50ma	50ma	45ma	30ma	100

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LCS-1 SINGLE OUTPUT MODELS
3 5/32" x 3 9/32" x 1 11/16"

Model	VOLTAGE RANGE	MAXIMUM CURRENT (MA) AT AMBIENT TEMPERATURE (1)				Price (2)
		40°C	50°C	60°C	71°C	
LCS-1-01	0-7 VDC	200ma	200ma	150ma	100ma	$85
LCS-1-02	0-18 VDC	95ma	95ma	95ma	80ma	85
LCS-1-03	0-32 VDC	65ma	65ma	65ma	40ma	85
LCS-1-04	0-60 VDC	35ma	35ma	35ma	25ma	95
LCS-1-05	0-120 VDC	12ma	12ma	12ma	12ma	95

NOTES:
(1) For operation at other than 57-63 Hz, consult factory for ratings and specifications.
(2) All prices FOB Melville, N. Y. All prices and specifications subject to change without notice.

OVERVOLTAGE PROTECTION

FOR USE WITH	Model	VOLT ADJ. RANGE	Price (2)
LCD-2-11, LCD 2-12, LCD-2-22, LCS-2-01, LCS-2-02, LCS-1-01, LCS-1-02	LC-OV-10	3-24 VDC	$20
LCD-2-13, LCD-2-23, LCD-2-33, LCS-2-03, LCS-1-03,	LC-OV-11	3-47 VDC	20
LCD-2-44, LCS-2-04 LCS-1-04	LC-OV-12	3-70 VDC	25

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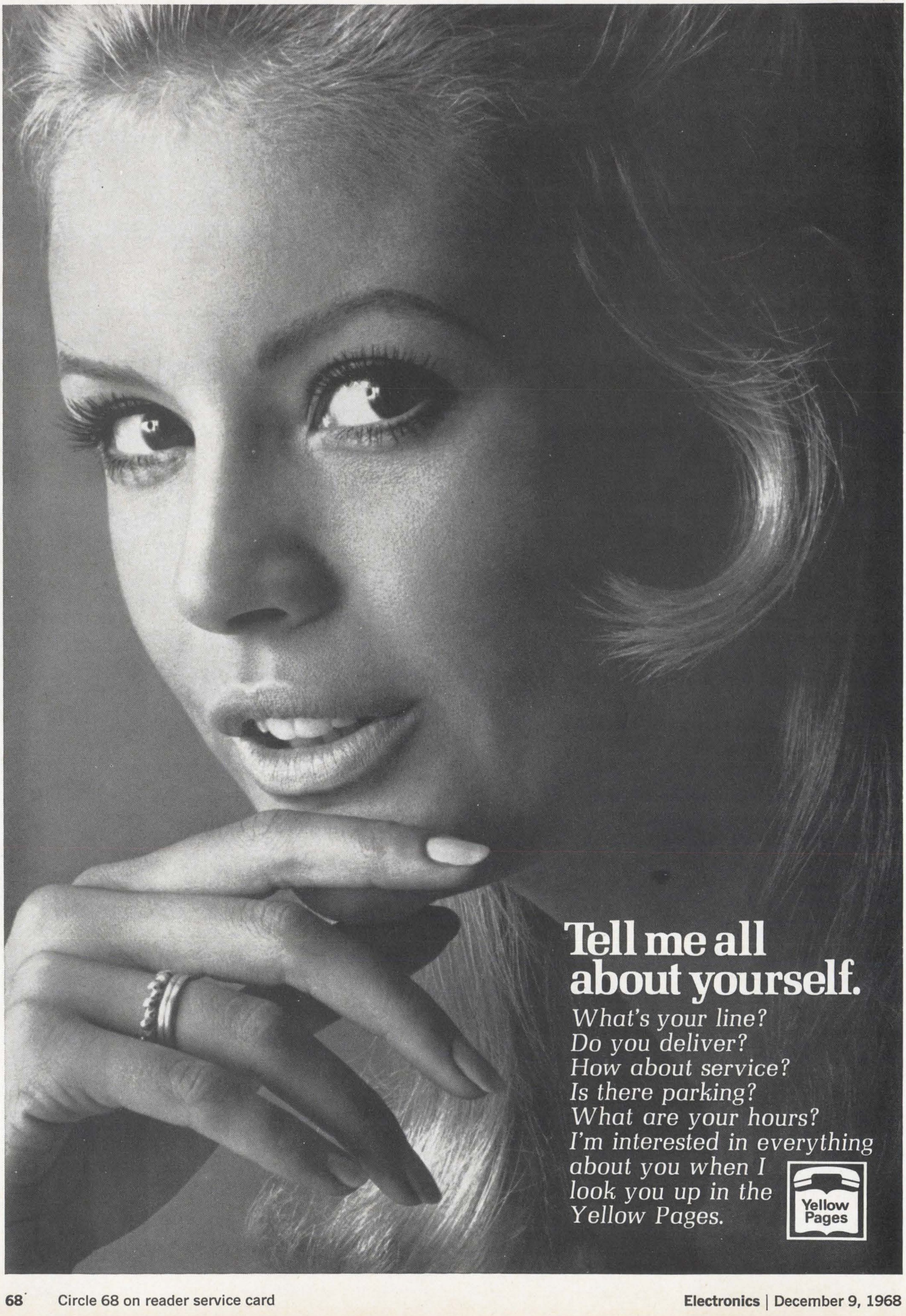
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What's your line?
Do you deliver?
How about service?
Is there parking?
What are your hours?
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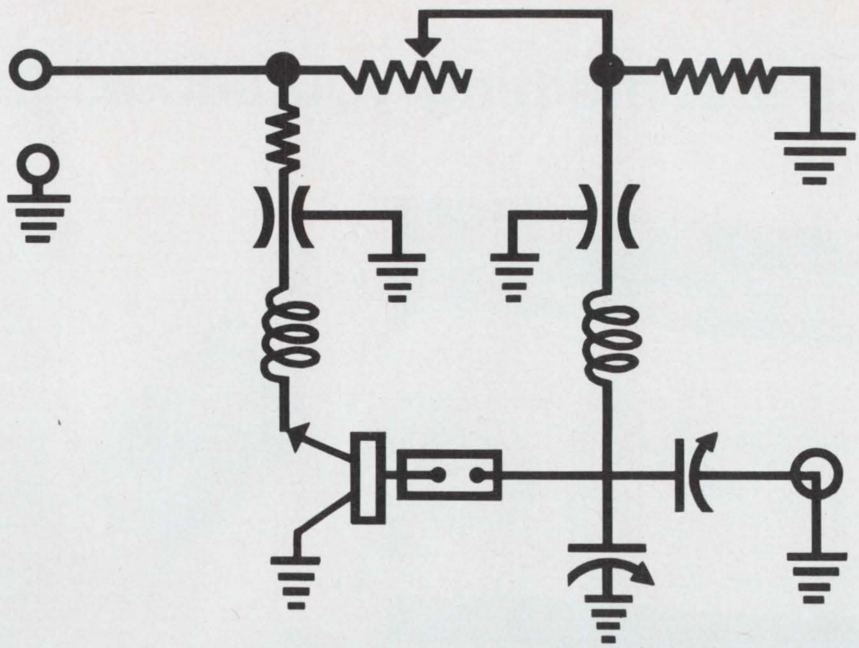
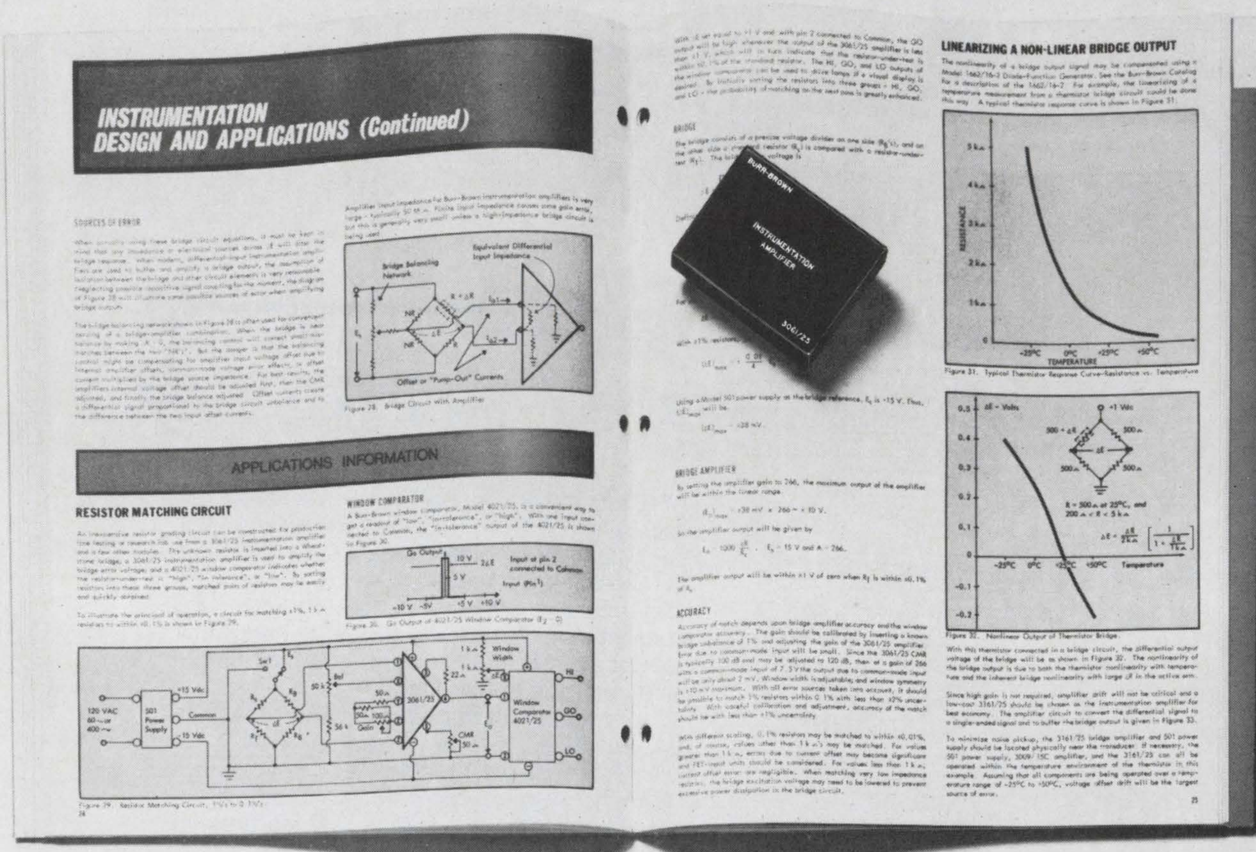


Here's something you should look into



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In addition, the catalog section contains DETAILED SPECIFICATION AND TEST DATA on Burr-Brown's broad line of standard instrumentation amplifiers. All units are covered including new high-performance, encapsulated devices with prices as low as $95 in single unit quantity.

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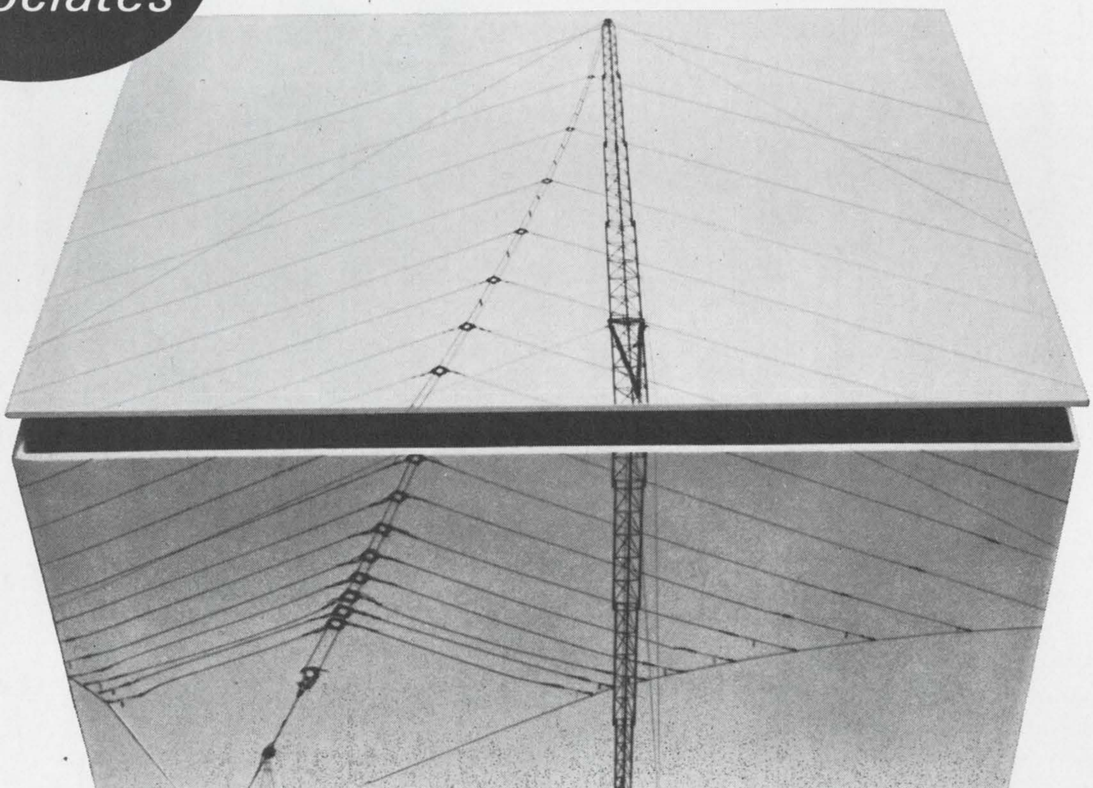
Circle 71 on reader service card



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2 anode strobing
new design permits all like-numerals to be driven in parallel for time sharing operation with improved brightness.

3 pin spacer
simplifies both PC board layout and tube insertion.

4 price
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ACTUAL SIZE

This new tube, type B-5750, has been engineered to achieve all these outstanding breakthroughs in a single design. The new slim-line tube not only has two internal decimal points but also has an "in-line" lead arrangement which is compatible with dual in-line IC's. In addition, the numeral aspect ratio has been designed to provide the optimum in readability and viewing distance.

The movable pin spacer – standoff, which is used to align the tube pins for ease of PC layout and insertion, is part of the tube assembly. The anode strobing/time sharing operation permits substantial reduction in driver costs for many multi-digit display applications. For more information on these and other features contact your nearest Burroughs representative or sales engineer, or write: *Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Department N6, Plainfield, New Jersey 07061 TEL: (201) 757-5000.*

Burroughs

Circle 74 on reader service card

December 9, 1968 | **Highlights of this issue**

Technical Articles

Computer can't forget its program
page 76

Compared to this minicomputer, the elephant has a memory like a sieve. The machine's program can be stored in a read-only memory that can replace a conventional read-write memory module. The Nova computer also has multiple accumulators—a feature characteristic of many third-generation computers, but only larger machines. Medium-scale integration is the secret. The Nova is shown on the cover, along with a resident of Boston's Franklin Park Zoo, who wasn't really as interested in the computer as in the peanuts the photographer scattered over it. He'd just polished off the last one when the picture was snapped.

Preleaded semiconductors are hitting the market
page 88

A survey of semiconductor makers shows that flip chips are becoming readily available and beam-lead devices are on the way. Most of the big companies should be offering production quantities of both next year. Keeping step with the semiconductor firms are the makers of automatic handling and welding machines for batch fabrication and bonding of the devices. This article concludes a two-part series begun in the last issue.

Active filters: part 5
page 98

The designer of inductorless filters has many circuit choices; two examples are the gyrator and the negative-impedance converter. However, when such devices are built with discrete components it's sometimes hard to control their frequency stability. By using operational amplifiers in these circuits, the designer not only obtains a stable circuit but minimizes the number of additional passive components.

Coming

The annual forecasts for European markets

How the markets stack up on the Continent and in Britain for 1969, with reports from a dozen countries and charts estimating sales of 82 product categories.

Nova can't lose its instructions

Program can be debugged in main memory and wired into read-only form for fail-safe operation in this very small multiregister machine

By Edson D. de Castro, Henry Burkhardt, and Richard G. Sogge
Data General Corp., Hudson, Mass.

An architectural approach, the key to many large third-generation computers, has been applied for the first time to a small computer. As in the designs of large-scale processors, the principal guidelines here are customer requirements and general trends in hardware technology.

Ideally, the availability of specific components does not influence an architectural design, but it is, of course, a factor in implementing the design. In this case, an economic advantage has been realized by employing integrated circuits. However, since the approach stresses function rather than hardware, the usefulness of the basic design is not limited by the economic life of a particular set of components. The computer has an intrinsic order and utility that are impervious to the quirks of some components.

One of the foremost characteristics of many modern computer designs is a multiaccumulator organization—the system's central processor contains a number of active general-purpose registers. Arithmetic and logic operations are executed more simply by manipulating data in these registers than they could be by transferring the data to and from the computer's memory.

Up until now, such registers have been considered impractical in small general-purpose computers, but medium-scale integration has changed all that. More than half the gates and flip-flops in the new machine are MSI circuits; this serves to reduce the number of interconnections and thereby shaves packaging costs.

Besides embodying an architectural design and featuring multiple registers, the new computer can have a braided read-only memory for program storage. This unit is made of wires preformed into a braid and dropped over U-shaped ferrite cores, which are then capped. It's unique in that it is homogeneous with the alterable main memory—that is, 1,024-word modules of read-only memory are directly interchangeable with main-memory modules made of conventional toroidal ferrite cores.

The user writes a program, debugs it in the alterable main memory, and orders it wired into read-only modules, which then replace the corresponding portion of alterable memory. From that point on, it is as immune to bugs as a program can be.

Targets

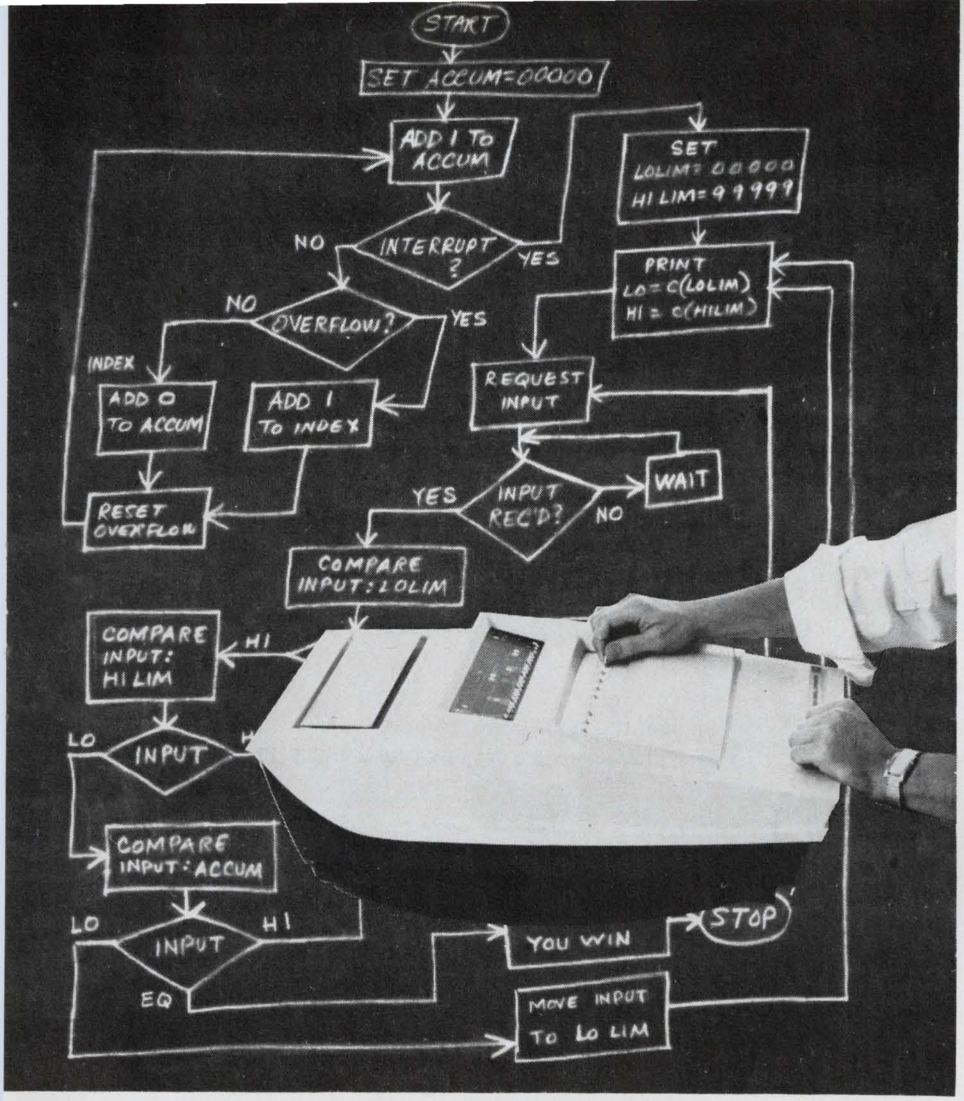
The computer described here is the Data General Corp.'s Nova, one of the growing class of so-called "minicomputers" that sell for under $10,000. Within the architectural framework, several rather unusual goals were set for the Nova design:

- A price of $5,000 or less in quantity for a complete system containing processor, power supply, and console, and having a full input-output capability and a memory comprising 4,096 words of 16 bits each.
- An absolute minimum number of interconnections, in the interest of reliability.
- No custom-designed components; all parts used must be produced in volume by a reputable manufacturer.

Besides these, several more or less conventional design objectives were established:

- A full cycle, including a memory cycle and accumulator access or indexing, in less than 3 microseconds.
- An input-output facility capable of both single-word transfer under program control and independent direct access to the memory by external devices, as well as a priority interrupt system that identifies the interrupting device.
- Room for expansion of either memory or input-output device controllers.
- Reliable operation over the entire commercial temperature range, 0° to 55°C.
- Minimum use of adjustable components.

All central processors consist of data paths, which are regular and repetitive, and the controls



Mighty midget. Small though it is, the Nova has all the characteristics of a much larger computer, as the flow-chart in the background indicates. The chart itself represents the stored-program concept, the diamond-shaped decision blocks indicate conditional branches, and the operations at the upper left show how the program can modify itself. Strictly speaking, the read-only memory prevents direct modification, and current programing practice frowns on it, but the concept is still valid.

—the irregular and hard-to-describe parts of the machine.

The regular portion consists of registers, adders, multiplexing gates, and the like. Its components, being common to all machines, represent a mass market for integrated-circuit manufacturers. The controls, on the other hand, are usually unique to a specific machine and therefore aren't economically feasible as large integrated chunks unless vast quantities of a single type of computer are being produced.

For instance, 16 flip-flops in a single package are available for use in regular registers, but only two flip-flops can be put in the same package for random control applications. Likewise, a four-bit adder containing 42 gates is available off the shelf, but four gates is the maximum available for individual use. Internal interconnections make the difference.

The Data General designers took into consideration that although regular components are being offered at ever-increasing densities and decreasing costs as technology progresses, the trend is much slower in the case of irregular parts. They therefore structured the Nova computer to utilize as few irregular logic groupings as possible. In practical terms, this was accomplished by keeping the instruction set straightforward—reducing the amount of irregular random control logic—and by designing the instructions' execution algorithms to operate efficiently in multiple general registers—sometimes at the expense of additional instructions in the set. By using an instruction format in which each bit has its own function, much irregular decoding logic was avoided.

For example, comparing two numbers in many small computers means complementing one of them, adding a 1 to it, adding the other number to it, and then testing the result—which is zero if the two numbers are equal. Any halfway decent computer needs all three of these instructions—complement, add (used twice here), and test. But the Nova achieves the same result with a single instruction—compare—in much less time; the one instruction covers the same four steps, but by whipping the numbers through the registers, it requires very little extra irregular logic.

For another example, one instruction in the Nova can subtract and shift the result to the left. This instruction, which is used in programed division, necessarily supplements an ordinary subtraction, but the logic to implement it is much less complex and irregular than a hardware divide would require.

Several such instructions make the Nova's set unusually efficient and easy to use.

Logical choice

To achieve the needed regularity in the processor's design, an IC logic family had to be selected. The designers considered several factors: breadth of line, cost, availability from several sources, noise immunity, and speed. They evaluated four lines and established the ranking diagramed at the right.

This diagram indicates that emitter-coupled logic is fastest of the four and has the best noise immunity, and that resistor-transistor logic is the least expensive circuit form. Diode-transistor and transistor-transistor logic are quite close to one another in speed and cost—although TTL has a small but distinct advantage in breadth of line and in its availability from several sources.

Several other factors were also considered, especially as they affected cost. For example, the number of new designs appearing in RTL and DTL is declining; thus the production of these lines may drop and prices increase. And because the cost of the printed-circuit board, its connector, and the wiring is often several times the cost of the component itself, the availability of complex functions in a single component could result in real savings in packaging costs.

Speed affects cost because it permits different levels of parallelism or seriality; a given level of performance can be achieved with a smaller number of relatively faster components.

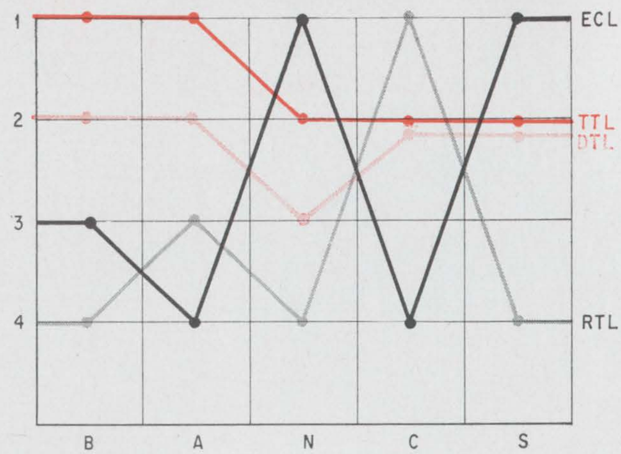
With all these factors in mind, the designers decided on TTL.

Even the most complex functions Data General chose to buy for the Nova were available in off-the-shelf circuits. These circuits have many applications, and the company believes this is a more useful definition of medium-scale integration than any arbitrary number of transistors or gates per chip.

MSI's major contribution is not low cost per function but rather a reduction of interconnections and a consequent improvement in reliability. It is true, though, that cost per function is usually somewhat lower with MSI components than with discrete gates and flip-flops.

Nibbling away

The Nova processes all data in groups of four bits, called "nibbles" because they're larger than a bit and smaller than a byte. This partly parallel organization represents a better choice than either a serial organization with a few fast components or a fully parallel organization with a larger number of slower parts. It's obviously only one of many possible choices; any submultiple of 16 bits—the word length—could have been used, each with its own advantages in cost and performance. But all in all, the four-bit path has more advantages and fewer disadvantages than any of the others.



Optimum choice. TTL circuits have the best combination of characteristics desirable for a small computer.

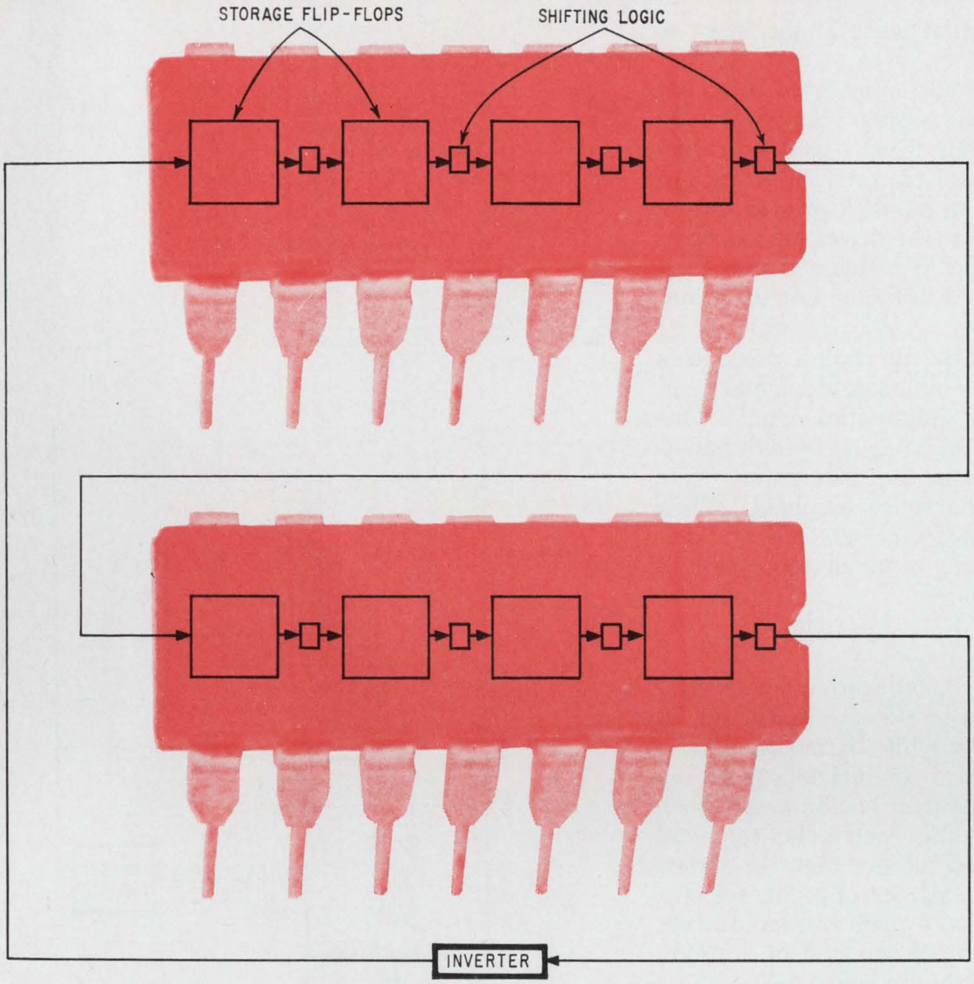
Among the advantages is the availability of standard off-the-shelf MSI circuits for several applications in the Nova. For instance, the accumulators consist of four 16-bit monolithic registers selected and sequenced by two MSI decoders. Each register unit contains 16 flip-flops addressed as a four-by-four matrix. One line from each of two groups of four selects the bit in a particular position in all four registers—four bits, or a nibble, in parallel.

As each register contains four bits from each of the accumulators, one of four control lines selects a particular accumulator. The other four lines are then brought up in sequence to access an entire accumulator four bits at a time. The output of the accumulator is gated into a four-bit adder —another MSI circuit in a single package. A full 16-bit addition is completed in four clock times as data passes through the adder a nibble at a time.

All the other machine registers are MSI four-bit shift registers. These include the memory address, memory buffer, and instruction registers, and the program counter. Data enters these registers from the adder output or passes from them to the adder input. An individual IC shift register will contain bits 1, 5, 9, and 13, for instance, instead of four adjacent bits of a word, so that a single shift operation is equivalent to a shift of four bit positions. Thus, four data entries and four shifts are involved in the transfer of a complete word.

Another interesting use of MSI is in the timing and control section. The entire machine's timing is locked to a single crystal controlled oscillator running at 10 megahertz.

The waveforms driving the memory system come from two MSI shift registers connected as an eight-bit, switched-tail ring counter, that is, as a single



Timing. These two shift registers feeding one another, plus the inverter, generate all the waveforms needed for the memory system in the Nova. The configuration is called a switched-tail ring counter.

shift register with an output that's inverted and fed back to the inputs, as shown above. Every time the counter shifts, one and only one bit changes state, so that the register as a whole has 16 different states.

Connecting various combinations of these eight bits to logic gates generates a wide variety of waveforms; those for the memory system are obtained from two-input AND gates.

Cores and stacks

As with the rest of the Nova design, the approach taken to the core memory was aimed at holding down both cost and physical size. A decision on the core size was easy to make. The required speed could be realized with a 30-mil core, a type now in high-volume production.

The question of stack organization was much thornier. So-called 2½-D arrays have become quite popular because they require only three wires through each core and are therefore inexpensive. But their associated electronic circuits are expensive, especially in small systems. The more common three-dimensional organization employs less electronics, but four wires must be strung through each core, increasing the array's cost.

The three-wire, 3-D scheme offers the best of both worlds in a small system. In this organization, the sense and inhibit functions share the same wire. In a conventional 3-D memory, the sense line is used for readout only and thus is active during only the read portion of the cycle. Conversely, the inhibit line is functional only during the write half of the cycle. The inhibit line requires a balanced drive and it's important that the sense line not be too noisy, but there's no logical reason why a single wire cannot be time-shared to perform both of these functions.

This sharing requires an unusual sense winding pattern, as shown on page 80. The basic pattern takes the form of a bow tie and gives first order cancellation of noise induced from the parallel selection line. The center-tapped winding is brought out as a twisted triplet; one wire from the center tap is connected to the inhibit driver, and one wire from each end of the bow-tie winding is connected to a transformer in a balun configuration. With this setup, any tendency of the current in one half of the winding to increase causes the impedance in that side of the balun to increase, blocking the current, and causes the impedance on the other side to decrease. The currents in the two halves are thus kept equal. And the maintenance of this approximate balance of current in the winding serves to reduce differential noise at the input of the sense amplifier.

The circuit not only provides balanced drive but allows the use of a low supply voltage for the memory because the inhibit driver sees the winding in two parts, each with half the total inductance of the array. These halves, in parallel, present only a quarter of the inductance to the driver, which, however, must provide twice as much current as it would if it were connected to the end of the winding.

During a write operation, the balun presents a very low impedance to common-mode signals and a very high impedance to differential signals. This forces the inhibit current to be equal in both halves of the winding and keeps the differential noise small at the input to the sense amplifier. When reading, the balun is effectively out of the circuit because the sense voltage is much too small to forward-bias the two diodes.

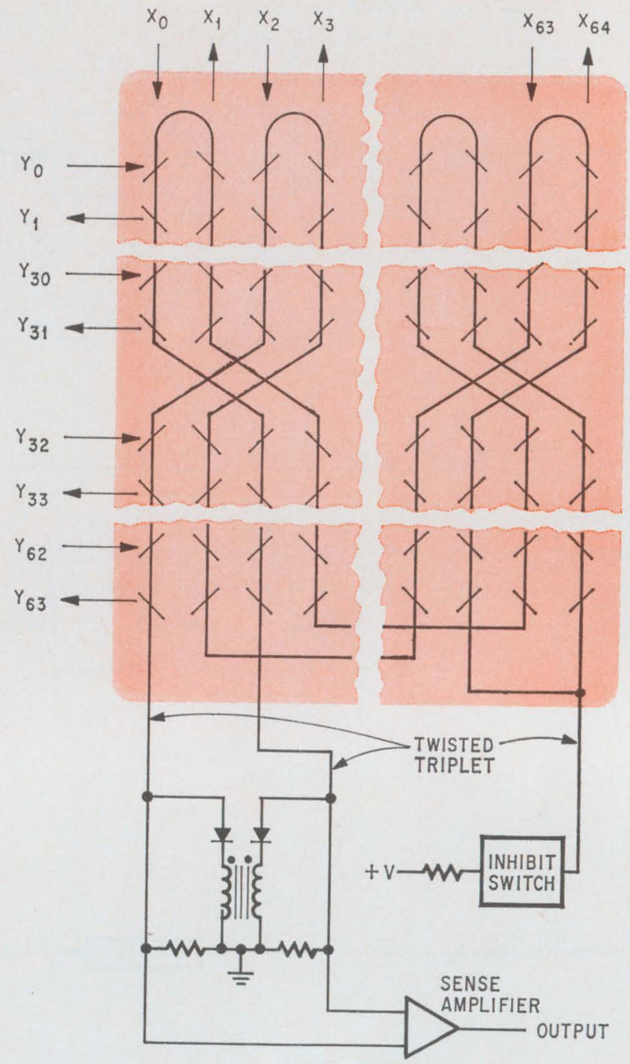
Plane and simple

The Nova's complete 4,096-word memory system, including sixteen 64-by-64 core mats and all the peripheral electronic circuits, is mounted on a single printed-circuit board 15 inches square, as shown on page 81. The system has 32 switches in its drive arrangement—eight at each end of the x and y windings, which thread all the mats in series. Four switches, one from each set of eight, select a single core in each of the 16 mats to read 16 bits in parallel. The core array, fabricated in a single plane, is soldered directly to the board.

Compared with the usual stack of individual planes, this arrangement offers many advantages in terms of cost and reliability. Interconnections are at a minimum because all lines are soldered directly to the main p-c board, all cores are directly accessible and can be repaired without disassembling the array, and lead lengths are short, reducing noise, stray capacitance, and inductance. Best of all, the entire memory is only a half-inch high, leaving plenty of room for more memory or other circuitry in the standard frame, which is 5¼ inches high.

A similar scheme using 32-by-32 mats didn't appear to offer the best packaging arrangement for smaller memories. Of course, smaller arrays cost less, but their use doesn't have much effect on the cost of the associated electronics. For example, chopping the array size from 4,096 to 1,024 words and retaining the 16-bit parallel readout would reduce the number of switches required from 32 to 24—not a very impressive saving.

But the fact that the processor handles bits four at a time affords an opportunity to cut costs by a significant margin. The 1,024-word memory need only be four bits wide instead of 16, and it uses four of the same 64-by-64 mats and the same 32 switches as the larger size. But it has only four inhibit drivers and four sense amplifiers, instead of 16 of each, and this results in a 15% greater saving than the elimination of eight switches and a handful of diodes with 32-by-32 mats and a 16-bit-wide memory.



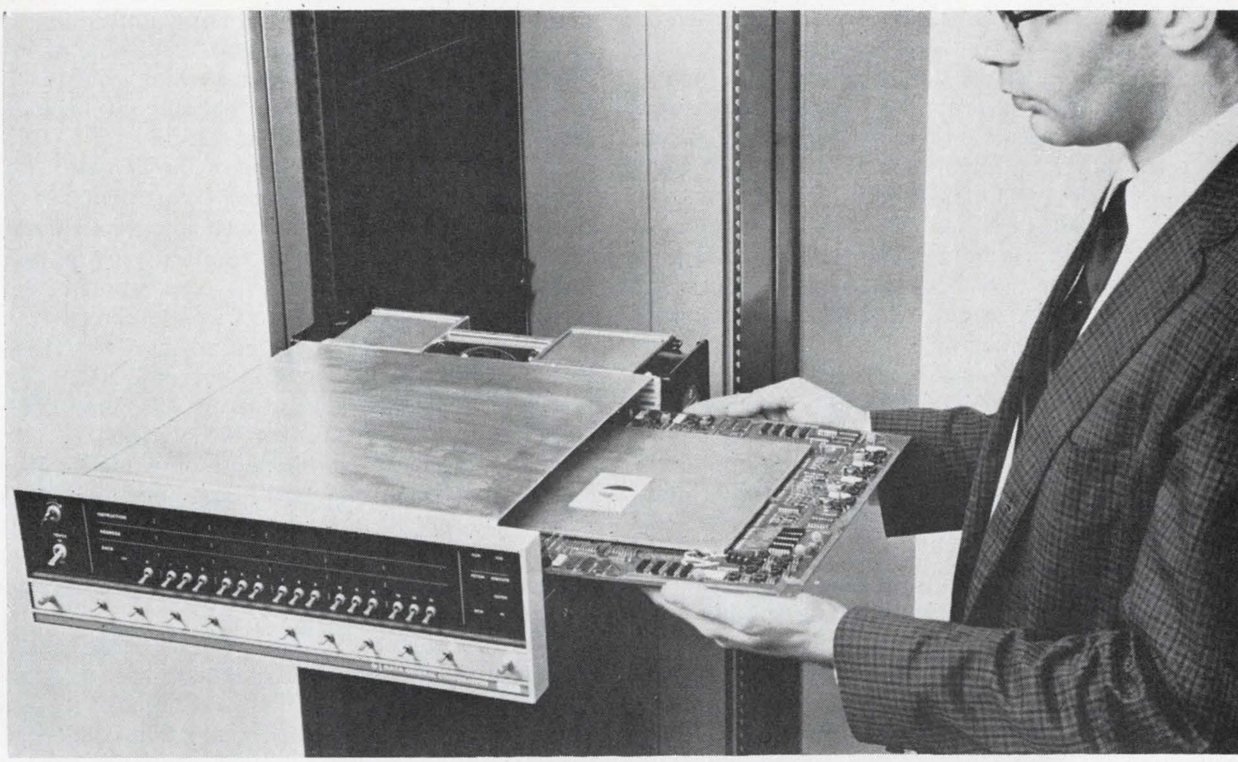
Bow tie. This sense winding pattern loads the driver symmetrically, and cancels most noise.

There's a catch, of course. With the larger memory, one memory cycle takes out 16 bits that the processor processes in four cycles. The four-bit-wide memory matches the processor speed cycle for cycle, meaning that equivalent jobs are executed more slowly by the machine with the smaller memory than by one with the larger.

Malleable memory

Because of its unique application, the Nova's read-only memory presented its designers with some requirements not ordinarily associated with this form of storage. Read-only storage has generally been used mainly for microprogram control in fairly complex processors. These memories have to be very fast, but they're also mass-producible because all computers of a given model usually have identical microprograms.

The Nova read-only memory, on the other hand, is a storage medium for the operating program.



Memory board. A complete memory containing 4,096 words and all drivers, decoders, and sense amplifiers, fits on this 15-inch-square board. Design is easily cut back to 1,024 words on a similar layout.

With it, a user can convert a general-purpose processor into a hard-wired control element without having to load new programs. The machine can thus be operated by unskilled workers in electrically noisy areas without affecting the program.

Only a very flexible system could satisfy the needs of this application. Because many of the programs wired into the read-only memory would be one of a kind, high setup or tooling costs couldn't be tolerated. Also, the designers felt that it should be possible to make changes in the field with ordinary tools and techniques. Last but not least, the user should be able to debug his program thoroughly before committing it to the read-only memory.

These requirements are met in the Nova's 1,024-word memory module. It contains 16 of the U-shaped cores with their multiturn sense winding, which functions as the secondary winding of a transformer. A wire for each word is strung through all the cores, passing through a particular core from right to left to store a 1, or from left to right to store a 0. When a current pulse passes through any of these wires, which function as the transformer primary windings, it induces a signal in the secondary winding, the phase of this induced signal depending on the direction of the primary wire through the core. The sense amplifier detects the phase of the output signal to determine whether the bit is a 1 or a 0.

In practice, a user initially loads his program into an alterable core storage and debugs it using normal procedures. After operationally checking the program's correctness, he simply dumps it on a paper tape and sends it to Data General. This tape serves as the basis for manufacturing the read-only memory and for verifying its contents. The assembled read-only memory can then be plugged into the user's machine in place of that part of the storage that originally contained the program.

If field modifications are required, a technician simply cuts out the wire corresponding to the word to be changed, inserts a new wire in the desired pattern, and solders it to the same parts the old wire was connected to.

Accessibility

There's room for many standard and custom-designed input-output interfaces within the Nova's standard frame. For example, the interfaces for the teleprinter, a high-speed paper-tape reader and punch, and a real-time clock are all mounted on a single board 15 inches square.

Nova's input-output interfaces provide for direct access to the memory, programed data transfers, the status testing of devices, priority interruptions, and identification of the device requesting interrupt service. With the input-output system, which is standard in the basic machine, the program can address up to 64 devices. A single instruction can transfer a word between an accumulator and a device and at the same time control the operation of the device.

A high-speed device such as a magnetic-tape unit or disk can gain direct access to the memory through a data channel and transfer a great many words following the execution of only one instruction. Likewise, a free-running external device such as a process-control sensor or pulse-height analyzer can store or fetch data in a reserved block of memory at any time without executing any instructions at all. In either case, the program simply pauses as access is made. The data channel logic can transfer data to or from the memory, increment the memory word, or add external data to a word already in the memory.

The interrupt system is particularly useful in process control applications. Several types of interrupt service may be employed by the central processor program depending upon the nature of the data rates and service time required by the input-output devices connected to the system. Each device's interface circuitry includes a flip-flop that enables or disables its interrupt signals.

A single processor instruction called Mask Out can change the flip-flops in all of the device interfaces simultaneously. This instruction, one of the first in a routine to which the computer branches when an external device interrupts it, is accompanied by a 16-bit word on the output data bus. The 1's and 0's of this word turn on or off the flip-flops for the various devices. Since each device's priority is established by the bit in the data bus to which its flip-flop is connected, the computer can enable or disable a particular device's interrupt but cannot change its priority rank.

When a device interrupts the computer, the Mask Out instruction disables the interrupts of all lower-priority devices. If a high-priority interrupt is received while another is being processed, the computer shifts its attention to the higher-priority device but later returns to the lower.

The key to this hierarchial scheme is Mask Out, the kind of instruction usually found only in computers much larger than the Nova.

Another instruction reduces the overhead time required to identify the device causing an interrupt. By transferring the selection code of the interrupting device from the interface to an accumulator, this instruction allows the interrupt service to branch quickly to the routine appropriate to the device.

No weak links

In devising a packaging scheme that minimizes the number of interconnections between components, the Nova's designers sidestepped some cost and reliability problems associated with earlier small computers. In the past, packaging has typically accounted for 40% of the manufacturing cost of small computers. This is true even of some machines using integrated circuits, because their designers simply replaced the discrete components on small printed-circuit boards with IC's, leaving the rest of the system unchanged. In such modules, every circuit connection is made through pins on the back panel; the circuit board functions only as a carrier for the IC. This technique multiplies the number of interconnections and thus reduces reliability. It also increases the cost of boards, the number of connectors, and the amount of back-panel wiring and cabinet space.

In the case of the Nova, one of the first decisions taken was to use higher-level components to reduce the number of parts. Each integrated circuit in the Nova is of a level of complexity equal to or higher than that found in a conventional logic module circuit card carrying discrete components.

The designers also decided to use only those levels of interconnection that increased the complexity of the system. In other words, they determined to avoid wasteful circuit carriers.

Putting high-level components on printed-circuit boards reduced wire lengths and increased reliability. The size of the printed-circuit board itself wasn't too important. With the conventional module replaced by the IC, boards could contain whole subsystems.

The conductors on the Nova's p-c boards replace almost all conventional back-panel wiring, while what back-panel wiring there is replaces cables. Thus the traditional level of connection complexity for this kind of system has been escalated one degree. Even when small IC modules are required for special device interfaces, connecting them on larger boards is better than accumulating nonfunctional connections in back-panel wiring.

Board size isn't limited by the capacity of existing cameras, copy plates, etchers, solderers, or other production equipment. Even those firms that are using small modules are building big boards and cutting them apart. Nor is yield a problem. Poor yield results from an inability to control process variables; lines are either etched through or short-circuited. The wider the line and the greater the spacing, the less likely are defects, and the Nova's boards have wide lines and wide spaces between them.

If a customer wants to configure his own system from the various memory sizes and peripheral devices available, or wants to interface special devices of his own, he'll find the Nova design accommodating.

The computer's basic rack mount unit holds seven 15-inch-square circuit boards. The central processor takes up two of these cards, so the other five are available for any combination of memory boards and input-output boards.

Interface boards are available for a complete line of standard computer peripherals, including teleprinters, card readers, line printers, displays, and magnetic tape. The customer can build special interfaces by mounting IC's on standard plug-in socket boards purchased from Data General. These boards contain eight interface areas, each with space for 12 standard 14-, 16-, 24-, or 36-pin IC's, either soldered or plugged in.

The user can also buy special circuit boards containing certain kinds of high-current drivers that have to be assembled from discrete components. ■

Circuit design

Designer's casebook

Squelch gate reduces amplifier's standby drain

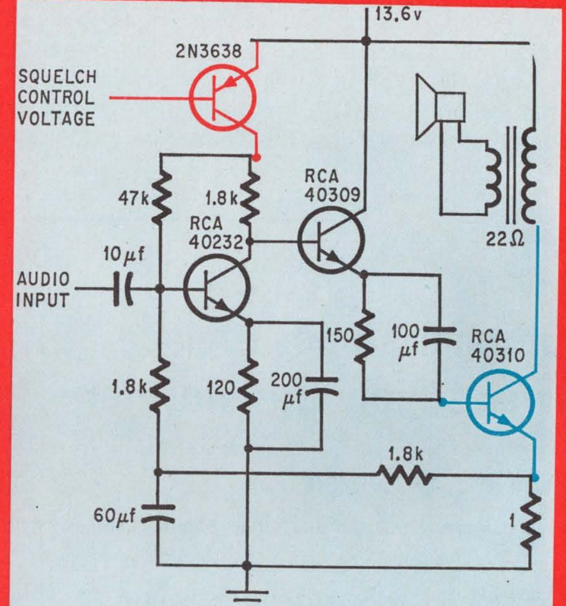
By A.T. Lehmann

Polytechnic Engineering Co., Mountain Lakes, N.J.

The push-pull type of audio output stage not only costs more than the single-ended stage but also suffers from crossover distortion at low current drains as class B operation is approached. For receivers operating mostly in the squelched condition, such as police and emergency receivers, the solution is simple: use a single-ended output stage and a squelched audio gate.

The three-stage, direct-coupled amplifier draws a fraction of a milliampere when squelched. When a positive control voltage is fed to the input of the squelch gate, the gate removes the supply voltage from the first stage. This, in turn, removes the bias from the second stage and thus from the output stage. The standby current is therefore only the leakage current of the transistors, which, with the silicon transistors used, is insignificant.

The circuit contains d-c feedback for stability. This cancels out the effects of temperature variations and assures constant operation with changing transistor parameters.



AMPLIFIER CHARACTERISTICS IN THE ON STATE

CURRENT DRAIN – 550 ma
POWER OUTPUT – 2.5 w
TOTAL HARMONIC DISTORTION – 2% AT 1 khz AND 2.5w
POWER GAIN – 87db
INPUT IMPEDANCE – 500Ω

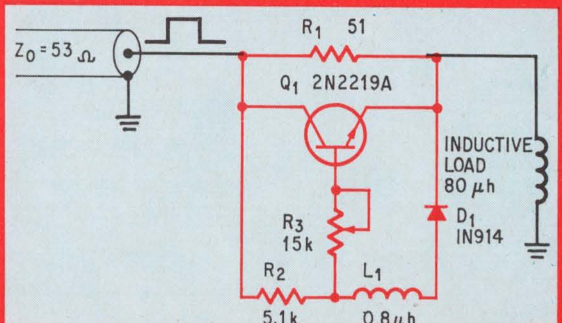
No bias. When the receiver is idle, the squelch gate ensures low standby current by removing the bias to the output stage.

Transistor circuit cancels inductive load effects

By Thomas E. Skopal

Burroughs Corp., Plainfield, N.J.

Overshoots develop in pulses delivered by coaxial cables to inductive loads. To compensate for the inductive reactance, a capacitor could be shunted across the inductor, but this might lead to ringing in the LC network, and the capacitor's leakage would bleed current from the pulse. The problem can be solved simply and efficiently by a one-tran-



Anti-inductive. Q_1 lowers the impedance of the network in proportion to the increased reactance across the load.

sistor circuit inserted between the cable and the load.

At the pulse's d-c level, no reactance is developed by the 80-microhenry load inductor, and the total load impedance is R_1, which with some inductive resistance is about equal to the characteristic impedance of the coaxial cable. Q_1 is just biased on by D_1.

The pulse's leading and trailing edges generate a voltage drop across both L_1 and the inductive load. The voltage at L_1 turns Q_1 on and lowers the impedance of the network to offset the increased reactance developed by the inductive load. The network's net effect is to terminate the cable in its characteristic impedance and cancel the inductive load's effect on pulse transitions. The exact characteristic impedance of the cable is found by adjusting potentiometer R_3 which controls the current flowing through Q_1 and thus the network's impedance.

For best compensation, the product of R_1 and the inductive load must be equal to the product of resistor R_2 and the inductor L_1. Another restriction is that R_2 must be large enough to avoid loading R_1 yet small enough to allow for enough transistor base current.

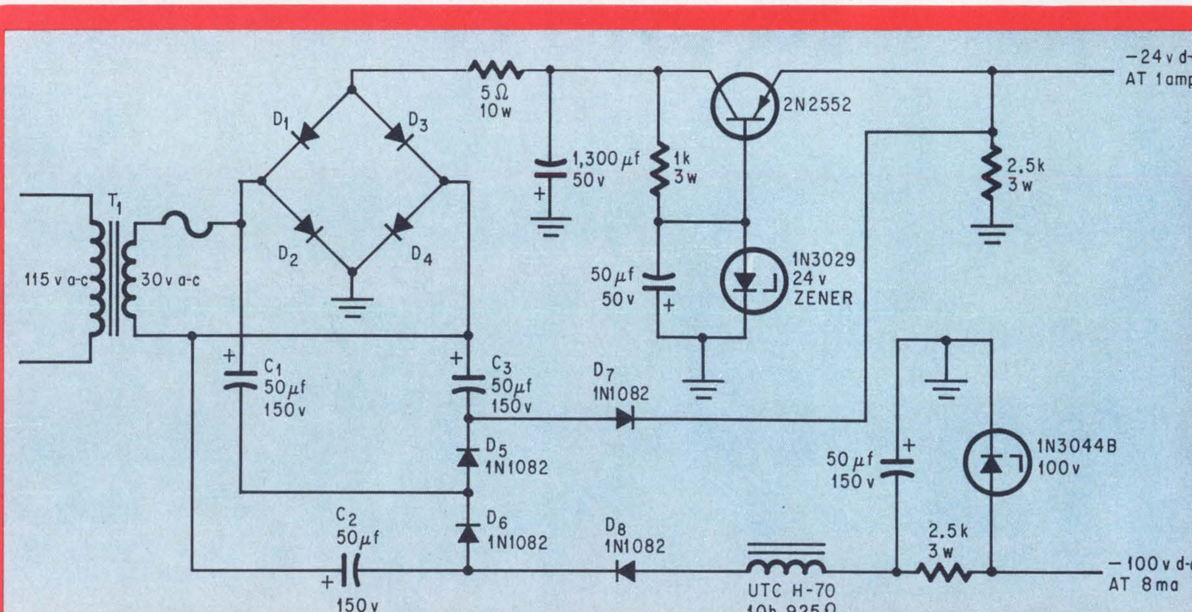
Multiplier stages replace power-supply transformer

By Merle E. Converse

Southwest Research Institute, San Antonio, Texas

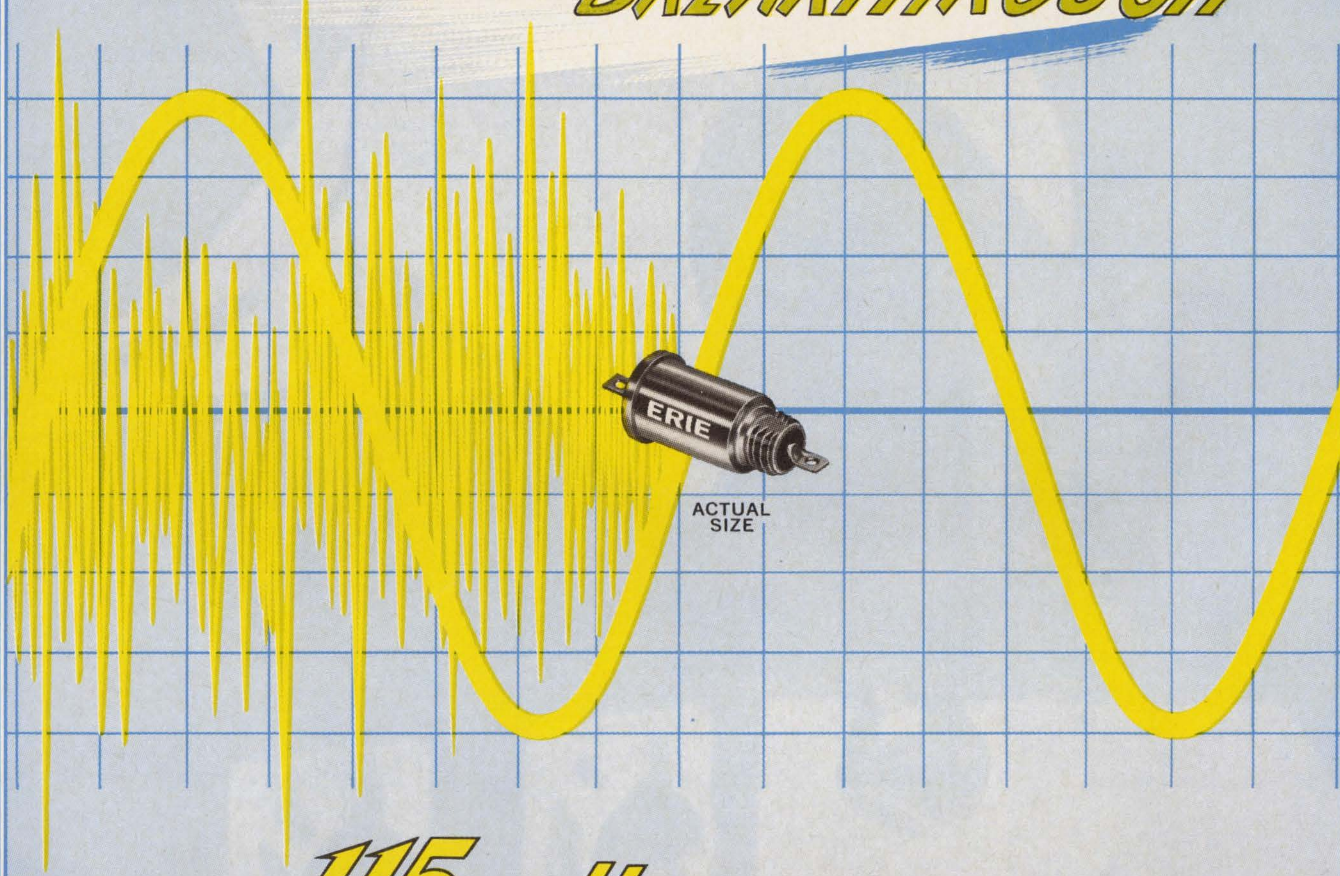
A dual-output d-c power supply can provide a high voltage output of between 100 and 200 volts and a low one of less than 50 volts without employing a separate transformer or a second winding and separate rectifier. A capacitor-diode multiplier connected to the same transformer and bridge rectifier that supplies the low voltage can develop the high voltage as an isolated output. Voltages of either polarity can be obtained.

Capacitors C_1, C_2, and C_3 couple the negative half-cycles of the transformer secondary to multiplier diodes D_5, D_6, D_7, and D_8; positive half-cycles are clamped by the bridge rectifiers, D_2 and D_4. The no-load voltage developed at the output of each stage of the multiplier is the d-c output of the previous stage plus 1.4 times the rms voltage at the transformer secondary. The output voltage is thus determined by the number of multiplier stages and by the load current.



Upstaging. Capacitors C_1, C_2, and C_3 couple the transformer secondary to the multiplier diodes D_5, D_6, D_7, and D_8. Each multiplier stage will raise the no-load output voltage by about 1.4 times the rms voltage at the transformer output.

EMI FILTER *BREAKTHROUGH*



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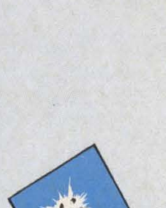

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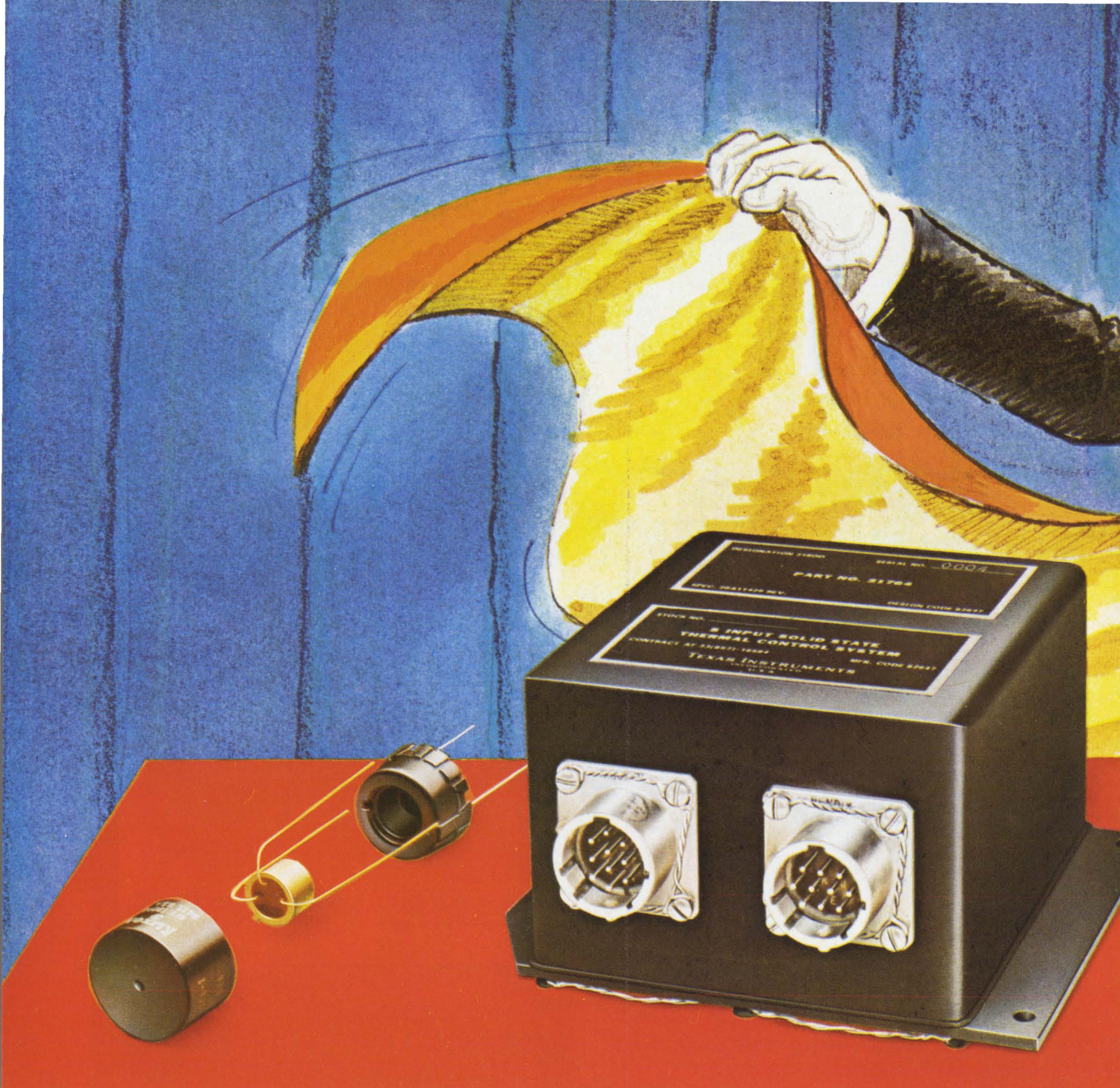

Introducing
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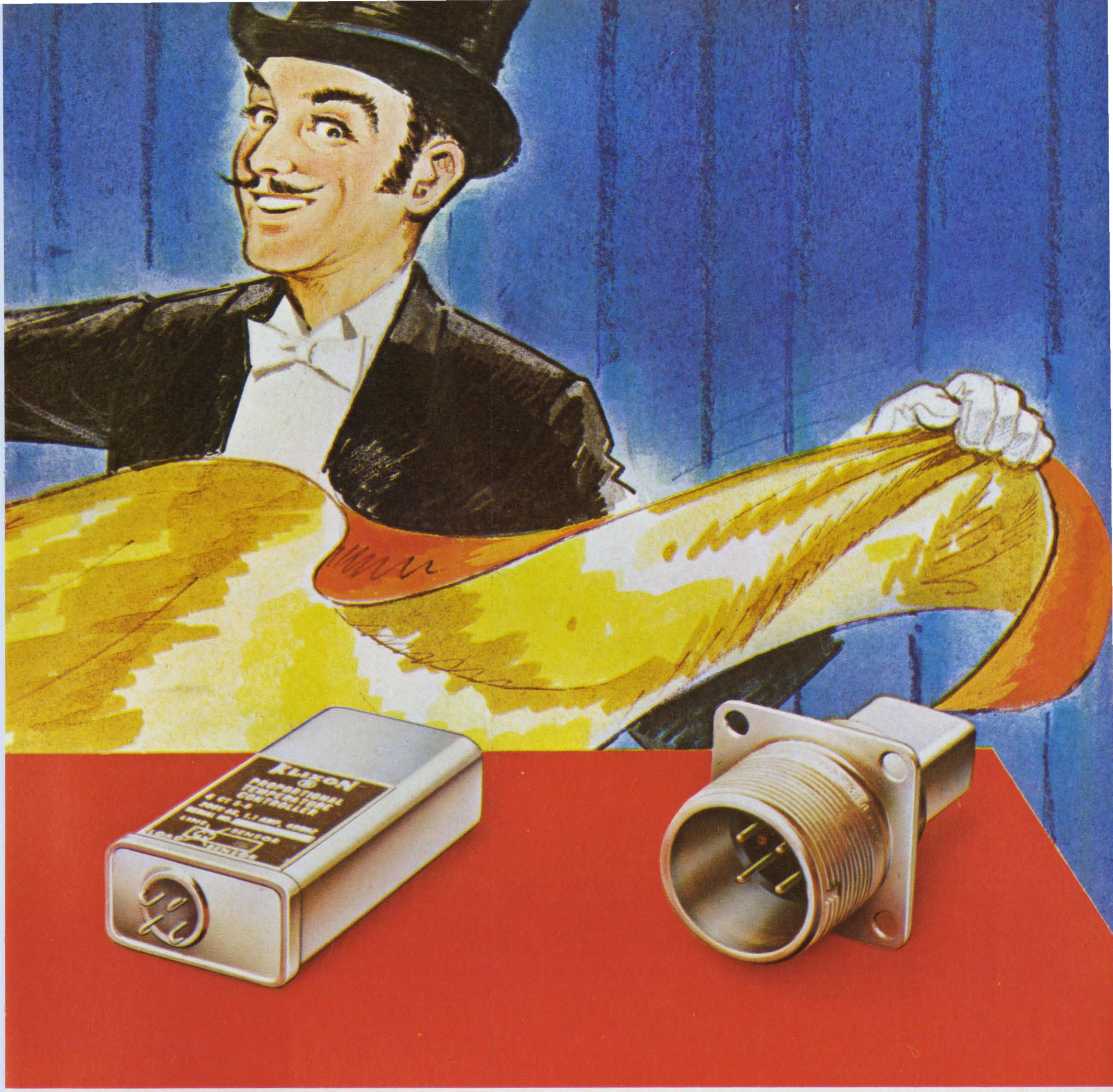
PROPORTIONAL
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Rival preleading schemes head for a market showdown

Flip chips have arrived and beam leads are on the way, with production quantities expected next year; the outcome of the battle may well hinge on the relative compatibility of the two techniques with MSI and LSI

By Lawrence Curran

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Prospective buyers of preleaded devices—whether bumped flip chips or beam-lead components—are getting restless. They know what the devices promise; they're questioning what the suppliers promise. Specifically, they're asking whether the semiconductor makers can deliver the goods. Increasingly, the answer is yes.

Texas Instruments and Sylvania, for example, are delivering discrete beam-lead diodes for microwave systems customers [see panel, p. 90], and Autonetics is getting some beam-lead IC's and discretes from Raytheon, although the volume isn't great. Members of the Bell System are getting beam-lead IC's from their Allentown, Pa., facility's pilot production line, but volume output there appears at least a year away. Flip chips, on the other hand, are farther along at most semiconductor houses making them, and some firms have been delivering production quantities for a couple of years.

Signetics is making some of its old triple-diffused series 100 diode-transistor logic in beam-lead form for use by Autonetics in the Minuteman missile program, and it expects to be shipping production quantities in the first quarter of next year. Signetics' R&D director, David Kleitman, says the firm wants to have beam leads available "as soon as possible for customers," but notes that "for in-house use—in our own IC lines—the whole effort is flip chip."

Donald Thompson, department chief of manufacturing development at Western Electric, the manufacturing arm of the Bell System, says that more than 30 different types of beam-lead IC's are either in pilot production or nearing it at Allentown. The roster includes counters, gates, and drivers—devices slated for duty in the ESS (electronic switching system), touch-tone telephones, traffic service precision consoles, PBX's, data sets, and carrier systems. Thompson predicts mass production of many of these circuits in a year to 18 months.

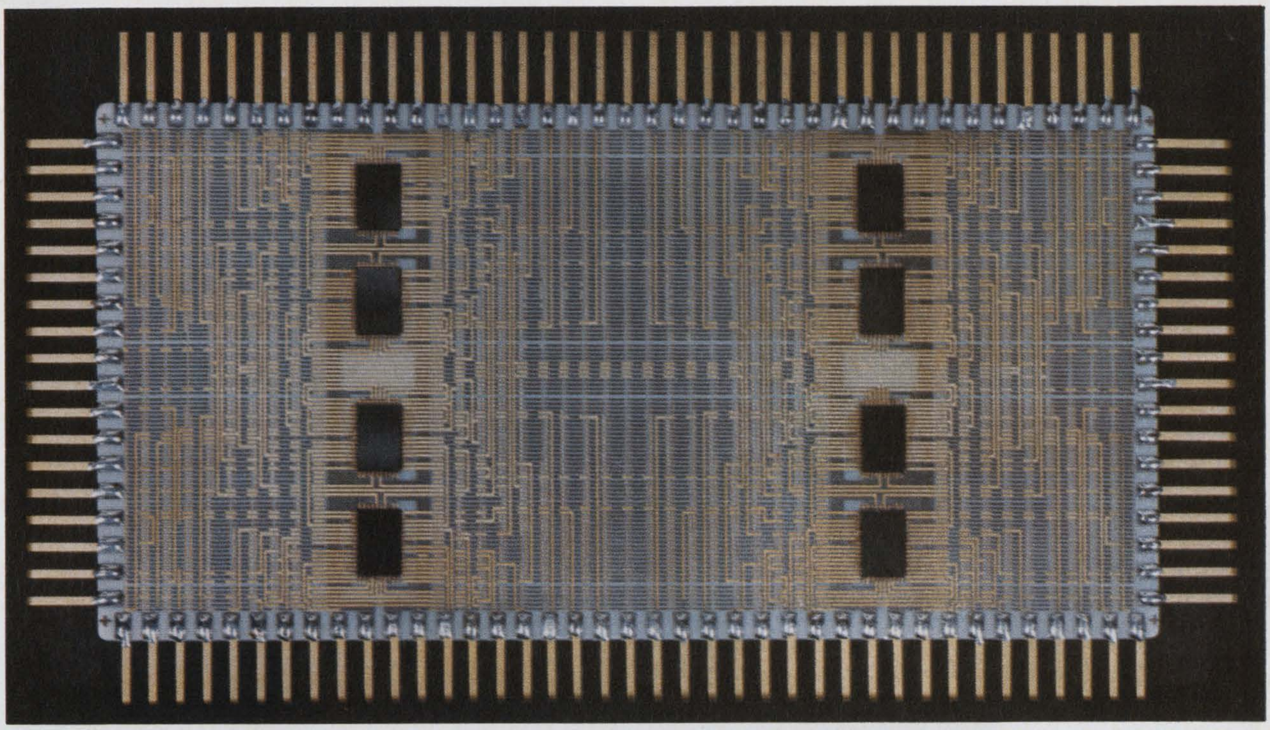
The plant is also turning out developmental quantities of monolithic and multichip beam-lead circuits, and is tooling up for LSI. The circuits in this category typically have about 100 elements per chip, and one device being developed has 1,000 elements on a 90-by-100-mil die. Multichip circuits have up to 200 chips on a hybrid substrate.

Conversion

Raytheon is laying out all its circuits with beam leads, according to Rudolph Thun, microelectronics manager at the company's radar and electronics lab. For conventional circuits already announced, the firm is going to standard chip sizes and standard chip-to-chip spacing to allow beam-lead attachment. Thun says the "retrofit" masking program already covers the series 200 and 930 DTL lines, the series 1,000 transistor-transistor logic, and Ray I and Ray II lines (corresponding to Sylvania's SUHL I and II TTL), plus all linear devices.

Raytheon's IC product manager, Paul Sullivan, observes that the firm isn't anxious to supply companies other than its sponsors—Autonetics plus two in-house operations—with beam-lead devices just yet. "But by mid-1969 we hope to have well over 50% of what we make commercially available in beam-lead form."

Autonetics expects Raytheon to start producing in volume the devices it has ordered early next year, according to Richard Bucheister, an Autonetics purchasing agent. This is essentially a production contract, but deliveries to date can't be considered production quantities. Autonetics is also



Leading somewhere. Experimental module built by Raytheon's Missile Systems division uses eight 40-gate TTL modules with beam leads. The top layer of the metalization pattern on the substrate sets up the circuit configuration.

attempting to qualify other suppliers of beam-lead devices for the FB-111A and F-111D aircraft. Barring drastic changes in these programs, Bucheister expects a follow-on to the Raytheon contract late next year, but he says that in all likelihood it won't be a sole-source procurement. The competition will be thrown open again at that time.

Motorola isn't giving out much information about the specific devices it has slated for beam leads. Richard Abraham, director of advanced IC programs, will say only that Semiconductor Products division will be ready to introduce beam-leaded products by the middle of 1969. "Just what products they'll be depends on which of our customers ask for beam leads," Abraham explains.

Brian Dale, chief engineer at Sylvania's Semiconductor division, expects his operation to bring out a line of beam-lead devices in early 1970, including 12 to 14 IC's to begin with. Meanwhile, Sylvania will continue to seek custom work in this field, and will sharpen its technology by working with discrete microwave beam-lead components. Dale says that while Bell Labs has put up to 56 leads on a beam-leaded chip, Sylvania's maximum figure to date is 40 on an array of 1,024 diodes.

Beyond this in-house work, Sylvania has an Air Force contract to investigate "means of building hybrid circuits without wire bonds." The award, received this summer and slated to run almost two years, doesn't specify beam leads, but Sylvania is applying that technology to its feasibility circuit —a four-bit, 12-chip shift register. The firm is also working on a beam-lead interdigitated transistor that's supposed to reach 5 watts at 2 gigahertz.

At Sprague Electric's Semiconductor division, Robert Pepper, director of research, development, and engineering, says production rates will depend on the beam-lead device market, which he doesn't see maturing for at least a year. "For the present, Sprague is going to settle for 'preproduction' volumes. But when the full market appears, we'll be geared for it," he adds.

Pepper says Sprague uses a straightforward Bell Labs cook-book format: gold or gold-molybdenum beams and silicon nitride passivation. The division tackled the beam-lead task head on, starting with a dual four-input NAND gate from its Super-Speed Logic (SSL) line. Explains Pepper: "We figured if we could solve the problems with this, one of our toughest-to-build IC's, we'd find other circuits easier. This circuit, like most high-speed TTL, has small device and contact geometries and is hard to build with ordinary aluminum metalization, much less with beam leads."

Sprague engineers had to overcome three problems with the initial circuit, one of them being the small geometries. "Fussy mask making solved this one," Pepper says, "but another hurdle was a problem no one has said much about—the fact that metalization in beam-lead IC's can easily short out to the substrate. This may also be the reason you don't hear much happy talk about beam-lead IC yields." Pepper won't say how Sprague got around this problem, but he does relate that it took about four months to isolate the problem, but only a week to add the solution to the production

Microwave beams

Integrated circuits aren't the only subjects of beam-lead research and development. The technique has much to offer microwave devices; for one thing, the wide leads reduce parasitic effects. Among the firms making microwave beam-lead devices, Texas Instruments and Sylvania appear to be the leaders, with both claiming to be number one.

TI's microwave beam-lead work got started about four years ago, with much of it stimulated by the Air Force's MERA (molecular electronics for radar applications) program. The company has put beam leads on such MERA components as mixer and varactor diodes, pin switching and detector diodes, and capacitors and resistors. Beam-leaded microwave transistors have also been built, but not for MERA.

Sylvania has been selling beam-lead Schottky-barrier diodes and mixers incorporating the diodes. And Marvin Groll, marketing manager for microwave semiconductors, says that before year's end the firm will be ready to introduce a redesigned Schottky diode with broad flat beams. Slated to bow later are Schottky diodes that will extend Sylvania's capability beyond its present Ku-band limit, and farther down the road are pin switching and varactor diodes and silicon-oxide capacitors.

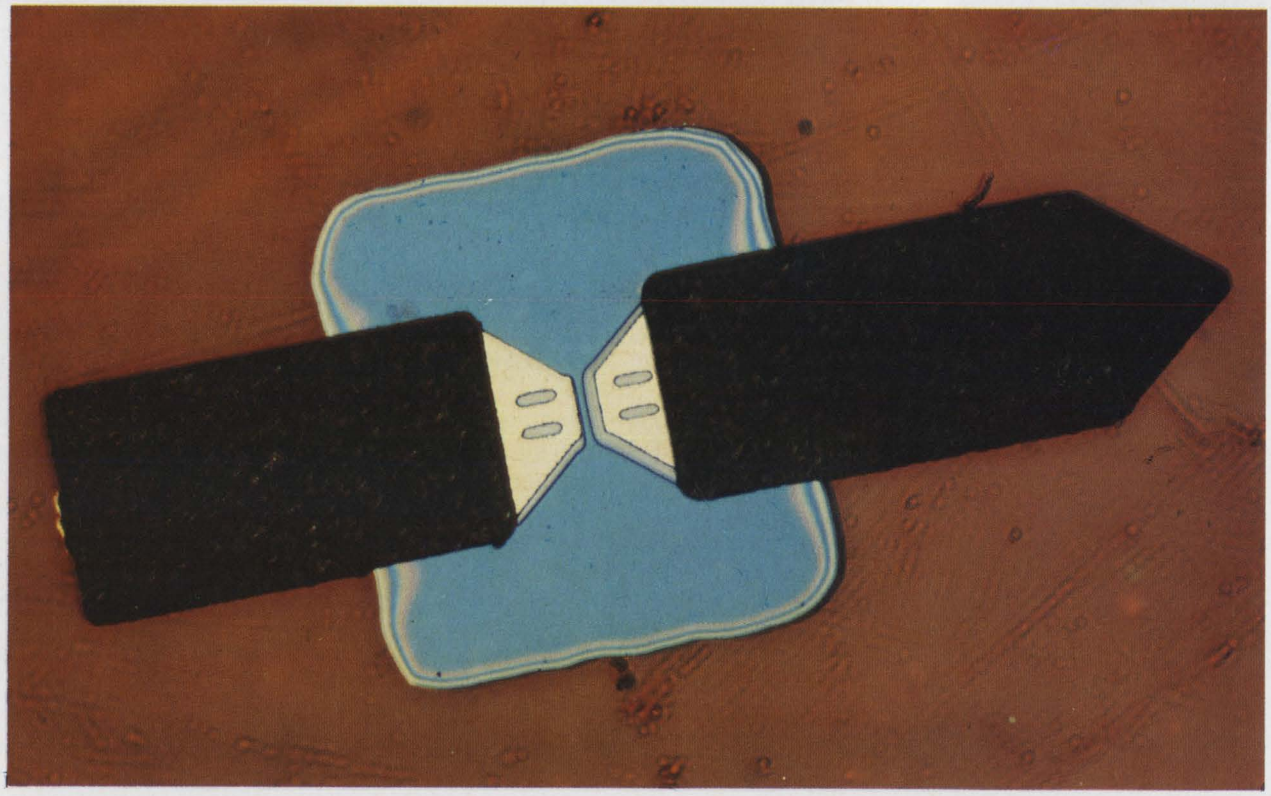
The reason why. Arthur Solomon, head of the solid state microwave components department at Sylvania's Semiconductor division, says he backs beam-lead devices because they're easy to mount with automated techniques, because the uniformity of the active devices allows preselection of matched diode pairs after only sample testing, and because they promise greater packing densities than chip-and-wire components.

"There's no good way to make a demountable test circuit for unpackaged chips," Solomon says, "but with beam-lead diodes, we can use lot sampling from the same wafer of about 1,000 chips. Because the boundaries of the semiconductor area and the beams are uniform, you get uniformity of parasitics."

Solomon also notes that with most nonactive material etched away, the devices can be mounted closer together on a stripline than would be possible with conventional diodes. "We've made multidiode switches using beam-lead pin diodes 8 to 10 mils on a side and put them side by side on a 20-mil-wide microstripline only one-quarter wavelength apart at Ku band and with only 25 mils between centers," he says. "This would be tough to do with conventional devices because chip pin diodes are about 20 mils a side. You need about 50 by 125 mils to mount two in parallel, against 20 by 50 mils for two beam-lead pin diodes."

Although his department hasn't investigated flip chips, Solomon is quick to observe that they don't afford the advantages of air isolation and lead shaping. "I don't know of any flip-chip work in the microwave area," he adds.

The heat's off. One of the advantages of beam-lead devices at lower frequencies works against them in



Isolationist. This surface-oriented pin diode, developed by Texas Instruments for use in the MERA program as a transmit-receive switch, has beam leads and provides better than 20-db isolation with an insertion loss of less than 0.5 db. Total capacitance is 0.1 pf and series resistance is 3 ohms.

microwave systems. They're virtually isolated from bonding heat because the leads dissipate the heat before it reaches the active regions. This limits their power-dissipation capabilities, Solomon says, because there's no intimate contact between the device junction and a heat sink. Thus, he says, the upper limit for switches with beam-lead varactor or avalanche diodes is several hundred milliwatts, compared with a few watts for the same devices using similar conventional diodes.

Developmental devices made with beam-lead components by Solomon's group include a 13.3-gigahertz integrated balanced mixer employing Schottky diodes, and an experimental i-f amplifier that uses the mixer and is centered at 450 megahertz.

The Army's SAM-D surface-to-air missile system has lent impetus to Raytheon's work in Bedford, Mass., on microwave components. Robert Chinchillo, a design engineer at the company's Missile System division—prime contractor for the program—says he's found that "beam leads give you some of the smallest devices available. They sit tight to the substrate and present much smaller obstacles to microwaves than other kinds of diodes."

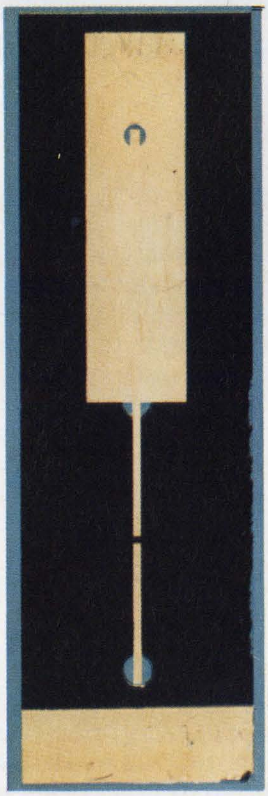
Beam leads permit the fabrication of Schottky's as small as 0.005 inch in diameter, Chinchillo goes on. "Before beam leads, we couldn't specify a matched pair of diodes and be sure we would get one. We can now pick diodes that were side by side on the wafer. It's as comfortable as you can get before actual testing at microwave frequencies."

SAM-D will have a phased-array radar, and Chinchillo notes: "We like beam leads for microwave mixers and phase shifters. One phased-array radar may have 5,000 or 6,000 elements with up to 40,000 diodes, so if beam leads get the nod, it will be a strong nod."

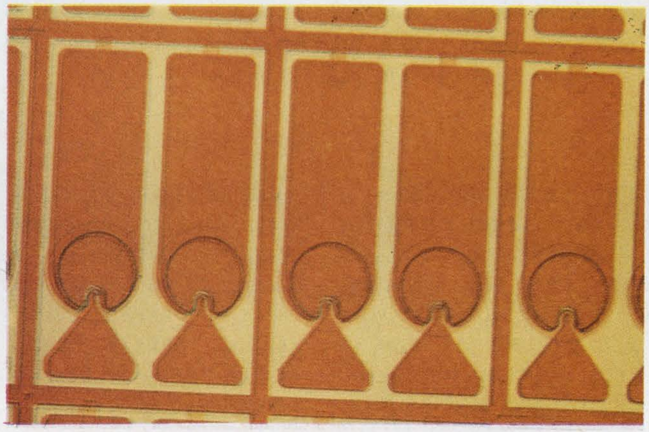
On the West Coast, Hewlett-Packard Associates is making a beam-lead, X-band, Schottky-barrier mixer diode that operates at 10 Ghz. Because it's batch processed, the diode sells for about $20 in small quantities.

Limited field. This is the only device Hewlett-Packard has shown in beam-lead form and there are no plans to introduce others soon. The argument at H-P is that only planar devices are compatible with beam leading, and this precludes the application of the technique to the firm's varactor and step recovery diodes. The Palo Alto, Calif., concern has also ruled out beam leads for power devices because of the leads' limited heat dissipation.

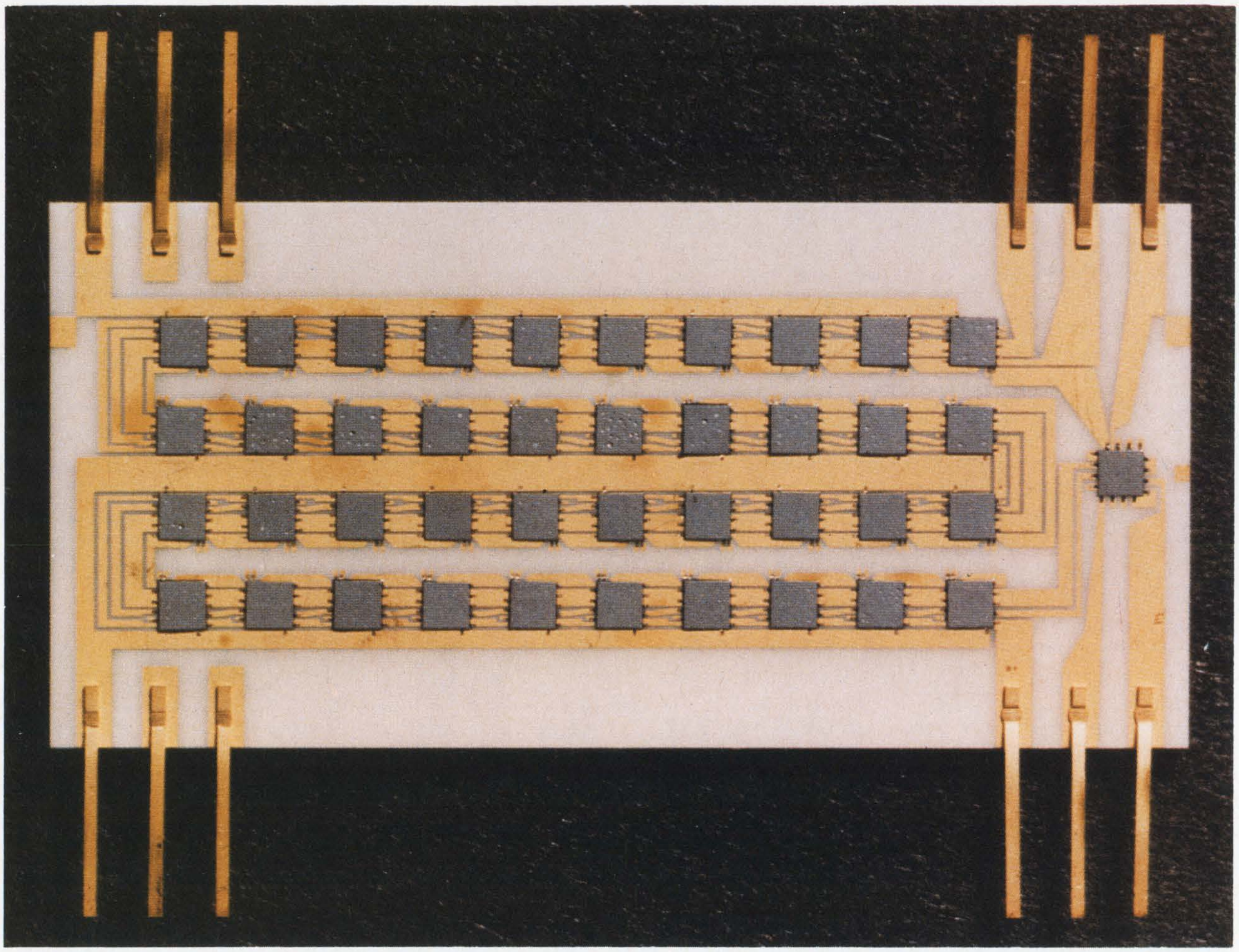
Hewlett-Packard isn't interested in flip chips. Donald Flynn, product marketing engineer, explains: "Our business is principally in microwave. The solder bumps on flip chips involve too much capacitance for devices in the 10-Ghz range in which we chose to work." Flynn says the firm uses sapphire as a substrate material because it has a uniform surface, and because it dissipates power better and has a more uniform dielectric constant than silicon.



Pulser. This beam-lead microwave pluse generator was built at MIT.



Broad beams. A group of Schottky-barrier beam-lead diodes from Sylvania's semiconductor division are lined up in the upper photo, while the lower shows a single diode placed in the center of the "tails" side of a penny. The devices are intended for use at about 13.3 gigahertz.



Big shift. Built by Bell Labs, this shift register has beam-leaded, insulated-gate FET stages with a single bipolar stage as a buffer. The substrate measures 0.625 by 1.3 inches.

technique. With this addition, yields doubled.

A third problem was gold segregation associated with nitride passivation. "Normally our SSL IC's are loaded with gold to cut storage time," Pepper says. "Unfortunately, this gold metalization isn't fully compatible with silicon nitriding. At some of the high temperatures needed for nitriding, the gold precipitates, doubling or tripling storage time. Our NAND gate initially ran at 15 nanoseconds, but we eventually worked out a way to use gold and silicon nitride together without degradation." Again, the solution is proprietary.

"With this first circuit, we knew we were in business and we went on to other IC's." That was last spring, and since then Sprague has been making twin mask sets for each new digital IC—one for bonding pads and the other for beam leads. The firm has beam-lead mask sets for such forthcoming additions to its lines as a quad double-input NAND gate, a 60-megahertz, charge-control flip-flop, a high-noise-immunity gate, an up-down counter, and a right-left shift register, all of them scheduled for introduction next spring. The company is also developing the capability to retrofit beam leads to older products.

James Hubbard, an IC manager at TI, says his firm is just getting started in beam-lead integrated circuits, although it's been working on discrete beam-lead microwave devices for about four years. "The microwave region was a natural for a beginning," says Hubbard. But outside that region, TI is putting both beam leads and bumps on silicon transistors and diodes and on DTL, TTL, and some emitter-coupled-logic IC's. "We have developmental contracts with a number of customers covering both beam-lead and flip-chip approaches," Hubbard says, "and I couldn't say at this point which method seems better. In the next few months we should have a lot more data from our two work groups and know a lot more."

Out into the world

While beam leads are probably at least a year away from volume production, flip chips have been on the market for as long as two years. Herbert Evander, assistant microelectronics manager at Hughes Aircraft, goes to the heart of the flip-chip advocates' argument when he says: "The Sentinel [missile] contract will help people get into commercial production with beam-lead devices, but it will be a long time before we see beam leads in competition. Flip chips are here today and beam leads are not, and flip chips are a proven process."

And even after beam-leads get into commercial production, Evander doesn't see them squeezing out flip chips. "There will always be flip chips," he declares.

Hughes has been putting bumps on discrete devices on a production basis for more than two years. Device families available from Hughes in flip-chip form include the 1N3602, 1N917, 1N918, and 1N4149 computer switching diodes, the 1N898, 1N4824, and 1N483 core driver switching diodes, and the 1N458A and 1N459A signal diodes. Transistors Hughes supplies with bumps are chiefly npn devices—2N2369 switching transistors, 2N915 and 2N916 amplifiers, 2N2221, 2222, and 2223 high-current switches, and the 2N930, 2N2484, and 2N918 transistors. The firm also supplies two pnp transistor types, the 2N2605 and 2N2907; the latter is a high-current switching transistor. In addition, Hughes' Newport Beach, Calif., plant is turning out a complete line of flip-chip zener diodes with an operational range from 6.6 to 33 volts.

Evander says he expects Hughes to be producing a variety of flip-chip IC's now in development by early next year. The logic families are the series 930 DTL and series 5400 TTL, and there are also some linear operational amplifiers scheduled for the flip treatment.

The small geometries of some TTL devices, particularly Sylvania's SUHL II line, present problems in bump spacing similar to those encountered by Sprague in trying to apply beam leads. "You can't put 14 bumps on a 40-mil-square chip and expect to get good bonding to the substrate," says Evander. The problem prompted Hughes to propose a standard flip-chip bump spacing of 5 mils to the Electronic Industries Association. SUHL II allows only about 1-mil bump spacing because of the closeness of bonding pads.

Hughes is anxious to share the wealth of knowledge it has acquired in applying bumps to chips in the hope that flip-chip bumping will become the most widely accepted face-down bonding technique in the semiconductor industry. The firm has selected another manufacturer as a second source for the Hughes process. "We helped them design the masks and we'll be talking about a license with them," Evander says. "This company looked at beam leads and rejected them. We're trying to promote several sources and we're completely open to licensing arrangements."

Siliconix first marketed flip-chips about a year ago after two years of development work. The company says almost all its conventional packaged circuits are available in flip-chip form, including MOS FET's junction FET's and IC's, the latter chiefly multichannel drivers and switches or driver-and-switch combinations. The firm also offers a line of flip-chip DTL and linear IC's—for example, the LM101 and 201, and LH101 and 201.

Prices for the bumped components are about the same as those for their packaged counterparts, according to the company (all Siliconix flip-chips are sold in chip form, but the firm is negotiating to sell bumped unscribed wafers).

It would be hard to prove that flip chips have arrived if your only evidence was the experience of the Big Three in the semiconductor business. Fairchild jumped in with the Fairpak process last year, but has now abandoned it. Texas Instruments like the Fairpak idea so much that they adopted it with little variation, but the firm's IC package development manager, Ross Schraeder, describes both the ceramic-and plastic-packaged flip-chip efforts as still developmental after 2½ years of effort. He says TI will market in next year's fourth quarter a standard line of bumped DTL and TTL IC's in ceramic packages with 14 to 16 leads. He also says the firm is looking at flip-chip packages with up to 64 leads.

Eventually, TI's plans call for making available in flip-chip form all IC's that don't have power dissipation limitations. "We are working hard to overcome power dissipation problems," says Schraeder. "If we can do this, the market for these devices would really mushroom." He feels there will be future requirements for higher-power devices that could give TI trouble, but for the present, DTL and TTL devices don't dissipate enough power to preclude bumped versions in standard packages. The official sees the flip-chip market beginning to open up next year, "but the real speedup won't come until 1970. We expect to be in high-volume production by then. The main problem now is market development rather than insurmountable technical production difficulties."

Meanwhile, Motorola continues to pour out spider-bonded IC's. Officials at the company's Phoenix, Ariz., plant are shy about describing production rates, but they do say that the technique is at least 20 times faster than chip-and-wire bonding. Two more spider-bonding machines are being built, so the firm will have two lines going early next year. Each reel of aluminum spider leads contains up to 25,000 piece parts, and considering Motorola's penchant for high-volume manufacturing, the peak production levels are probably eye-popping.

But spider bonding is suited only for monolithic IC's. How compatible, then, are the different approaches with the automatic assembly lines of their users, who are mainly making hybrid circuits?

The IBM solid logic technology (SLT) process—a form of flip chipping—is obviously highly automated, and its apparent successor—"controlled collapse"—may be, too. But arguments rage about the relative degree of automation of conventional flip-chip bonding and beam-lead bonding.

IBM and Bell Labs officials appear to see things differently and there's even disagreement within the Bell System itself about the bonding rates users of beam leads might expect. IBM executives point out that automatic handling and automatic etching techniques for beam-lead devices aren't in hand yet. At least one Bell Labs official agrees, noting that beam-lead bonding rates are now as low as 90 devices an hour, which he concedes is unacceptable for use today. This same source says bonding rates of 400 an hour might be acceptable to users, but that's a far cry from the 2,000-per-hour rate claimed by Aerojet-General for flip-chip bonding and the 1,800-per-hour pace expected by Evander once Hughes' automatic bonder reaches the market next year.

Other Bell officials, however, maintain that Western Electric will have automatic handling and etching mastered in a year to 18 months. There's no indication, however, of how many devices a beam-lead user might reasonably expect to be able to bond per hour.

Brighter side

Automation is a way of life at Motorola, and Abraham remains undismayed about the problems faced in speeding up the beam-lead bonding process. "The first wire bonder wasn't very fast, you know," he says. "Once the dice are separated from the wafer and mounted on a carrier, and once the backs of the beams are probed the same way an IC die is probed, the dice are arranged on a substrate in the same pattern they had on the wafer. You can align a pickup tool so the chips line up in an outline in the reticule of the optics, and then orient the header to the same outline. You can then pick up the chip and put it down for bonding automatically."

Autonetics officials foresee no major obstacles to automating beam-lead bonding in their hybrid thin-film MICRA (microelectronic integrated circuit replaceable assembly) packages. The company's thin-film superintendent, Kenneth Pascoe, says Autonetics made its decision to go the beam-lead route about 18 months ago after considering—and rejecting—flip chips. "We wanted to automate as much as possible, and the blind interconnect associated with flip chips made us uncertain of the bump location and orientation in relation to the contact pads," Pascoe explains.

He further states that the scribing and breaking of flip-chip wafers creates rough edges that make the chips difficult to handle automatically. In contrast, he says, back-etched beam-lead dice have smooth, symmetrical edges.

One flip-chip advocate has solved the rough-edge problem by sawing the dice apart instead of scribing and breaking the wafer. Walter Chin, assistant manager of the microelectronics department at Aerojet General's Electronics division, says the saw is used to produce a square pattern compatible with the company's automatic equipment.

Seeing is relieving

Another advantage of beam leads cited by Autonetics' Pascoe is that unlike flip-chip bumps, the overhanging beams are visible after the devices are turned face down, providing an orientation reference. "We want to locate the dice to a tolerance of 1 or 1.5 mils in bonding them to the contact pads so we need the orientation," he says.

Compatibility with thin films appears to be a beam-lead feature that flip chips may not be able to match. "We don't want to subject the films to more than 150°C in bonding," Pascoe says. This, he asserts, rules out flip chips because they have a substrate that has to sit on a platform heated up to 300°C during bonding.

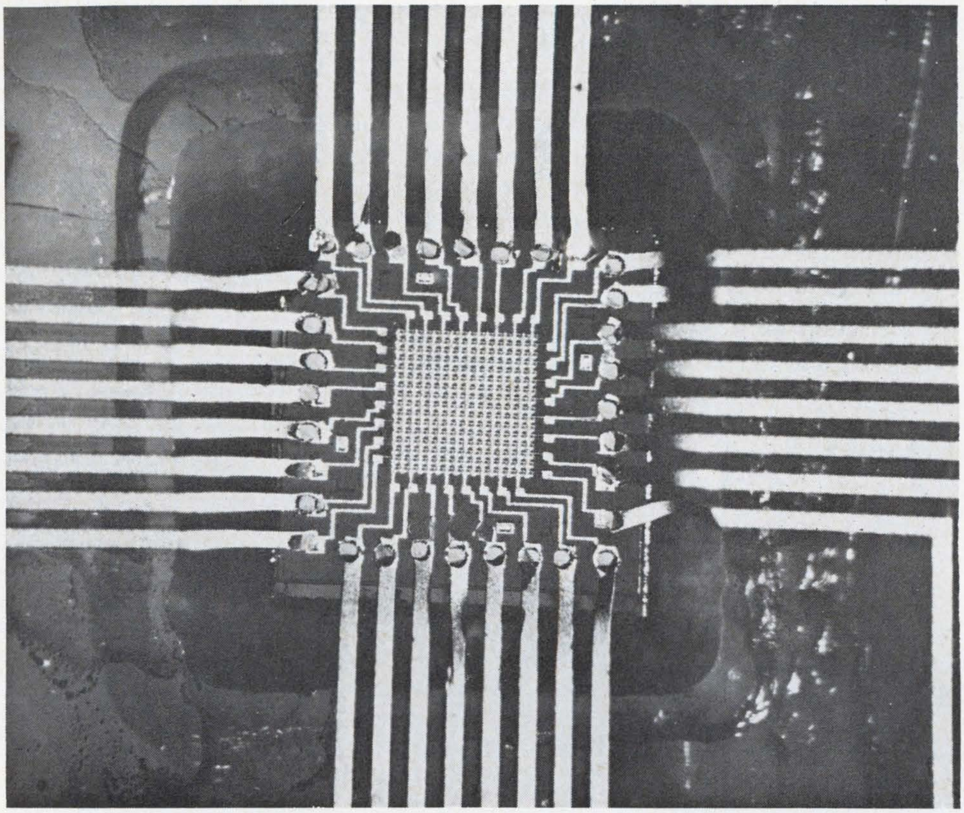
Raytheon ships etched-apart dice to Autonetics oriented the same way they were on the wafer and held on a flat surface by a proprietary adhesive. Autonetics' Bucheister says bad devices will either be marked or removed from the adhesive backing. Pascoe would rather they were removed to facilitate automated assembly because he says it's easier to automatically sense a vacant space on the surface than it is to sense a marked die.

Sylvania's Dale is another who likes the prospects for automated assembly of beam-lead devices. He explains that because etch separation preserves the geometrical orientation present in the photomask, each die in a matrix of devices will be in a known location and orientation. "This makes it possible to program a pickup tool for repetitive assembly," he says. Further, "because the positions of the leads are in known positions for the same reasons, beam leads look good for automated bonding. We have a hand-operated compliant bonder in our lab now that should be operating late this year or early next."

According to Dale, Sylvania has had in mind the retention of the matrix geometry. "At first we used a foil of gold that acted as a grid within which we laid out our IC's. Then we tried Bell's wax, screen, and sapphire approach. Now we feel we've improved on it in our most recent work." The nature of that improvement is proprietary, but Dale says that with it, chips are laid out "within a mil or two" of each other.

But users assembling multichip circuits can't live on promises about automated bonding of beam-lead devices. Aerojet-General shelled out some $150,000 to Bulova for two machines that give the firm possibly the most highly automated hybrid, thin-film, flip-chip assembly operation anywhere. Aerojet-General buys bumped discrete dice—junction FET's, npn and pnp bipolar transistors, and some diodes—principally from Hughes, Amelco, and Intersil. Gordon Carville, a marketing engineer in Aerojet-General's microelectronics department, explains the company's fondness for flip chips in one word—automation.

The Bulova equipment consists of a flip-chip sorter and classifier connected to a Teradyne IC tester. This combination automatically classifies flip chips fed from a vibrating spiral trough into one of eight categories, probes them, and automatically loads them into cartridges for transfer to the bonding machine. The equipment has a top speed of 3,000 dice an hour. As the bumped chips slide from the vibratory feeder, they pass down a



Over the edge. In this read-only memory from MIT's Lincoln Lab, the beam leads are formed on the substrate overhanging the cavity into which the chip is inserted.

section in the trough that's scored with grooves parallel to the axis of dice movement. Unless the dice are properly oriented and have their bumps down to catch in the grooves, they slide back down to the bottom of the vibratory feeder for recycling.

After the dice are moved to the ultrasonic bonder, which incorporates a Hughes bonding head, the magazines in which they're loaded are placed in the machine. This unit is driven by punched paper tape and has rotating vacuum pickup tools that take the dice from the cartridge in the rear of the machine, turn 180°, and place them on one of two thin-film substrates on tables in the front of the machine. The tape program dictates which dice will be selected from which cartridge, and also controls the indexing of the tables bearing the substrates so that the right die is bonded to the right substrate. The bonder handles up to 2,000 four-bump flip-chip dice an hour.

Hugle Industries is now designing an automated system that will be delivered to a large flip-chip user in 1970. William Hugle, president, says it will sell for $50,000. Describing its operation, he says the dice will be loaded into a notched tape in their wafer orientation. They will already have been wafer-probed and sorted. When the dice are unloaded face down, they'll be set into a square hole in an arm that extends from the bonder. The bumps will fit into small depressions inside the hole, and a-c tests will be made there. Alignment will be done by vibration.

Hugle says the arm must be exactly aligned with the substrate below because a vacuum needle picks up the dice after they're tested and places them on the substrate for bonding. System accuracy is about 2 mils, which Hugle admits isn't outstanding. However, he says the key consideration is to maintain the same chip orientation from wafer to wafer. The system will be required to bond 24,000 dice per day.

Hughes Aircraft's Evander, while promising a flip-chip bonder capable of handling 1,800 devices an hour next year, says 250 devices an hour is a more realistic rate for most present machines. "Some of our customers are doing that well now, and the beam-lead people would settle for those rates. Some technique for handling and sorting will have to be found before anyone can talk about bonding rates of 1,800 an hour for beam leads."

Texas Instruments' Schraeder notes that the company has automated its flip-chip production line for monolithic IC's slated for ceramic packages, "and we see no reason why we can't come up with workable gear for the plastics." He observes that most of the problems with plastic-packaged flip chips arise before the molding operation. "If you can get them through molding, the main problems are licked," he says. "To keep your manufacturing operation together until molding makes it almost mandatory that you have automated machines to do the job. We are now designing machines to do this for us."

At MIT's Lincoln Laboratory in Bedford, Mass., the sparse supply of beam-lead devices led researchers to find a new way to put the leads on devices [Electronics, Aug. 19, p. 52]. They're putting the beam leads down on substrates—either ceramic or silicon—and then bonding standard IC dice to them. In this "beam-lead substrate" approach, holes the size of the IC die are cut in the ceramic substrate and filled with an easy-to-etch material. A layer of metalization is then added and etched to create interconnection patterns.

The holes in the substrate are etched out, too, and the IC dice (resistor-transistor logic and TTL have been used) are deposited in the holes with their bonding pads aligned with the ribbon-like beam leads overhanging the windows. A modified ball bonder completes the electrical connections.

An oxide layer is grown over the silicon substrate before the metalization pattern is put down. After the interconnection paths have been etched on top of the slice, windows for the dice are etched into the back of the substrate. With this approach, the monolithic chip can be placed directly on a heat sink, which should mean that higher-power devices can be made.

Testy arguments

Supporters of the beam lead raise some points that the flip-chip advocates, on balance, can't seem to explain away. One of these is the testing and inspection problems inherent in the "blind" bonding of flip chips. Another is the need for high heat and pressure levels in flip-chip bonding. But possibly the clincher in deciding future trends will be the relative compatibility of the two processes with medium- and large-scale integration.

Looking at inspection and testing problems first, these appear to be the most important reasons for Autonetics' choice of beam leads for its F-111 programs. Says Bucheister, "As far as we know, Raytheon is the first firm that has shown an ability to do 100% testing—a-c and d-c—over the temperature range of uncased devices at the wafer level."

Because Raytheon can do 100% wafer testing, Autonetics isn't overly concerned about inspection. Pascoe says, however, that in the final look at devices after they've been bonded into the package, bad beam-lead bonds "jump right out" at an inspector.

Evander of Hughes dismisses the "invisibility" of flip-chip bonds as more a psychological hazard than a real problem. "The answer I give the reliability people when this argument comes up is that you can't tell anything about beam-lead bonds either unless you X-ray them. I don't really have a good defense, but I don't think the fact that you can see the beam-lead bonds is a good offense either. You still have to stress the part to see if it's sound."

Roger Murray, a senior projects engineer at Amelco, lines up with Evander on this issue. "Visual inspection sounds good, but it really tells you nothing more than whether the upper side of the lead is dented. You still have to use some other method to find the bad bond." Murray says that "to find that die is a monumental problem, but once you do, you can repair flip-chip hybrid circuits much more quickly than circuits with beam leads."

Under stress

Regarding the heat and pressure applied to flip chips during bonding, Raytheon's Thun says that this may be no problem with DTL devices, but it could degrade the higher-speed TTL circuits.

Evander discounts the heat and pressure stresses, asserting that the wafer never sees more than a few hundred degrees in bump applications, and that these levels don't interfere with diffusion. Bump formation imposes no pressure on the chip because the bumps are grown, he says. "The bumps do take some pressure in bonding to the substrate, but this is in a peripheral area, not an active area of the chip. Besides, beam leads also take some pressure in bonding to the substrate."

As to the question of compatibility with MSI and LSI, even some flip-chip boosters point out that there is a lower limit on the number of bumps or balls that can be applied to a chip than there is to the number of beam leads. "The key question," says Signetics' Kleitman, is whether a flip chip with as many as 40 leads can be made reliable. "We think it can." Hugle agrees, noting that Autonetics has bonded as many as 50 to a flip chip. "We thing the number is certainly more than 20," he says. "The limiting factor is the amount of force needed to deform the bumps plastically."

However, John Hall, a senior engineer at Intersil, says there may be a point at which customers will ask for beam leads. He believes that point may be reached when devices have to have more than 14 leads. "Beyond that number," he says, "there would be too much force required to squash the bumps into acceptable bonds. The chip would probably suffer." Intersil, one of a few companies doing a substantial business in flip chips, is preparing to meet that demand by developing its beam-lead technology, also.

Evans of Siliconix believes that alignment problems become so complex somewhere between 10 and 20 bumps that flip chipping isn't feasible at that point. Evans, a flip-chip backer, concedes that "when the theoretical limit of flip chipping is reached, beam leads might become more practical."

On the other side of the fence, Bell Labs doesn't foresee any mechanical limitation on the number of beam leads that can be put on a chip. One engineer there says, "we're regularly making beams spaced 4 mils apart center to center."

This article concludes a two-part series on methods of eliminating wire bonds. The first article covered the basic fabrication of preleaded chips.

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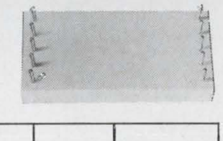
POWER AUDIO AMPLIFIER CIRCUITS



Part Number	Maximum Power Output (W)	Voltage Range (V)	Input Voltage (mV)	Frequency Response (Hz)
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BHA0004	5	11 to 20	20	25 to 20K
BHA0002	15	14 to 40	350	25 to 20K

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Circle 97 on reader service card

Active filters: part 5
Applying the operational amplifier

These devices are cheap and readily available in integrated form, and make it possible to drive other networks without an isolating stage

By George S. Moschytz
Bell Telephone Laboratories, Holmdel, N.J.
and Ralph W. Wyndrum Jr.
Bell Telephone Laboratories, Murray Hill, N.J.

Operational amplifiers with their inherent high input and low output impedances offer the designer of inductorless filters several advantages over circuits built from negative-impedance converters or gyrators. For example, a negative-impedance converter is used to provide the difference of two large numbers in the denominator of the transfer function. This results in the desired complex poles; however, these are highly sensitive to variations in network elements. Furthermore, it is difficult to d-c stabilize the network.

When a single gyrator configuration is used, a wide spread of capacitor values may be required. And although a gyrator can readily simulate a grounded inductor, a floating inductor is much more difficult to achieve. Low loss capacitors must be used to get high Q values, and at present no integrated circuit gyrators are available. With op amps the filter's pole and zero locations are determined by the op amp's gain and by the added RC passive networks. Appropriate techniques are available to make the pole locations relatively stable and independent of changes in the active elements.

Basically, the op amp is defined as a voltage-controlled voltage source (VCVS) of high input impedance, low output impedance, wide bandwidth, and very high gain. For typical applications, requiring high-quality units, the input impedance may be several megohms, but the output impedance only fractions of an ohm. Such amplifiers can simulate inverting and noninverting devices required to produce active filters, and can be connected in a single or multiple feedback arrangement.

In the nonideal operational amplifier, shown on the facing page in the inverting and noninverting modes with corresponding equivalent-circuit diagrams, R_i and R_o are the open-loop input and output resistances, R_b is the intrinsic-feedback resistance, and A_o the open-loop differential voltage gain of the op amp by itself. Although these parameters are frequency-dependent, they're treated as constants for the purpose of this analysis. The remaining three resistors, R_G, R_F, and R_n, are outside the amplifier. Resistors R_G and R_F determine the closed-loop gain; R_n is required to minimize offset voltage at the output. The voltage at the inverting input terminal is V_i, and that at the noninverting terminal V_n.

D-c characterization of the op amp

The gain of the op amp in either mode of operation can be written in the form

$$G = \frac{V_{OUT}}{V_{IN}} = \left(\alpha\right)\left(\frac{A\beta}{1 + A\beta}\right) \qquad (1)$$

where the forward gain A is proportional to A_o but smaller. The reduced value results because of the input and output impedances of the op amp. The term α is the closed-loop gain for an ideal op amp, defined by

$$A_o = \infty; \quad R_i = \infty; \quad R_o = 0 \qquad (2)$$

Using the subscripts I and N to differentiate between the inverting and noninverting modes

$$\alpha_I = -\frac{R_F}{R_G} \quad (3)$$

$$\alpha_N = \frac{R_F + R_G}{R_G} \quad (4)$$

For the inverting mode, A corresponds to the output voltage when a 1-volt signal is applied to the input of the op amp—terminals 2 and 5—and V_{IN} is set equal to zero. For the noninverting mode, A corresponds to the output voltage when 1 volt appears at the amplifier input—terminals 2 and 3—and the signal source V_{IN} is removed. The feedback factor is β.

In the inverting mode, β corresponds to the voltage fraction at the input when a 1-volt signal is applied across the output terminals and the input signal source, V_{IN}, is short-circuited. In the noninverting mode, β corresponds to the voltage fraction appearing across input terminals 2 and 3 under the same conditions. At low frequencies, the feedback factor β_o for both types of an ideal op amp in either mode of operation is given by

$$\beta_o = \frac{R_G}{R_G + R_F} \quad (5)$$

The ratio of actual to ideal closed-loop gain is

$$\frac{G}{\alpha} = \frac{1}{1 + \frac{1}{A\beta}} \quad (6)$$

The term $A\beta$, the amplifier's loop gain, must be much larger than unity for low-gain sensitivity. To verify the effects of this term, equation 6 is expanded in a Taylor series as follows

$$\frac{G}{\alpha} = 1 - \frac{1}{A\beta} + \left(\frac{1}{A\beta}\right)^2 - \left(\frac{1}{A\beta}\right)^3 + \cdots = 1 - E \quad (7)$$

where E is the gain error. For $|A\beta| >> 1$, E can be approximated by the linear term, $1/A\beta$, in equation 7.

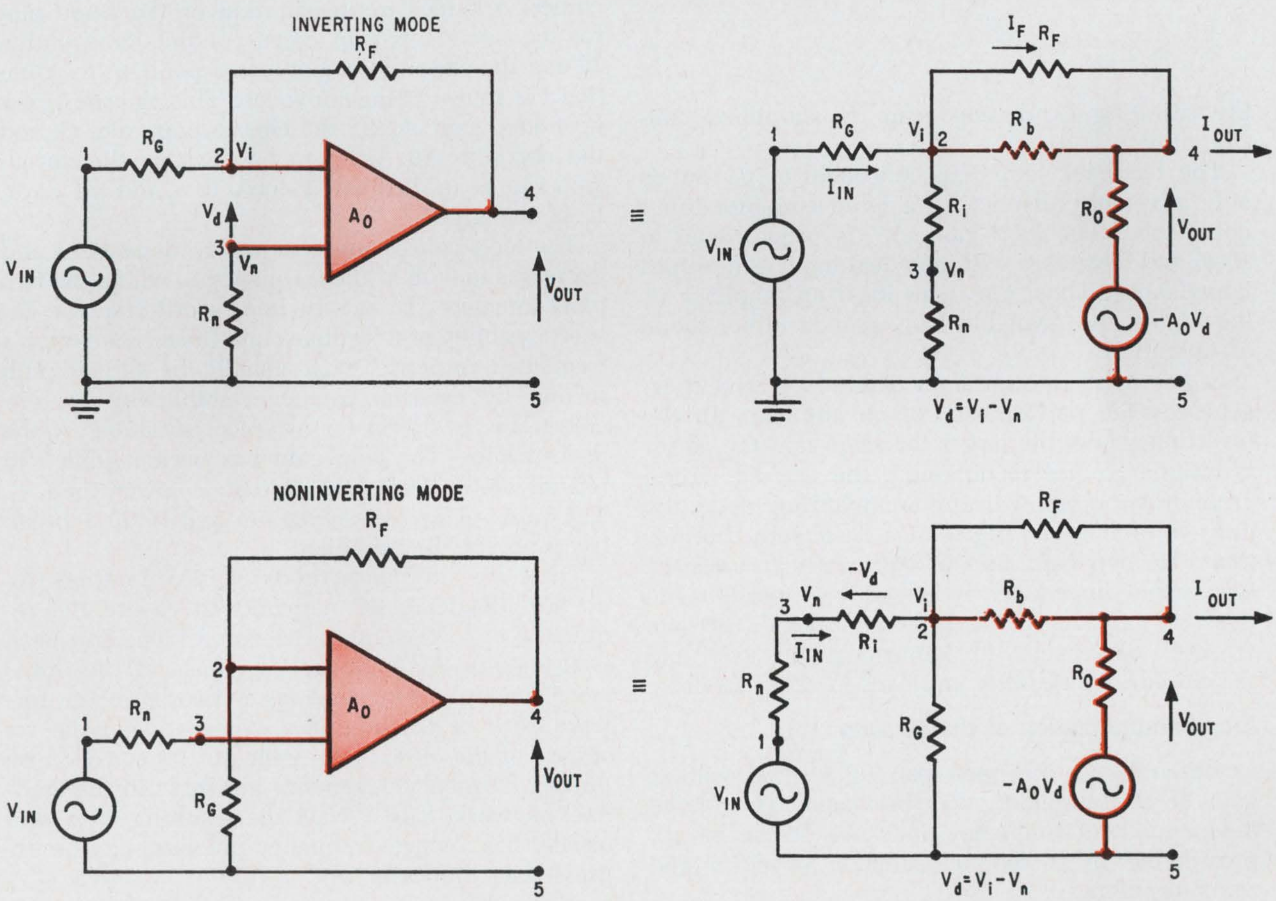
By assuming a minimum closed-loop gain, R_F/R_G, of unity and inserting this value into equation 5, an upper limit for β_o is established as 0.5. When R_F/R_G equals infinity, the lower limit for β_o becomes zero. Thus, the limits on β_o are:

$$0 \leq \beta_o \leq 0.5 \quad (8)$$

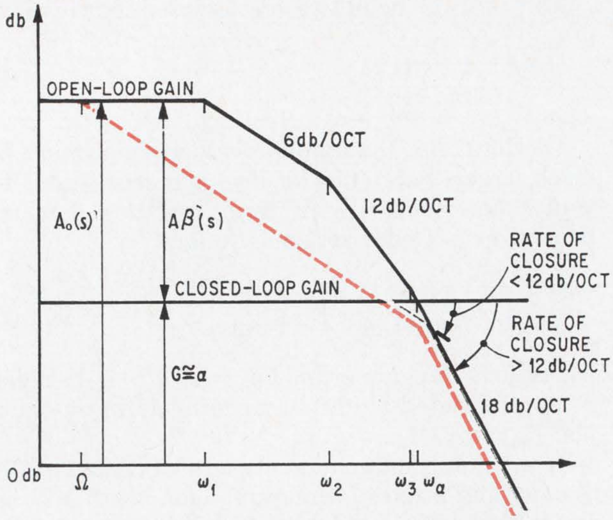
To minimize d-c offset, the external resistor R_n must satisfy the condition

$$R_n = R_G \| (R_F + R_o) \quad (9)$$

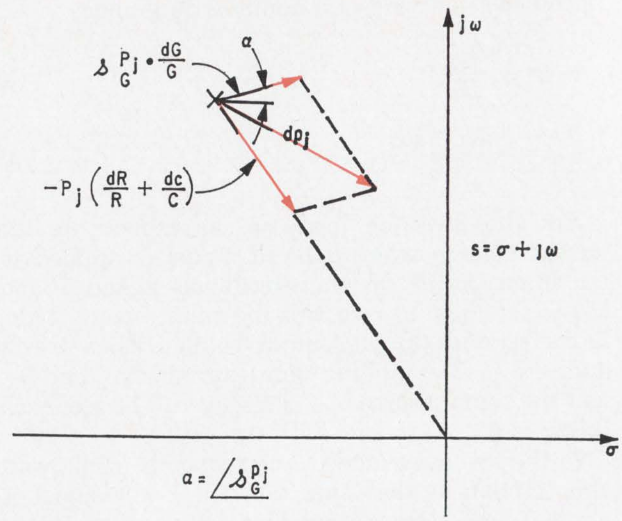
Expressions for the forward gain, A, and feedback



Operating modes. Terminal connections are indicated for both the inverting and noninverting modes of operation of an operational amplifier. At the right are the respective equivalent circuits for both modes.



Graphing the gains. Bode plots for the open-loop and closed-loop gains of a typical operational amplifier. Dashed line represents the gain response of a modified op amp whose stability is assured by added RC components.



Pole displacement. The vector diagram represents the pole displacement for an active RC feedback network consisting of an active device G and resistors and capacitors. These passive components must track closely.

factor, β, of the op amp can then be obtained from the equivalent diagrams. Since

$$A_o \gg 1 \tag{10}$$

and

$$\frac{R_o}{R_F} \ll 1 \tag{11}$$

the resulting expressions can be simplified considerably.

The feedback loop is proportional to β_o, but is only adversely affected by a finite amplifier input impedance. The loop gain, $A\beta$, is proportional to $A_o\,\beta_o$ and decreases with nonideal input and output impedances. Thus, the more ideal an amplifier is, the higher the available loop gain in either mode of operation.

In any application, this available loop gain characterizes the performance of an amplifier. In the inverting mode, the larger the loop gain the closer a designer comes to obtaining the desired virtual ground at the input. In the noninverting mode, the desired high input impedance is directly proportional to loop gain, and in both cases the desired low output impedance is inversely proportional to the loop gain. As indicated by equation 7, the gain error, E, decreases with increasing loop gain, and the closed-loop stability improves in either mode.

A-c characterization of the op amp

Although A_o, the open-loop differential voltage gain of the amplifier, was previously considered independent of frequency, it is not. It can be approximated by a rational function of poles and zeros as follows:

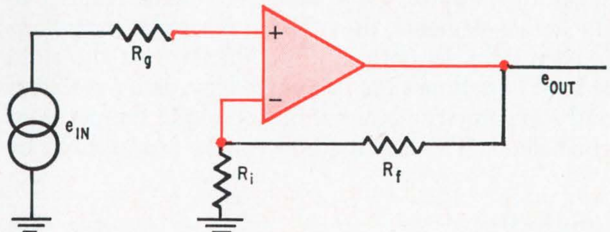
$$A_o(s) = \frac{A_o}{(s + \omega_1)\,(s + \omega_2)\,(s + \omega_3)} \tag{12}$$

This representation corresponds to the Bode plot of the open-loop gain, where ω_1, ω_2, and ω_3 are the corner frequencies in the band of interest and the slope is increased by 6 decibels per octave at each corner. A typical representation of the Bode plot for the open-loop gain corresponding to equation 12 and the closed-loop gain corresponding to equation 1 is shown at the above left. This plot shows the open-loop gain, $A_o(s)$, the closed-loop gain, G, and the loop gain, $A\beta$. As long as $A\beta$ is large the closed-loop gain is approximately equal to α, and the error, E, is negligible.

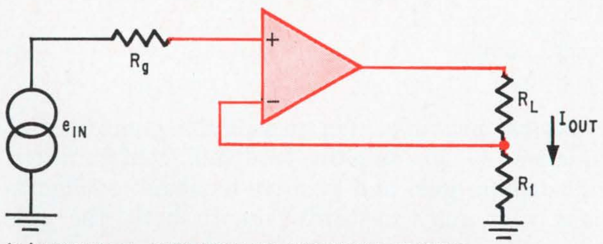
The loop gain is now frequency dependent and decreases to 0 db at the frequency ω_a where the two plots intersect. To satisfy Bode's criterion for absolute stability of a feedback amplifier, the op amp's frequency response must usually be limited still further by external frequency-stabilizing RC circuits. This is shown for a typical situation by the dashed lines. The loop gain has been modified to roll off at the frequency Ω that is lower than ω_1. The value of ω_1 represents the first natural break frequency of the amplifier.

There are various methods of incorporating frequency-stabilizing RC networks to ensure the required 6 db/octave rate of closure.[1-3] One approach is to modify the frequency response of the open-loop gain by putting lead-lag networks in the forward path of the amplifier. Alternatively, the response of the closed-loop gain can be modified by putting frequency-dependent networks in the feedback network. Either way, the resulting loop gain usually has a single-frequency pole and can be expressed in the form

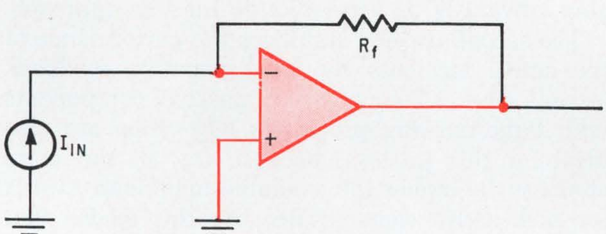
$$A\beta(s) = A\beta\,\frac{\Omega}{s + \Omega} \tag{13}$$



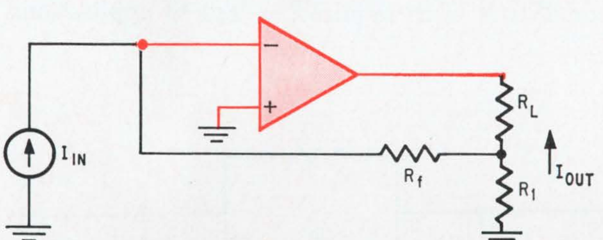
(a) VOLTAGE AMPLIFIER



(b) VOLTAGE-CONTROLLED CURRENT SOURCE

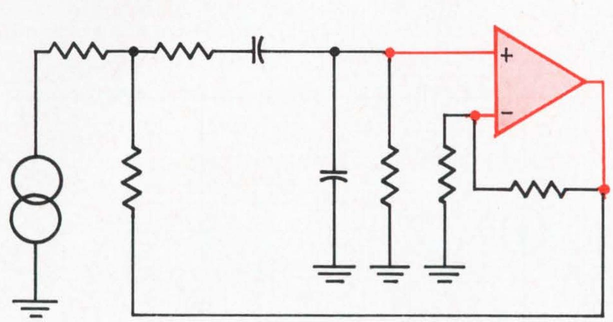


(C) CURRENT-CONTROLLED VOLTAGE SOURCE



(d) CURRENT AMPLIFIER

Applying controlled sources. Four basic types of controlled sources that use operational amplifiers are shown above. When combined with RC passive networks the system can be used to provide desired transfer functions, having adjustable complex poles.



Second-order transfer functions. A typical circuit that can be used to produce second-order transfer functions is this one proposed by Sallen and Key. It assures stable frequency operation and is easily built with a small number of components.

The corresponding loop-gain magnitude thus becomes

$$|A\beta\,(j\omega)| = (A\beta)\,F\omega \qquad (14)$$

where

$$F_\omega = \frac{1}{\sqrt{1+\left(\frac{\omega}{\Omega}\right)^2}} \qquad (15)$$

$A\beta$ is real, then, below $\omega = \Omega$.

Gain stability

Op amps are popular in active-network synthesis because their high open-loop gain can provide highly stable closed-loop gain. Gain stability depends mainly on the amount of available loop gain and the stability of the feedback network.

In terms of the sensitivity of a network function ψ with respect to an element x as defined by

$$S_x^\psi = \frac{d\psi}{dx}\left(\frac{x}{\psi}\right) \qquad (16)$$

the relative variation in closed-loop gain with small variations in amplifier characteristics is given by:

$$\frac{dG}{G} = S_{Ao}^{G}\frac{dA_o}{A_o} + S_{\beta o}^{G}\frac{d\beta_o}{\beta_o} + S_{Ri}^{G}\frac{dR_i}{R_i} + S_{Ro}^{G}\frac{dR_o}{R_o} \qquad (17)$$

the relative variation in closed-loop gain with small similar for both the inverting and noninverting modes. Assuming that the available loop gain is much larger than unity—one reason for using an op amp in a feedback mode—the sensitivity functions in equation 17 turn out to be very simple. The sensitivity to variations in open-loop amplifier characteristics—gain, input and output impedance—is inversely proportional to the available loop gain. The actual functions can be approximated by the gain error, E, given by equation 7.

The sensitivity to variations in the external feedback network varies from 1 to 2 for the inverting mode and is approximately equal to 1 in the noninverting mode. This relatively high sensitivity, which isn't reduced by loop gain, can be made by selecting sufficiently stable components for the feedback network.

In practice, it's useful to consider finite differentials rather than derivatives when evaluating equation 17. Thus, $\Delta A_o/A_o$ represents the relative tolerance and drift due to temperature changes of the open-loop gain. This is usually specified by the manufacturer; $\Delta\beta_o/\beta_o$ gives a measure of the stability and tracking capabilities of the external feedback network. Similarly, $\Delta R_i/R_i$ gives a measure of input-impedance drift and $\Delta R_o/R_o$ of output-impedance drift.

It is well known that one of the major problems in active RC network synthesis is that of minimizing the network sensitivity. The two main reasons for this are that the individual network elements, especially the active ones, may drift appreciably with ambient variations, and that active networks, unlike passive ones, are only conditionally stable. The location of active-network transmission poles isn't limited to the negative s-plane, and drift may cause severe underdamping or even oscillation. Thus, to ensure the stability of an active RC network, it's especially vital that the sensitivity of the dominant poles be minimized.

Pole displacement

Assuming uniform passive-component variations, such as those available from integrated circuits, and the effects of the active elements lumped into those of a single equivalent active device, the drift of the jth pole due to drift in all capacitors, resistors, and the active element, G, is given by

$$dp_j = S_G^{p_j} \frac{dG}{G} - p_j\left(\frac{dR}{R} + \frac{dC}{C}\right) \quad (18)$$

The pole displacement given by this expression can be represented by a vector diagram in the s-plane, as shown on page 100. It can be easily verified that the displacement due to the passive elements, RC products, takes place in a radial direction, but the displacement due to the active element has the same direction as the pole sensitivity with respect to that element.

Active-network synthesis with op amps works especially well in two of the many methods of minimizing this pole displacement. One technique seeks to minimize pole sensitivity with respect to the active elements, the other to minimize variations in their gain. In both, the second term on the right side of equation 18 is minimized by using resistors and capacitors with equal but opposite temperature coefficients. The first method can be represented by

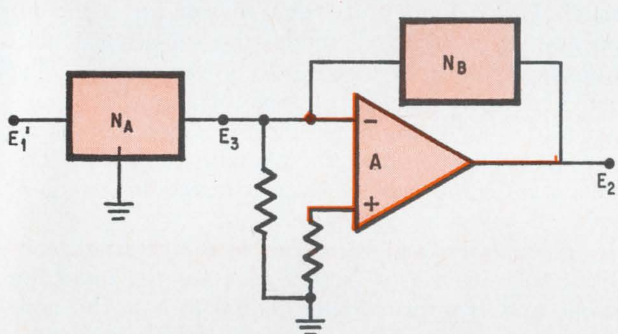
$$S_G^{p_j} \rightarrow 0 \quad (19)$$

and the second by

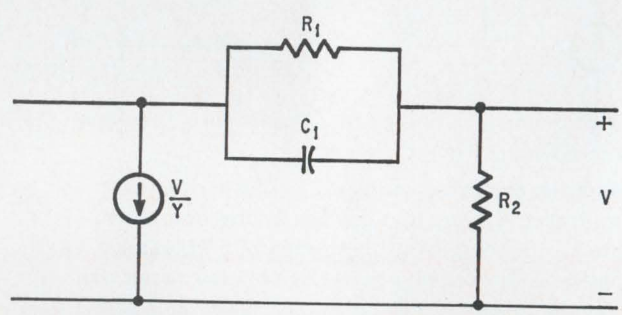
$$\frac{dG}{G} \rightarrow 0 \quad (20)$$

Typical networks that permit the realization of equation 19 are negative-feedback configurations with infinite gain and positive-feedback configurations with unity forward gain. In both, the pole sensitivity to G can be minimized by using amplifiers with sufficiently high loop gain. And the op amp, obviously, is very suitable for this approach.

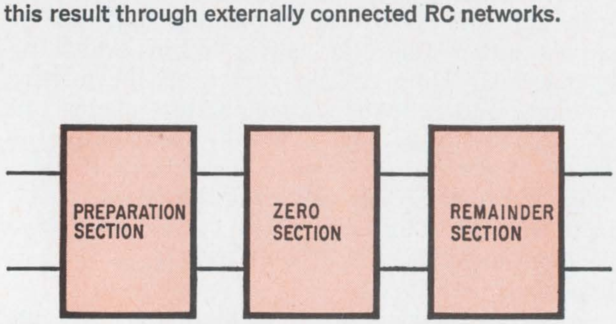
The second method stabilizes the performance of the active elements by local negative feedback around each element, using passive components with tight tracking properties. Op amps are also ideal for this process, because it's all the more effective the higher the available open-loop gain is for each active element. Because this means that the available closed-loop gain of each amplifier is reduced by individual feedback, more than one amplifier is often required in high-Q applications.



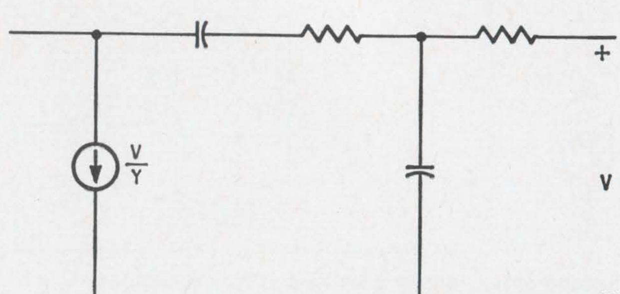
Simultaneous operation. A single operational amplifier is used to provide both the zeros and poles of a desired transfer function. It accomplishes this result through externally connected RC networks.



Zero section. A single transmission zero is produced in the right-half plane with this typical active-zero section.



Cascading. Transmission zeros and driving-point admittance can be achieved simultaneously with a three-section arrangement connected in cascade.



Pairing. Several groups of zero transmissions, including complex pairs, can be achieved with this active network. A controlled source is required for the transmission zero.

Active-network design with op amps was first proposed by H.H. Scott.[1] He foresaw the usefulness of the twin T as a parallel ladder-network capable of producing complex transfer-function zeros. These then produce complex poles by imbedding the passive network in the feedback loop of a high-gain vacuum-tube amplifier. The poles of such a configuration are then determined by the rejection frequency of the twin T. If the twin T gives a transfer function A(s)/B(s), the configuration has a voltage transfer function given by B(s)/A(s) when the forward amplifier's gain is large enough.

Some amplifier-oriented active networks require amplifiers with very high gain, while others use lower, but carefully controlled, gains. Both use op amps, but the latter type usually require controlled sources.

Four categories of controlled sources that use op amps are identified on page 101. Most of the synthesis procedures developed in recent years use controlled sources with passive RC networks to provide transfer functions. The passive twin T, however, remains particularly attractive when complex zeros of transmission or readily adjustable complex poles are needed. Algorithms such as those derived by W.H. Orr[2] have ensured the continued survival of the twin T in modern network design. These algorithms make it possible to design networks for prescribed, and independently switchable, notch depths and center frequencies.

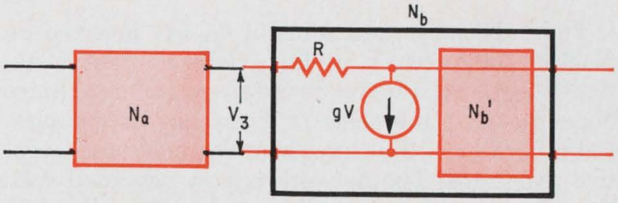
A classical active-network approach using controlled sources is that of R.P. Sallen and E.L. Key.[3] Their technique is useful for producing second-order transfer functions of the form

$$G(s) = \frac{a_2s^2 + a_1s + a_0}{b_2s^2 + b_1s + b_0} \tag{21}$$

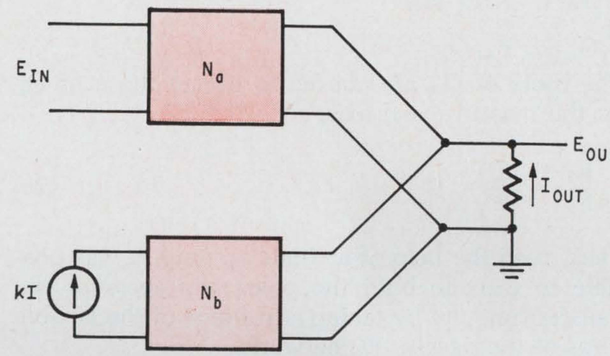
Higher-order transfer functions, whether voltage or current gains, or transfer impedances or admittances, are best achieved by cascading second-order sections. This approach improves sensitivity and simplifies design and adjustment by ensuring control of a single conjugate pole pair by a single active circuit.

Sallen and Key compiled a catalog of 18 basic networks used to produce complex or real poles or zeros, or both, for voltage-gain functions. All their results were frequency-normalized to ω_0 so they could be conveniently denormalized for any application. The networks require two or three capacitors, one or two op amps (as controlled sources), and two or more resistors. Critical pole frequencies depend on the RC products of passive networks; their damping, or bandwidth where appropriate, is a function of the amplifier gain.

This catalog provides alternate means of achieving a G(s) and lists criteria for choosing a network. One factor is the range of RC values needed. High-Q poles tend to need larger ratios of element values—the ratio of the largest to the smallest—and the most appropriate circuit might be one that minimizes this range. The designer must include not only the R's and C's required for the Sallen and Key design but also the bias resistors and compensation capacitors that help to make up the entire circuit.



Horowitz' synthesis. This cascaded arrangement achieves its RL transfer function from the zeros developed in the N_a and N_b' networks.



Kuh's method. An open-circuit voltage transfer function within a constant multiplier is made possible with a single control source and a few RC elements.

Another criterion is the network's sensitivity to changes in the passive and active elements. Some configurations provide for low sensitivity because they have unity gain and positive feedback. Finally, the complexity of the biasing and stabilization circuitry required by the various gains must be considered. A typical Sallen and Key configuration is shown on page 101.

Norman Balabanian and B. Patel[4] extended the work of Sallen and Key to include simultaneous realization of transmission zeros and poles located more independently of one another.

The most common op-amp network with a single loop and infinite gain is shown in the upper left network on the previous page. Assuming that N_B is a passive-feedback network with the voltage transfer function

$$G_B(s) = \frac{P_B(s)}{Q_B(s)} \tag{22}$$

then the function

$$\frac{E_2}{E_3} = \frac{A}{1 + AG_B} \tag{23}$$

as $A \to \infty$,

$$\frac{E_2}{E_3} \to \frac{1}{G_B} = \frac{Q_B(s)}{P_B(s)} \tag{24}$$

Thus, the poles and zeros of G_B are inverted by placing the network in the feedback path of A. Roots $Q_B(s)$ must lie on the negative real axis. Since N_B is passive, the zeros of $P_B(s)$ can be complex. Ratio E_2/E_3 can thus have complex poles and negative real zeros. The network is now cascaded with N_A. The impedance levels are intentionally mismatched to minimize interaction between networks. The over-all transfer function becomes

$$\frac{E_2}{E_1} = \frac{P_A}{Q_A} \cdot \frac{Q_B}{P_B} \qquad (25)$$

if $G_A = P_A/Q_A$.
The roots of Q_A are chosen to cancel those of Q_B on the negative real axis, so

$$\frac{E_2}{E_1} = \frac{P_A}{P_B} \qquad (26)$$

Thus, with the help of a single op amp, it was possible to provide both the poles and zeros of the transfer function by taking advantage of the flexible zeros of the passive RC networks.

The Horowitz procedure

Isaac Horowitz[5] suggested a cascade synthesis arrangement to realize transmission zeros and driving-point admittances simultaneously. Because a voltage transfer function is given by the ratios of a transfer and driving-point immittance (each assumed to have the same denominator or poles), Horowitz's procedure makes it possible to achieve a voltage transfer function to within a constant. That is,

$$G(s) = \frac{E_2}{E_1}(s) = \frac{y_{21}}{y_{11}} = \frac{\frac{N_{21}}{D}}{\frac{N_{11}}{D}} = \frac{N_{21}}{N_{11}} \qquad (27)$$

The zeros of N_{21} specify y_{21} to within a constant, and y_{11} is realized exactly. The zeros of N_{21} can be complex (they can even be on the positive real axis). Those of N_{11} must be negative and real, however.

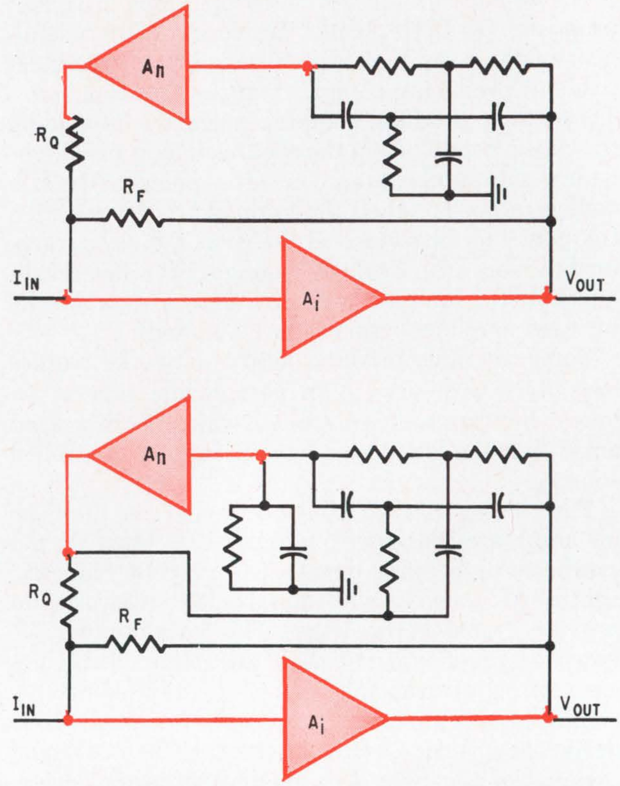
To realize a single transmission zero in the right-half plane, an active zero section is used. For pairs of zeros, including complex pairs, the active network shown on page 102, bottom right, may be used (notice the controlled source in each case).

In the same report, Horowitz outlined a procedure for realizing an open-circuit transfer impedance of a two-port network by using a single voltage-controlled voltage source. Here

$$z_{21} = \frac{Z^a_{21}\, Z^b_{21}}{Z^a_{22} + Z^b_{11}} = \frac{N}{D} \qquad (28)$$

where Z_{21} can be related to the two driving-point functions in its denominator. One is RC, the other RL; possible expansions for the denominator D are

$$Z^a_{22} = \Sigma \frac{k_i}{s + \sigma_i} \text{ and } Z^b_{11} = R_1 - \Sigma \frac{k_j}{s + \sigma_j}$$



Frequency emphasizing networks. Circuit on top provides medium Q transfer functions; for high selectivity the bottom network is used.

The circuit at the top of the previous page can be used to realize the RL function with an active RC network. At the same time, the transmission zeros are developed from z^a_{21} and z^b_{21}. Standard ladder-type passive networks usually meet the needs.

Kuh's approach

Another approach was proposed by E.S. Kuh.[6] It provides for the realization of a prescribed open-circuit voltage transfer function within a constant multiplier. The method requires one controlled source and a few passive RC components. The configuration is shown in the lower drawing on page 103, where the load impedance is assumed to be resistive and normalized to 1 ohm.

For this configuration

$$E_2/E_1 = \frac{y^a_{21}}{y^a_{22} + y^b_{22} + 1 + ky^b_{21}} = H\frac{N(s)}{D(s)} \qquad (29)$$

The designer can arbitrarily choose a polynomial q(s) with distinct zeros on the negative real axis. Depending on the technique chosen, the degree of q(s) should be equal to or one less than that of D(s). Then

$$-y^a_{21} = H\frac{N(s)}{D(s)} \qquad (30)$$

and

$$y^a_{22} + y^b_{22} + 1 + ky^b_{21} = \frac{D}{q} \qquad (31)$$

Taking a Foster expansion of D/q yields,

$$\frac{D}{q} = k_0 + k_\infty s + \sum_i \frac{k_i s}{s + \sigma_i} - \sum_j \frac{h_j s}{s + \sigma_j} \qquad (32)$$

and

$$y^b_{22} = -y^b_{21} = G + \sum_j \frac{h_j{}^* s}{s + \sigma_j} \qquad (33)$$

If $(k-l)G + k_O - 1 \geqq 0$ and $(k-l)h_j{}^* - h_j > 0$ for all j, y^a_{22} can be realized as an RC admittance. This completes the synthesis.

Many other synthesis procedures are available for active networks. Some use two op amps to produce the appropriate active filter characterizations.

Filter building blocks

If integrated filters are to become economically feasible, a method of network synthesis that allows circuit standardization must be used. This has been proven in the field of digital integrated circuits, where complex systems are broken down into small families of logic building blocks; high production quantities mean low cost. Two methods of designing filter building blocks with op amps have been advanced recently. The first uses frequency-emphasizing networks (FEN's), the second the Miller integrator.

The FEN technique was developed to synthesis general second-order transfer functions of the form

$$T(s) = K \frac{s^2 + \frac{\omega_z}{q_z} s + \omega_z{}^2}{s^2 + \frac{\omega_p}{q_p} s + \omega_p{}^2} \qquad (34)$$

Higher-order transfer functions are obtained by cascading second-order sections. The synthesis method consists of decomposing T(s) into the product of two functions. The first function is the transfer admittance of a passive RC network that provides the asymptotic characteristic of the function T(s), namely

$$(y_{21})_R = K_R \cdot \frac{s^2 + \frac{\omega_z}{q_z} s + \omega_z{}^2}{s^2 + \frac{\omega_p}{q_R} s + \omega_p{}^2} \qquad (35)$$

where

$$q_R < 0.5 \qquad (36$$

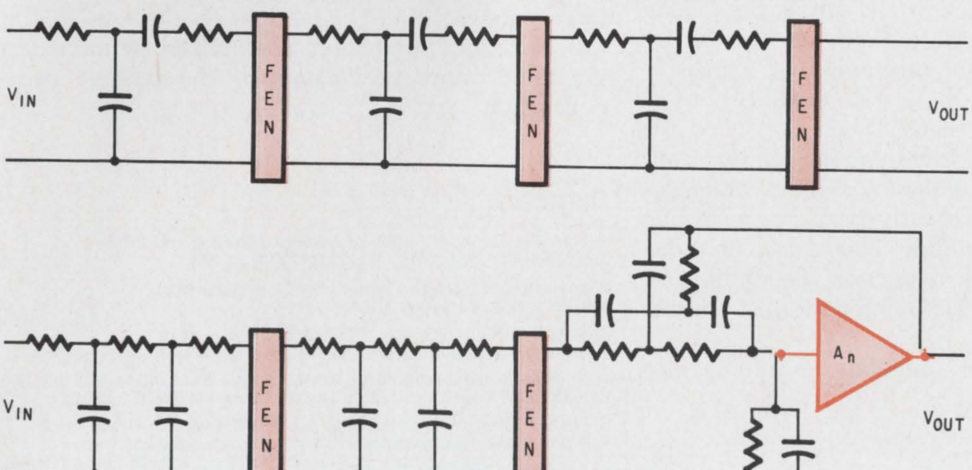
for a passive network. The second function is the transfer impedance of an active correcting network. Such a network is cascaded to the passive network to provide the prescribed characteristic T(s) by pole-zero cancellation, thus:

$$(z_{21})_A = K_A \cdot \frac{s^2 + \frac{\omega_p}{q_R} s + \omega_p{}^2}{s^2 + \frac{\omega_p}{q_p} s + \omega_p{}^2} \qquad (37)$$

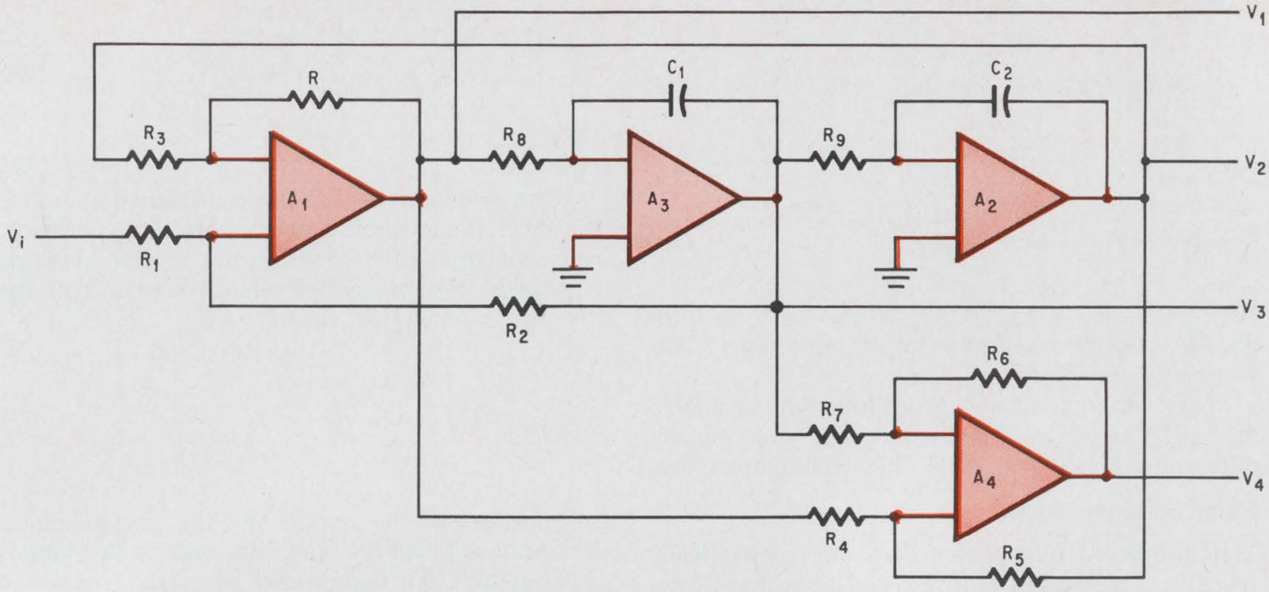
Regardless of the nature of T(s), $(z_{21})_A$ defines the response of a FEN. The filter type to be synthesized is therefore determined by $(y_{21})_R$. There are many techniques for producing specified RC short-circuit transfer admittances.

The circuit configurations on the opposite page provide a transfer impedance with FEN characteristics; A_i is an inverting and A_N a noninverting op amp. For medium-selectivity transfer functions—those with q_p values of less than 50—the top configuration is used. For high-selectivity realizations, this configuration is modified to that of the bottom one, which has a second feedback loop. This approach can yield high-selectivity filters with closed-loop gain values of A_N that are close to unity. The closed-loop gain of A_i is restricted only by the loop gain necessary to maintain a specified degree of Q-stability. For absolutely stable high-Q filters, the bandwidth of A_N must exceed that of A_i. To obtain perfect pole-zero cancellation between $(y_{21})_R$ and $(z_{21})_A$ in high-selectivity filters, $(y_{21})_R$ must also be active in the form of a Sallen and Key network. With only modest q_R values for the Sallen and Key networks, stable high Q-transfer functions T(s) can be realized.

The FEN's are stabilized by minimizing the gain variations of the active elements. Thus, by distrib-



FEN filter synthesis. A sixth-order bandpass filter (top drawing) and a sixth-order elliptic lowpass filter (bottom drawing) are built with frequency emphasing networks (FEN's). These units provide the RC networks with resonance properties similar to those of LC networks.



Miller integrator. One approach to achieving a desired transfer function is to use a basic Miller integrating network consisting of amplifier and RC network. Several such units are employed here to produce second-order transfer functions.

uting the gain of the active feedback loop between two op amps, each can be sufficiently stabilized by local negative feedback to ensure high-Q stability. Frequency is stabilized by matching the temperature coefficients of the resistors and capacitors of the frequency-determining twin T in the feedback loop. Two typical filter configurations using FEN's are on the bottom of the previous page. The top drawing shows a sixth-order bandpass filter, the other a sixth-order elliptical low-pass filter. Note that here transmission zeros aren't obtained by cascading an RC null network (twin T) with a FEN. The active feedback loop of a high-selectivity FEN is used instead, because it contains an appropriate active frequency rejection network. This economizes on components and twin-T tuning, but it's feasible only for medium-selectivity filtering.

The integrator method

Active-filter realizations using the Miller integrator as a building block are as old as the analog computer. Familiar synthesis methods use the integrators to simulate the reactances in a passive filter on a one-to-one basis. A modification of the leapfrog filter has recently been suggested for the design of tunable low-frequency filters and stable high-Q bandpass filters. A similar configuration shown above has recently been suggested as an all-purpose filter building block that provides any second-order transfer function, depending on which output terminal—or combination of output terminals—is used.

The resulting transfer functions of interest are

$$\frac{V_1}{V_i} = K_1 \frac{s^2}{as^2 + bs + c} \quad (38)$$

$$\frac{V_2}{V_i} = K_2 \frac{1}{as^2 + bs + c} \quad (39)$$

$$\frac{V_3}{V_i} = -K_3 \frac{s}{as^2 + bs + c} \quad (40)$$

Complex zeros are obtained at the output of the summing amplifier, A_4, which adds weighted quantities of the outputs V_1, V_2, and V_3.

The constants, K_1, K_2, and K_3, and the coefficients, a, b, and c, depend only on the passive-circuit components provided the open-loop gain of the four op amps A_1 to A_4 is high enough.

Stability is obtained here by minimizing the pole sensitivity with respect to the active elements. Except for some negligibly small terms that depend on the passive components, the pole-sensitivity functions with respect to the active devices depend primarily on terms that are inversely proportional to the respective open-loop gain values. If these are large enough, high-Q stability results. As in the FEN technique, frequency is stabilzed by matching the temperature coefficients of the passive components. ■

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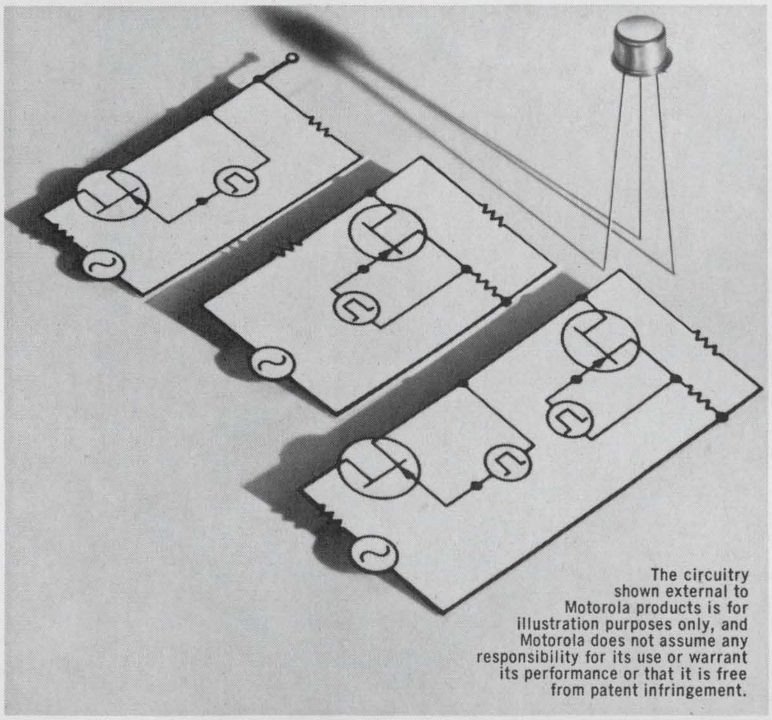
16 FET SOLUTIONS TO CHOPPER PROBLEMS



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MFE2008	30	30	15	25	20	0.75	3.50
MFE2009	20	30	15	25	50	0.75	4.50
MFE2010	25	50	20	25	15	0.75	3.50
MFE2011	15	50	20	25	40	0.75	5.00
MFE2012	10	50	20	25	100	0.75	6.50
2N4091	30	16	5	40	30	0.2	4.10
2N4092	50	16	5	40	15	0.2	3.10
2N4093	80	16	5	40	8	0.2	2.30
2N4391	30	14	3.5	40	50-150	0.4	4.30
2N4392	60	14	3.5	40	25–75	0.4	3.30
2N4393	100	14	3.5	40	5–30	0.4	3.80
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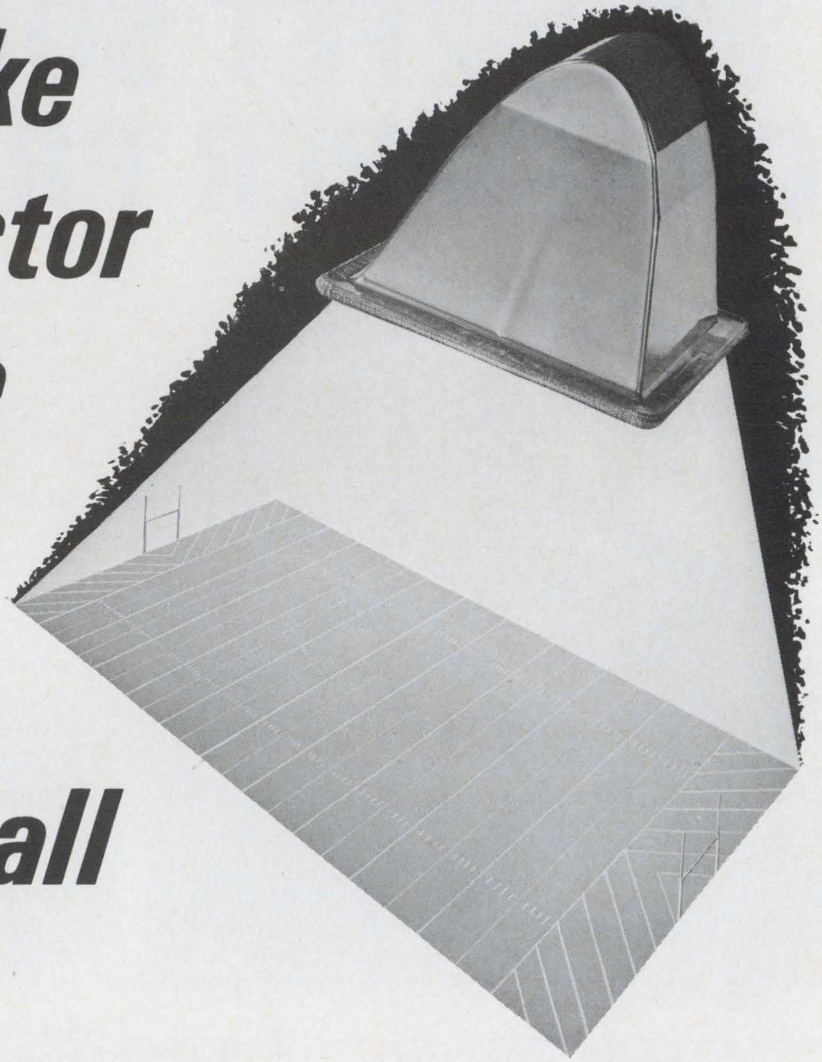

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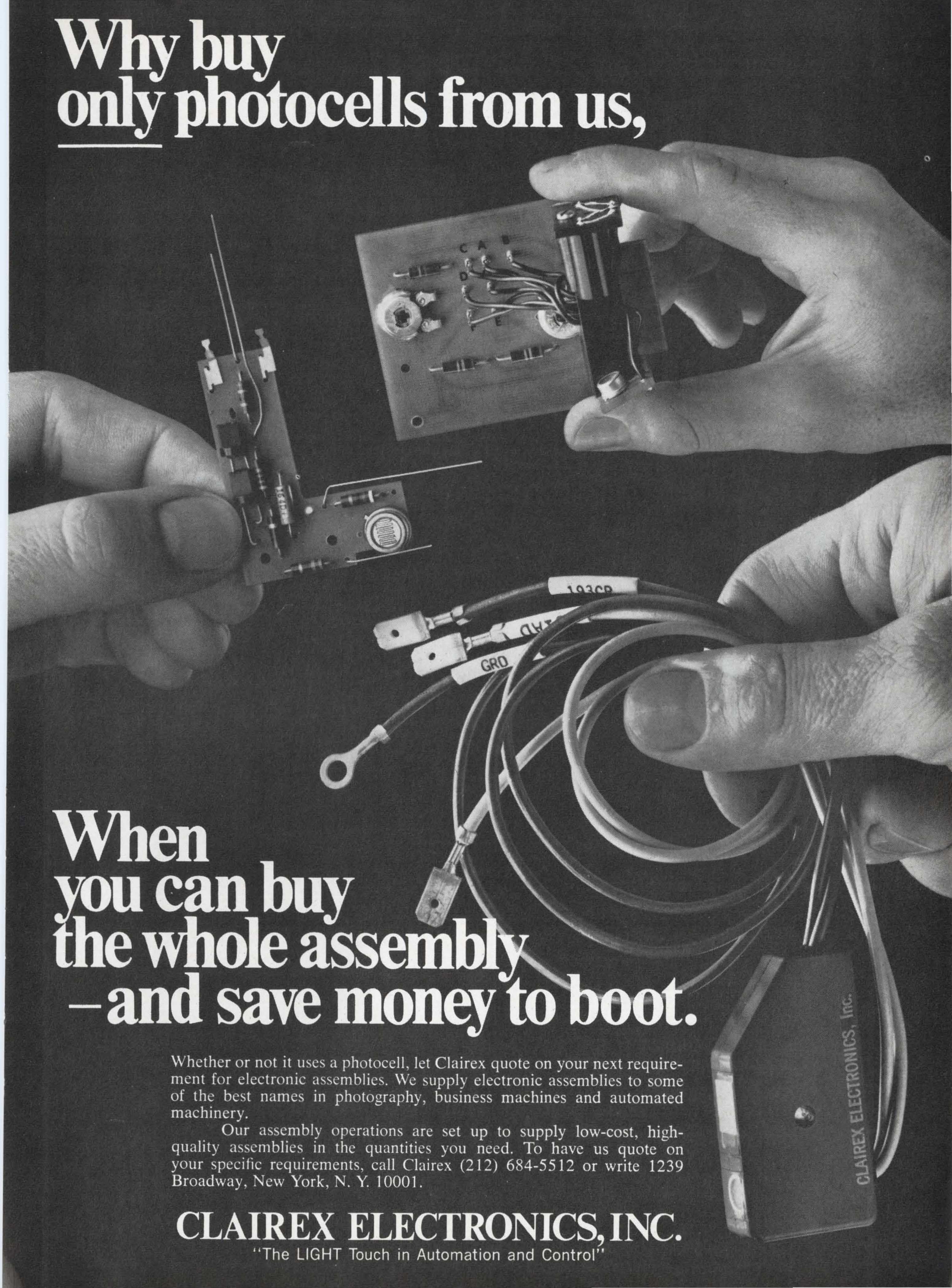
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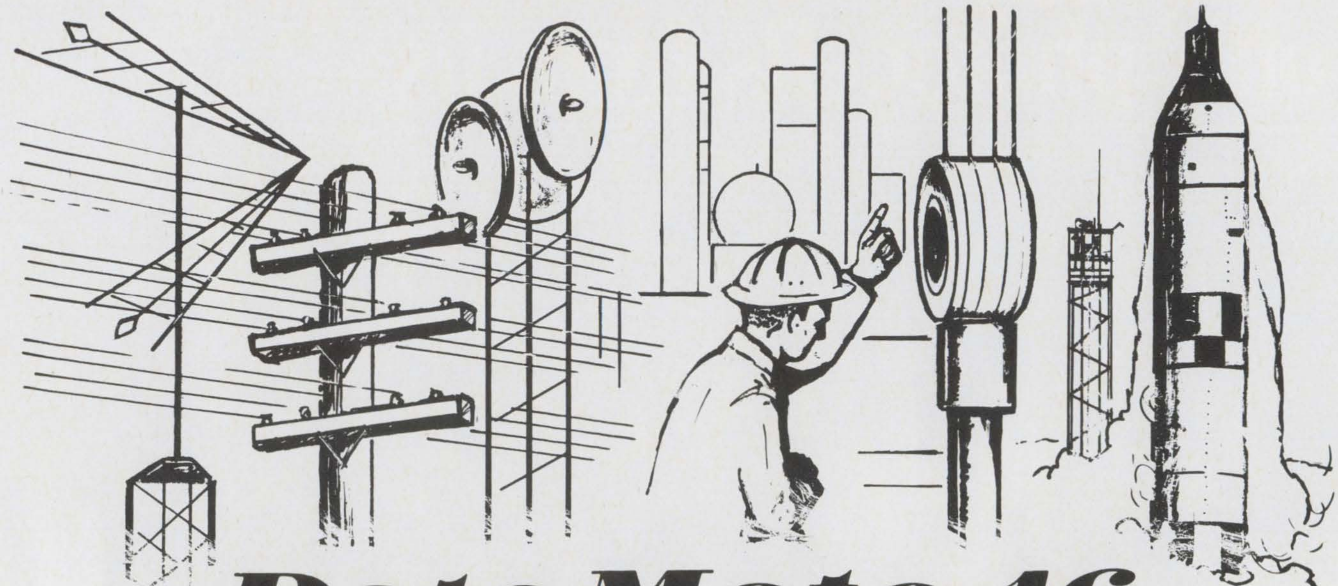

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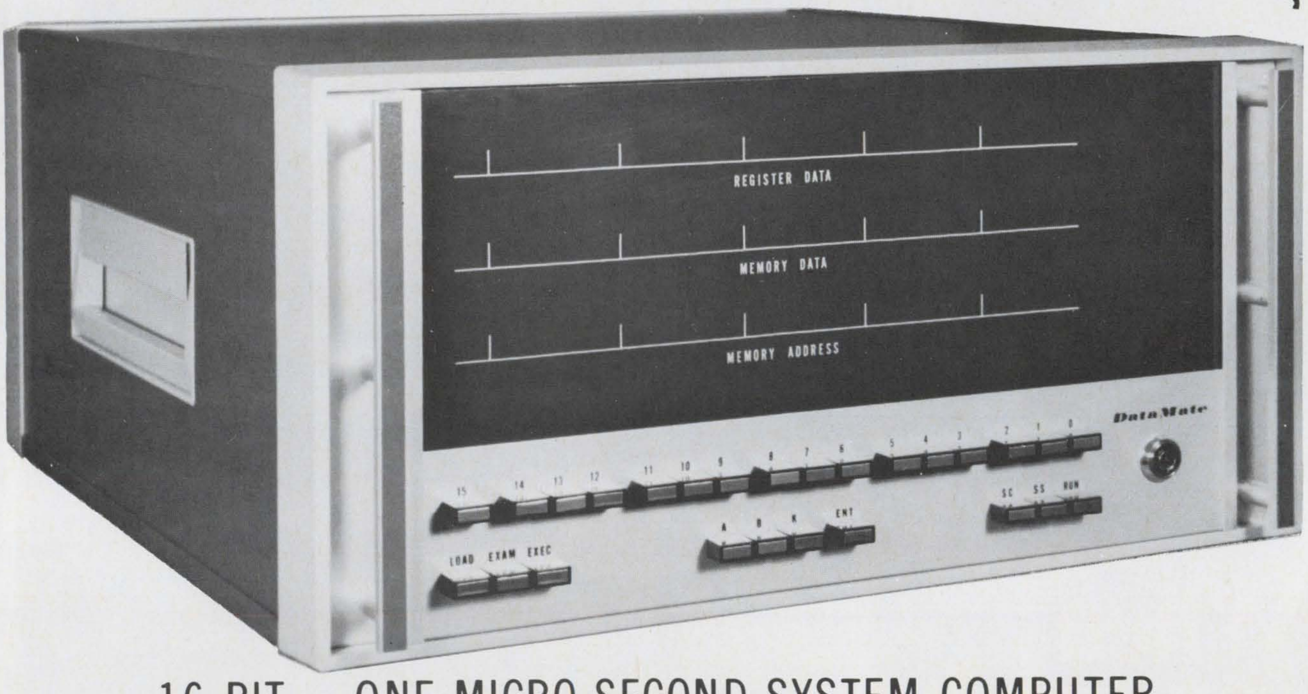

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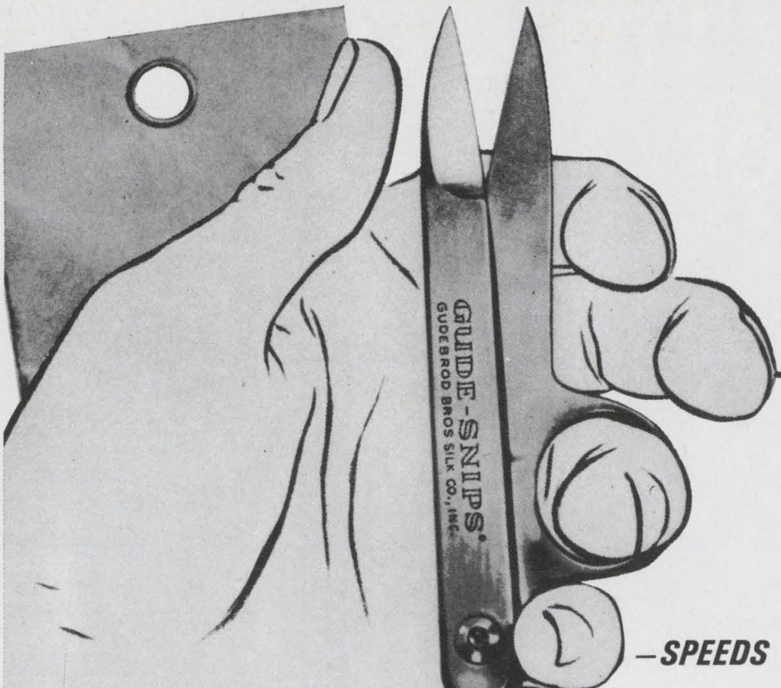

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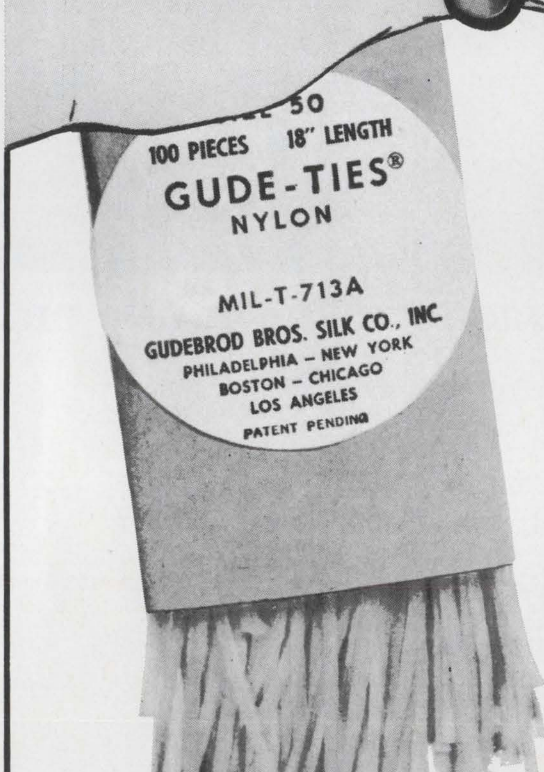

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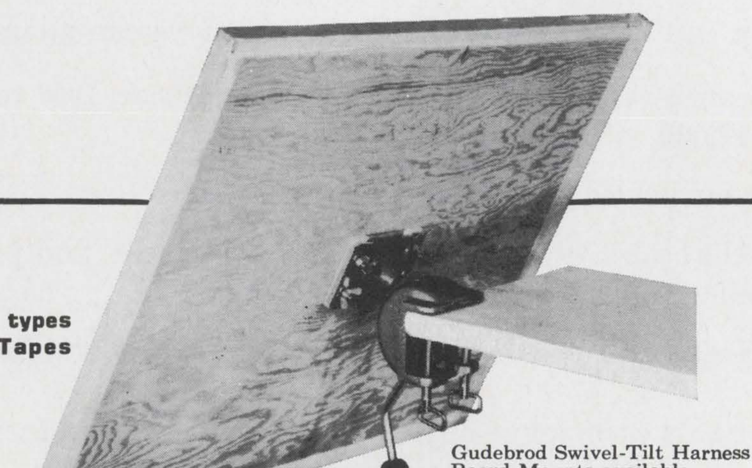

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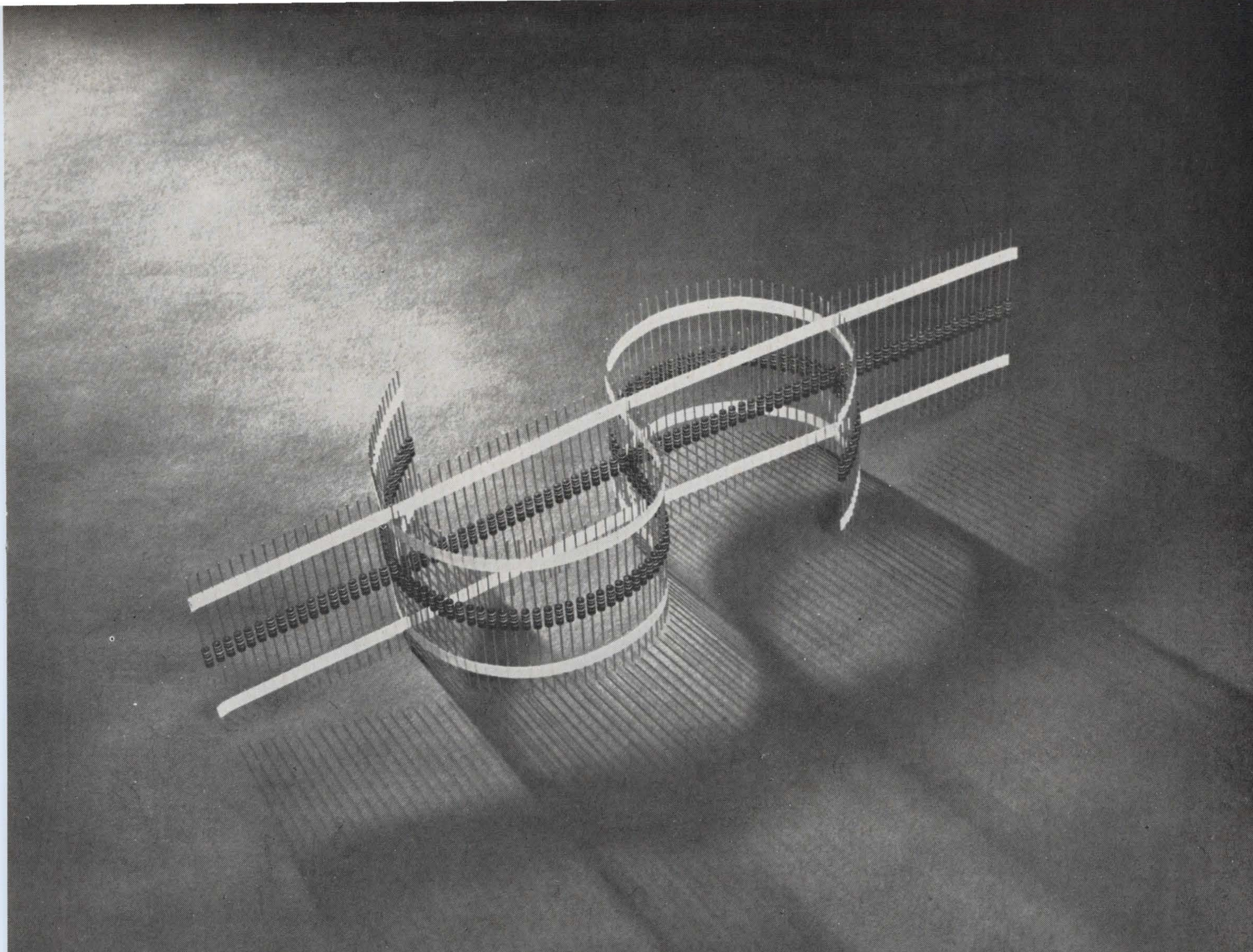

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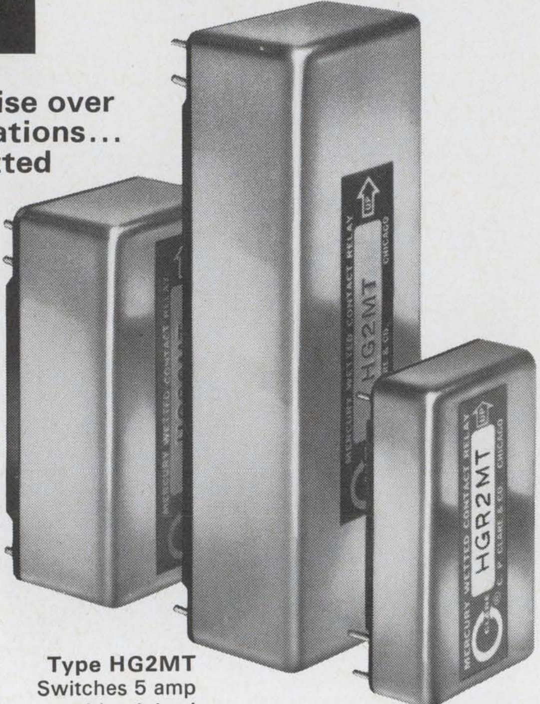

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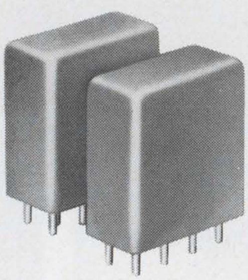

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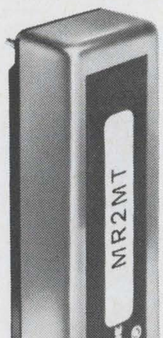

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MR2MT	2 Form A	10 μv max.	5 μv max., P-P
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Federal outlets tough for foreigners

The world's largest electronics customer prefers to deal with U.S. concerns, but firms with unique products can do well, particularly at civilian agencies

By Robert Skole
Washington bureau manager

Many foreign electronics firms have all but given up trying to sell the U.S. Government, especially military outlets. But some have tackled this market and done surprisingly well. The situation, of course, is of more than passing interest to the domestic electronics industry—parts of which have proved extremely vulnerable to competition from imports.

At first glance, the problems in doing business with the world's biggest customer appear almost insurmountable for an overseas concern. For one thing, there's the Buy-American act, which gives preference to domestic manufacturers competing for Government contracts. Although each Federal department and agency works out its own specifics for implementing the law, the upshot is that foreign firms must be willing to bid at least 6% under the lowest American company to get a job on a competitive basis. If small businesses or firms based in depressed areas are involved, foreign bids must be at least 12% under the lowest American bid.

The Department of Defense, on orders from former Secretary McNamara, has made it even tougher for foreign firms to compete. Armed services procurement regulations established last year provide that foreign bids must be "adjusted" by upping the bid 50% exclusive of duty. The "best" foreign figure is then rated against the lowest American bid. Finally, all cases of foreign bidding are decided by senior officers rather than lower echelon procurement officials. And the Secretary of Defense must approve all foreign contracts exceeding $100,000.

McNamara made it quite clear that he thought it was a long-run waste to buy foreign equipment unless it was unique and unavailable from American firms. He figured the administrative cost of supervising quality control abroad and ensuring an adequate supply of spare parts and ready service was simply too high. And the same philosophy permeates the Pentagon now that McNamara's gone.

Overcoming the odds

Nonetheless, some foreign electronics products have been sold—and are being sold—to the military. On the whole, however, overseas firms have less trouble selling civilian agencies, which use only the 6% and 12% penalties and often encourage foreign competition "to keep American suppliers' pencils sharp."

Foreign firms that sell the military normally do so through competitive negotiation or as sole sources of supply. Only 11.5% of all military contracts are actually awarded through competitive advertised bidding; 30.6% are let through competitive negotiations, and 57.9% by single-source negotiation. When a foreign firm is a sole supplier on a contract that is negotiated, there's no 50% penalty.

"Competition with the 6% and 12% penalty is possible," says one British trade official. "We don't like it, but it doesn't stop business. But the 50% impost does stop us, and I guess that's what it's intended to do."

British manufacturers got a chance to enter the American military market on a no penalty basis under the terms of the sale of $2.5

Caught in the act

If President-elect Nixon is protection-minded on the subject of trade, he might consider ordering some American-made tape recorders. Last year, when President Johnson announced that the Government would reduce its purchases of imported goods to help stem the flow of gold from the country, his words were being preserved on Swiss tape recorders.

The White House Communications Agency, a branch of the Army, has about 30 tape recorders manufactured by Nagra of Switzerland. Price at around $1,000 each, these machines have been storing LBJ's utterances for several years now. A White House sound technician asked about the use of Nagra, rather than American-made machines, answers: "They're the best ones made." Nagra, however, is not cashing in on this "testimonial." Like most other firms selling Uncle Sam, it prefers to let well enough alone.

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. . . foreign firms do better going after subcontracts . . .

billion worth of F-111 aircraft to the Royal Air Force. The 1966 agreement which lapsed a few months ago allowed British concerns to sell about $300 millon of goods, including Rolls-Royce engines, Jetstream aircraft, survey ships, and Elliott Automation's head-up display.

Caveat vendor. "We learned that even if the Buy-American act was waived, it was no piece of cake to get prime contracts from the Department of Defense," the trade official says. "It's fairly obvious to us now that the best way to break into this market is to go in for subcontracting, and that's what we're encouraging our manufacturers to go after."

He points out that under normal procurement regulations overseas firms can serve as subcontractors without running into Buy-American obstacles as long as the value of foreign components is less than half the total. British concerns supplied some important electronic equipment for the C-5A transport—including monitoring gear and an "artificial feel" device that provides the pilot with proper stick tension and play.

But the American services don't necessarily beat paths to the doors of manufacturers with better mousetraps. A classic example is the mortar locating radar manufactured by EMI of Great Britain. Although this equipment has been used by British forces and several NATO countries for almost 10 years and this type of apparatus is at the top of the priority lists for service in Vietnam, the Army has turned thumbs down on it. One reason given by the brass is that it wants 300° radar; the EMI equipment scans only 180°.

A Pentagon source familiar with the situation says that if EMI had been more aggressive in marketing its equipment it probably would have been able to sell some. "Hell, if I were them, I'd put units into the hands of the Australians in Vietnam," he says. "Get a few good news stories about the sophisticated equipment the Australians have—and the American don't—and some Congressmen would start squawking. Then you'd see how fast doors open around here."

Walk softly. "One of the secrets of selling to the Government is never get so big that you are hurting an American firm," says one representative of a foreign company. "And it also helps if your American competition is active in your own home country. You'd never hear IBM complain about a Dutch computer sold to the American Government, would you?" As a matter of fact, the Dutch giant, Philips, has been successful in selling computer-based equipment to the Federal Aviation Administration for use in message switching.

Another company in the same field, Addo-X, of Sweden, has been selling to both civilian agencies and the military. The company makes equipment for capturing data on punched tape; one feature of this gear is that errors are detected before they go into the computer. Addo-X has sold a $75,000 installation to the Federal Housing Administration, for use in field offices' data collections, and has also done business with the Department of Agriculture and the Internal Revenue Service.

Inside jobs

Some foreign companies have cracked the Government market through licensing or U.S. manufacturing subsidiaries. Decca, for example, does both and imports equipment from Great Britain. The basic Decca Mark 8A navigation equipment is made under license by the Laboratory for Electronics, while the company's Houston plant manufacturers marine navigation equipment. The Decca Omnitrac system is made in Britain. "Some of our products are 100% British made, while others are 99% American made," says a Decca official.

Racal, a British communications equipment company, has established a plant in Rockville, Md., near Washington, with an eye to being close to the big military buyers. Racal officials say they have no problems selling to the Government even though they must often demonstrate new equipment that has been manufactured in Britain. The company makes gear that's commonly used for monitoring by the "spook shops"—the Defense Intelligence Agency and the

Central Intelligence Agency. The fact that it is designed in Britain is evidently no deterrent to sales. But a source at the Air Force Electronics Systems division points out that security is a major consideration when it comes to dealing with foreign suppliers. "We might need cryptographic equipment, for instance," he says. "And we wouldn't want to compromise our security by letting the specifications out of the country."

The ESD says several overseas electronics companies have bid for some of its work but only one—Japan's Nippon Electric—has succeeded. Nippon is now installing a microwave communications network in Japan for use with the service's Pacific area communications system. The contract, worth $13 million, was granted in December 1966. Buy-American act provisions don't apply to equipment to be used abroad, and the Air Force says it was logical to award the contract to a low-bidding Japanese firm.

Business is business. Some large American firms such as Raytheon, report that they rarely if ever subcontract abroad. But others, such as Sylvania Electric Products, like to operate there—albeit on a selective basis. "Many distributors of foreign products call on us, and often foreign firms' salesmen come over. On occasion, we'll send representatives to trade shows in Germany or Great Britain and other countries to get the feel of the market or look for certain items," says an official.

The Sylvania spokesman gives several reasons why his firm is willing to buy abroad. "Perhaps an American company can't deliver soon enough because he has so many orders or can't quite meet specs," he says, "and a foreign firm might do custom work to fulfill the contract. In a high-volume situation, a foreign company might give us a better price. We always try to have two or three sources for a product, and one might be overseas."

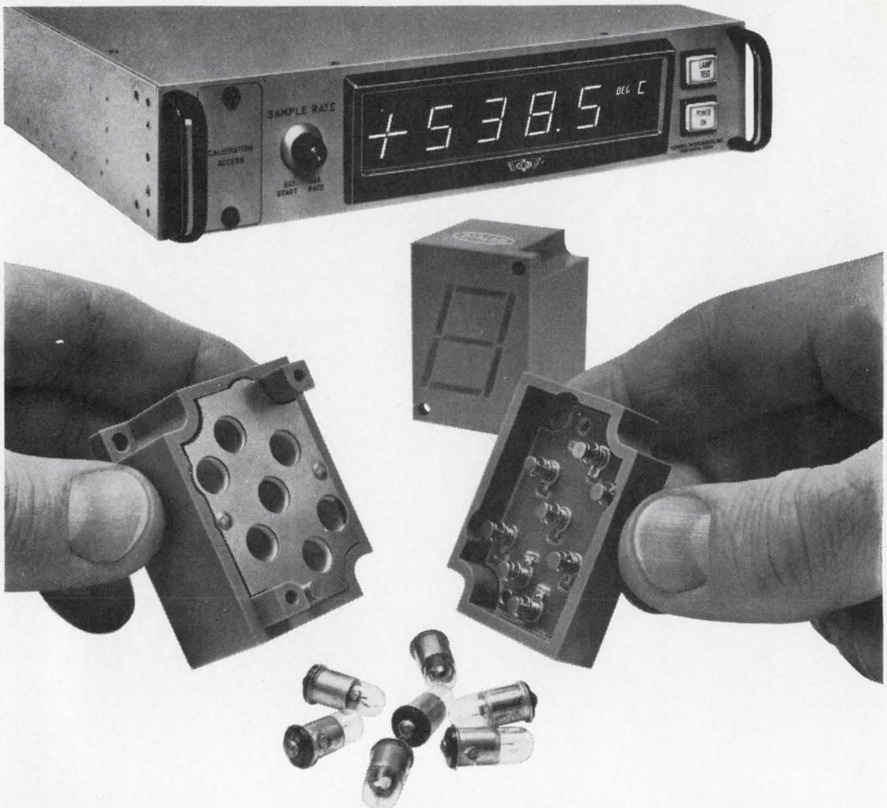
But, he points out, there are problems involved in buying outside the U.S. "Prices are not alway better abroad; they may look good there, but the cost of shipping, plus tariffs, may make the items more expensive than U.S. parts." Spare parts can also cause difficulties. "We must have continuity. A foreign firm that does just one run for a specific order will not be able to help when we come back a year later for more parts."

Better pickings. Although the Pentagon is the most tempting target for electronics salesmen from overseas, it's a lot easier for them to grab the much smaller fruits found in the civilian agencies. One of the most receptive to foreign companies these days is the Post Office. The Assistant Postmaster General for Research and Engineering, Leo Packer, makes it clear that he's ready to buy the best postal equipment available—no matter where it comes from. He even has one contracting specialist, a linguist, assigned to dealing with foreign suppliers.

Until a few years ago, whenever there was an international postal conference, top political figures would attend as representatives of the U.S. Foreign agencies, however, send technical specialists who spend most of their time discussing the latest developments in mechanization, automation, or whatever with their counterparts from other lands. Now the situation is quite different: the American Post Office assigns specialists with orders to see what they can learn.

The Government's number two electronics purchaser, NASA, isn't a particularly happy hunting ground for foreign firms. NASA has let only a few contracts to foreign firms—largely for on-site work at overseas tracking stations. But the agency will buy equipment from foreign companies when it is unavailable in the U.S.; on this list are special optical gear, electron microscopes, and cameras.

"Foreign businessmen should not be discouraged," says one space agency procurement official. "Aside from the Buy-American act, they face the same problems as domestic companies. It's a matter of ringing doorbells and wearing out shoe leather." He adds that NASA definitely wants to see foreign firms in the bidding. "Who knows?



. . . Government sales can be made in unlikely outlets . . .

They could very well come up with something we need. And more bidders keep things competitive."

On the other hand, a trade official of one foreign embassy says, "On the whole, the only firms that are ever going to sell here are those that have established a presence and that follow the market. That is one of the major advantages the American firms enjoy—they have built-in protection."

Specialties. A broad range of Government agencies are potential markets for companies that specialize. Although by American standards many of these outlets seem small in terms of dollars, the volume is significant abroad. For example, AGA, of Sweden, developed a laser geodimeter for the U.S. Coast and Geodetic Survey, under a contract worth about $78,000. The company made no profit on the job, but took on the project to get experience in the field. As a result, AGA now has commercial orders for about $150,000 worth of these surveying instruments and expects to get more Government work. American parts in the AGA laser equipment account for more than half the cost, so the gear doesn't fall under the Buy-American act.

Another example of successful specialization is the measuring equipment being made by Bruel and Kjaer Precision Instruments of Denmark for the National Bureau of Standards. The gear, which costs about $70,000, will monitor sound and vibration so standards can be set for homes underwritten by the Federal Housing Authority.

The Government market is so big—and sales, like that of the Danish measurement gear, can be hustled in such unlikely places—that covering all possible outlets can be a problem for foreign firms. The British are tackling this difficulty systematically. The commercial section at the embassy is studying the market—department by department and agency by agency. "At least we'll know what they are looking for and we'll be able to contact the right people," says an official. "That's often a major problem in itself for a foreign businessman."

Electronics abroad

Russia—an open market

Soviets give preference to foreign electronics suppliers since domestic industry can't handle all of nation's needs

By Jack Winkler

Moscow news bureau

Western electronics firms interested in the expanding Russian market have a better chance for quick success than their counterparts in other industrial fields. Automated instrumentation and control systems, medical equipment, and integrated circuits are high on the Kremlin's list of priorities, and the Soviet industry is admittedly weak in these areas. So prospects in this $50 million or so market look good for some time to come.

One possible limiting factor on exports to Russia might be the extent of its willingness to spend foreign exchange on electronics rather than other goods. But in view of the USSR's 1967 trade surplus of $1.2 billion—including $700 million from hard-currency capitalist nations—and government pronouncements stressing the need for automated production, improved information processing, and computer-based systems for a variety of applications, the outlook for continuing purchases is bright.

Guessing game. Just what this means in dollars, however, is a very moot point. Experienced traders put the current import market for electronic goods at anywhere from $15 million to $100 million. However, a check of all trade classifications that are nominally electronic suggests that last year's volume was about midway between.

Apart from the money involved, businessmen repeatedly report that the USSR is atypically receptive to pitches for electronic wares. In general, the Russians are considered fair but tough trading partners. Companies exhibiting electronic goods at collective trade shows seem to sell a higher percentage of the equipment they display than firms in other industries. And more important, the representatives of electronics concerns are more likely to be asked to arrange private showings of their lines.

As a rule, companies interested in selling the Soviets must make repeated appearances at large, highly competitive exhibitions, and their representatives must work hard to wangle an invitation to put on a lucrative solo show. The advice of the experienced is that most newcomers should be prepared to hoe a long, hard row to build their sales in Russia.

Shopping list

The preference accorded electronics firms doesn't result from naiveté. Soviet engineers know very well what's available and where it stands technologically. The USSR's generally excellent technical intelligence service is particularly strong in electronics. Every month, a volume running to 600 or 700 pages carries abstracts in Russian of reports on basic and applied research from all over the world.

Another advantage for electronics salesmen in Russia is a lack of competition. Most of the giant American electronics firms avoid Russia because of the U. S. embargo on strategic exports. And, among the continental firms Philips and AEG-Telefunken, for example, do very little business with the USSR. The leading seller of medical electronic equipment is a small Japanese firm, Nihon Kohden. Its gross sales are only $9 million but 10% are to Russia.

Rx for growth? Though the medical electronics field is wide open, surprisingly few foreign companies have made a play for it. Last July, on the 50th fiftieth anniversary of

Circle 127 on reader service card

. . . Russia lags the West in measurement techniques . . .

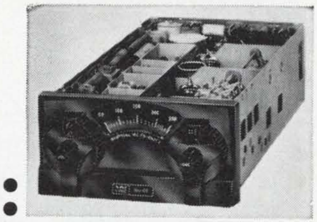
the Soviet Health Service, Minister Boris Petrovsky made so many exhortations for putting electronics into medicine that only the deaf could not have heard. He covered virtually every level—from setting up a nationwide computer network for medical data to equipping hospitals with the latest patient-monitoring equipment. How many of his proposals will eventually be realized is questionable, but the will—and presumably the money—is clearly there.

One American firm that has just entered Russian markets thinks process analysis equipment, particularly for the chemical field, is a good bet. The company, seeking a quick return on its investment, investigated a number of high-potential outlets before choosing to concentrate its merchandising efforts on this sector.

Fair play. Electronic measuring equipment is also a potentially lucrative area, according to knowledgeable sources. The bandwagon has already begun moving. Being held simultaneously at the end of last month, for example, were: a seven-day private show of measuring instruments by Hitachi in Moscow; a joint exhibit by 25 French firms in Novosibirsk, and a Moscow show with participation by nine electronics firms. The last was nominally for the automotive industry, but a substantial section was devoted to measuring and control equipment.

Firm after firm dealing with Russia reports that in every measuring area Soviet industry is years, if not decades, behind advanced Western practices. The Soviets know this, and a series of nine highly specialized invitation-only exhibitions this winter will deal with production applications. In every case the welcome mat is out only for firms with expertise in relevant measurement and control equipment and systems.

Soviet researchers frankly admit their shortcomings in integrated circuits. And, they concede, they can't even get into production with such technology as they have. Attempts to establish cooperative technical liaisons with American



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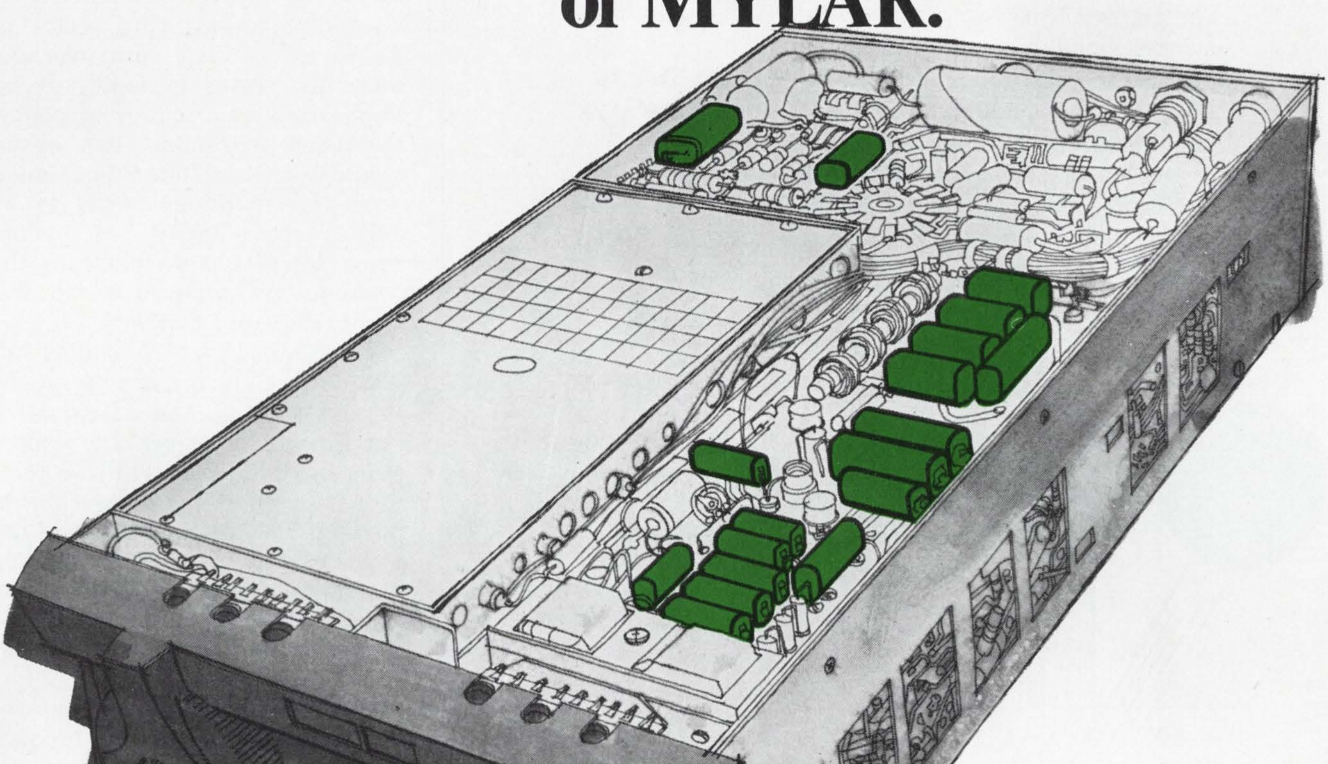

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. . . Russia's economy suffered a third-quarter slump . . .

firms have generally failed.

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Home front

The Soviets' concentration on buying foreign technology persists despite the buoyancy of their domestic electronics industry; with output running 18% ahead of 1967, it's the fastest-growing sector of the Soviet economy. Moreover, the consumer sector is finally being emphasized as a matter of policy. Television production, 15% ahead of last year after 10 months, should reach the ambitious target of 5.7 million sets. Radio and phonograph outputs were close to the 6-million level after 10 months, up about 8% from 1967.

The Soviet Union's economy suffered a third-quarter slump largely as a result of the invasion of Czechoslovakia. Over the longer term, however, there will be pressure from shortfalls in investment funding. Electronics obviously has some priority in the competition for capital, but it still isn't getting enough. Thus, the country should continue to welcome overseas firms.

Western visitors often observe that the USSR isn't getting the productive fallout from its space electronics programs that the U.S. is. But at least part of Russia's backwardness in electronics centers on getting advanced theoretical developments into mass production. This has led to some ludicrous situations. For example, the Soviets recently achieved a notable research breakthrough: theoretical development of phased-pulse multistable circuits that can work directly on a decimal system instead of a binary code and can be integrated. But the USSR is now trying to license its development abroad because, as one engineer discreetly puts it: "The industry is too weak here, and it would take us so long to get into production."

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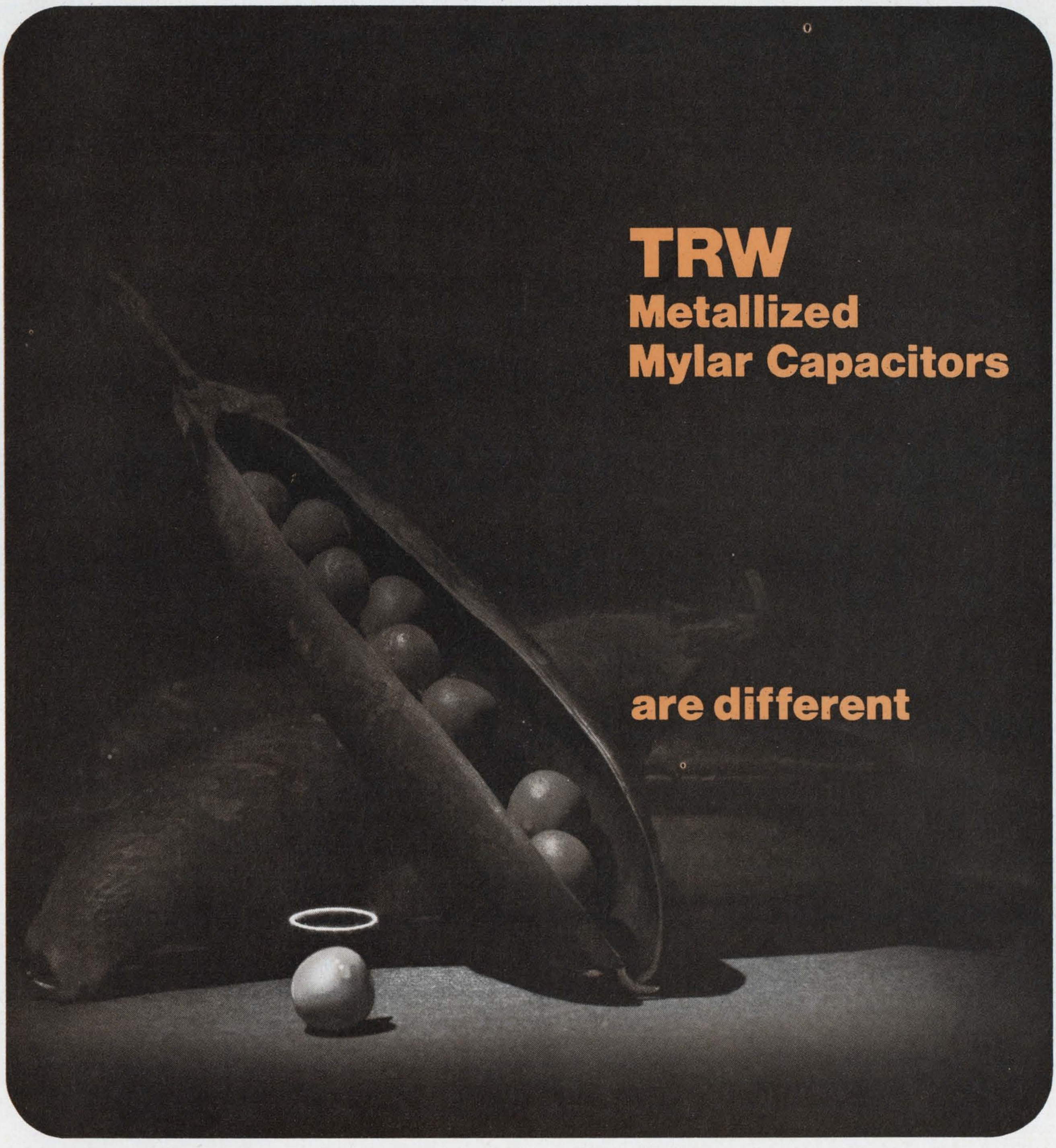

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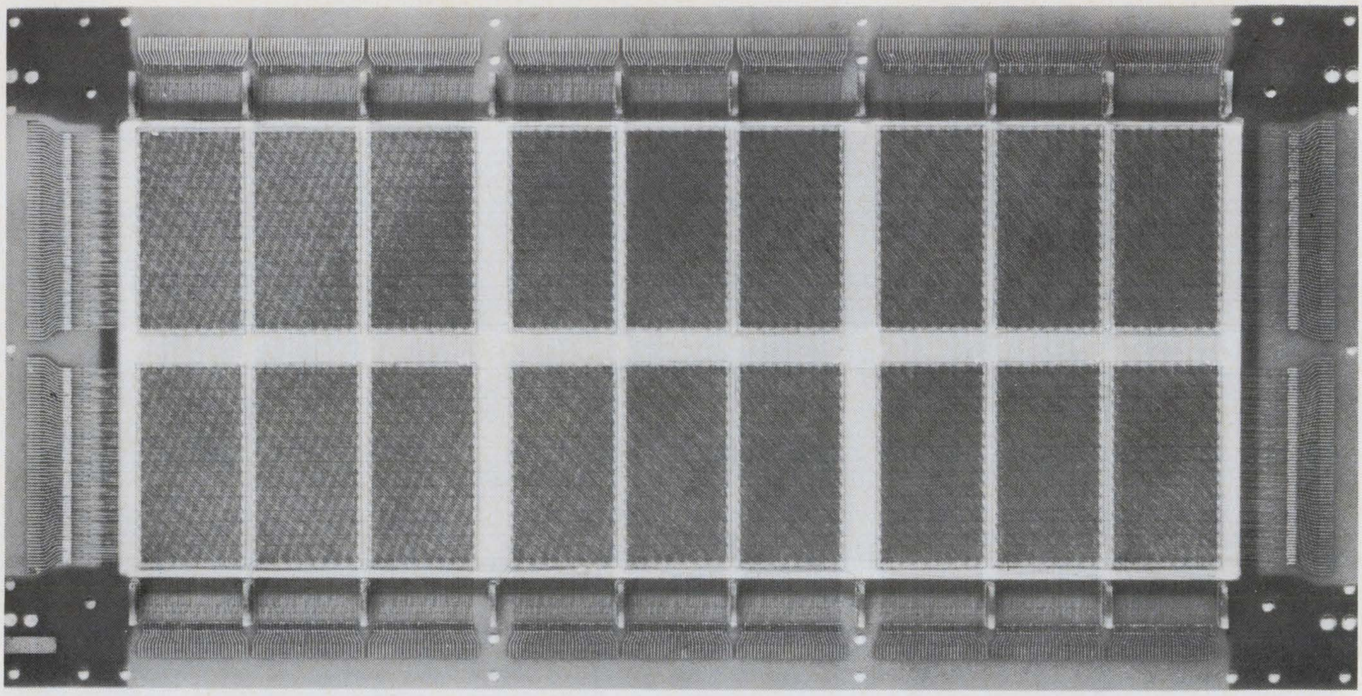

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			Drive Current Conditions			Output Signals			
			I_f/I_d (mA)	t_r (μsec)	t_w (μsec)	DV_1 (mV)	DV_z (mV)	t_p (μsec)	t_s (μsec)
Conventional Standard	50	H 5031	360/180	0.200	1.000	53	10	0.50	1.10
	30	HFC 338	520/260	0.100	0.300	54	7	0.20	0.35
	30	HFC 330	520/260	0.100	0.300	52	7	0.19	0.34
	30	HFC 308	680/340	0.100	0.320	60	6	0.20	0.35
	20	H 5020	680/340	0.050	0.180	46	6	0.11	0.20
Medium Temperature Range	50	H 5033	550/275	0.200	3.500	55	7	0.450	0.900
	30	H 5006	550/275	0.100	0.350	51	7	0.240	0.460
	18	H 5009	520/260	0.100	0.280	38	2.2	0.19	0.315
	18	H 5015	750/375	0.050	0.200	54	4.5	0.12	0.21
	16	H 5022	700/350	0.030	0.120	60	8	0.07	0.120
Wide Temperature Range	30	HFC 354	740/370	0.100	0.400	56	6	0.21	0.45
	20	HFC 258	894/447	0.050	0.160	42	4.8	0.11	0.19
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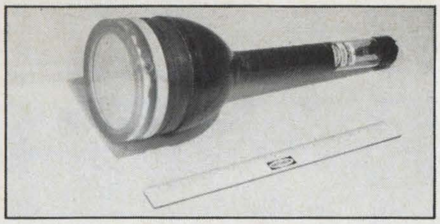

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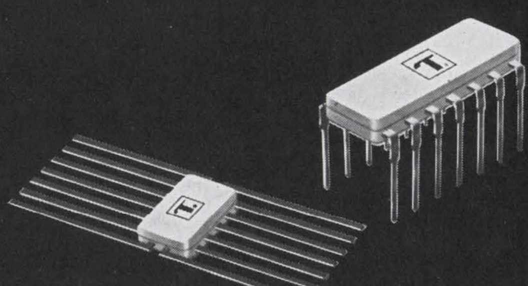

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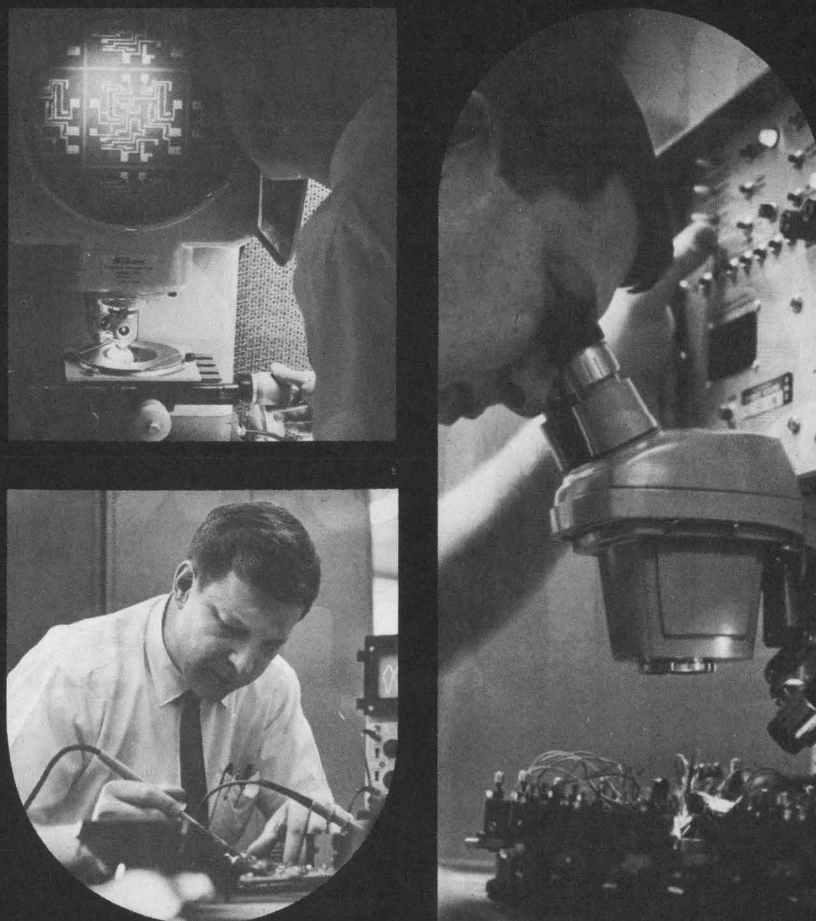

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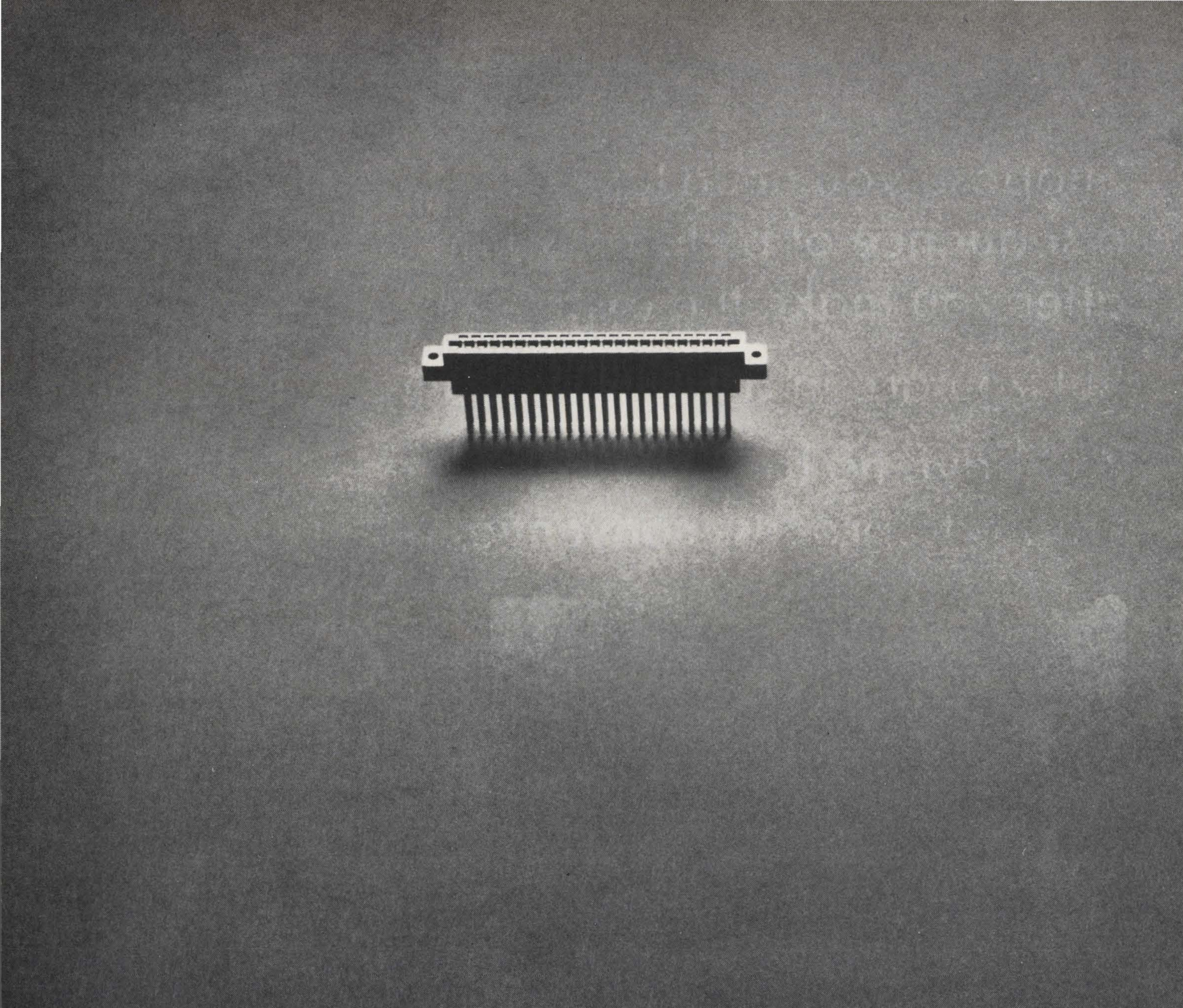

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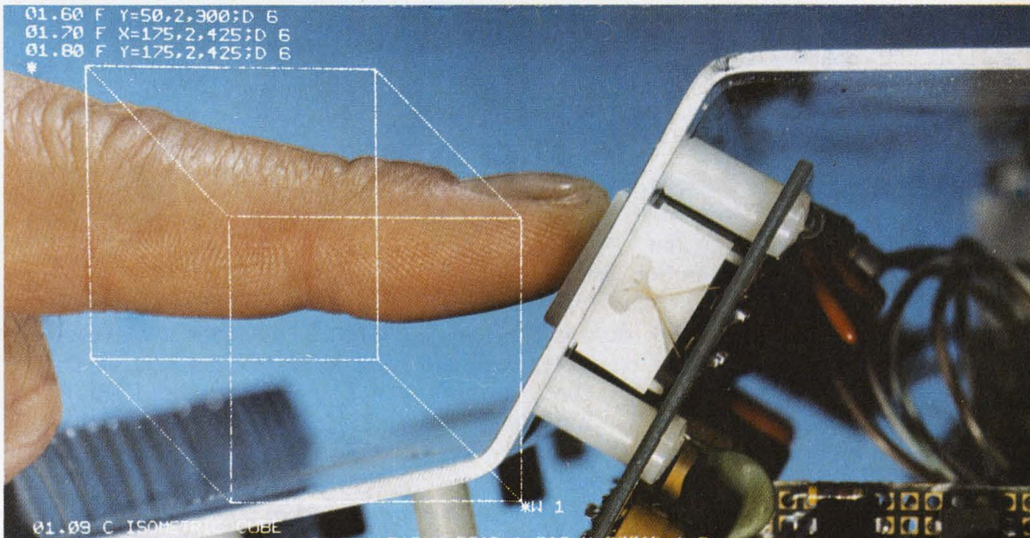
Graphics terminal displays attractive figure: under $10,000

Unit with storage crt handles alphanumerics and vectors; it's being unveiled at Fall Joint Computer Conference

By Walter Barney
San Francisco bureau manager

When Tektronix Inc. introduced last year a storage cathode-ray tube suitable for use in a graphic-display computer terminal [Electronics, Oct. 16, 1967, p. 165], many figured that it was only a matter of time before the company followed up with a complete terminal. They were right. At the Fall Joint Computer Conference in San Francisco, Tektronix is unveiling its type 4002 graphics computer terminal, including storage crt, terminal control, character generator, and keyboard. The terminal provides full alphanumeric and graphic display of data entered from a keyboard or auxiliary input, at a price which the company says will be under $10,000.

The storage tube, which doesn't require refreshment to maintain its display, is most suitable for time-shared computer systems, because it can operate at the end of a 2,000-bit-per-second telephone line. The first terminal has been tailored to the Digital Equipment Corp.'s PDP-8 computer; the terminal control inputs and outputs operate with standard DEC software. Tektronix has indicated that the terminal may be marketed through DEC or other computer manufacturers as well as through Tektronix' own sales force and field offices.



Controller. Pushbutton switches just above terminal keyboard use integrated circuits for switching and logic functions.

Keith Williams, vice president and marketing manager, expects the 4002 to appeal to some users who are now making manual plots from computer data. He concedes that the popular x-y plotter made by California Computer Products Inc. does provide a kind of low-cost graphics, but he indicates that Tektronix thinks of the Calcomp plotter as complementary equipment to the 4002. Williams also says that the 4002's faster writing means using less computer time than either an x-y plotter or a teletypewriter

Loner. Terminal reads out alphanumerics and vectors, retains display without recycling of information by computer.

is likely to use.

Blank buttons. The terminal won't be available until next August. John Griffin, manager of the electronics section of Tektronix' Information Display division, says the advance peek during the conference will "give computer people time to start thinking about graphics software." Three buttons that will be blank on the terminal shown at the conference will have a function that relates to one of the major drawbacks of the storage tube when used for computer display: the inability to erase selectively. Neither Williams nor Griffin will give details, but the terminal that will be available next summer will have some sort of off-line editing capability.

Meanwhile, Tektronix has doubled its ceramic tube production, indicating that it expects the storage tube to grab a good share of the terminal market. The 611 display unit introduced a year ago is already going into a rival computer terminal built by Computer Displays Inc. [Electronics, Feb. 19, p. 50]. It is priced at $12,750.

The 4002 has these features:

- Flicker-free display covering more than 50 square inches on an 11-inch diagonal.
- The ability to retain traces indefinitely; however, erasure after an hour is recommended.
- The ability to plot lines, points, and characters in any format.
- A writing speed of 1,000 characters per second and a line-drawing speed of 200 inches per second.
- The capacity to display 2,800 characters.
- The ability to generate the full ASCII code of 96 characters and 32 commands.

The terminal consists of the display unit, a character generator, a control unit that contains plotting logic and a digital-analog converter, an input/output module to interface with a computer or a data modem, and a keyboard. All but the last were designed and built by Tektronix; the keyboard is purchased from the Micro Switch division of Honeywell Inc. [Electronics, Sept. 16, p. 169].

Discrete memory. The tube is a modified version of the direct-view, bistable 611. The screen will present up to 35 lines of alphanumeric characters (with 80 characters per line) any kind of graphics, or both graphics and alphanumerics.

The graphics can be preplotted by subroutines, plotted incrementally, or drawn by linear interpolation, in which the computer plots a line between two addressed points on the crt. The interpolator, says Griffin, is a high-speed integrator consisting of two current sources to charge separate capacitors that deliver voltages to the x and y deflection plates.

Characters are generated in the usual way by a read-only memory built with 1,600 diodes. The ASCII code—seven bits from the computer—for a character is decoded into one of 96 lines that address the read-only memory. Simultaneously, x and y counters set the beam to stepping through a 7-by-9-dot matrix; these x and y lines are also two of three inputs to three-way AND gates in a scanning sense array; if it indicates that a given dot is in the character pattern, the gate opens and the signal unblanks the beam.

Griffin says that Tektronix may at some point integrate the read-only memory but that at present monolithic memories can't compete in price with the discrete types. There are, however, Tektronix-designed integrated circuits in a new type of pushbutton on the front panel. One such switch, for example, changes the terminal from keyboard to magnetic or paper tape operation.

The switches were designed to be shallow yet to permit multiple functions and be lighted from multiple sources. The button travels only 1/16 of an inch to operate the switch, and thus is unlikely to get out of trim. The IC has a flip-flop to establish its binary state and multiple outputs to send logic signals to the rest of the circuitry and to light the switch lamp. Eight packages perform the switching, logic functions, and lamp-driving for all 13 special switches on the front. Griffin says the new switches will undoubtedly show up in other Tektronix instruments.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 **[338]**

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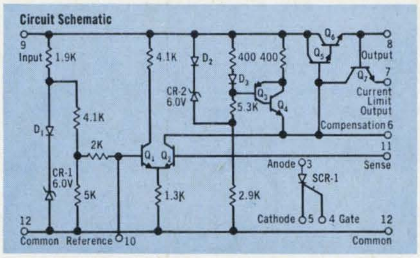

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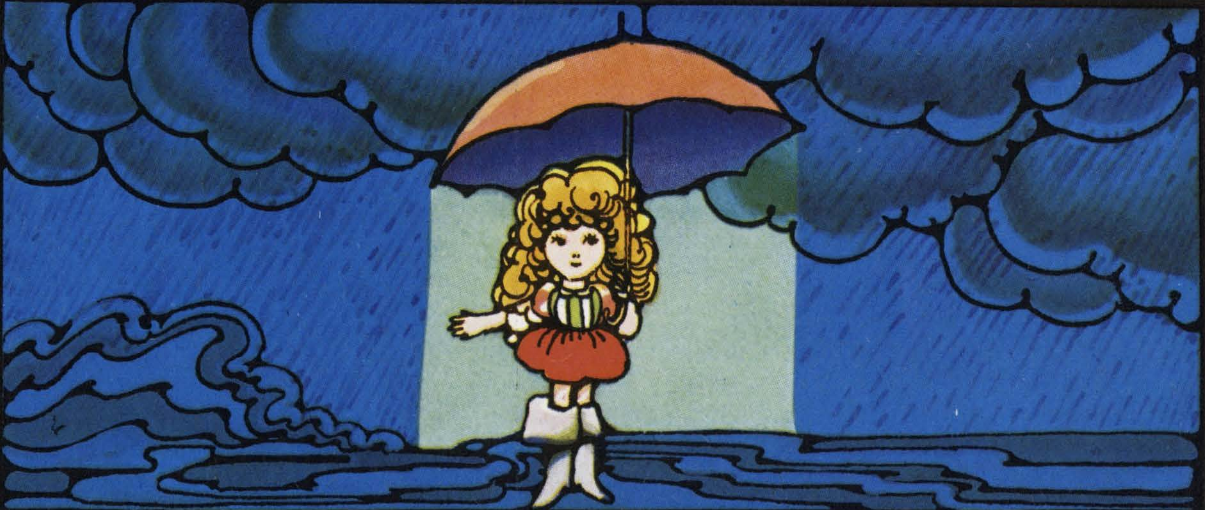
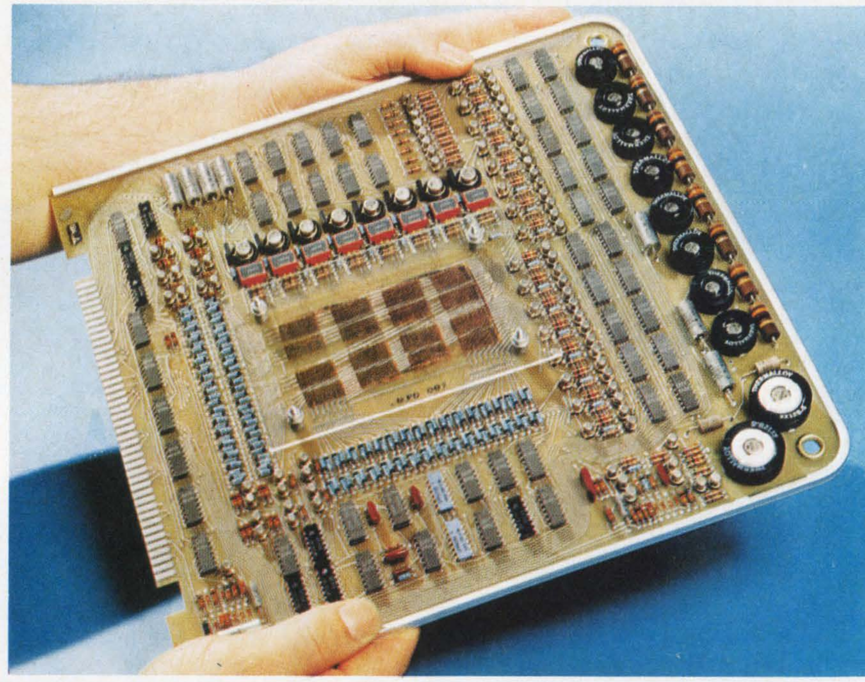


Total recall on one board

Core memory for small computers and peripheral equipment has its own drive, decode, and power monitoring circuits



All together. Arrayed around mats of memory cores in center are the drive and decode electronics that make this assembly a complete memory.

Half a memory may be better than none, but equipment makers are primarily interested in complete memories that can be plugged into their small computers, peripheral equipment, or numerical control directors.

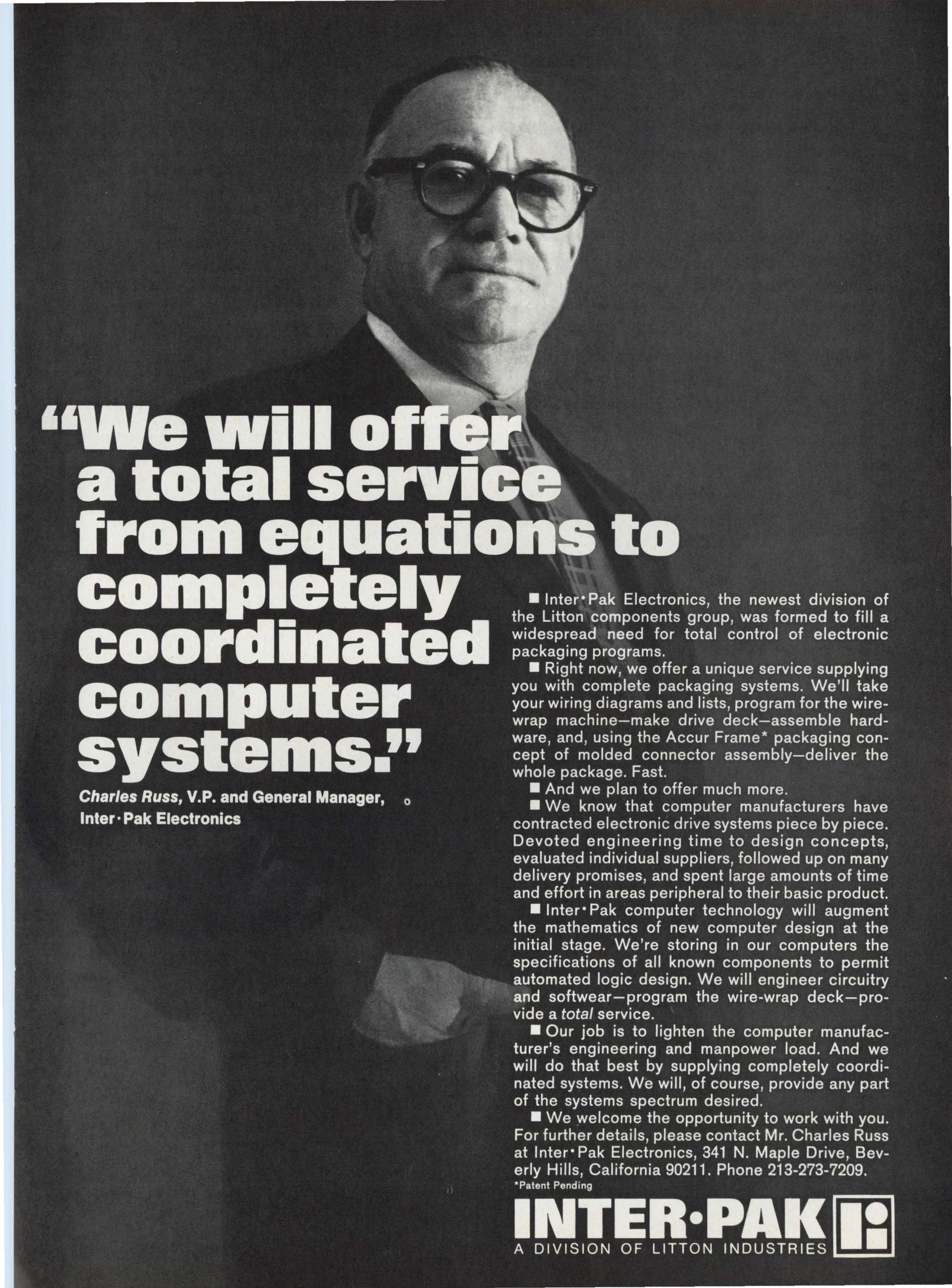
That's how Sanders Associates sees the market for memories, and that's why it developed Memcard, a series of core memories complete with drive and decode electronics.

These complete memories for the digital equipment market also have to be inexpensive. The first of the Memcard series, to be introduced at the Fall Joint Computer Conference, is a 1,024-word, 8-bit-per-word random access memory that will sell for about $650 in 100-unit lots. It is a 3-D, three-wire memory of coincident current design.

The price is $50 to $150 less than for competing equipment, according to John H. Freeman, marketing manager for memory products at the Nashua, N.H., firm.

Fast cycle. Prices are figured in many ways in the memory business, so it's tough to tell whether $650 is good or bad unless it's known what it buys. In this case, it buys core mats, address, digit, and decode registers, a built-in clock, and a feature usually reserved for main-frame power supplies: a power monitoring circuit that helps preserve the stored data if power fails.

The memory is on a printed-circuit board 12 by 11.375 by 0.75 inches—a format used in the special circuit boards developed for the Data General Corp.'s Nova computer [Electronics, Sept. 30, p. 147]. According to John R. Gillespie, senior staff engineer at Sanders, the devices Memcard would compete against use three or more cards, and are 30% to 50% bulkier. "We wanted to build something a man could insert into a single multipin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. . . display refreshment is one sales target . . .

connector without having to worry about connector adapters or interfacing logic. We've tried to put it all in one piece," Gillespie says.

Memcard's cycle time is from 1 to 1.5 microseconds; competing units average about 4 microseconds. Access time for the Memcard 1,024-word memory is 450 to 600 nanoseconds, Gillespie says.

Much of the savings in Memcard result from volume purchase of parts and the resulting low unit prices. Also, Sanders' production is fully automated. "It takes only 4½ minutes to make one of the 1024's," says Freeman. "Besides, we were already in this business, having sold core memories for avionic systems, for electronic-counter-measure systems, and even some for large commercial computer applications. It was just a case of borrowing the expertise from other parts of the company."

This expertise has resulted in a system with what Gillespie calls "a more than adequate waveform. The user who takes care with mainframe lead dress won't even need to use baluns" (costly and bulky devices for load matching).

Refreshing job. According to Gillespie, the inexpensive core system may compete with delay lines for the job of refreshing computer displays.

"Memcards organized on a one-bit-per-word, 8,000-odd word basis could sell for about $300 to $350," he says. "Delay lines are only $75 or so cheaper and offer no random-access capability. Memcard could offer not only random access but sequential character generation."

Sanders' own model 720 display console may be the first system to use this inexpensive refreshment system. Coming up in January is a larger Memcard module, this one a 4-kilobit, 18-bit-per-word model that will be expandable to 32 kilobits. It will take two cards, but Freeman says other devices need from four to seven p-c boards to do the same job.

Delivery time for the first Memcard is 30 days.

Sanders Associates Inc., 95 Canal St., Nashua, N.H. 03060 [339]

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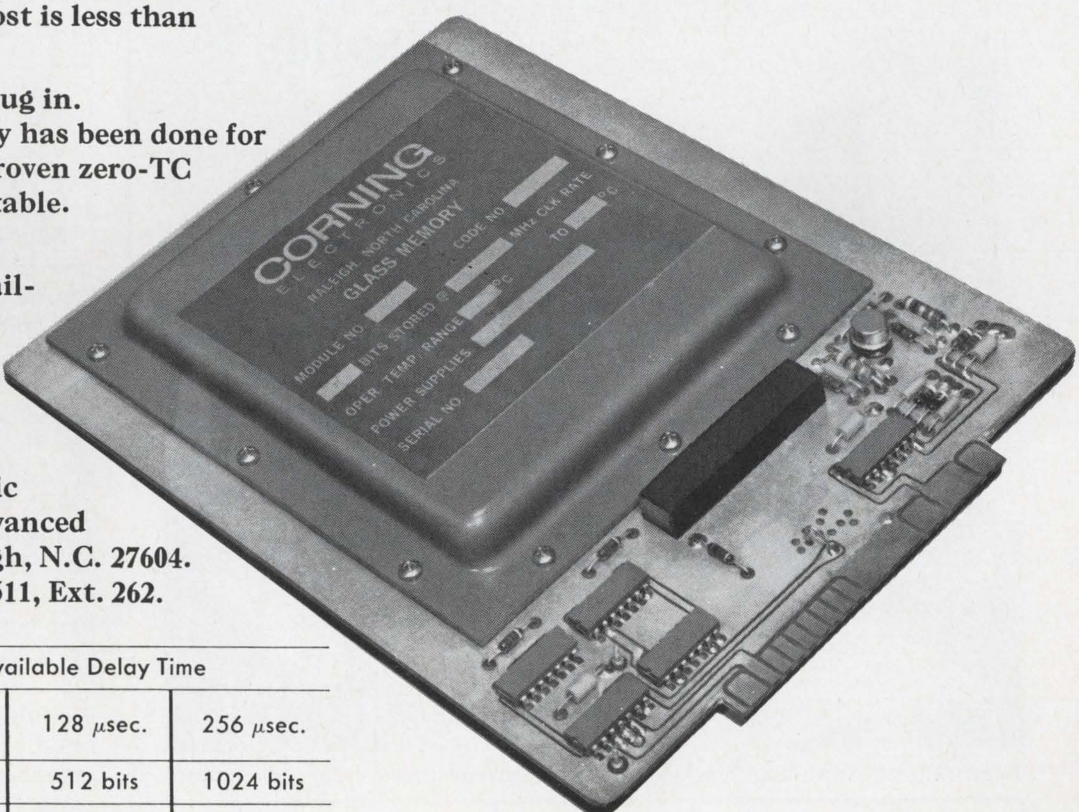


Available Frequencies	Available Delay Time		
	64 μsec.	128 μsec.	256 μsec.
4 MHz	256 bits	512 bits	1024 bits
8 MHz	512 bits	1024 bits	2048 bits
16 MHz	1024 bits	2048 bits	4096 bits

CORNING
ELECTRONICS

Circle 147 on reader service card

A quick-change braid memory

Potted-core module can be replaced in 15 seconds

One of the advantages of braided-wire read-only memories, which are sold principally by Memory Technology Inc., is the ease with which a user can rewire their contents. Merely looping fine wire around U-shaped cores in a given pattern can change the binary content of a stored word.

Often, however, a word or a bit isn't enough, and a new read-only memory is needed. For example, if a programed machine tool is to stop making nuts and start making bolts, the difference is enough to require a new set of data.

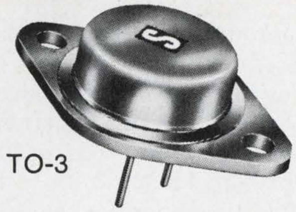
Now such new sets can be supplied in as little as 10 or 15 seconds. Memory Technology has developed a quick-change version of its braided memory and will announce both military and commercial versions this week at the Fall Joint Computer Conference.

Four boards. "In many ways, our new braid system is similar to our standard small-braid system; both can hold up to 20 kilobits of data," says John J. Marino, MTI president. "The differences lie in the shape and size of the new memory and the ease with which it can be changed—and exchanged."

The standard system is bolted to a single printed-circuit board about 9 by 11 inches, but the new memory contains the same circuitry on four boards in a package 10.5 by 6 by 2 inches. One board contains the solid, potted array of cores and the interconnection wire called the braid. The others hold the sense amplifiers, decoders, and other parts. Thus, to exchange the content of one memory for another, the user pulls out the memory board and inserts another.

This will be an advantage for:

▪ Computer builders whose products use "firmware," microprogram-



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2N4347	TO-3	7.0A	120V
2N3442	TO-3	10.A	140V
2N4348	TO-3	10.A	120V
2N3055	TO-3	15.A	60V
2N3773	TO-3	15.A	140V
2N3772	TO-3	20.A	60V
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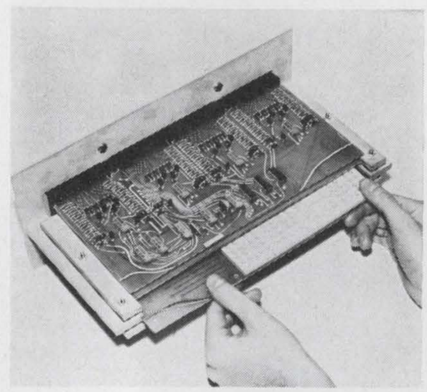
ing, or subroutine control. Equipment makers could offer libraries of subroutines to suit their equipment to divergent applications. The new braids would also serve as easily changed look-up tables.

▪ Makers of numerical-control devices who want as much flexibility in their controller's capabilities as possible. A library of read-only memories could contain a variety of repetitive control programs.

▪ Manufacturers of process-control equipment who need long programs that are usually reserved for tape input but must operate in damaging environments. The potted braid is nearly impervious to damage and as easy to change as a creel of tape.



Alteration. Pluggable contents board is being removed from read-only memory.

▪ Makers of computer typesetting equipment who need to change fonts quickly.

One manufacturer of computer peripheral equipment plans to make the plug-in braid memory available. "If not the braids themselves, at least sockets for them," says Robert H. Stotz, president of Computer Displays Inc., Waltham, Mass. His partner and vice president, Thomas B. Cheek, says, "We have often had calls for display fonts in other than ASCII standard styles—everything from Greek letters to chemical and military symbols. Certainly, the plug-in braid would be a simple way of making such changes quickly."

The quick-change braid also offers the advantage of being user-proof. The equipment maker would state each braid's content and Memory Technology would supply it to specification. This approach differs from such designs as the

General Electric introduces a faster, more convenient and less costly technique for production line encapsulating and potting. And the RTV's used in the process are as tough as any previously available.

Called the RTV-800 series, the new liquid silicone rubbers do not need a catalyst to activate them, so no premixing is needed.

They cure at temperatures ranging from 200°F to 450°F, so pot life is far longer than is customary with RTV's. A typical deep section cure would be one hour at 300°F. For really rapid cure, components can be preheated and dipped into the RTV.

These three new products are supplied in both opaque and clear grades, with viscosities ranging from very pourable to pourable. They can be blended with one another to suit your particular encapsulating job.

For more information about these new encapsulating RTV silicones (they also make good short-run molding materials), write Section 300, Silicone Products Dept., General Electric Company, Waterford, N.Y. 12188.

TYPICAL PROPERTIES

Uncured	RTV-815	RTV-830	RTV-835
Color	Clear	Beige	Beige
Consistency	Easily pourable	Pourable	Easily pourable
Viscosity, cps	3500	200,000	8000
Specific Gravity	1.02	1.28	1.18
Solids, %	100	100	100
Shelf Life, months	4	4	4
Cured, ±1 hr. @ 150°C	**RTV-815**	**RTV-830**	**RTV-835**
Hardness, Shore A durometer	35	50	35
Tensile Strength, psi	700	800	500
Elongation, %	150	250	200
Tear Strength, lb/in.	15	100	20

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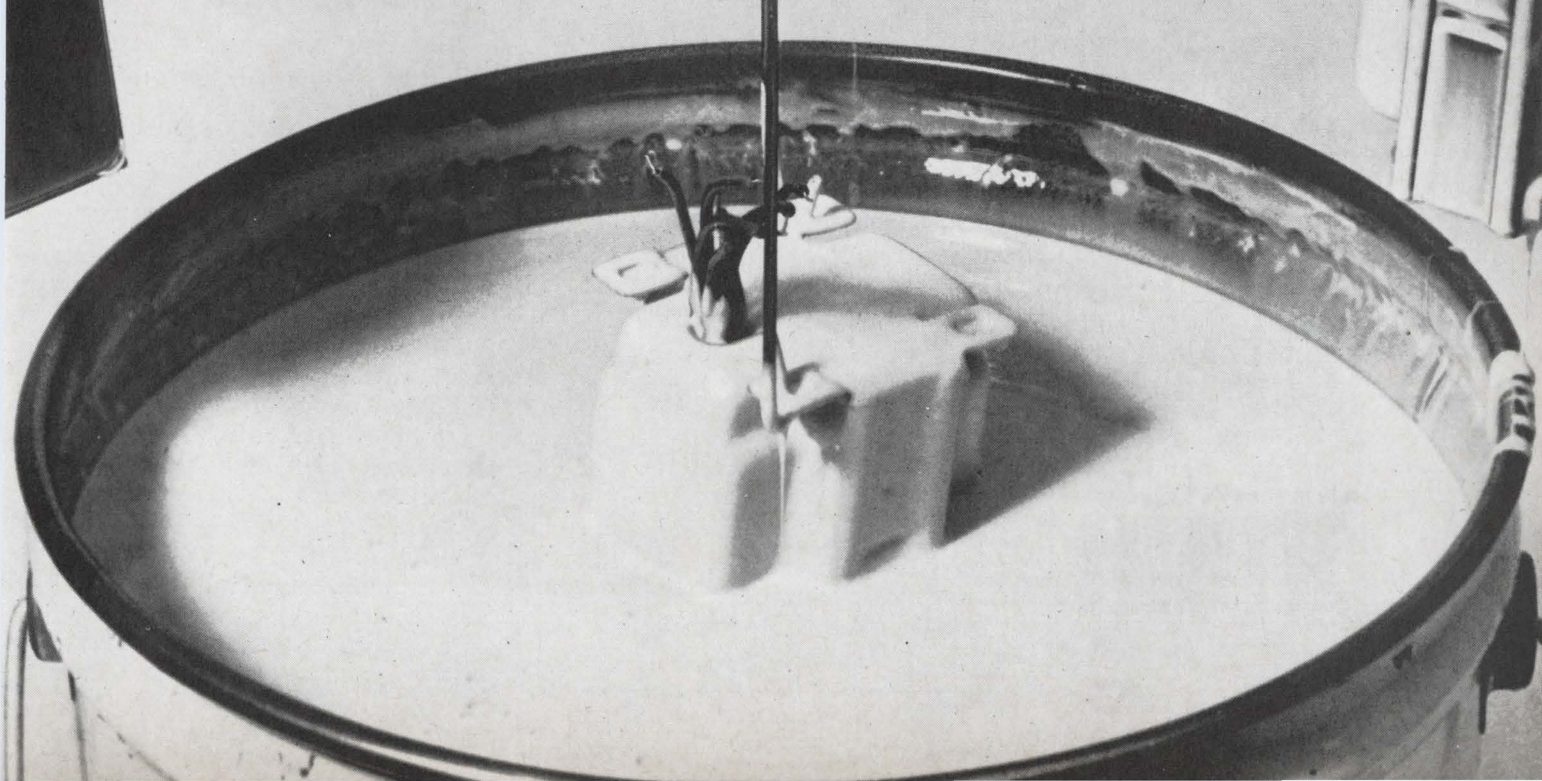

Honeywell read-only memory, which can be altered by the manufacturer only. The quick-change braid would allow the user to exchange one subroutine for another without damaging the central processor's operation.

Mylar retrofit. Marino also points out that users can change the memory by gluing down copper circuit strips on a Mylar overlay. He says, "This would make possible speedy field alterations of existing equipment, using plastic sheets sent out from the manufacturer's home office."

The memory shown at the conference will have the speed characteristic of braided systems: a 650-nanosecond cycle time and a 300-nsec access time for the mil-spec version, and a 500-nsec access time and sub-microsecond cycle time for the civilian model.

Prices haven't been set but Marino says they shouldn't be too far from those of present braided memories: for a 1,000-word memory with 10 bits per word, about $900 each, or $580 in quantities of 100. Delivery takes about a month.

Memory Technology Inc., 223 Crescent St., Waltham, Mass. 02154 **[340]**

Data handling

Widetrack trend is accelerated

Nine-channel tape system transmits or records data at 800 bits per inch

Between the Spring and Fall Joint Computer Conferences this year, one company switched tracks to steer its efforts toward the data communications market created by the latest computers.

In San Francisco this week, the Communitype Corp. will demonstrate a nine-track magnetic-tape system that records data at a density of 800 bits per inch, making the equipment compatible with all IBM System 360 computers. Only last spring, Communitype introduced a similar system that reads

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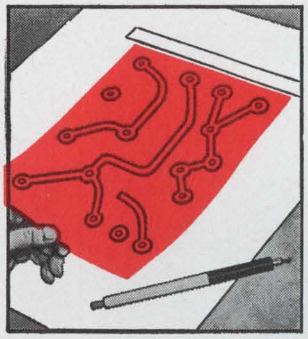
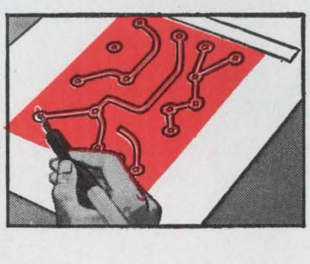
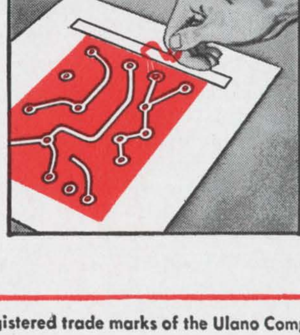


Cut a piece of the desired film large enough to cover area to be masked. Tape it down firmly at the top *with dull-side up.*

With sharp blade, outline the areas to be masked. *Do not cut through the backing sheet.* The Ulano Swivel Knife does the job quickly, easily.



Using the tip of the blade, lift up a corner of the film thus separating it from the backing sheet.



Now carefully peel off the film as outlined leaving a completed mask, positive or negative, that corresponds exactly to the desired pattern.

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and writes on seven-channel tapes at 556 bpi. But "there's a clear-cut trend in industry to 800 bpi, nine-track equipment," explains Communitype's president, Robert N. King.

The new system, designated the 850, can send and receive computer-generated data at high speed over direct-dial telephone circuits. Its primary use will be on the receiving end of the company's 100SR Data Communication System, an input-output data terminal employing a standard-keyboard IBM Selectric typewriter. A single unit at a computer center could serve widely dispersed 100SR installations.

Data central. Unit at computer site records data from many locations.

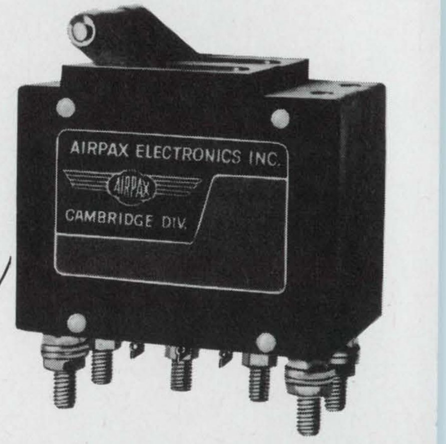
Data received by the 850 is translated into code compatible with 360-type computers and recorded on compatible tape. The 10½-inch tape reel holds 20 million characters at 800 bpi. The system will also transmit computer-generated data to 100SR units in remote locations by reading it block by block into a 160-character buffer memory consisting of metal oxide semiconductor field effect transistors.

Delivery of the 850 will start next spring. The unit will sell for $24,-000 and will rent for a price the company says could be "as low as $528 a month."

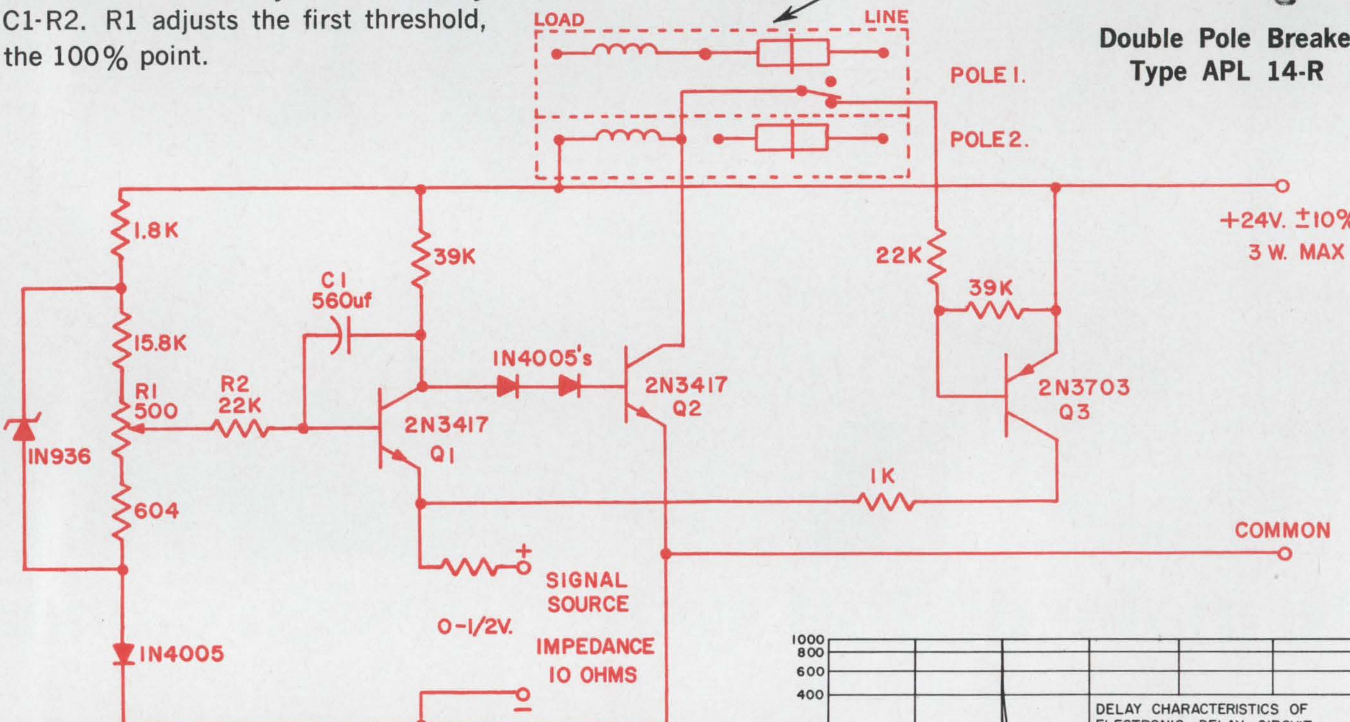
Communitype Corp., 292 Madison Ave., New York, N.Y. 10017 **[341]**

DOUBLE THRESHOLD TIME DELAY

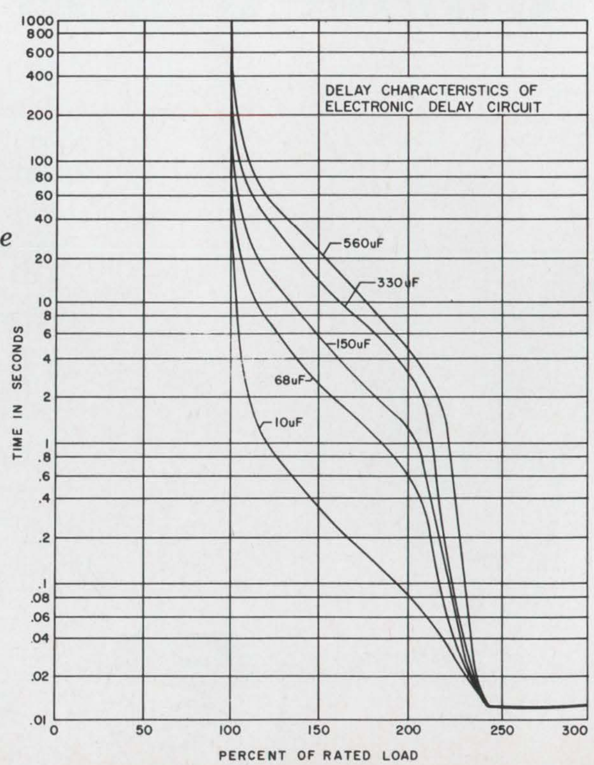
Magnetic circuit breakers permit accurate and reliable control circuits. The circuit shown allows an adjustable time delay responding to the average, (*average*, not rms) value of an overload, no trip below rated current, a time delay between 100% and 200% of rating, essentially zero delay above the adjustable limit. A ½ volt input corresponds to 100%. 1 volt input corresponds to about 200%. Between these limits time delay is furnished by C1-R2. R1 adjusts the first threshold, the 100% point.



Double Pole Breaker
Type APL 14-R



Electronic time delay circuit



Double threshold characteristic curve

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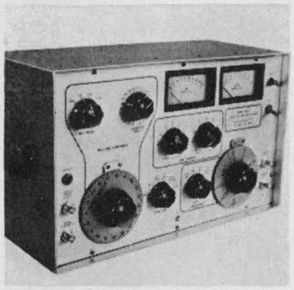
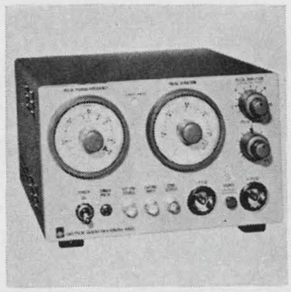
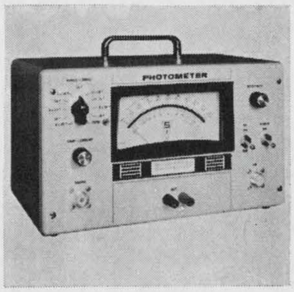


Power meter 6863-1 provides information on conducted EMI, displaying corrected EMI current, line impedance and calculated EMI power values. Current probes couple to the unknown impedance and measure impedance magnitudes from 0.3 to 1,000 ohms and phase angles $\pm$ 180° from 15 khz to 30 Mhz. Solar Electronics Co., 901 Highland Ave., Hollywood, Calif. **[361]**

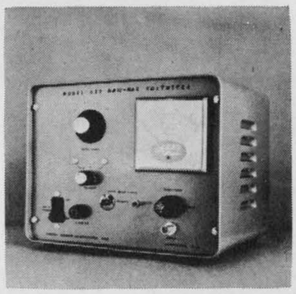


General purpose pulse generator type 1340 features wide ranges of pulse repetition frequency and pulse duration (both $10^8/1$). Prf is as high as 20 Mhz or as low as 0.2 hz and pulse duration can be varied from 25 nsec to 2.5 sec. Ground-based positive and negative pulses are available simultaneously. Price $395. General Radio Co., West Concord, Mass. 01781. **[362]**

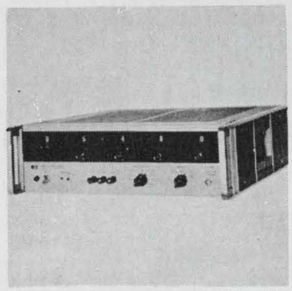
Pulse generator model 605P can provide 20 kw of power in pulse widths from 0.05 to 1,000 μsec. Pulse repetition rates can be varied from a single shot to 1,000,000 pps. Pulse amplitude is continuously variable to a maximum of 2,000 v. Standard rack mounted units are $3,890; benchtop, $3,990. Cober Electronics Inc., 9 Gleason Ave., Stamford, Conn. **[363]**



Solid state photometer, for use with photomultipliers, has an electrometer type current meter with a FET input for measuring currents from 300 μa to 3 na. It has a 6-inch meter readout as well as a 5-v output with $\pm$2% accuracy. The built-in h-v supply is adjustable from 400 to 600 v and operates a load up to 2 ma. Schoeffel Instrument Corp. Westwood, N.J. **[364]**

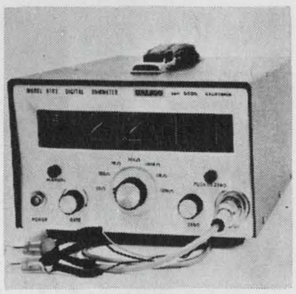


Model 222 Maxi-Max voltmeter accepts input transients and stores the peak value for reading on the built-in meter, or for plotting using the external output. It can describe the larger of the plus or minus peaks of a given transient. The voltmeter has a dynamic range of −50 db from 10 v. Price is $1,500. Marshall Research and Development Corp., 15A St., Burlington, Mass. **[365]**



A-c calibrator 6921A has a 25-w output and supplies either a calibrated voltage or current to its load. The rms amplitude of its output is within $\pm$0.25% of selected value. The unit has 4 voltage ranges: 0 to 1.4, 14, 140, or 280 v rms. It has 5 current ranges: 0 to 1.4, 14, or 140 ma rms, or 0 to 1.4 or 5 amps rms. Hewlett-Packard Co., Locust Ave., Berkeley Heights, N.J. **[366]**

Solid state electrometer 610C will measure 81 ranges of d-c voltage, current, resistance and charge. It has: 11 ranges from 1 mv full scale to 100 v; 28 ranges from 10^{-14} amp full scale to 0.3 amp; 25 ranges from 100 ohms full scale to 10^{14} ohms; 17 ranges from 10^{-13} coulomb full scale to 10^{-5} coulomb. Price is $585. Keithley Instruments Inc., Aurora Road, Cleveland. **[367]**



Seven ranges, covering resistances from 0.0001 ohm to 1 megohm, are offered in the model 8103-421 digital ohmmeter. One ohm minimum full scale is displayed as 1.0000 ohm to an accuracy of 0.1%. A large, illuminated digital readout provides a full 4-digit presentation with 10% overranging to the 5th digit. California Instruments Corp., 3511 Midway Dr., San Diego, Calif. **[368]**

New instruments

How are you? x-y plotter will tell

Compact recorder displays eight channels of medical data on 8¼-by-11-inch paper and runs for as long as 9 hours

The intensive-care section of a hospital isn't an R&D laboratory. Hospital people are understandably reluctant to handle the rolls of recording-chart paper needed to monitor critically-ill patients, and they're equally reluctant to allocate much space to bulky recording equipment. Designers in the Hewlett-Packard Co.'s Moseley division, however, are betting that the medical technicians won't mind changing a sheet of 8½-by-11-inch paper once in awhile.

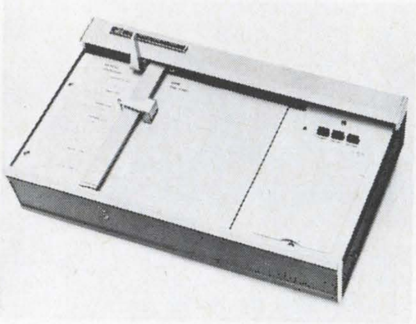
H-P's new recorder, the 7597A medical monitoring instrument, is 19 by 10½ by 6¼ inches and handles eight channels of data.

H-P has adapted x-y recorder techniques for the 7597A. Instead of handling rolls of strip chart, technicians need only place the standard-size sheet of paper in the recorder, which will plot data for nine hours on one sheet. The compactness of the presentation makes trends easier to spot and interpret. And the price is about $1,200. The recorder can plot eight parameters for one patient or one parameter for eight patients.

No ink. H-P hopes that the instrument, with different papers and in a slightly different package, will also be used in nonmedical applications. Trend measurements from transducers or instruments such as voltmeters and power meters are possibilities.

The recorder sweeps over the 9⅝-inch length of the recording area, continuously sampling the channels. A complete sampling cycle takes about a minute. The device can be programed to bypass any combination of channels in the scanning sequence. The sensitivity of each channel is adjustable between 0.5 and 3 volts per inch; the input impedance is 100 kilohms. Accuracy depends on the y-axis span of each channel; for a 1-inch span it's 1.5%, for a 3-inch span 0.5%.

The writing is done electrically; an ink pen would require too much attention from hospital personnel. A separate reed switch in each channel actuates the pen. When the reed is closed, a pair of transistors apply 28 volts to the pen's tip, creating a dot in that channel. A series of such dots forms the trace. The electrosensitive paper, 7 inches high, is held on the instrument electrostatically.



On record. The sensitivity can be set between 0.5 and 3 volts/inch.

Anatomy. The servo loop circuit that drives the pen includes a dual field effect transistor, an integrated-circuit operational amplifier, and complementary output transistors in a Darlington configuration. The input signal is applied to one gate of the FET and the other gate is connected to the slidewire wiper. The FET is connected as a source follower, so that when the two gates are at the same voltage, the voltage differential between sources is zero and the system is in balance. But if the gate voltages are unequal,

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7201	2.15	1.43	1.28	1.07
7203, 5, 7, 9	2.55	1.70	1.52	1.27
7211	2.85	1.90	1.70	1.41
7213	3.15	2.10	1.87	1.55
7215	3.45	2.30	2.06	1.71
7301	3.85	2.57	2.30	1.92
7303, 5, 7, 9	4.80	3.20	2.87	2.38
7401	4.85	3.28	2.90	2.43
7403, 5, 7, 9	6.05	4.10	3.61	3.00
7411, 13, 15	6.90	4.30	4.11	3.41

PUSHBUTTON SWITCH MODELS	1-24	25-99	100-499	500-999
P8121	$ 2.55	$ 1.70	$ 1.52	$ 1.27
P8221	3.45	2.30	2.06	1.71
P8321	4.80	3.20	2.87	2.38
P8421	6.05	4.10	3.61	3.00

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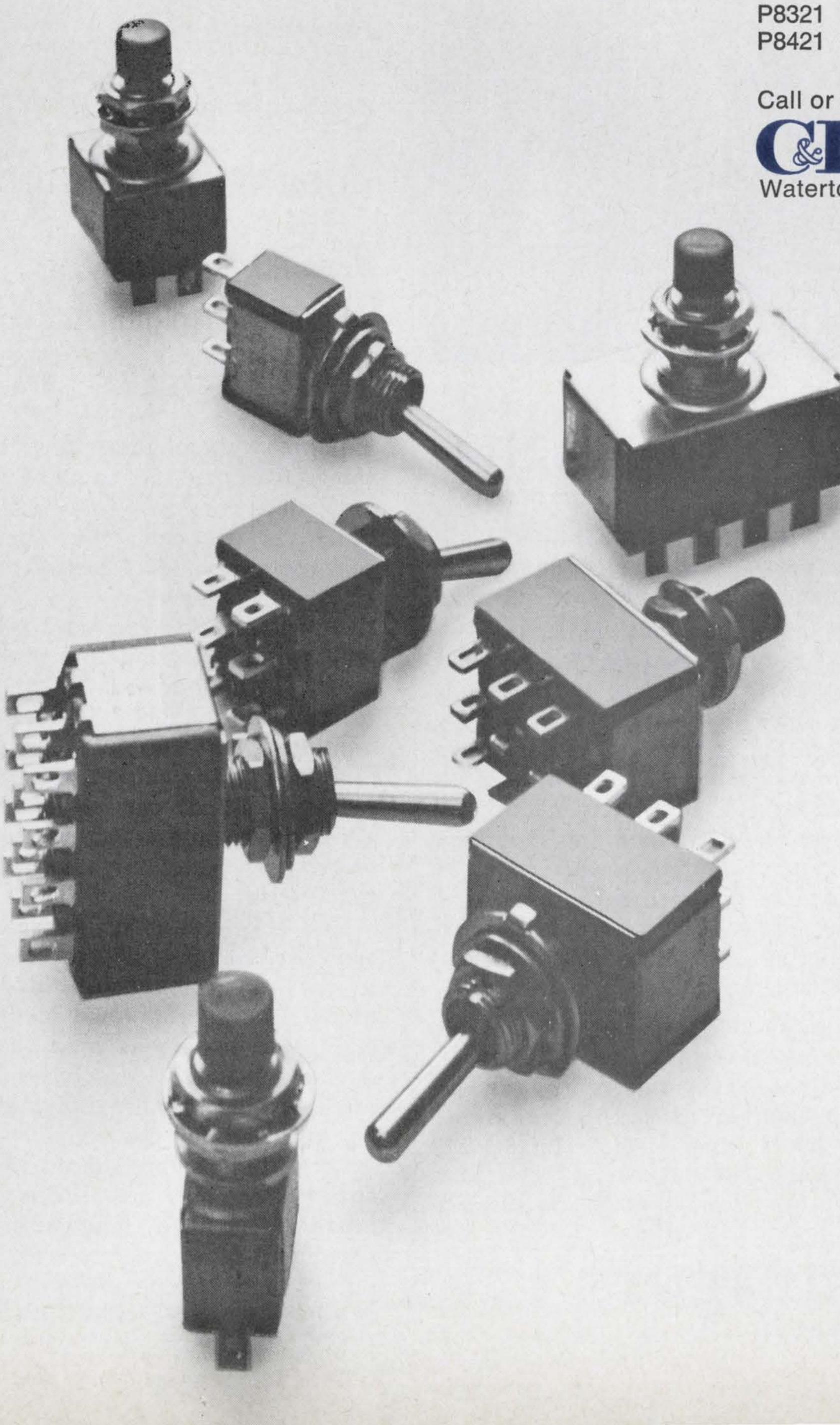

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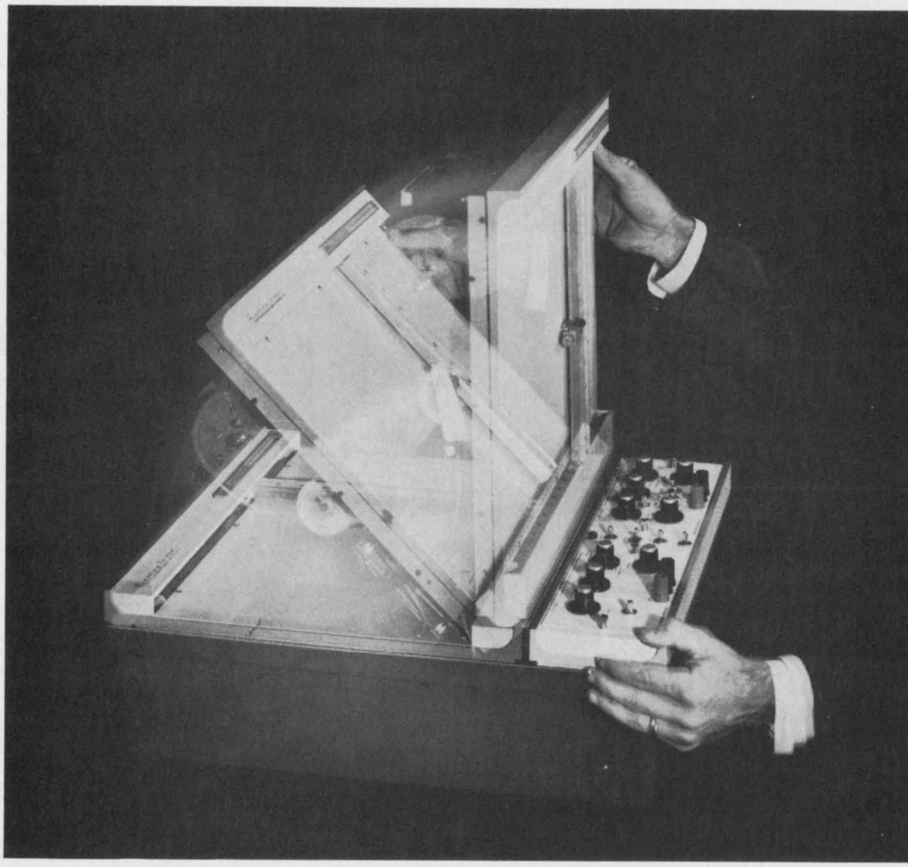


a differential voltage exists between the two sources.

The d-c op amp amplifies the differential source voltage (with a gain of approximately 2,000). The next stage is the motor driver—the Darlington amplifier. The npn transistors conduct and drive the motor in one direction for positive-going signals and in the opposite direction for negative-going signals. The voltage gain of this stage is one. The Darlington configuration increases the current gain and reduces the load on the op amp.

Hewlett-Packard Moseley Div., P.O. Box 791, Pasadena, Calif. 91102 **[369]**

New instruments

Circuit tester does double duty

Versatile device handles op amps and digital IC's manually or automatically

Equipment manufacturers who use integrated circuits in small or moderate quantities look for versatility in a tester; they can't afford special-purpose apparatus. The model 716 circuit tester developed by Microdyne Instruments Inc. goes a long way toward meeting this requirement. The instrument will test both discrete and monolithic operational amplifiers, as well as all digital logic IC's on the market, the manufacturer says. It can be manually operated or programed, by means of prewired patch plugs, as a functional tester.

The 716 takes about 30 seconds, typically, to make a complete set of d-c and functional tests on a circuit in the programed mode. It can accommodate as many as 36 device terminals. Measured values are displayed on a three-digit readout or a high-low indicator.

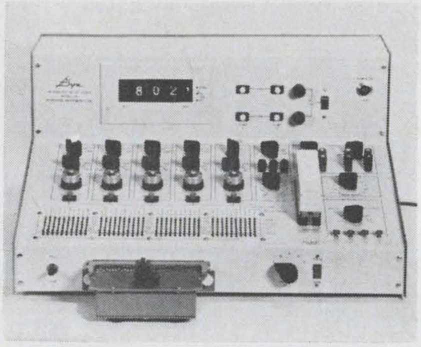
On op amps, the Microdyne instrument can measure voltage gain, input voltage offset, input bias current, input differential current, output voltage under full load, total current drain, and gain-bandwidth

product.

On DTL, RTL, TTL, and ECL circuits, the 716 can measure input load currents, shorts between inputs, thresholds, input leakage, output 0 under load, output 1 under load, output short-circuit current, and total current drain. It can also clock flip-flops.

The accuracy of the digital readout is 0.25%. The meter voltage ranges are 1, 10, and 100 volts, with 0.1 volt optional. The current ranges are 1, 10, and 100 milliamperes, with 0.1 ma optional.

Hand work. The 716 comes with four constant-voltage supplies, capable of sourcing or sinking current regardless of output polarity, a sweep-voltage supply, a constant-current supply, a pulse generator with repetition rates from 10 hertz to 1 megahertz and adjustable amplitude, and selectable circuit loads, both resistive and capacitive.



Choice. Operator can set conditions with patch panel or manual adjustment.

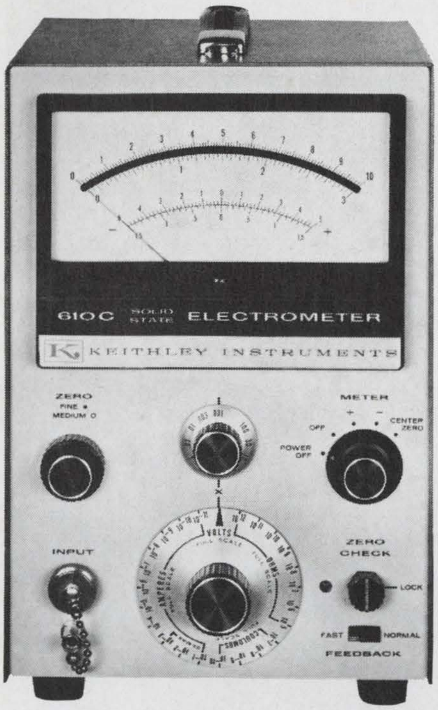
A 10-by-40 matrix selector switch is used for manual operation. By adjusting the slider positions, the operator can connect power supplies, grounds, output voltage comparators, pulse generators, output displays, and loads to the device in any configuration.

The patch plug provides a semiautomatic mode of functional testing. The plug is wired to connect the terminals of the device under test to the appropriate components of the instrument. An operator inserts the device, rotates the test selector switch, and observes a high or low indication on the comparator lamps.

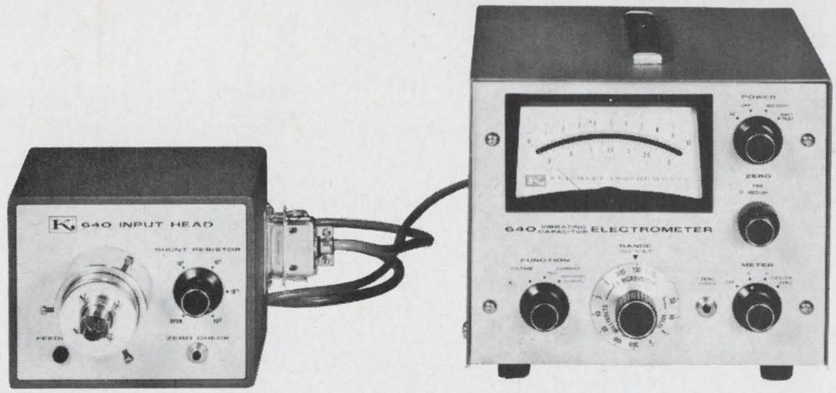
The tester sells for $2,195.

Microdyne Instruments Inc., 225 Crescent St., Waltham, Mass. 02154 **[370]**

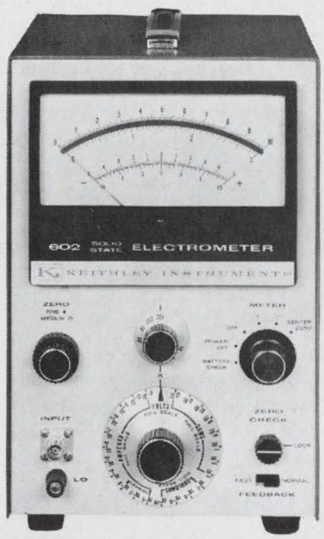
MEET A NEW GENERATION OF ELECTROMETERS



All New, Line Operated DC Laboratory



Vibrating Capacitor Electrometer



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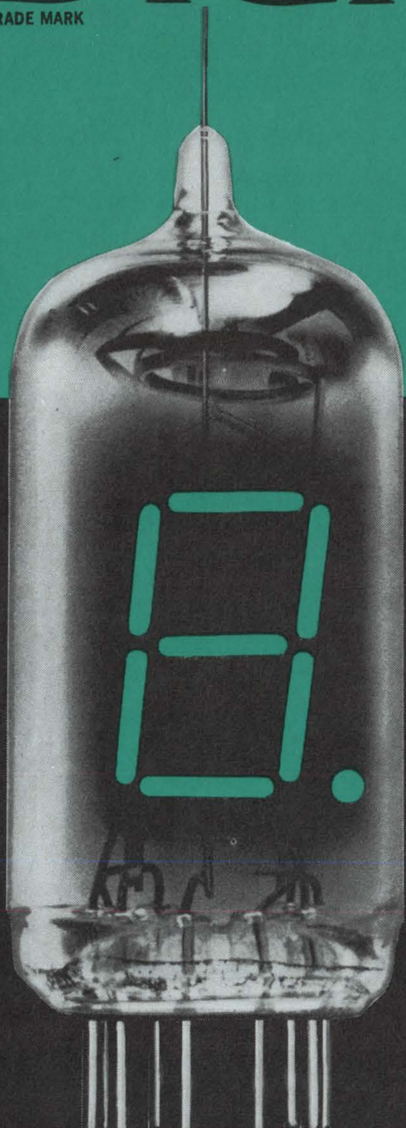

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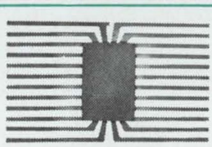

ACTUAL SIZE

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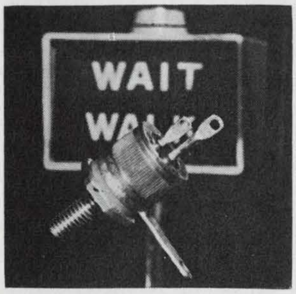
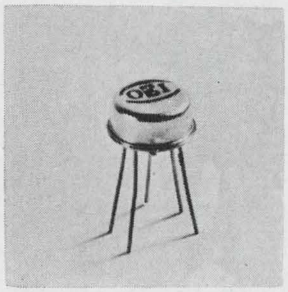
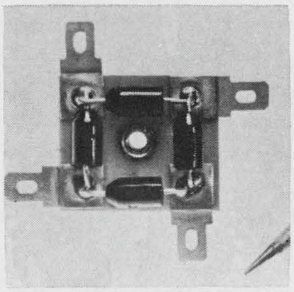


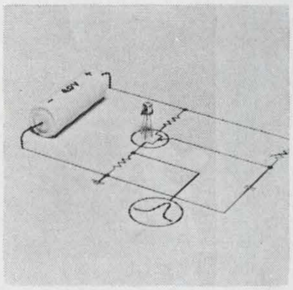
Bidirectional triode thyristors series BTV0400 handle up to 3,600 w and provide their own built-in electrical isolation. The case is fully insulated from the mounting stud. Five types are available for use with peak off-state voltages of 100 to 600 v. All types handle up to 10 amps of on-state rms current. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. [436]



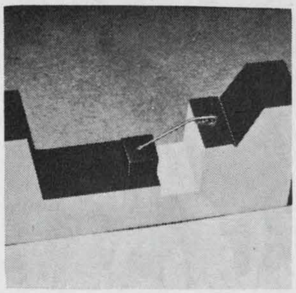
Monolithic voltage comparator model 5501 provides a maximum comparison error of ± 1 mv including gain and offset errors. Features include 80 db minimum voltage gain, ± 25 ma minimum output current, ± 10 μv/°C maximum input voltage drift. The unit is packaged in a 5-lead TO-5 low profile can. Price (1-9) is $27 each. Optical Electronics Inc., Box 11140, Tucson 85706. [437]



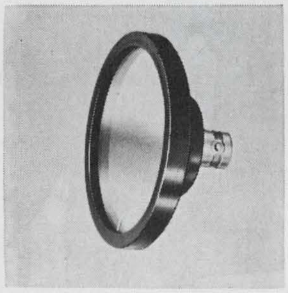
Industrial bridge rectifiers series B786-QD are now available with four quick-disconnect terminals that can be mounted simply and quickly into equipment by a 6-32 screw and push-on-terminals. The rectifiers use controlled avalanche devices. They are stocked in 2-amp and 4-amp types with piv up to 1,000 v. Solitron Devices Inc., 256 Oak Tree Road, Tappan, N.Y. 10983. [438]



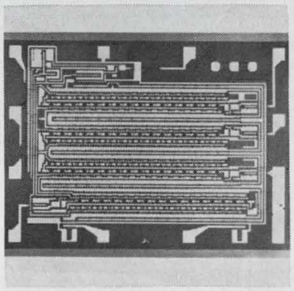
Unijunction tranistor type 2N5431 is characterized for operation on source voltages as low as 4 v. Fabricated by a process similar to that used on silicon Annular transistors, it has an emitter leakage current of only 10 na maximum. Maximum reverse emitter voltage is 30 v; maximum emitter current, 50 ma rms. Motorola Semiconductor Products Inc., Box 20924, Phoenix. [439]



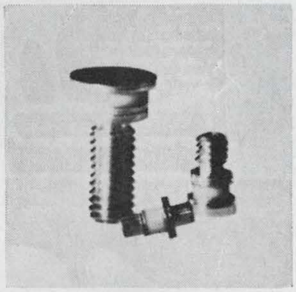
Schottky barrier mixer diode type CAY13A is a gallium arsenide device with an over-all noise figure of 6.5 db at X-band frequencies. Vswr is 2 max. I-f impedance is 350 ohms. Temperature range is $-55°$ to $+155°$C. The unit is mounted on a ceramic carrier 1.9 x 0.8 x 0.35 mm. Metalized lands simplify bonding to substrate. Mullard Ltd., Mullard House, Torrington Place, London WC1, [440]



Silicon Schottky barrier photodiode PIN-25 has an active area of 7 cm^2. Response time is 5 nsec or less. Capacitance at 90 v is less than 100 pf/cm^2. Linearity of response extends over 8 decades. Noise equivalent power is 10^{-13}w in a 1 hz bandwidth. Reverse leakage current is less than 10^{-7} amps cm^2. United Detector Technology, 1732 21st St., Santa Monica, Calif. [441]



Two 64-bit shift registers, each with a single-phase clock, provide high speed operation from d-c to 1 Mhz and power consumption of less than 3 mw per bit. The MOS products are the 3305 quad 16-bit unit in a dual in-line package, and the 3306 dual 16-bit/single 32-bit unit in a TO-100 container. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 04041. [442]



P-i-n diode series MA-47000 is a complete family of 27 diodes designed for control applications such as r-f switching, limiting, duplexing phase-shifting, modulation and pulse forming. They feature peak power to 3 kw, switching speed of 100 to 500 nsec. Minimum breakdown voltage ranges from 500 to 800 v. Microwave Associates Inc., Burlington, Mass. 01803. [443]

New semiconductors

IC voltage regulator delivers 0.5 amp

Regulator-within-regulator design of monolithic device keeps output impedance low over a wide voltage range

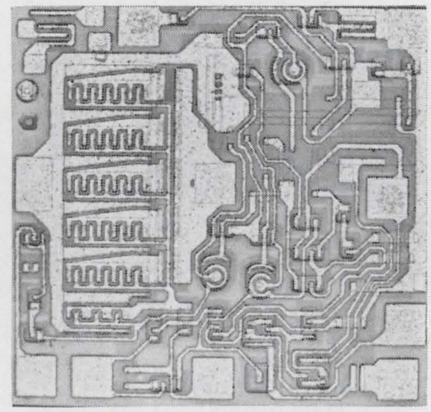
Motorola's Semiconductor Products division says it's ushering in the third generation of monolithic voltage regulators with the MC1560, a linear integrated circuit with an output current of up to 500 milliamperes—more than three times that of its nearest IC competitor.

Clay Tatom, manager of linear IC product planning, points out that National Semiconductor introduced a monolithic regulator more than a year ago, "but it can't be used much over 15 milliamps, and it's designed to go with a couple of external transistors to get to 5 amps. Then Fairchild introduced the μA723." And at 150 milliamps, Tatom says, this is the MC1560's nearest monolithic competitor. He adds that with the addition of one external transistor, the Motorola device can regulate a 10-amp load current.

The TO-66 package, a nine-pin variation of the widely used power transistor case, enables the regulator to dissipate 10 watts at a case temperature of 65°C and 17.5 watts at 25°C. This model carries the designation MC1560R; the other military version, the MC1560G, housed in a 10-pin TO-5 can, will dissipate 1.8 watts at 25°C and can regulate a 200-milliamp load current.

Steady impedance. The MC1560R sells for $20 in quantities of 100 or more, and the MC1560G costs $15. Commercial versions of the device, the MC1460R and G, have a narrower temperature range: 0 to 75°C against −55 to +125°C. The civilians cost $3.50 per 100 in the TO-5 can (the MC1460G) and $4.50 for the MC1460R in the TO-66 case.

Motorola has incorporated a regulator within a regulator on the same chip to give the MC1560 its low typical output impedance of 20 milliohms, which varies only a few milliohms over an output voltage range of 2.5 to 17 volts. Output impedance also remains low over a wide frequency range, reaching only 60 milliohms at 1 megahertz. Motorola engineers say the output impedance of all the other IC voltage regulators they know of varies widely with output voltage.



Steady climate. Compensation circuits keep drift down to ± 0.002%/°C.

With the regulator-within-a-regulator feature, the reference voltage for the output stage is the output of another regulator. The reference for the second regulator is a temperature-compensated zener. Tatom explains, "Each stage of the MC1560, then, has a temperature-compensated bias to give better performance over the temperature range. We don't get bias drift with temperature changes in the differing stages." The typical change in input voltage is just ±0.002% per degree centigrade.

Two other features Tatom says are important are the regulator's shut-down control and its transient-

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. . . recovery from transient effects takes 50 nsec . . .

response characteristics. Application of a control voltage to the shutdown terminal turns off both the load and the regulator bias current, reducing system power consumption. "If you want to shut the power supply off with a logic signal, you just supply the signal and it will cut the regulator off," Tatom says. This can't be done with most other IC regulators, he says, except the Fairchild device. Shutdown can be triggered in the MC1560 by logic levels of resistor-transistor, diode-transistor, transistor-transistor, and high-threshold logic for all possible regulator output voltages, with no damage to the circuit. The shutdown feature can also act as a dissipation control to protect the regulator during sustained short-circuits.

Quick recovery. As for transient response, Tatom says that for a large change in input voltage, there's little change in output voltage. "The input can change in 20 nanoseconds and you don't get a big spike in the output. For a 5-volt input change taking place in 20 nsec, the typical change in the output is just 3 millivolts. You can also adjust the short-circuit limiting current easily—to make sure you never draw too much current into the load—by adding a very small external resistor, and this doesn't appreciably affect the output impedance."

Typical recovery time for the MC1560 for a drop in load current from 100 to 50 milliamps is 50 nsec, compared with the microsecond recovery times typical of other regulators, either discrete or monolithic. This feature is said to be particularly important for digital systems in which switching causes large current changes in a short time. The device also offers high ripple rejection, typically 0.002% per volt.

Tatom says the MC1560 will be applicable in any system using a power supply that has a 20-volt input and a 17-volt output. A device to handle inputs up to 35 volts will be ready in a few months.

Motorola Semiconductor Products, Phoenix, Ariz. 85036 [444]

New semiconductors

Power sealed in TO-3 case

Package for transistors has low leak rate for military jobs

In the brief period between its abandonment of the industrial power-transistor business and the decision of the new management to reenter power in a big way, Fairchild Semiconductor continued producing power devices for the military, at a rate of about 70,000 per month.

To further exploit this market, the company has developed what it says is the first hermetically sealed TO-3 package.

The TO-3 is a low-profile package in which the power-transistor chip is mounted on a steel or copper plate and lead-bonded to two pins. The pins are sealed with glass where they pass through the plate, and since the coefficient of expansion of glass is different from that of copper or steel, the seal isn't hermetic.

Fairchild switched to Kovar pins, with glass seals, and found that hot-welding the pins to steel weld rings produced a package that meets hermetic standards (a leak rate of 10^{-8} cubic centimeter of helium per second).

Expansion rates have also contributed to failures in mounting chips. To spread heat in a power device, the silicon chip is normally mounted on the base plate with lead-tin, lead-silver, or lead-indium solder a mil or two thick. As the silicon expands it deforms the solder, so that eventually, after many cyclings, the bond will fail like a solder wire bent once too often.

Fairchild solved this problem, says Thomas J. Moutoux, manager of power transistor and silicon controlled rectifier engineering, by putting a relatively thick (30-to-40 mil) disk of molybdenum, beryllia, or silicon-tungsten between the chip and the plate. The silicon expands at the same rate as the disk, which is thick enough to expand within the elastic limits of the material, thus acting like a spring.

The disk and the steel weld rings for the pins are braised to the base plate. The disk has a gold surface and the chip is coated with silicon-doped gold; when heated, the gold and silicon form a melt which, as it cools, forms a gold-silicon eutectic interface.

Fairchild, which has been providing samples of the TO-3, is ready to do the same with a hermetic version of the TO-66 that's essentially a smaller version of the TO-3.

Fairchild will put seven circuits into its new TO-3 and TO-66 cans: the 6207 2-amp npn amplifier/switch and its pnp complement, the 0403; the 7207 5-amp npn amplifier/switch and its pnp complement, the 0400; the 8207 10-amp npn amplifier/switch and its pnp complement, the 0402; and the 2N5264 180-volt 7-amp npn switch.

Moutoux says the new packages will cost slightly more than their non-hermetic forerunners.

Fairchild Semiconductor Division, Mountain View, Calif. **[445]**

New semiconductors

Nordic trigger pulled by light

Schmitt device is made with photosensitive FET; handles up to 20 watts

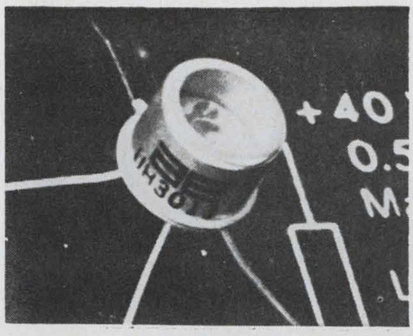
Photoelectric control almost always involves a photoresistor. But the people of the fjords have shown a way to get along without one.

Norway's A.S. Akers Electronics has built a Schmitt trigger whose firing level can be fixed by light intensity. The company says that its device, called the UH 3011, can be used in counters, readers, smoke detectors, and lamp drivers; it may also have a place in long-time delay lines, optical-logic devices, and process controllers.

Built into a TO-5 can, the UH 3011

is a thin-film hybrid integrated circuit. The key element is a light-sensitive field effect transistor. The Schmitt trigger can be fired by either raising the control voltage or shining light of sufficient intensity on the IC.

Lead on. Four wires come out of the device. The first one is for control voltage, which can go from 4 to 10 volts; the second lead is connected to the TO-5 can. In most applications, a gate resistor, grounded at one end, is attached to lead three. The load and the supply voltage—40 volts maximum—are connected to lead four.



Norwegian hybrid. The trigger is a thin-film IC made for counters and readers.

The minimum intensity at which the trigger fires is a linear function of control voltage. For example, if a 10-megohm gate resistor is attached, if the wavelength of the illumination is 9 microns, and if the control voltage is 5 volts, the device fires when the illumination intensity exceeds 200 lumens per square meter and turns off when the intensity falls below 150 lumens. If the control voltage is raised to 9 volts, 525 lumens are needed to turn on the trigger, and it doesn't shut off unless the intensity drops below 350 lumens.

The UH 3011 switches up to 20 watts with a 10-megohm gate resistor attached, and its trigger level stays the same for shifts in the 0°-to-85° range. If the gate resistor is only 1 megohm, the operating range goes out to 120°C.

In the off state the switch draws 1 milliamp from the control supply if the control input is 4 volts, and 2.6 ma at 10 volts. If the device is on, the current ranges from 2.5 to 8.0 ma.

A.S. Akers Electronics, Horten, Norway
[446]

New Books

Bifocal and bright

Applied Optics: A Guide to Modern Optical System Design
Leo Levi
John Wiley & Sons Inc.
620 pp., $18.95

Many recent developments in optics have resulted from the application of principles from theories of communication, amplifiers, oscillators, and feedback. This has been especially true in the areas of image analysis, holography, and coherent light. Levi's volume is thus intended for engineers attempting to straddle several technological disciplines as well as for those working with optical systems. Doing a good job for both these groups is a formidable task, but Levi has succeeded amazingly well.

Three major sections deal with fundamentals and with generators and modifiers of light. A second volume will deal with detectors. The fundamentals section discusses principles of radiometry, photometry, and colorimetry; the wave nature of light; communications-theory aspects of optical images, and the quantum nature of light. However, the chapters on modifiers, such as lenses and prisms, are the most extensive and best presented. Also included are pages of tables, which will be especially useful to practicing optical engineers.

Levi stresses the areas of practical importance, giving academic or theoretical topics only brief treatment. This emphasis leads to the inclusion of subjects bordering on optics, such as incandescence and discharge lamps, photoluminescence, roetgenoluminescence, cathodoluminescence, electroluminescense, cathode-ray-tubes, image tubes, and X-ray viewing and recording systems. Similarly, the tables—many computed especially for this volume—include detailed data on black-body radiation, extensive tables of sin x/x, precise values of maxima and zeros of $(\sin x/x)^2$ and $J_1\ (x)/x)^2$, and modulation transfer functions of diffraction-limited lenses. Finally, the references are abundant and relevant.

The volume's faults are few but annoying. The author devotes 84 pages to prisms but only 42 to the much broader topic of lasers and related devices. Holography gets only two short paragraphs and nonlinear optics three pages. And this section stirs further disappointment when it accepts as formal fact the long-standing joke among some laser researchers of calling a laser oscillator a loser, for light oscillation by stimulated emission of radiation.

A.J. DeMaria
United Aircraft Research Laboratories
East Hartford, Conn.

Doing a model job

Computer-Aided Integrated Circuit Design
Gerald J. Herskowitz
McGraw-Hill Book Co.
423 pp., $15

Designing a new integrated circuit—linear or otherwise—or determining which types of IC's will work best in a system requires accurate mathematical models of the components and their interactions.

To study a circuit's response and sensitivity as parameters and environmental conditions change, the engineer feeds into a computer a model that can represent a variety of conventional IC's substituted at will into larger circuit or subsystem models. Models can also be employed to describe the operation of a proposed IC. Before the device is manufactured and tested, it can be evaluated and modified through simulated operation in the computer.

The problem is that it's difficult to model an integrated circuit element by element. The elements may be fabricated by a wide variety of techniques, some of which can encourage interactions that are difficult to describe. For example, a single integrated circuit might contain both diffused and thin-film resistors, which require different models. And models for diffused transistors may vary depending upon how the devices are to be isolated from other elements in the circuit.

Further, the choice of an active-device model may depend on whether the studies are being made for small-signal operation or for switching applications.

In some cases, IC elements can be represented by the same models used for their discrete counterparts. The model for a transistor fabricated on a substrate and ideally isolated from the remainder of the circuit is identical to the one for the comparable discrete transistor, for instance.

These are the subjects covered in Herskowitz's book. The focus in this work is on three broad areas, the first involving modeling procedures—including the experimental determination of model parameters—the second relating network and system computer techniques, and the third dealing with the use of modeling to achieve specific IC designs with the aid of a computer.

Herskowitz describes specific methods and outlines seven operating programs that have been applied to the design of currently available IC's. Included are three on-line optimization programs for use with time-shared computer systems.

Recently published

Introduction to the Basic Computer, Donald Eadie, Prentice Hall Inc., 430 pp., $11.50

Covering the fundamentals of computers, this book reviews number systems, logic schemes, and solid-state circuits. An up-to-date chapter on peripheral equipment precedes the concluding chapter on analog and hybrid techniques. For engineers unfamiliar with digital techniques.

Digital Computations in Basic Circuit Theory, Lawrence P. Huelsman, McGraw-Hill Book Co., 203 pp., $6.95

Designed for use in undergraduate circuit theory courses. Illustrates how digital-computation techniques can solve engineering problems. Subroutines are developed to solve both linear time-invariant and time-varying nonlinear networks, partial-fraction expansions, inverse Laplace transforms, Nyquist plots, and root-locus plots. Included are two subroutines that use the computer's printer to plot the data from the problem's calculations.

Time-Sharing Computer Systems, M.V. Wilkes, American Elsevier Publishing Co., 102 pp., $4.95

Surveys a rapidly expanding field, covering problems that have been solved and those that remain to be solved. Describes essential elements of systems, including swapping, scheduling, multiprogramming, paging, multiplexing, segmentation, and memory lockout. Discusses satellite computer system communication problems, graphic display systems, and managerial aspects. Intended for both the software and hardware designer.

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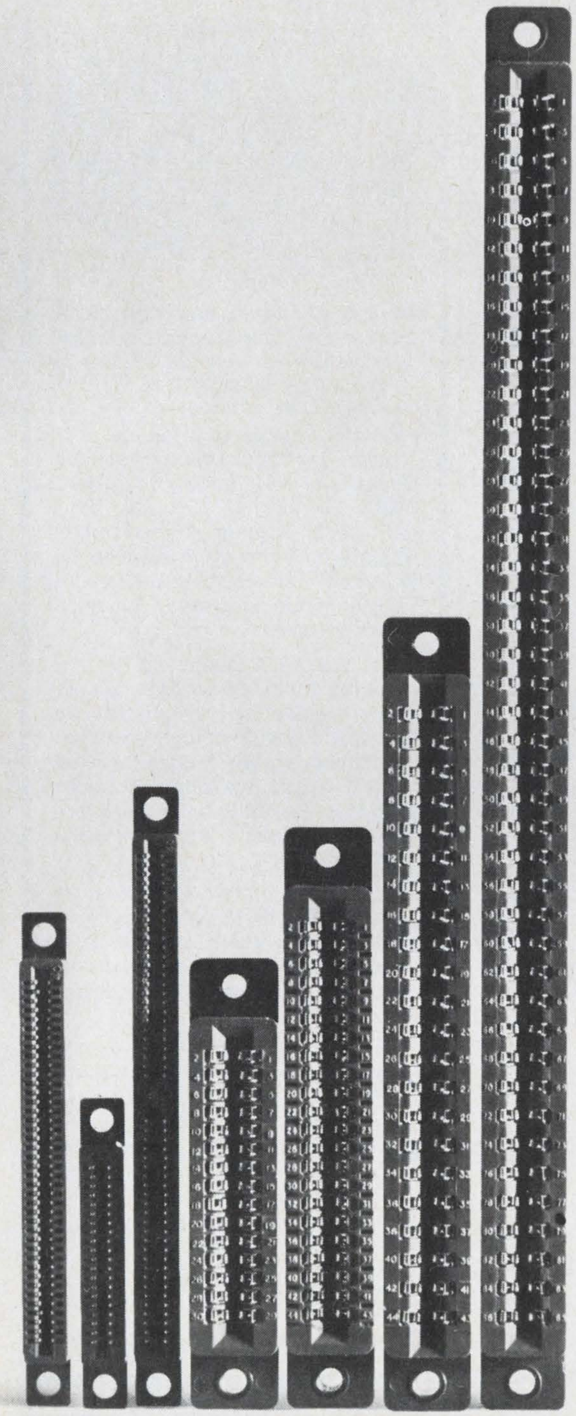

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Technical Abstracts

Reverberations

Amplified ferrimagnetic echoes
G.F. Herrmann, R.M. Hill, and D.E. Kaplan
Lockheed Research Lab
Palo Alto, Calif.

A new solid state effect may permit the development of a new class of microwave devices. Called a ferrimagnetic echo, the effect can be used to amplify, delay, or change the shape of short pulses of microwave energy.

The word echo is used here in a special way. In the simplest form of the effect, a microwave signal pulse is stored in the resonances of a medium such as yttrium iron garnet. After a waiting period, a second pulse—a recall pulse—is applied to the garnet at the same frequency. The two disturbances are then mixed so that an output signal or echo is radiated by the garnet at times determined by the period between pulses.

The discovery is part of a continuing study that has resulted in the finding of echoes in ionized plasmas (cyclotron echo) and molecular gases.

The echo effect is improved when irregularly shaped crystals biased by inhomogeneous magnetic fields are used. The conditions under which these echoes can be produced are particularly suitable for applications in new devices.

Microwave pulse-delay devices can now be exceedingly small and light because they can operate efficiently without either cryogenic cooling or a very homogeneous magnetic field. Delays of 2 microseconds are possible with a single recall pulse; with multiple recall pulses, delays may exceed 10 microseconds. The echo pulses are amplified by as much as 50 decibels in relation to the signal pulses.

Time compression or expansion of microwave pulses is also possible using a modified pulse sequence. To compress a microwave pulse by this method, the input and recall pulses are both frequency modulated. If the duration of the recall pulses is adjusted to be half that of the signal pulse, the echo pulse is very much shorter than the

signal. Compression ratios in excess of 250:1 have been achieved, so the pulse compression techniques may extend into the nanosecond range.

In a radar application this would permit the resolution of target features that vary over little more than a foot in depth with transmitter pulses more than a thousand feet long. As an added dividend, the technique amplifies weak radar-return echoes at the same time that it compresses the pulses.

The Lockheed development relies upon restricted mutual coupling between the oscillatory modes of the ferrimagnetic system. This is done with inhomogeneous internal magnetic fields that allow a given oscillator, or spin mode, to make exchanges of energies close to its own. As a consequence, a nonlinear energy flow process induced by the recall pulse causes certain groups of spin modes to be rapidly pumped up in amplitude with energy derived from their neighbors.

These highly excited modes eventually unite to form a large radiating magnetic moment at a time determined by the interval between the signal and recall pulse. The disturbance initially impressed upon the system by the signal then reappears as a strongly amplified echo.

Presented at the 14th Annual Conference on Magnetism and Magnetic Materials, New York, Nov. 18-21.

Small strain

IGFET strain transducers utilizing piezoelectric materials

James Conragan
Electronics Research Laboratory
University of California, Berkeley

Insulated-gate field effect transistors fabricated from piezoelectric semiconductors can be used as small and fast thin-film transducers. The IGFETS produce a d-c response when they're strained and they don't need the external amplification required by conventional piezoelectric strain transducers. The twin functions of strain sensing and amplification are built into the device.

Any insulating material, from

comparatively rigid glass to a highly flexible polyamide film, can be used as the substrate. Cadmium sulfide shows the greatest piezoelectric activity among the semiconductors that are suitable. Cadmium selenide and tellurium are two other materials that have been used. The insulating layer is made of silicon monoxide, and aluminum is used for the electrode material.

When the thin-film IGFET is strained, a piezoelectrically induced field is produced in the semiconductor. This field is neutralized by carriers within the semiconductor itself, a process that takes place at a rate determined by the dielectric relaxation time of the semiconductor. This produces a change in the charge distribution within the IGFET's channel, causing a corresponding change in the drain current. Because this change in charge distribution remains as long as the strain is applied, the result is a d-c response to the strain.

Cadmium sulfide's piezoelectric activity is due primarily to the high crystal orientation of its deposited film. Film thickness is approximately 10,000 angstroms, while the channel depth ranges from 100 to 1,000 Å. Resistivity of the sulfide material must be on the order of 10^4 ohm-centimeters to reduce unwanted bulk currents between source and drain. This gives a dielectric relaxation time of about 10 nanoseconds and represents the upper limit of response to an applied strain.

The transducers have a typical stress sensing area of 100 square mils or less. So far, only these fairly large-area devices have been studied; response time is limited to 1 microsecond.

The thin-film IGFET can also be used as a current source or a voltage source if an additional load-resistor is deposited and a second IGFET is used as a source follower.

Work is currently underway to improve the sensitivity and stability of the devices, which can also be used in microphones and surface acoustic wave detectors.

Presented at the 35th convention of the Audio Engineering Society, New York, Oct. 21-24.

New Literature

Power conversion equipment. Topaz Inc., 3802 Houston St., San Diego, Calif. 92110, has released a 12-page catalog describing solid state power conversion equipment.
Circle **446** on reader service card.

Dual in-line packaging. Scanbe Mfg. Corp., 1161 Monterey Pass Rd., Monterey Park, Calif. 91754. Dual in-line packaging is described in a 20-page designer's catalog. **[447]**

Rfi filters. U.S. Capacitor Corp., 2151 N. Lincoln St., Burbank, Calif. 91504, has published bulletin No. 2000 covering a new line of 50 wvdc, L-section rfi filters. **[448]**

Panel meter catalog. Voltron Products Inc., 403 S. Raymond Ave., Pasadena, Calif. 91101, offers catalog DA68 giving complete information on the DA series 2½-, 3-, 3½- and 4-inch panel and switchboard instruments. **[449]**

Data generator. Datapulse Division of Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. Advance specification 212 describes a 75-Mhz, 16-bit data generator with simultaneous +5 v and −5 v NRZ outputs and ±2 v baseline offset. **[450]**

Flat ribbon cable. Spectra-Strip Corp., P.O. Box 415, Garden Grove, Calif. 92642, has published a data sheet describing Spectra-Twist flat ribbon cable, which consists of twisted pairs of round conductors, bonded. **[451]**

Germanium detectors. Laboratory Products Division, Isotopes, a Teledyne Co., 50 Van Buren Ave., Westwood, N.J. 07675. A six-page brochure covers a full line of lithium drifted germanium detectors. **[452]**

Broadband detectors. I-Tel Inc., 10504 Wheatley St., Kensington, Md. 20795. Bulletin 1929-21 contains dimensions, performance specifications, and prices for a line of broadband detectors. **[453]**

Desktop modem. Ultronic Systems Corp., Mt. Laurel Industrial Park, Moorestown, N.J. 08057, has available a technical bulletin on the series 2400 Data Pump, a 2400 bits/sec desktop modem. **[454]**

Power supplies. Technipower Inc., Benrus Center, Ridgefield, Conn. 06877. Catalog 691 gives complete electrical and mechanical specifications and prices of thousands of power supplies. **[455]**

Videotape recorder. Ampex Corp., 2201 Lunt Ave., Elk Grove Village, Ill. 60007, has issued a brochure containing a description and specifications of the VR-5100 portable, closed-circuit videotape recorder. **[456]**

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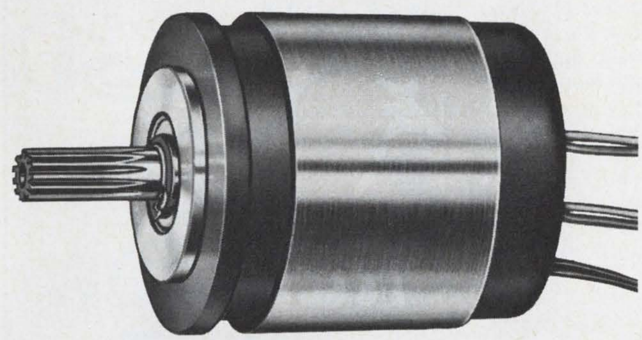

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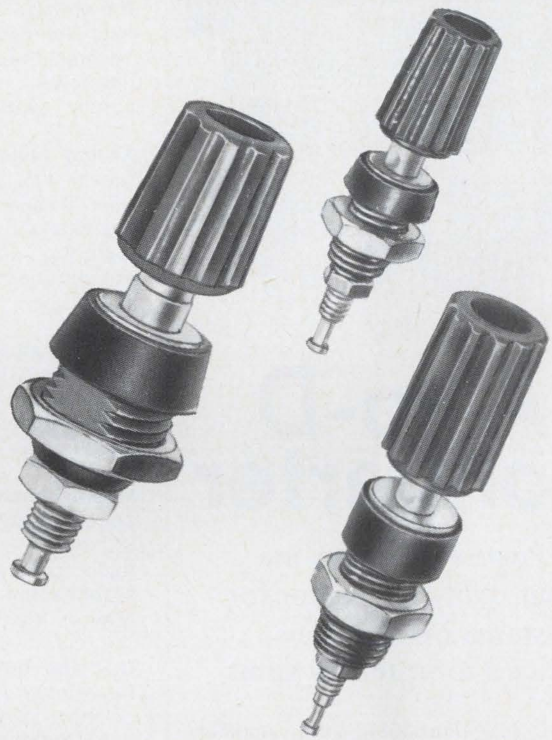
Dependable binding posts



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New Literature

Electronic readout. Endevco Corp., 1675 Stierlin Rd., Mountain View, Calif. 94040, offers a data sheet on a portable, low-cost electronic readout for use with pressure, force, and acceleration measuring transducers. **[457]**

D-c voltage standard. Cohu Electronics Inc., Box 623, San Diego, Calif. 92112. Technical data sheet 15-76 covers a d-c voltage standard with 0.001% accuracy. **[458]**

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 a four-page brochure. **[459]**

Power supplies. Elgin Electronics Inc., P.O. Box 1318, Erie, Pa. 16512. A four-page technical data folder for design engineers deals with low-voltage power supplies for integrated circuits. **[460]**

Modular instrumentation systems. New London Instrument Co., 153 California St., Newton, Mass. 02158. A six-page folder covers modular instrumentation systems for modulation analysis, calibration, and testing. **[461]**

U.S. and foreign computers. Auerbach Info Inc., 121 N. Broad St., Philadelphia 19107, has released a four-page brochure providing a comprehensive guide to American, European, and Japanese computers. **[462]**

Solder flux. Micro Co., Box 543, Easton, Pa. 18042, offers bulletin No. 12 on Microflux-A, a water-soluble solder flux for p-c boards and other soldering applications. **[463]**

Data set. Sangamo Electric Co., Box 359, Springfield, Ill. 62705. A data set that transmits and receives asynchronous serial digital data over direct distance dialing networks at rates from 0 to 1,200 bps is described in bulletin 5305. **[464]**

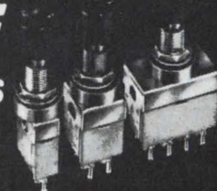
Gallium arsenide semiconductors. Monsanto Co., 10131 Bubb Rd., Cupertino, Calif. 95014. Performance and physical characteristics of III-V light-emitting semiconductors are detailed in a short-form catalog. **[465]**

Components catalog. James Electronics Inc., 4050 N. Rockwell St., Chicago 60618, offers a general catalog outlining a line of electromechanical and solid state devices. **[466]**

Push-button switch. Micro Switch, a division of Honeywell, 11 W. Spring St., Freeport, Ill. 61032. A two-page product sheet describes the 15PB miniature unlighted push-button switch. **[467]**

Momentary or Push On, Push Off

MINIATURE Push Button Switches



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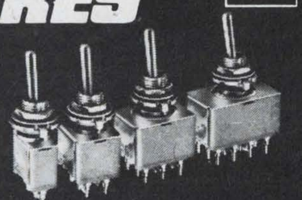

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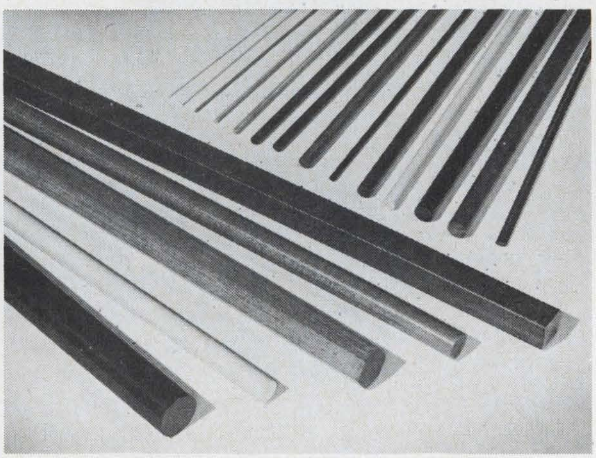

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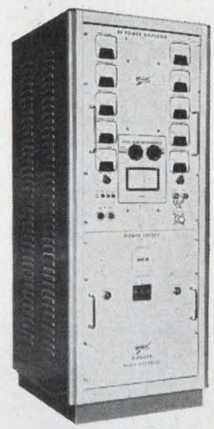

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10038	200-260	125 watts	13	5 MHz
10039	220-400	125 watts	13	5 MHz
10270-11043	40-200	1.0 KW	13	1 MHz
10270-11044	200-400	1.0 KW	13	5 MHz
10270-11045	400-800	1.0 KW	13	6 MHz
10270-11046	800-1000	1.0 KW	12	4 MHz
11017	400-450	2.5 KW	13	6 MHz

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10282	4K3SJ	1700-2400	1.0 KW	47-45	4-6	—	—
10283	4K3SL	1700-2400	1.0 KW	41-38	9-12	38.3	13-14
10284	4K3SK	2400-2700	1.0 KW	43-42	10-15	—	—
10285	4K3SN	2850-3050	1.0 KW	45	7	—	—
10276	VA888	4400-5000	1.0 KW	51	6-8	41	13-19
10233	VA834B	4400-5000	1.0 KW	51	5.5-7.5	41	11-17
10277	VA834D	5500-5850	1.0 KW	51	5.5-7.5	41	11-17
10278	VA861	5900-6400	1.0 KW	58	7-8	48	11
10286	VA866	7100-8500	1.0 KW	59	12	50	20
10287	VA930	15000-18000	0.5 KW	50	12	40	20

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See MCL "MICROWAVE MARKETPLACE" Spread, 1969 Electronics Buyers' Guide

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New Literature

Laser systems. Korad Department, Union Carbide Corp., 2520 Colorado Ave., Santa Monica, Calif. 90406. Series K-1 pulsed, solid state laser systems are described in a four-page brochure. **[468]**

Low level limiters. DeMornay-Bonardi, division of Datapulse Inc., 1313 N. Lincoln Ave., Pasadena, Calif. 91103. Technical data sheet DB-359 covers precision low-level limiters using silicon epitaxial devices combined with a filter structure. **[469]**

Semiconductor bases. The Nippert Electric Products Co., 801 Pittsburgh Dr., Delaware, Ohio 43015. Bulletin TR-368 describes semiconductor mounting bases produced with integral weld rings by a process of cold extrusion and coining. **[470]**

Display and control. Transistor Electronics Corp., Box 6191, Minneapolis 55424. A complete line of information display and control components, assemblies, and systems are described in catalog 629. **[471]**

Concentration converters. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. Digital and standard concentration converters are discussed in bulletin 7139. **[472]**

IC parameter definitions. IC Metrics Inc., 121-03 Dupont St., Plainview, N.Y. 11803, has available a 32-page text on linear IC parameter definitions. **[473]**

Adjustable toroids. Vanguard Electronics, a division of Wyle Laboratories, 930 W. Hyde Park Blvd., Inglewood, Calif. 90302. Applications and operating characteristics of miniature high-frequency adjustable toroids, called Varoids, are described in a specifications brochure. **[474]**

Data handling. Tally Corp., 1310 Mercer St., Seattle 98109, has published Tech Topics No. 3, entitled "Data Handling in a Transmission Network". **[475]**

Filter catalog. TT Electronics Inc., Box 180, Culver City, Calif. 90230. The 1968-69 filter catalog lists highpass, lowpass, bandpass and band-reject types. **[476]**

Rotary pulse generators. Trump-Ross Industrial Controls Inc., 265 Boston Rd., North Billerica, Mass. 01862. Bulletin 808A contains revised data on the type 10 and type 11 Tru-Rota rotary pulse generators. **[477]**

Holographic systems. Jodon Engineering Associates, 145 Enterprise Dr., Ann Arbor, Mich. 48103. Two complete systems for holography and nondestructive testing are described in an illustrated brochure. **[478]**

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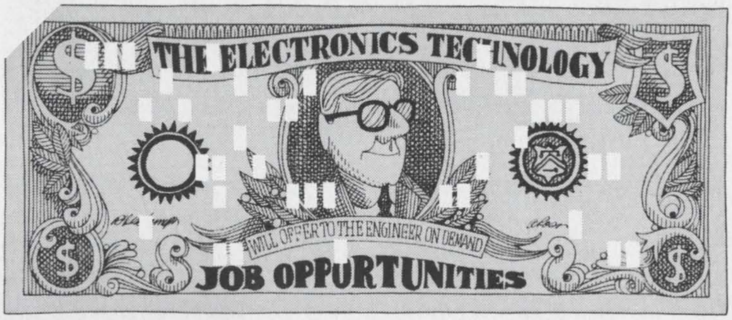

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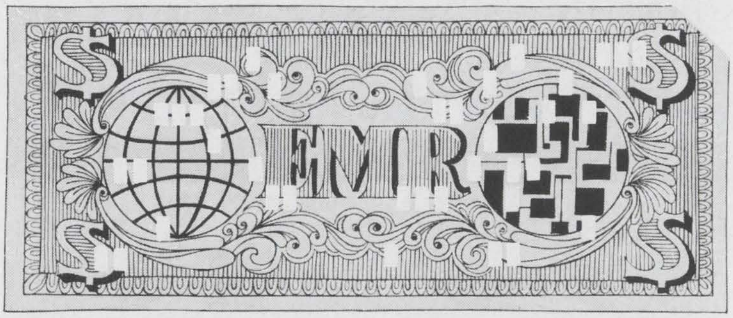

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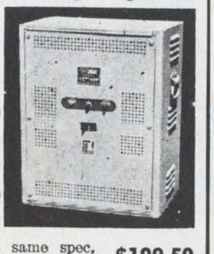

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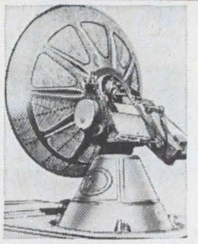

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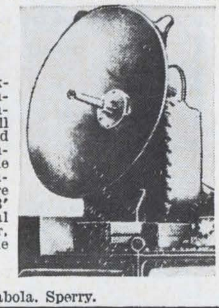

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TYPE	CHANNEL	MODE OF OPERATION	DESCRIPTION	TEMP RANGE	CASE #	$V_{GS(th)}$ (VOLTS TYP)	$I_{D(ON)}$ (mA TYP)	I_{DSS} (nA TYP)	BV_{DSS} (VOLTS)	Y_{fs} (μmhos TYP)	C_{RSS} (pF TYP)	$R_{DS(ON)}$ (Ω TYP)	G_{PS} (dB TYP)	NF (dB TYP)	PRICE 1-99	PRICE 100-999
MEM511 2N4353	P P	Enhancement Enhancement	General Purpose MTOS-FET†	−65° to +125°C	TO-72	−4.0	−6.0	−0.2	−30	2,500	2.0	150	*	*	8.00 10.00	5.35 6.70
MEM511C	P	Enhancement	General Purpose MTOS-FET†	−50° to +100°C	TO-72	−4.0	−6.0	−1.0	−25	2,500	2.0	150	*	*	1.98	1.30
MEM517	P	Enhancement	Power MTOS-FET†	−65° to +125°C	TO-33	−3.5	−60	−0.3	−30	12,000	10	30	*	*	19.00	12.75
MEM517A	P	Enhancement	Power MTOS-FET†	−65° to +125°C	TO-5	−3.5	−60	−0.3	−30	12,000	10	30	*	*	19.00	12.75
MEM517AC	P	Enhancement	Power MTOS-FET†	−50° to +100°C	TO-5	−3.5	−60	−1.5	−25	12,000	10	30	*	*	3.98	2.70
MEM517B	P	Enhancement	Power MTOS-FET†	−65° to +125°C	TO-72	−3.5	−60	−0.3	−30	12,000	10	30	*	*	19.00	12.75
MEM517BC	P	Enhancement	Power MTOS-FET†	−50° to +100°C	TO-72	−3.5	−60	−1.5	−25	12,000	10	30	*	*	3.98	2.70
MEM517C	P	Enhancement	Power MTOS-FET†	−50° to +100°C	TO-33	−3.5	−50	−1.5	−25	12,000	10	30	*	*	3.98	2.70
MEM520	P	Enhancement	MTOS-FET	−65° to +125°C	TO-72	−4.0	−6.0	−0.2	−30	2,500	2.0	150	*	*	8.00	5.35
MEM520C	P	Enhancement	MTOS-FET	−50° to +100°C	TO-72	−4.0	−6.0	−1.0	−25	2,500	2.0	150	*	*	1.98	1.30
MEM550 3N151	P P	Enhancement Enhancement	Dual MTOS-FETS†	−65° to +125°C	TO-77	−4.0	−5.0 −7.0	−1.0 −0.2	−30	1,400 2,000	1.1	250	*	*	17.50 17.50	11.30 11.30
MEM550C	P	Enhancement	Dual MTOS-FETS†	−50° to +100°C	TO-77	−4.0	−5.0	−0.5	−25	1,400	1.1	250	*	*	3.98	2.70
MEM551	P	Enhancement	Dual MTOS-FETS	−65° to +125°C	TO-77	−4.0	−5.0	−0.2	−30	1,400	1.1	250	*	*	17.50	11.30
MEM551C	P	Enhancement	Dual MTOS-FETS	−50° to +100°C	TO-77	−4.0	−5.0	−1.0	−25	1,400	1.1	250	*	*	3.98	2.70
MEM554	N	Depletion	VHF Cascode	−65° to +150°C	TO-72	−1.5	10	*	20	13,000	.02	50	20 @ 200 MHz	2.8 @ 200 MHz	8.00	5.35
MEM554C	N	Depletion	VHF Cascode	−50° to +125°C	TO-72	−1.5	10	*	20	11,000	0.2	50	18 @ 200 MHz	3.5 @ 200 MHz	1.50	1.10
3N140 3N141	N	Depletion	VHF Amplifier VHF Converter	−65° to +150°C	TO-72	−1.5 −1.5	10 10	* *	20 20	11,000 11,000	.02 .02	50	18 @ 200MHz 17	3.2 @200MHz *	1.60 1.50	1.15 1.10
MEM556	P	Enhancement	High Voltage MTOS-FET†	−65° to +125°C	TO-72	−4.0	−7.0	−0.1	−50	950	0.3	700	*	*	10.00	6.70
MEM556C	P	Enhancement	High Voltage MTOS-FET†	−50° to +100°C	TO-72	−4.0	−7.0	−0.5	−45	950	0.3	700	*	*	2.98	2.00
MEM557	N	Depletion	VHF Triode	−65° to +150°C	TO-72	−2.0	8.0	*	20	10,000	.32	200	19 @ 200 MHz	2.5 @ 200 MHz	5.35	3.60
MEM557C	N	Depletion	VHF Triode	−50° to +125°C	TO-72	−2.0	8.0	*	20	8,000	.32	200	17 @ 200 MHz	3.0 @ 200 MHz	1.60	1.00
MEM560	P	Enhancement	General Purpose Switch†	−65° to +125°C	TO-72	−2.0	−20	0.5	−40	3,500	3.0	100	*	*	8.00	5.35
MEM560C	P	Enhancement	General Purpose Switch†	−50° to +100°C	TO-72	−2.5	−15	1.0	−35	3,000	3.5	175	*	*	1.98	1.30
MEM562	N	Enhancement	General Purpose Switch	−65° to +125°C	TO-72	1.5	15	0.5	20	4,000 @ 10 mA	0.3	150	*	*	5.85	3.80
MEM562C	N	Enhancement	General Purpose Switch	−50° to +100°C	TO-72	1.5	15	3.0	20	4,000 @ 10 mA	0.3	150	*	*	1.65	1.10
MEM563	N	Enhancement	High Gain Switch	−65° to +125°C	TO-72	1.5	40	1.0	20	7,000 @ 10 mA	0.3	50	*	*	8.00	5.35
MEM563C	N	Enhancement	High Gain Switch	−50° to +100°C	TO-72	1.5	40	5.0	15	7,000 @ 10 mA	0.3	50	*	*	1.98	1.30
MEM564C	N	Depletion	VHF Cascode†	−50° to +125°C	TO-72	−1.5	10	*	20	12,000	.02	50	17 @ 200 MHz	3.5 @ 200 MHz	1.65	1.25
MEM571C	N	Depletion	VHF Triode†	−50° to +125°C	TO-72	2.0	8.0	*	20	10,000	.32	200	17 @ 200 MHz	3.0 @ 200 MHz	1.75	1.15

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International Newsletter

December 9, 1968

Northern Electric leads race to build Canadian satellite

The feeling in Ottawa is that a consortium headed by the Northern Electric Co. has the inside track on the contract for Canada's proposed communications satellite system. **Subcontractors would be Canadair Ltd. of Montreal and the Hughes Aircraft Co.** The recent selection of Northern Electric to manufacture Intelsat 4's $1 million repeater subsystem as a Hughes subcontractor strengthens the feeling that it will get the big order.

If legislation to set up a Crown corporation with private participation is presented to the current session of Parliament, 1971 should see two 6,000-channel Canadian-designed birds in stationary orbit at about 95° longitude. Besides the Northern Electric group, a consortium headed by RCA Ltd. (with Spar Aerospace Products Ltd. of Toronto and TRW Inc.) has submitted a proposal. **Both groups have suggested that one 1,000-pound satellite be launched by a U.S. rocket to cover all of Canada from the Arctic to the U.S. border, and that a second be orbited about 3° away to take care of solar transit interference.** A third satellite would stand by on the ground.

No cost figures have been disclosed, but it's estimated that the three satellites, plus launching by Thor Delta or Atlas rockets, would cost about $45 million. Officials of Canada's Department of Industry will discuss the proposals with both consortiums in mid-December, then turn them over to the newly formed Communications Department, which will be responsible for development of the program.

New Hitachi IC for fast computers

Engineers at Hitachi Ltd. have built a new family of diode-emitter-coupled logic IC's for extremely fast computers. **The nonsaturating circuits are intended for large machines with an addition time on the order of 50 nanoseconds.**

The Hitachi IC's, described in a paper given at this week's National Electronics Conference in Chicago, **are designed to eliminate the disadvantages of conventional current-mode logic IC's**—easy oscillation, a high density of elements per gate, and a high propagation delay-power product when used in registers. Diode gates at the circuit's input suppress oscillation and provide an additional logic stage, decreasing both the number of elements per gate and the propagation delay-power product.

Most of the delay in Hitachi's DECL circuit is in the current switch. The switches described at the conference gave a delay of nearly 2 nsec—the figure for conventional CML—but the company says its latest units are providing a delay of 1.34 nsec per logic stage, close to the 1 nsec claimed for Motorola's MECL-3.

NEC unveils Japan's biggest computer

That Nippon Electric Co. computer destined to be the largest commercial machine developed in Japan [Electronics, April 1, p. 144] has finally been officially announced by the company, **which says the first one will be delivered in March 1970.** The computer, the Neac Series 2200 Model 700, was first mentioned last spring when Fujitsu introduced its Facom 230-60, at the time the biggest domestic machine and the first featuring multiprocessing.

The 700, which also has two central processors, will be the first Japanese computer to have an associative memory. It will also have a main core memory with a capacity of 2,097,000 characters per central processor. **Fixed-point calculations will be done in 0.5 microsecond, floating addition in 0.8 μsec.** This compares with the 230-60's fixed-point addition time of 1.26 μsec. The 700's cycle time will be 0.5 μsec per 48-bit word; the 230-60's is 0.92 μsec per 42-bit word.

Nippon Electric claims that the only machines more powerful than its 700 are IBM's 360/85, Control Data's 6600 and 7600 [see p. 45], and perhaps Burroughs' 8500.

ELDO undismayed by rocket fizzle

Failure of its three-stage Europa 1 to carry a test satellite into orbit hasn't left the European Launcher Development Organization distraught. **As a matter of fact, some observers are calling the shot a limited success.** The reason: one of the prime purposes of the launch was to check separation and ignition, and these processes went without a hitch.

What failed in the Woomera, Australia, test was the third stage. Made by a group of German firms, it was supposed to deliver full thrust for 6 minutes, pushing the 550-pound Italian-made satellite into a polar orbit. Instead, the stage delivered full thrust for just 7 seconds. **German space officials suspect a loss of pressure in the helium supply** due to a line break or a malfunctioning valve in the system designed to reduce pressure from 700 pounds per square inch to 280 psi.

The next test shot—the eighth of a total of 11—is scheduled for next May at Woomera. But the last two shots will probably take place at ELDO's new space range in French Guiana.

German firm expects some Phantom work

At least one West German avionics firm—Fluggeraetwerk Bodensee GmbH—stands a pretty good chance of building some of the electronics for the 88 McDonnell Douglas RF-4E Phantom jets being purchased by the Bonn government [Electronics, Nov. 11, p. 308]. **A General Electric Co. spokesman has indicated that his firm is willing to give a contract to Fluggeraetwerk to produce and maintain the GE-designed automatic flight control system used in the Phantom.** The German government, however, has the final word on which company will get the contract.

Addenda

Australia's overseas telecommunications commission has awarded contracts totaling $1.7 million to two affiliates of Japanese firms for work on a second satellite communication station at Carnarvon. Mitsubishi Australia will supply $900,000 worth of antenna systems, while Sumitomo Shoji Australia will receive $800,000 for microwave and multiplex installations. Upon its completion in about a year, the station will take over the NASA functions of the present Carnarvon station, which will then be used to handle international telecommunications. . . . Jeumont-Schneider of France is negotiating for the sale of an "important interest" to Westinghouse. Jeumont appears to be seeking technical aid in its competition with such European giants as Siemens and English Electric-GEC, while Westinghouse may be demanding capital participation in exchange for such aid. The French company has been in the red since it was formed in a 1964 merger. . . . At the same time, Westinghouse's decision to stop manufacturing television sets has been met with interest by Japanese set makers. For some time, the company has been importing small-screen models from Japan; from now on the 20- and 23-inch models also will come from across the Pacific.

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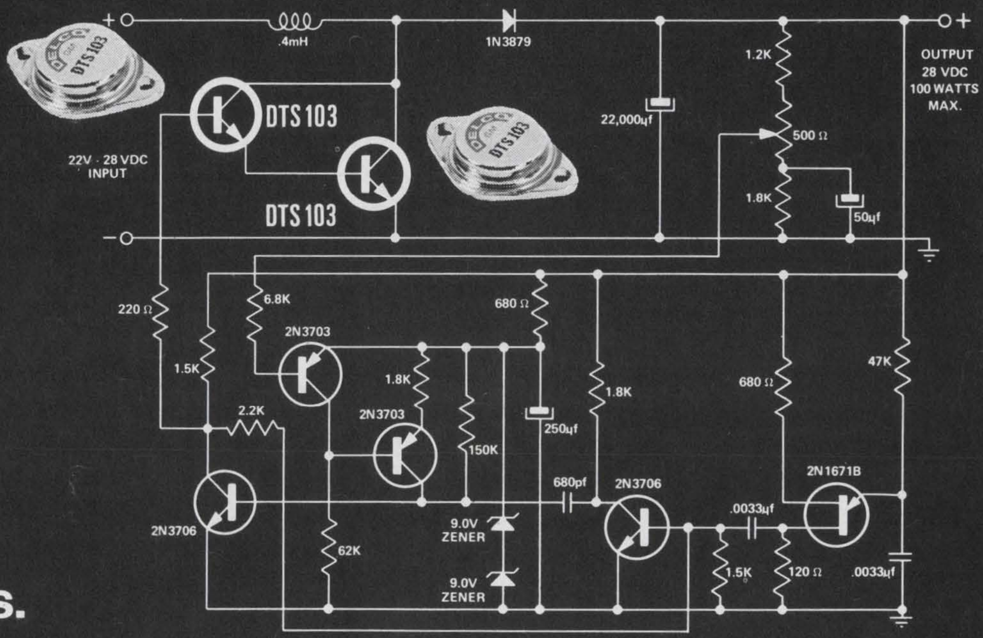

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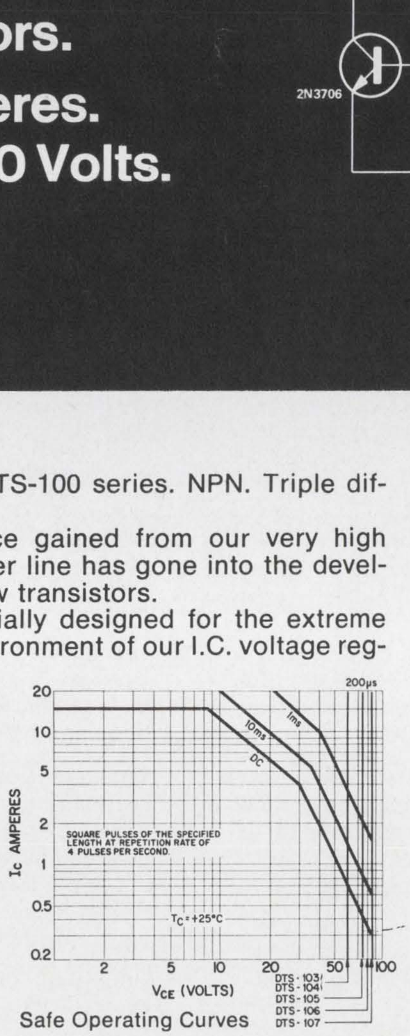

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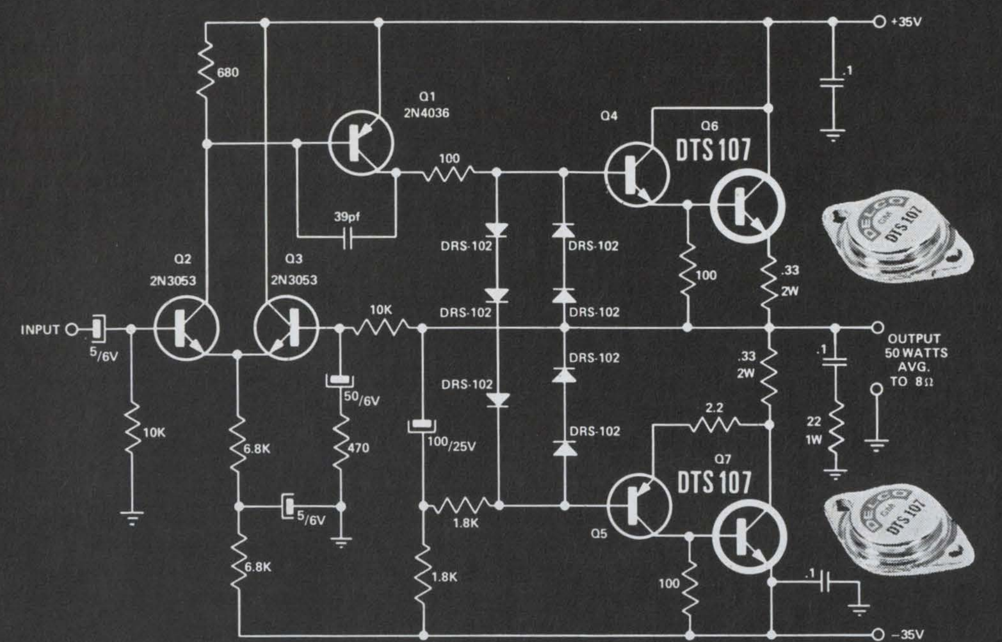

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DTS-105	15	20	100	80	75	20-55	5	1.8	4	125
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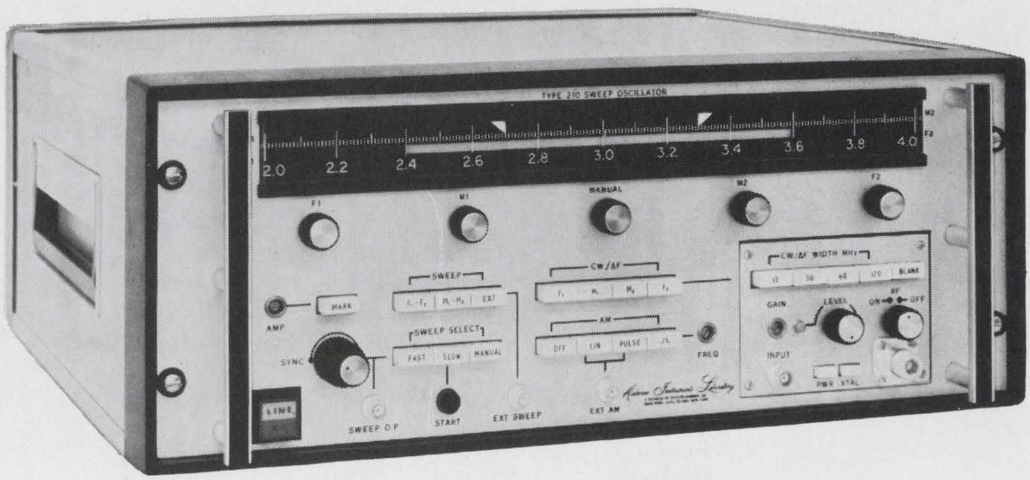

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France

Gathering clouds

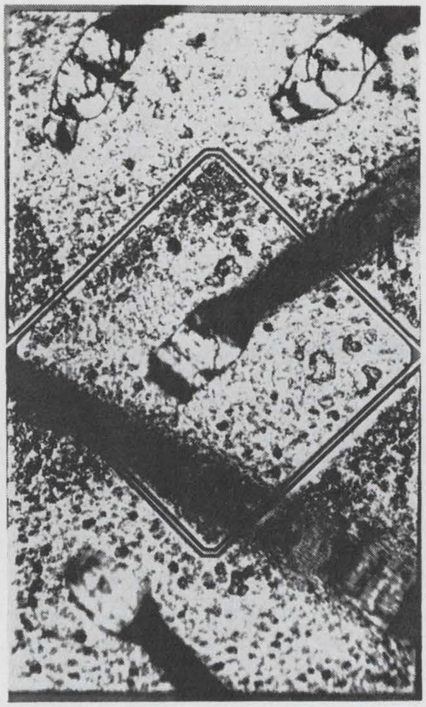
President de Gaulle's austerity measures are making the electronics sales outlook quite gloomy.

By further reducing the 1969 budget in an effort to slow inflation, the Gaullist regime probably will strangle all but the most urgent capital investment projects. For example, Jean-Marie Fourier, finance director of Thomson Houston-Hotchkiss Brandt, expects more reductions next year in government equipment purchases. The military establishment and such state-owned utilities as Electricité de France and the phone system will be under strong pressure to postpone expansion projects. Sums up Fourier: the consequences for the electronics industry could be "very hard." Even France's 1969 contribution to the Concorde SST has been cut and her nuclear tests canceled.

Less to spend. Industry sources also assume that government plans to hold down wages will cut into consumer demand. The prospect is particularly galling because the consumer sector was expected to be one of the few bright areas in a generally mediocre 1969. Another round of wage increases—promised last July for next March—is presumed dead.

On the other hand, electronics exports will almost certainly rise. The combination of French export incentives and Germany's decision to give imports a 4% price advantage will speed French electronics equipment across the Rhine and make competition easier elsewhere. Germany, which buys 20% of France's exports, is her biggest electronics customer.

Finally, many observers fear the austerity measures will increase Leftist discontent and fuel new student and worker unrest.



Up there. IBM's experimental MES FET has gate enclosing central drain. Gate width is only 1 micron; oscillation frequency can go to 12 gigahertz.

Switzerland

Microwave FET's?

Circuit designers may soon have a new component to work with – a Schottky-barrier field effect transistor operating well up in the microwave range.

At its present stage of development at IBM's research labs near Zurich, the new transistor, christened MES (for metal semiconductor) FET, has a maximum oscillating frequency of 12 gigahertz. That's considerably higher than the 9 Ghz reported so far for conventional insulated-gate FET's or bipolar types. And power gain for the new device is about 2 db at 10 Ghz, dropping to 0 db at 12 Ghz; gain-bandwidth product is up to 3.5 Ghz.

Karsten E. Drangeid, head of the Swiss research team, says the main goal of the work is to find out how far FET frequencies can be pushed into the microwave range, but he also hints at some applications for MES FET's. For example, they could be used as low-pass, wideband amplifiers in small-signal applications or as input stages in microwave systems. They might also serve as switches in digital circuits or replacements for low-power traveling-wave tubes.

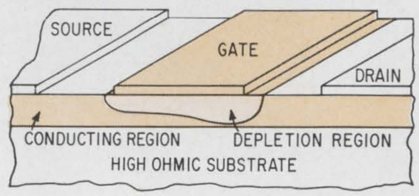
A square pad. Basically, the high oscillating frequency is attained by reducing the width of the Schottky gate to about 1 micron. Since a Schottky element is structurally simpler than a MOS FET, it's easier to narrow that gate. As a result, says Drangeid, IBM's new MES FET can be mass-produced without too much trouble.

The device is made of a high-resistivity silicon substrate covered with an n-type epitaxial silicon film. That film, between 0.2 and 0.3 micron thick, is the conducting channel. The 0.2-micron gate contact is a gold-chromium-nickel sandwich enclosing the central drain. The source and drain pads are of alloyed gold-antimony.

Another major difference between the new device and MOS FET's is the absence of an insulating layer between the gate and the semiconductor material. A rectifying contact is formed directly at the metal-semiconductor junction below which the Schottky effect produces a charge-free, or depletion, region. The region's depth depends on the applied voltage. The substrate's resistivity is between 10 kilohm-centimeters and 50 kilohm-centimeters; that of the silicon film is about 0.1 kilohm-centimeters.

In one of Drangeid's MES FET versions, the drain is a square pad; each of the four legs surrounding the drain is 100 microns long, in effect making the transistor a parallel connection of four gates with a total effective length of 400 microns. This cuts the gate resistance caused by the small cross-section of the gate legs. And to minimize the losses and parasitic capacitances to which high-impedance FET's are very sensitive, the Swiss researchers have used a high-resistivity substrate and enclosed the drain.

Shaving it down. The narrow gate is made by a projection masking technique developed three years ago by AEG-Telefunken. The mask is reduced about 40 times by conventional methods. Then a high-resolution microscope lens is used to shrink the mask still further by a factor of 25, and the mask is projected onto the wafer. Finally, holes are etched into the silicon oxide layer.



View. Cross-section of MES FET shows 1-micron gate. It's in the form of legs paralleling the sides of drain.

A sequence of evaporation and resist-stripping methods is used for metalization. Gold is then deposited on the contacts to reduce resistance, and 8-micron wires are bonded to them.

Japan

Forbidding FET

Two Japanese researchers have used a semiconductor material they first investigated for their work on photocells to develop a thick-film field effect transistor. The material is sintered cadmium silicon sulfide (Cd_4SiS_6); it promises more reliable FET's, say the researchers, Miyoshi Haradome and Hirokuni Kawashima of Nihon University.

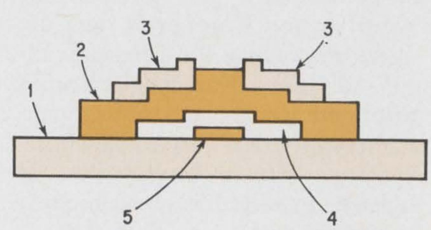
Because of the high electric potential applied to the semiconductor layer in FET's, a wide forbidden band is desirable. (The forbidden band is the energy gap just below the conduction band.) The wider the band, the more reliable the device. One commonly used semiconductor material, for example, is cadmium sulfide, which boasts a forbidden-band width of 2.4 electron volts. The cadmium silicon sulfide in the new FET, on the other hand, has about 2.8 electron volts. What's more, the material shows little tendency to decompose during sintering.

There also are manufacturing advantages. Inexpensive thick-film techniques—compatible with those for passive components—are used, and the transistors are on the same substrate as passive components.

No vacuum. The transistor is an inverted structure on an alumina substrate. Gold paste is deposited with a silk screen to form the gate electrode, source, and drain. The remainder of the structure can be made in the same way, so a vacuum isn't required. After the gate and insulator are deposited—and fired at a low temperature—the semiconductor is put on with paste that's a mixture of cadmium silicon sulfide powder, cadmium chloride, and ethylene glycol. The semiconductor is sintered at 500°C for 10 minutes.

A typical device has a transconductance of 500 micromhos at a gate bias of +5 volts. D-c input resistance is more than 10^{10} ohms, and input capacitance with bias applied is about 100 picofarads. Gain is constant at about 500 μmhos up to 10 kilohertz; the gain-bandwidth product is 1.2 megahertz.

Using the earlier evaporated thin-film electrodes, transistors can be made with source-to-drain spacing of 50 microns. With deposited paste electrodes, transistors can be made with 500-micron spacing.



Parts. Thick-film FET's elements are substrate (1), semiconductor layer (2), source and drain (3), dielectric layer (4), and gate (5).

One application that appears to offer promise is use of the FET, with a threshold bias of zero volts, as a diode; this is because it would be easier to make a diode array with thick-film techniques than to interconnect conventional diodes. For diode operation, source and gate are connected to serve as one electrode; the drain is used as the other electrode.

Twice the fax

Japan's fiercely competitive national newspapers have made facsimile reproduction a potent circulation weapon. Stories are written and set in type in Tokyo, made up into pages, and faxed to the provinces. There, pages of local news are added, plates are photolithographed, and the newspaper is printed. Thus, news is available from one end of Japan to the other within hours.

But as newspapers prosper they add pages, and it takes eight minutes to fax each page. So about two years ago the nation's leading financial sheet, the Nihon Keizai Shimbun, asked two professors at the University of Tokyo to develop a band-compression method for fax. The two, Tamiya Nomura and Yasuhiko Yasuda, specialize in space communications; the newspaper figured that anyone who could develop communication and telemetering systems sophisticated enough for space could certainly do something to cut the time needed to fax a newspaper page.

Half as long. The newspaper figured right. The Tokyo team devised a system that cuts transmission time to four minutes a page—by trading signal-to-noise ratio for speed. Still, the 6-decibel loss—to 39 db—is acceptable because 45 db is more than is needed for facsimile.

The old system used a two-level analog signal (one for black, the other for white) amplitude-modulated onto a carrier, passed through a sideband filter, and transmitted over a phone channel 48 kilohertz wide. Scanning density is about 12 lines a millimeter; for the fine lines

Circle 201 on reader service card

—about 50 microns—in Japanese characters the transmission rate approaches 150,000 bits a second.

Many efforts to speed transmission use digital systems, but new problems crop up in these more complex circuits. Nomura and Yasuda avoided these difficulties by sticking with the analog signal. At the same time, though, they took the same general road as other researchers—the tradeoff of signal-to-noise ratio for speed.

One more. Their system transmits three signals instead of two. The center level is used for black, the lowest and highest for white. Simple logic circuits select which white level is to be used alternatively. This either reduces the maximum frequency by half or doubles the transmission speed for the same bandwidth. And since the signal is still analog, no synchronizing circuits are needed at the receiver. The professors developed improved phase compensation and synchronous detector circuits for the receiver; otherwise, transmission is the same as for conventional fax.

Commercial equipment using the new system is being made by the Nippon Electric Co. Interestingly enough, Nippon was one of two companies – the other is Toho Denki – to develop sampling systems for increasing transmission rate at the expense of signal-to-noise ratio. However, printout is degraded by serrations at black-to-white transitions, lines that are actually a series of dots, and moire patterns in halftones. Also, more complex signal processing and synchronization techniques are required, because loss of sync means complete loss of signal.

Western Europe

Coming back

Freed of a marketing agreement that kept it from competing effectively in Europe, Fairchild Semiconductor is readying a new assault on a market that President C. Lester Hogan thinks is potentially as big as that of the U.S. "By 1973-75," says Hogan, "the total semiconductor market in free Europe could equal that of the U.S.; even if the curves don't intersect, the European market will certainly be 80% of that in the U.S."

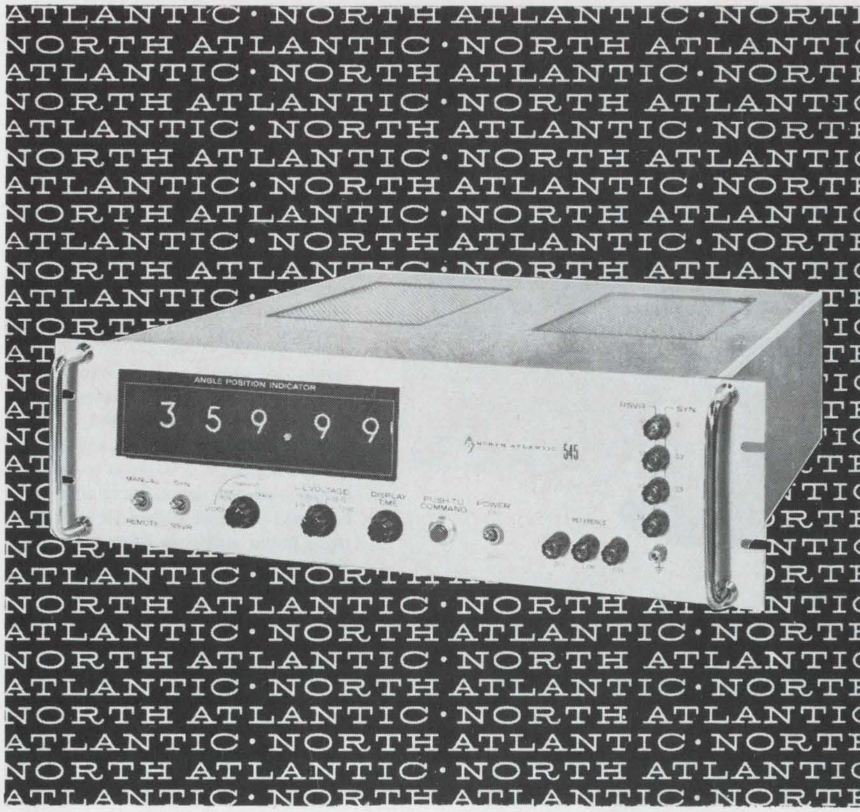
For that reason, says Hogan, "We're going to go into Europe and we're going to build a factory." Exactly where that factory will be is yet to be determined, but it will be in one of the Common Market countries. After his thorny experience with the de Gaulle government at Motorola Inc., Hogan will probably steer clear of France; the best bet at the moment seems to be Germany or Belgium (though Hogan will not even speculate that far).

The decision will be made by Christmas, and will depend in part on the fresh light on European manufacturing that can be shed by Douglas J. O'Connor, the new Fairchild marketing director. O'Connor spent two years in Germany, first as European marketing director for Texas Instruments and then as director general of Texas Instruments Deutschland.

"He knows more than any of us about how to obtain government cooperation and what the availability of labor is," Hogan says. "I listen carefully and attentively when he talks."

In—but out. It will take all the expertise that Hogan can command —and that is considerable—plus large expenditures of cash, to put Fairchild back in the European market. Profitable though it was, the agreement under which Societa Generale Semiconduttore SpA marketed Fairchild products in Europe put the continent off-limits to Fairchild's own aggressive sales and marketing staff.

Meanwhile, Motorola and TI had built plants, and Signetics and National Semiconductor have reached advanced planning stages for doing so. But Hogan doesn't think that Fairchild will have even the shell of a finished building in Europe until March 1970. "The negotiation phase can't be too quick," he says, "or you give up some advantages. I don't see how we can start build-



ing before March, and construction itself will take a year."

In the interim, then, Fairchild will establish sales offices throughout Europe and maintain an inventory there, set up distributors, and provide applications engineering and customer service. It will have 100 to 150 employees stationed on the Continent. Hogan doesn't believe that he will be at too much of a disadvantage with TI and Motorola during this period. "You have a higher profit margin on an incremental basis for U.S.-manufactured parts," he explains, "and you don't have the extra factory overhead, so you can afford to pay some duty."

"In any case," he adds, "my guess is that from 30% to 50% of what TI sells in Europe is made in the U.S. anyway."

A start. Initially, Fairchild's European plant will do only assembly and final testing. It will be a 40,000-square-foot expandable "module." By the time it's ready, Fairchild may already be building another plant in Europe, possibly in the United Kingdom or another European Free Trade Association country. But the debate now, Hogan says, is whether to add onto the first module or build three or four in different places. "About 600 to 1,000 employees, living off Fairchild technology, could run a satellite plant [with complete fabrication] in Europe," Hogan says. "If you want a totally integrated factory, you'd better go to 2,000 employees. We aren't making that decision now."

Because Fairchild must reestablish itself in Europe, its sales there will probably be less than 10% of the total next year. But eventually, says Hogan, "if we do an adequate job, we could do 40% of our business in Europe. That's the kind of investment we're thinking of."

Great Britain

Reading the meter

As Britons warily eye the approaching end of traditional coin values and a switch to the decimal system—it's to be completed by February 1971—engineering and systems companies are preparing for the accompanying change to the metric system. The government would like to see all manufacturers working in metric units by 1975, but it'll probably take the entire decade for all of Britain's industry to drop the feet-and-inches system.

However, at least some of the electronics houses are meeting the challenge of change head-on and experiencing no great problems. Welcoming it with relish are the makers of desktop calculators. Sales of ordinary decimal machines have been restricted in Britain because they're no good for computations involving money, weight, or distance unless the operator can convert all his figures to decimals before using the machine. Volume is estimated at only $10 million to $12 million, a figure that could triple within three years as U.S., Continental, and Japanese firms intensify sales efforts.

One plus one. The parade has already started. First with a third-generation integrated-circuit machine is Burroughs Machines Ltd., whose C3000 was introduced recently at a price of $1,000 to $1,500. Addo Ltd., British offshoot of the Swedish company, and Sumlock Comptometer, the only indigenous British manufacturer, will soon be selling British-designed IC machines in the same price range. Addo's will use 400-transistor metal oxide semiconductor chips supplied by General Instrument (UK) Ltd., a subsidiary of the U.S. company.

So far as component and system designs are concerned, the electronics manufacturers will find it easier than other industries to make the adjustment and should meet the target date easily. For one thing, the more important parameters of most hardware—frequency, current, resistance, and so on—will be counted as they always have been.

Harry Lightfoot, who studied the problems involved for the Marconi Co., sums it up: "The changeover will not be difficult in the electronics industry, provided a company does good solid prep work." Ferranti Ltd. has run a pilot project in which everyone from senior engineer to junior draftsman worked in metrics; the company found that it was far more difficult to get them to return to the old illogical Imperial units than to use the metric versions.

Thinking right. Of course, many companies already work partly in metrics. These include the component divisions of Mullard Ltd., a Philips subsidiary, and ITT's Standard Telephones & Cables, which are part of large international organizations that demand interchangeability of parts, specs, and drawings. And companies that export have had to consider metric requirements even when those requirements haven't influenced design. Finally, the heavy scientific content of electronics means that most designers habitually think metrically even though their specs are in feet and inches.

However, throughout Europe printed-circuit boards are designed to the 0.1-inch module. The biggest problem in this area could occur in the computer field: American dominance is so marked that if there should be a conflict between inch-sized and metric-sized components, the Yankee inch is almost sure to win. This could force British firms to make similar components to two standards if they want to retain the business of U.S. companies manufacturing in Britain.

Around the world

Italy. The embattled Elsi plant in Palermo, formerly owned by Raytheon, finally has a new owner. The Italian state holding company—Istituto per la Ricustruzione Industriale—has taken over the plant and appointed its communications and telephone subsidiary, STET, to run it. The component factory was the focal point of an ugly battle between Raytheon and Italian authorities during a general election earlier this year when the American company decided to close the money-losing operation and lay off its workers.

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Midwest Regional Manager
[312] MO 4-5800
Regina Hera, Directory Manager
[212] 971-2544
Thomas M. Egan, Production Manager
[212] 971-3140

Circulation Department

Isaaca Siegel, Manager [212] 971-6057

Research Department

David Strassler, Manager [212] 971-6058

Advertising Sales Staff

Frank E. LeBeau [212] 971-6464
Advertising Sales Manager

Wallis Clarke [212] 971-2187
Assistant to sales manager

Donald J. Austermann [212] 971-3139
Promotion Manager

Warren H. Gardner [215] LO 8-6161
Eastern Advertising Sales Manager

Atlanta, Ga. 30309: Michael H. Miller, 1375 Peachtree St., N.E.
[404] 892-2868

Boston, Mass. 02116: William S. Hodgkinson McGraw-Hill Building, Copley Square
[617] CO 2-1160

Cleveland, Ohio 44113: William J. Boyle, 55 Public Square, [216] SU 1-7000

New York, N.Y. 10036
500 Fifth Avenue
James R. Pierce [212] 971-3615
John A. Garland [212] 971-3617
Michael J. Stoller [212] 971-3616

Philadelphia, Pa. 19103:
Jeffrey M. Preston
Warren H. Gardner,
6 Penn Center Plaza,
[215] LO 8-6161

Pittsburgh, Pa. 15222: Warren H. Gardner, 4 Gateway Center, [412] 391-1314

Rochester, N.Y. 14534: William J. Boyle, 9 Greylock Ridge, Pittsford, N.Y.
[716] 586-5040

Donald R. Furth (312) MO 4-5800
Midwest Advertising Sales Manager

Chicago, Ill. 60611: Kenneth E. Nicklas Ralph Hanning, 645 North Michigan Avenue, [312] MO 4-5800

Dallas, Texas 75201: Richard P. Poole, 1800 Republic National Bank Tower,
[214] RI 7-9721

Houston, Texas 77002: Robert Wallin, 2270 Humble Bldg. [713] CA 4-8381

Detroit, Michigan 48226: Ralph Hanning, 856 Penobscot Building
[313] 962-1793

Minneapolis, Minn. 55402: 1104 Northstar Center [612] 332-7425

St. Louis, Mo. 63105: Kenneth E. Nicklas, The Clayton Tower, 7751 Carondelet Ave.
[314] PA 5-7285

James T. Hauptli [415] DO 2-4600
Western Advertising Sales Manager

Denver, Colo. 80202: Joseph C. Page, David M. Watson, Tower Bldg., 1700 Broadway
[303] 255-5484

Los Angeles, Calif. 90017: Ian C. Hill, John G. Zisch, 1125 W. 6th St.,
[213] HU 2-5450

Portland, Ore. 97204: James T. Hauptli, Thomas McElhinny, 218 Mohawk Building, 222 S.W. Morrison Street,
Phone [503] 223-5118

San Francisco, Calif. 94111: James T. Hauptli, Thomas McElhinny, 255 California Street,
[415] DO 2-4600

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European Director

Paris: Denis Jacob
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United Kingdom and Scandinavia

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34 Dover Street, London W1

Milan: Robert Saidel
1 via Baracchini Phone 86-90-656

Brussels: F.I.H. Huntjens
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Frankfurt/Main: Hans Haller
Elsa-Brandstroem Str. 2
Phone 72 01 81

Geneva: Denis Jacob
1, rue du Temple Phone: 31 95 60

Tokyo: Takeji Kinoshita 1 Kotohiracho Shiba, Minato-Ku Tokyo [502] 0656

Osaka: Ryoji Kobayashi 163, Umegae-cho Kita-ku [362] 8771

Business Department

Wallace C. Carmichael, Manager
[212] 971-3191

Stephen R. Weiss, Production Manager
[212] 971-2044

Thomas M. Egan,
Assistant Production Manager [212] 971-3140

Dorothy Carmesin, Contracts and Billings
[212] 971-2908

Frances Vallone, Reader Service Manager
[212] 971-2865

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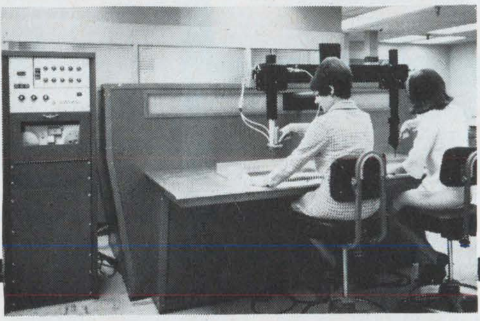

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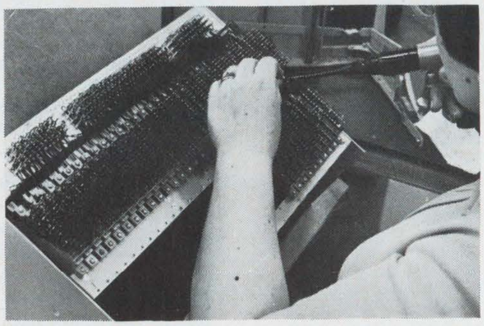

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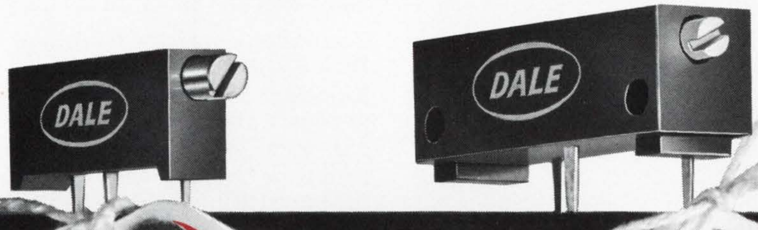

3/4″ ECONO-TRIM

2400 SERIES/WIREWOUND
8400 SERIES/FILM

SPECIFICATIONS

Dimensions: .31″ H x .16″ W x .75 L

Standard Resistance: 2400 = 10 ohms to 50K ohms; 8400 = 10 ohms to 2 Megohms

Resistance Tolerance: 2400 = ±10%; 8400 = ±10% 100 ohms thru 500K ohms, ±20% all other values

Power Rating: 2400 = 1 watt at 40° C; 8400 = .75 watt at 25° C

Operating Temperature Range: −55° C to 125° C

Mechanical Adjustment: 20 turns nominal

Mechanical Stops: None. Clutch permits overtravel without damage

Models: Sealed or unsealed with gold-plated PC terminals

DALE ELECTRONICS, INC.
1300 28th Avenue, Columbus, Nebr. 68601
In Canada: Dale Electronics Canada, Ltd.

1″ ECONO-TRIM

2300 SERIES/WIREWOUND
8300 SERIES/FILM

SPECIFICATIONS

Dimensions: .36″ H x .28″ W x 1.00″ L

Standard Resistance: 2300 = 10 ohms to 50K ohms; 8300 = 10 ohms to 2 Megohms

Resistance Tolerance: 2300 = ±10%; 8300 = ±10% 100 ohms thru 500K ohms, ±20% all other values

Power Rating: 2300 = 0.5 watt at 25° C; 8300 = .75 watt at 25° C

Operating Temperature Range: −55° C to 105° C

Mechanical Adjustment: 15 turns nominal

Mechanical Stops: None. Clutch permits overtravel without damage

Models: Sealed or unsealed. Gold-plated PC terminals or gold-plated hook type solder lugs

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