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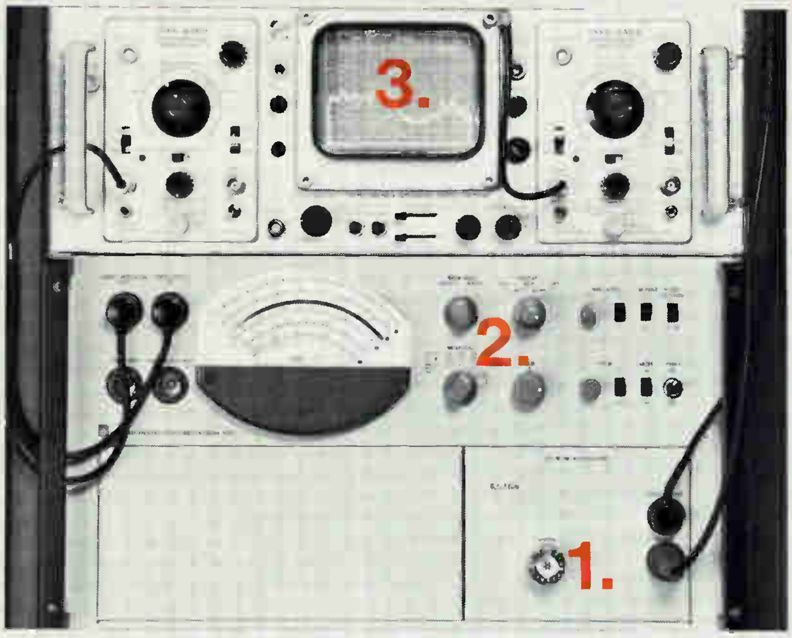
January 20, 1969

Electronics®



New 1641 Sweep-Frequency Reflectometer (0.5-to-7.0 GHz model shown)

Three-Step Sweep Reflectometry 20 MHz to 7 GHz

1. Connect unknown to the input. All the microwave "plumbing" is behind the one GR900® connector on the front panel, so you spend your time making *measurements*, not *connections*.

2. Select what function you want to measure: SWR, insertion loss, or both. Make *one* initial calibration. No need to recalibrate for function- or range-scale switching.

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Connector Type	Typical SWR at 300 MHz	3 GHz
GR900	1.007	1.015
N	1.01	1.02
TNC	1.01	1.03

Where else can you find this accuracy and resolution?

Measure. Reflections: SWR, return loss, magnitude of reflection coefficient, $|s_{ii}|$; Transfers: insertion loss, attenuation, isolation, gain, magnitude of coupling coefficient, and $|s_{ij}|$. Measure faster, easier, and with fewer errors (residual or operational) than with any other instrument.

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20 MHz to 1500 MHz, rack model: $4150
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20 MHz to 7.0 GHz, rack model: $5600
(Typical storage oscilloscope required: $1355)

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For more information, call your nearest GR office, or write General Radio Company, W. Concord, Massachusetts 01781, telephone (617) 369-4400.
In Europe: Postfach 124, CH8034 Zurich 34, Switzerland.

GENERAL RADIO

Circle 900 on reader service card

Trading off
ACCURACY FOR SPEED?

Get both in your system

with Hewlett-Packard's 2402A Integrating Digital Voltmeter

It doesn't make sense to keep using one of those DVMs that forces you to sacrifice speed or accuracy, does it? Why slow down your system to measure signals buried in noise? And why tolerate preamp errors and delays when measuring low-level signals?

Hewlett-Packard's 2402A Integrating DVM offers an unequalled combination of speed, accuracy, and noise immunity in a single instrument. No trade-offs necessary. It makes 5-digit measurements 43 times per second, resolving answers down to a microvolt with 0.01% accuracy at full speed. You get *lab* accuracy at *system* speed, even in noise that would slow active-filter DVM's to a virtual halt.

Full programming and BCD output are standard and make the 2402A ideal for use with digital computers and automatic measuring systems. Plug-in options measure AC, frequency, and resistance with equal ease, and a fast autoranger covers all five ranges from 100 mV to 1000 volts. Price: $4800.

Isn't it time to take the trade-offs out of your system?

Start by calling your local HP field engineer for more information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

06817

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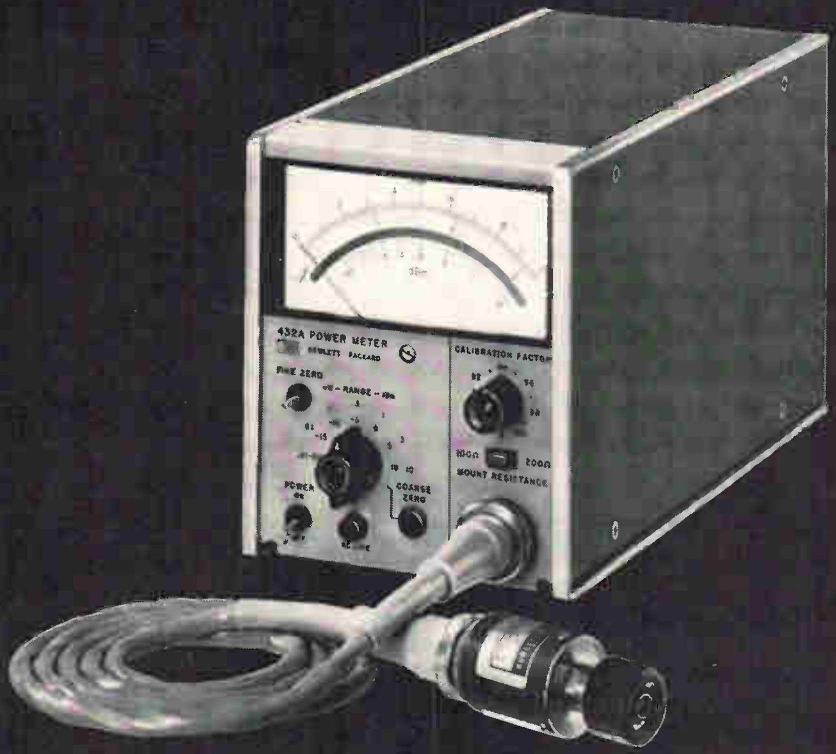
DIGITAL VOLTMETERS

How do you make the best power meter better?



Automatic zero setting, for one thing.

The new Hewlett-Packard 432A Power Meter offers even more performance and convenience than the well-known HP 431C. For one thing, you simply press a toggle switch on the front panel and the meter balances to zero automatically.

For another thing, the 432A offers ±1% of full scale accuracy over an even broader power and temperature range. This accuracy holds for all seven power ranges, from 10 mW (+10 dBm) down to 10 μW (−20 dBm)—and over the temperature range from 0°C to 55°C. Frequency coverage is 10 MHz to 40 GHz with interchangeable thermistor mounts.

Improved "zero carryover" adds still more convenience. With the HP 432A Power Meter, zero set shifts less than ¼% for a range change. And because the 432A is dc biased exclusively, the thermistor mount cable can be flexed without affecting the zero set.

The new power meter operates with the same thermistor mounts used with the 431C. And its Calibration Factor control lets you normalize the meter reading, using the mount efficiency data supplied with each HP temperature-compensated thermistor mount. This assures highest overall power measurement accuracy.

Price: $495 (add $100 for optional rechargeable battery pack).

Call your HP field engineer for more details, or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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MICROWAVE TEST EQUIPMENT

04812

Electronics

Volume 42, Number 2 January 20, 1969

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U.S. Reports

Electronics International

New Products

Technical Articles

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Readers Comment

How long?

To the Editor:

The interesting item on micron-size transistors [Oct. 28, 1968, p. 56] says the problem of high packing density in computer circuits has been partly solved by Richard Matta and L.C. Scala of Westinghouse Electric through the development of metharylate-type electron resists that make it possible to fabricate transistors with 1-micron geometries by high-resolution electron-beam exposure.

Although the process seems very promising, the article failed to mention the time required by the electron beam to fabricate the array of 12 million transistors. This exposure time is usually one of the major limitations in serially fabricated devices.

I would also like to point out that metharylate-based electron resists were invented and have been used at IBM since 1966. Transistors of 1-micron and 0.5-micron dimensions have been fabricated using methacrylate-type resists.

Michael Hatzakis
Thomas J. Watson Research Center
IBM
Yorktown Heights, N.Y.

Rickel is right

To the Editor:

Your article "One-tube color camera" [Dec. 9, 1968, p. 47] contains some misleading information.

Paragraph three states, "Resolution of the new color system is about 200 lines, adequate for most educational purposes but far short of the 525-line broadcast quality." I feel sure that the 200 lines refers to horizontal resolution or number of picture elements that can be resolved on any one line, while 525 is the number of scanning lines present in most standard American television systems. The shadow mask in most picture tubes limits the horizontal resolution to about 400 lines anyway.

Paragraph nine mentions "an ordinary $130 1-inch 8507A vidicon." I'd like to buy 8507A vidicons for

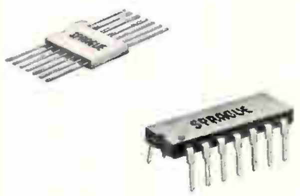
New Series 54/74 gates.

The 54/7408-a Quad 2-input

AND

The 54/7411-a Triple 3-input

AND



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24°

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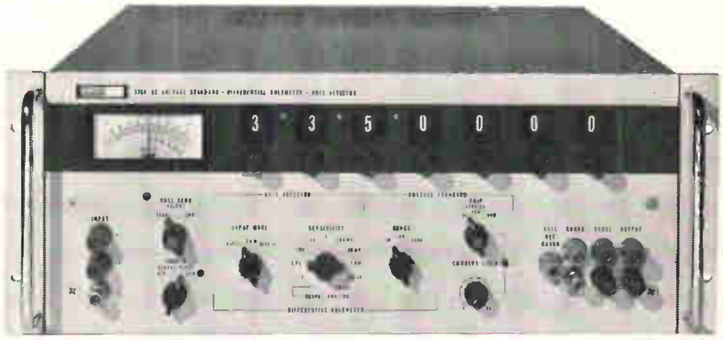

28°

Model 335A

Ordinary room temperatures are just dandy for Fluke calibrators. For instance, our Models 332B and 335A are specified to an accuracy of 20 ppm at 23° C. And, in typical room environments, accuracy is degraded by only 10 ppm.

How accurate should a calibrator be?

Naturally, every engineer wants the most accurate calibrator he can get for his dollar. At Fluke we believe the best price/performance tradeoff is 20 ppm. This performance provides a 5 to 1 accuracy ratio for calibration of 0.01% instruments. At the same time, it allows our engineers to design instruments whose accuracy can be maintained with a minimum of external equipment. We estimate that 10 ppm calibrators on the market today require about $6,000 worth of extra test equipment to keep them on line.

What calibrator should I buy?

If your requirements are only for a calibrator, compare the Fluke 332B with any other unit on the market. If a multiple purpose instrument is your need, give the hard eye to the Fluke 335A DC Voltage Calibrator, Differential Voltmeter and Null Detector.

Models 332B and 335A measure and supply dc voltages from 0 to 1100 volts with an output of 0 to 50 ma. Accuracy is 20 ppm. Stability is 20 ppm per year. Line variation of ±10% under load from 0 to 50 ma will not significantly degrade the 0.002% accuracy. Overcurrent protection automatically limits output current at any present level between 1 ma and 60 ma. Any voltage within the range of the instrument can be selected as an overvoltage trip point. Ripple and noise are less than 40μv rms on the 1000 volt range. Model 335A offers an accuracy of 20 ppm used as a differential voltmeter. The Model 335A can be used as a null detector and voltage source simultaneously with no interaction. An output meter allows the user to read voltage or current at a glance. Price of the Model 332B is $2295, the Model 335A, $2485.

More information

Your local Fluke sales engineer will be happy to go over his "tell-all" comparison chart with you, provide complete literature and arrange a demonstration of these units. His name and number are listed in EEM and EBG. Or you may contact us directly if it's easier.

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Readers Comment

$130. American-made vidicons usually net at $200 and carry a list price of $250.

Jack A. Rickel
Jack A. Rickel Associates Inc.
Washington, D.C.

Powerful pulses

To the Editor:

Electronics Newsletter [Sept. 2, 1968, p. 33] mentioned a kiloampere pulser being developed for powers in the 600- to 700-megawatt range and said, "Such powers have never before been achieved in such short pulses."

Sorry to shoot down that illusion. A commercially available electron accelerator provides a peak power of 4.2 gigawatts (7,000 amperes at 600 kilovolts) with a pulse length of 3 nanoseconds. It is the Febetron 706, and its applications vary from radiation-effects studies to high-speed photography with electrons, X rays, and super-radiant light. There is also a 2-millivolt version, called the Febetron 705. These devices represent applications of newly practical field-emission electron sources.

W.P. Dyke
President
Field Emission Corp.
McMinnville, Ore.

▪ The article referred to the achievement of r-f power pulses at high repetition rates for use with radar systems, not to the achievement of high-power electron-beam and X-ray pulses for lab use.

Laser displays

To the Editor:

The item on our work with laser displays [Nov. 25, 1968, p. 33] may leave your readers with an erroneous impression of the current state of this technology. The experimental model mentioned was delivered to the Air Force several years ago and was accepted as meeting the requirements and goals of our program with Rome Air Development Center. That model was developed to show feasibility, which it did, and was not intended for extended usage.

Appreciable progress has been made in laser-display technology during the past two years. Much of this progress is described in a review article by Charles Baker of Texas Instruments that appears in the December 1968 issue of the IEEE Spectrum.

A. Ray McCord
Equipment group
Texas Instruments
Dallas

Pride of ownership

To the Editor:

May we call to your attention the fact that "Picturephone" is not a common descriptive term but AT&T's registered service mark for its visual telephone.

Norval S. Ewing
General patent attorney
The American Telephone & Telegraph Co.'s
New York

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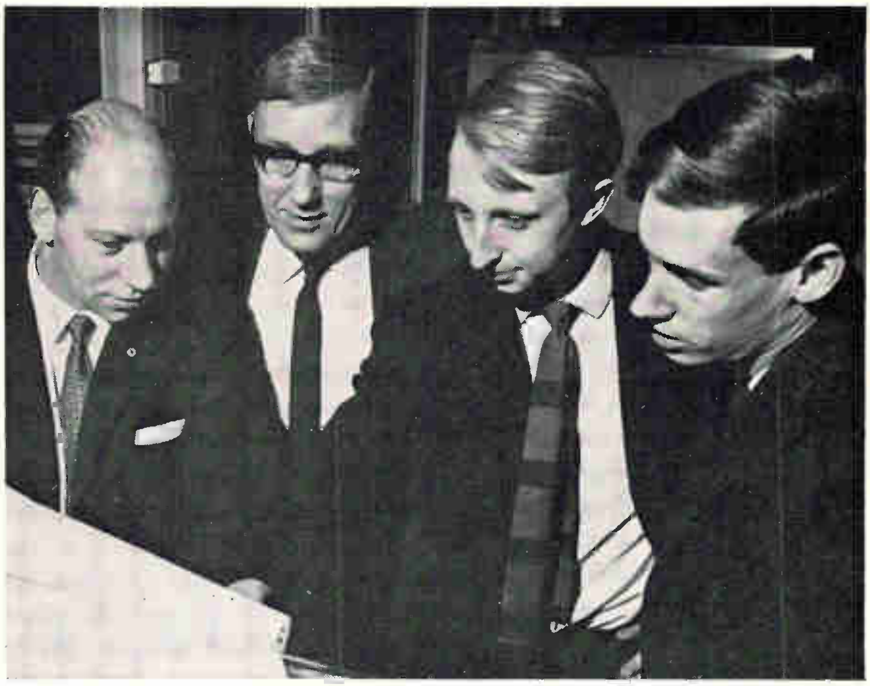
Who's Who in this issue



Rowe Jackson Radley Horsley

Nationalism, in case you haven't noticed, is an important spur to technology. And if this engineering team at Britain's Standard Telecommunications Laboratories has anything to say about the matter the big American semiconductor houses will be encountering stiffer competition in British outlets when it comes to production know-how. In the series of articles beginning on page 74, the group outlines three closely related aspects of the labs' processing operations.

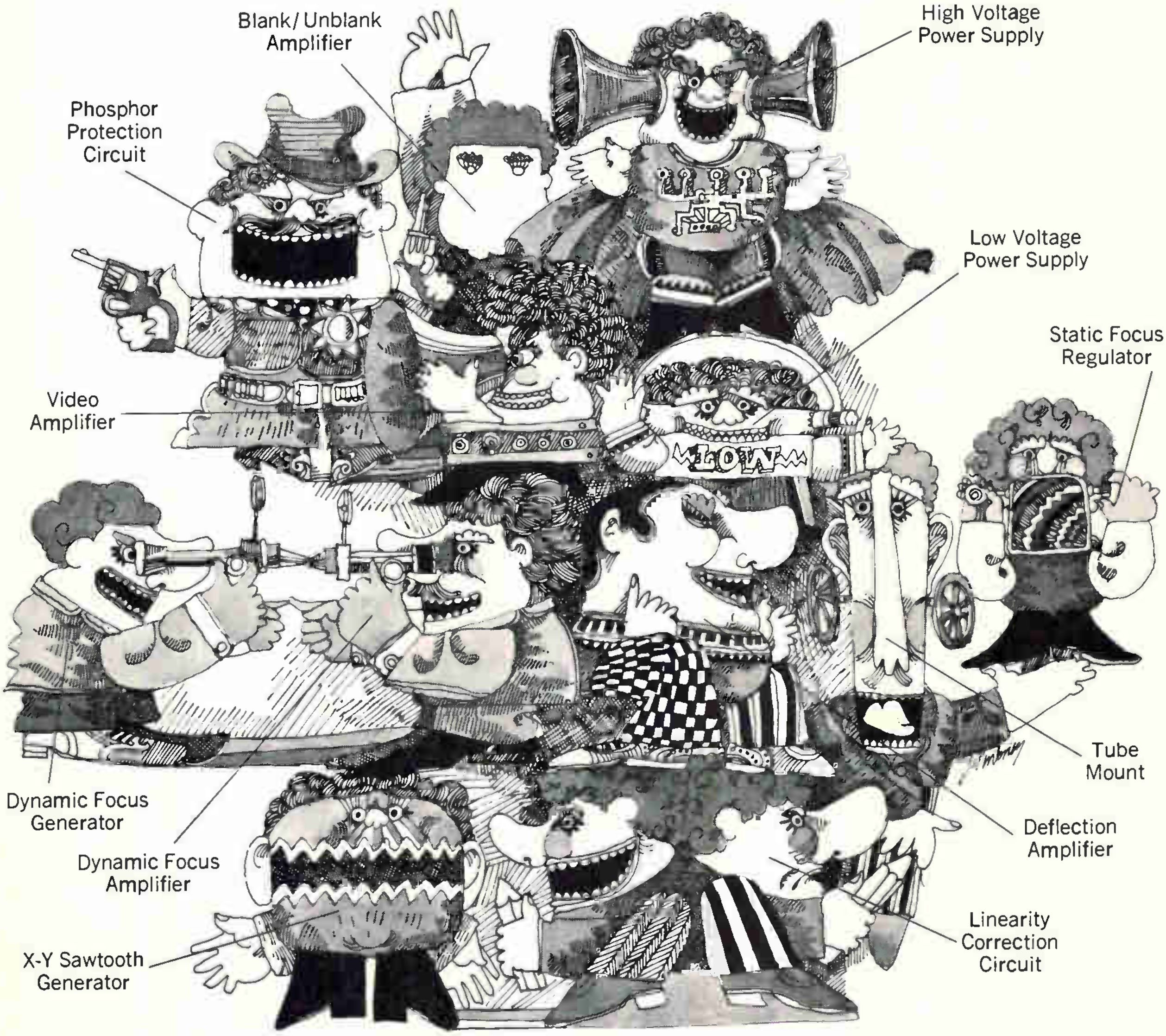
Peter Radley, who wrote the computer-aided design article, began his engineering career in 1965 by developing a method for designing and producing thin-film hybrid circuits from multicoated substrates. This led him to computer techniques for laying out LSI.

"Jackie" Jackson and Tom Rowe specialize in fabrication and processing. Jackson introduced micromachining techniques in millimeter-wave klystron fabrication, and later adapted the idea to the laser mask-making machine discussed in the article on page 81. Rowe, Jackson's co-author, has worked on transistor production methods and process control; most recently, he has concentrated on STL's computer-laser system for IC fabrication.

Tony Horsley, author of the article on page 84, started out with STL doing theoretical semiconductor studies. He later moved on to work involving LSI fabrication techniques, and is now concentrating on microwave IC's.

Turning on Philip Shapiro is no problem. Just mention infrared detectors and you'll trigger a rapid-fire exposition. Shapiro has spent years digging into the physics and engineering aspects of this subject. At the moment, his job at Acrojet-General is to put the finishing touches on some exotic and expensive mercury- and copper-doped detectors for industrial control applications. In the past, Shapiro has applied his i-r expertise to the Redeye missile system, and he proudly reports having once designed a 100-element silicon detector array. Shapiro compiled the table of commercially available detectors on page 91 during the course of his work since receiving his degree from the University of California at Los Angeles in 1961.

The Mod Squad.



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SN5442/7442	BCD to decimal decoder
SN5473/7473	Dual J-K FlipFlop
SN5474/7474	Dual D FlipFlop
SN5475/7475	Quad Latch
SN5476/7476	Dual J-K FlipFlop with pre-set & clear inputs
SN5490/7490	Decade counter
SN5492/7492	Divide by 12 counter
SN5493/7493	4 bit binary counter

*Trademark of Burroughs Corporation

Second to none

DM7200/8200	4 bit digital comparator
DM7210/8210	8 channel digital switch
DM7220/8220	Parity generator & checker
DM7520/8520	Modulo N divider
DM7560/8560	Up-Down decade counter
DM7563/8563	Up-Down 4 Bit binary counter
DM7570/8570	8 bit serial in parallel out shift register
DM7590/8590	8 bit parallel in serial out shift register
DM7800/8800	Dual TTL/MOS translator
DM7820/8820	Line receiver
DM7830/8830	Line driver
NH0006/0006C	Hi current driver
NH0008/0008C	Hi current driver

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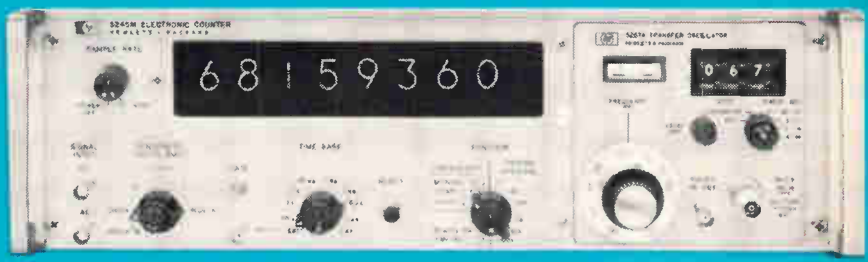
Circle 11 on reader service card

MEASURE MICROWAVE FREQUENCIES WITH COUNTER ACCURACY:

HP offers three foolproof techniques



Hewlett-Packard's 5245 series plug-in counters can be extended to measure microwave frequencies up to 18 GHz—and even 40 GHz—with the same accuracy, reliability and ease of operation as is common with frequencies below 135 MHz. Transfer oscillator, heterodyne converter, or automatic frequency divider—whichever you use, you get the easiest to use, most versatile instrument of its kind. Select the technique that's best for your application, or call your HP field engineer for his help. Compatible HP counters start at $1800.

TRANSFER OSCILLATORS The transfer oscillator lets you measure all types of signals—CW, pulsed or FM. Combines exceptional versatility with unique features.

The HP 5257A Transfer Oscillator plug-in adds broadband sampling technique to basic counter performance. You get the wide frequency range, from 50 MHz to 18 GHz, operation without offset frequency, single dial tuning and direct readout on the counter. Automatic phase lock tolerates noisy CW and FM signals with up to ±0.2% change. No reading is displayed if the signal drops out or if the 5257A isn't tuned. Characteristics as a down-converter, with a range of 50 MHz to 18 GHz, are superb. Price: $2100.

The HP 2590B Transfer Oscillator is a free-standing counter accessory. It offers excellent versatility over the range from 500 MHz to 15 GHz (12.4 to 18 GHz optional). It has automatic phase locking for CW signals and lets you observe jitter, drifting signals and AM or FM. A precision FM discriminator is built in. Price: $2150.

For greatest economy, the HP 540B Transfer Oscillator goes from 10 MHz to 12.4 or 18 GHz and, while it doesn't phase-lock, has an accuracy of 1 part in 10^7 for CW inputs. It costs only $1150.

But to reach 40 GHz with greatest performance and convenience use the E40-5245L. It provides all benefits of the 5245L Counter and 5257A Transfer Oscillator from DC to 18 GHz. From 12 GHz to 40 GHz a versatile HP 8690B Sweep Oscillator with the H15-8692B plug-in (usable separately for other lab applications) is used as the local oscillator to give uncrowded lock points, only one harmonic number (10) to use from 20 to 40 GHz, and accurately calibrated dial for speed and certainty. Wide phase-lock range (±0.1%) measures noisy CW signals. Price: $10,500 complete.

HETERODYNE CONVERTERS The heterodyne converter technique is used when greatest resolution is required in the shortest time, with either CW or heavily modulated signals. HP converters cover the widest range available anywhere — to 18 GHz.

HP frequency converter plug-ins give you 1 Hz resolution in 1 to 4 seconds, without spurious responses. You simply dial upward in frequency until the meter needle indicates "tuned"— and read your answer. Constant bandwidth cavities give easy, consistent tuning over the entire range. With the 5255A and 5256A, you get no reading if the signal drops out or if the converter isn't tuned, and they include a prescaler for automatic 1 to 200 MHz measurements. Prices: 5253B (50 to 512 MHz), $500; 5254B (0.2 to 3 GHz), $825; 5255A (3 to 12.4 GHz), $1850; and 5256A (8 to 18 GHz), $1950.

AUTOMATIC FREQUENCY DIVIDERS This technique for CW measurements is used primarily in automatic systems where speed and unattended measurement capability are important, and in production testing where relatively non-technical or inexperienced personnel are employed.

Both the HP 5260A Automatic Frequency Divider and 5240A Digital Frequency Meter extend your automatic counting range to 12.4 GHz and represent a significant cost savings over using a group of narrow-band instruments to cover the same range. An HP-developed broadband sampler is the key to this exceptional performance. Phase locking to CW signals is automatic, readout is direct once locked on, and *no tuning adjustments or calculations by the operator are required*. Readout is inhibited until phase lock is achieved. Prices are: 5260A (counter required), $3,700; 5240A (combines the 5260A and a high-performance IC counter . . . nothing else to buy), $4,750.

Call your HP field engineer for more information about HP's complete selection of counters, plug-ins and accessories. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

02829

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

Circle 13 on reader service card

Who's who in electronics

Seamans

"I'd like to explore the military technology inventory to see what might be declassified for use in the public sector," says Robert C. Seamans, the newly selected Secretary of the Air Force.

Although this doesn't mean that Seamans plans to search through Pentagon archives ripping red and orange covers off secret documents, he does mean that "before anything new is classified, I'll want to know why it can't be released. I just don't believe in classification of new techniques for reasons of suspicion or just for the sake of classification."

Apply technology. A former deputy administrator of the National Aeronautics and Space Administration, Seamans indicates that as head of the Air Force he intends to apply technology to the utmost. "I want as much cross-fertilization between civilian and military aerospace efforts as possible. Civilian aerospace technology is an area on which we can draw heavily for national defense; but it's a two-way street," he explains.

Assessing the U.S. research and development situation, Seamans feels that "the last few years have been excruciating. Vietnam spending has deprived us of much valuable R&D, and may have cut into our strategic posture." He would like to foster as much new research as the budget will allow.

One area ripe for funding, he feels, is the manned military space program. "The military needs to learn and practice the arts of space, and this means near-earth missions and perhaps some synchronous orbits. We need a full, fast exploration of the military's potential space capabilities to help decide goals and requirements. One can only borrow so much from NASA's efforts; after a point, different missions dictate separate paths."

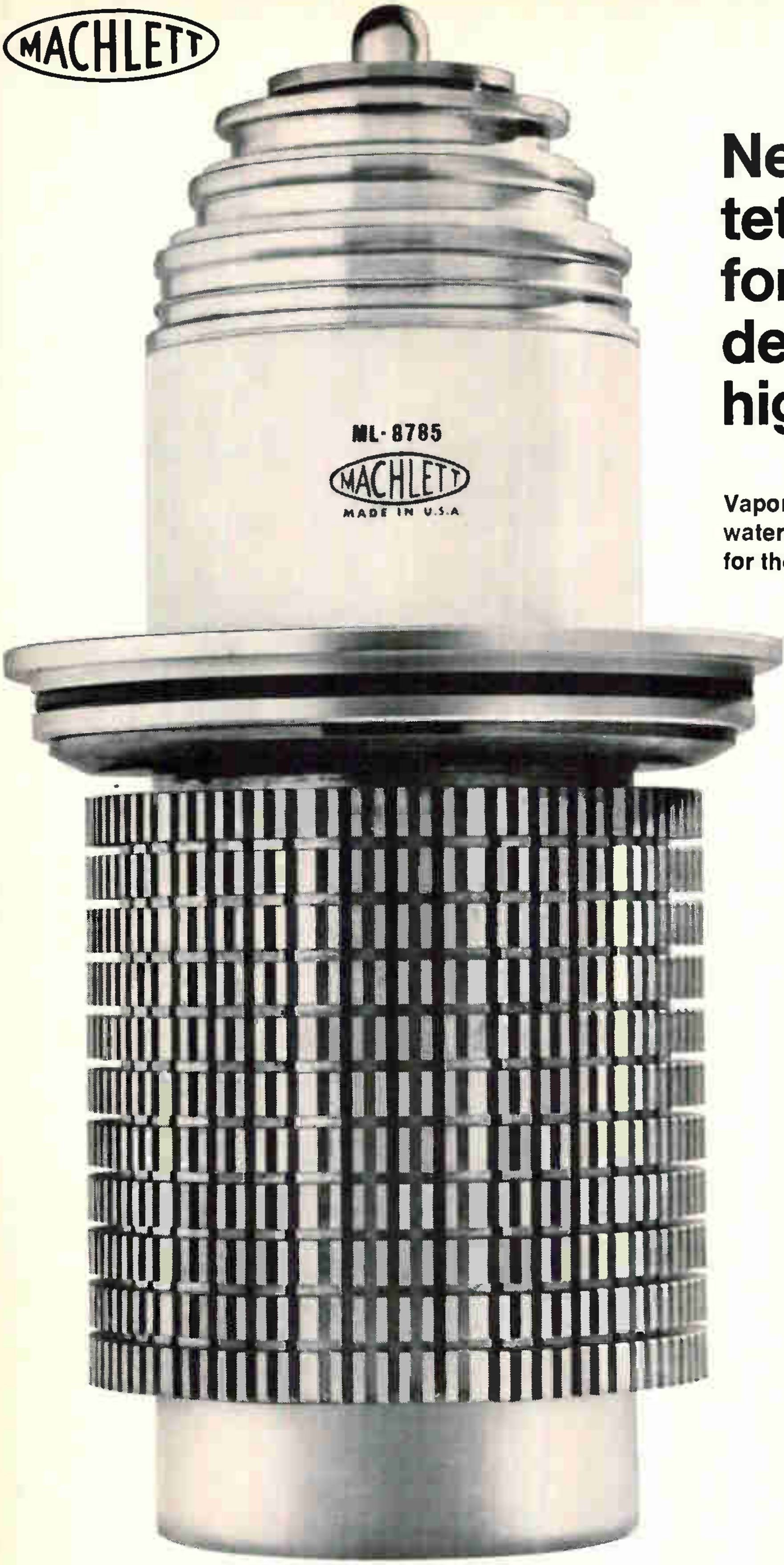
The scene. One of Seamans' former associates remarks, however, that on his way to a separate path, Seamans is sure to exploit the control and guidance techniques already developed in civilian efforts for the communications satellites. The on-board guidance and control methods already proven in Apollo 7 and 8 will quickly find their way into the military inventory.

Finally, and perhaps most importantly, Seamans will be able to deal with Congress. "He knows the entire Government scene," says Albert J. Kelley, another former NASA official. "He holds the respect of Congress."

Military services adopted the concept of a central office to coordinate research and development efforts some time ago. But their pacific cousin, the 178-year-old Coast Guard, seemed content to leave things as they were. Consequently, R&D was spread out through many offices, and hampered by low funds ($1.5 million in fiscal year 1968.) The Service often had to buy Navy equipment which too often didn't fit its needs.

Recently, however, the Coast Guard established an Office of Research and Development and chose Rear Adm. Orvan R. Smeder, 53, to launch it. Smeder, who was one of the service's first helicopter pilots, believes a vigorous research

MACHLETT



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

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

High Power Communications

Class C Telegraphy...to 350 kW

Linear RF Power Amplification

Class AB—Suppressed Carrier Service to 260 kW PEP

Pulse Modulation or Amplification

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

Pulse Power to 15 Mw

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

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Smeder

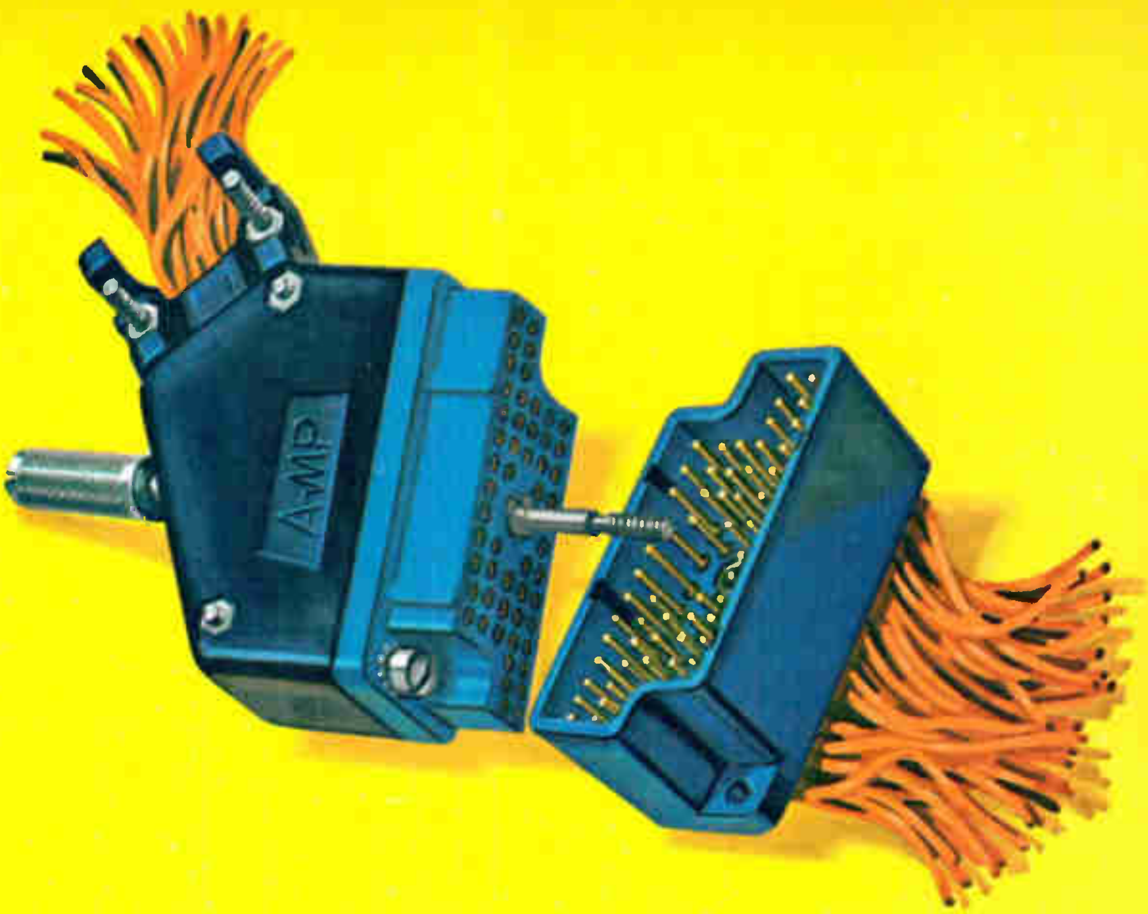
program is vital to the Guard's growing role, which may grow still further under the recommendations of the President's Commission on Marine Sciences.

Under the new setup, additional research should now be possible. Funded with $4 million for fiscal year 1969, the Guard, is asking Congress for $15.8 million for fiscal year 1970. Some $10 million is logged for the National Data Buoy System, a projected network of buoy-mounted sensing platforms which would monitor the ocean for the protection of ships. With the rest of the money, the Service wants to meet some pressing needs, many of them electronic.

Watch the ice. High on the list is the replacement of its 1950-vintage radar systems used for deep ocean search and rescue operations and for spotting icebergs whose presence in the North Atlantic menaces shipping during spring and summer.

In September the Office expects to begin a traffic control test in San Francisco Bay. It will combine radar tracking of ships with a radio information network. In this system, radar and a direction finder combine to isolate a particular ship when the harbor pilot identifies himself over the radio.

Up to now this country has relied on passive navigation aids such as buoys and lights, but if the harbor program is favored by shipping interests, Smeder believes the concept could "evolve to something closer to active control, like the FAA's air traffic control."



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- Five amp rating. Eight ounce maximum engagement. Half ounce separation force. Ten pound retention in housings.
- Cable clamp handles up to half-inch cable.
- One side-feed stripper-crimper automatic tool applies both pins and sockets and provides assembly Economation with speeds up to 4000 terminations per hour.
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Write for complete details to AMP Incorporated, Harrisburg, Pa. 17105

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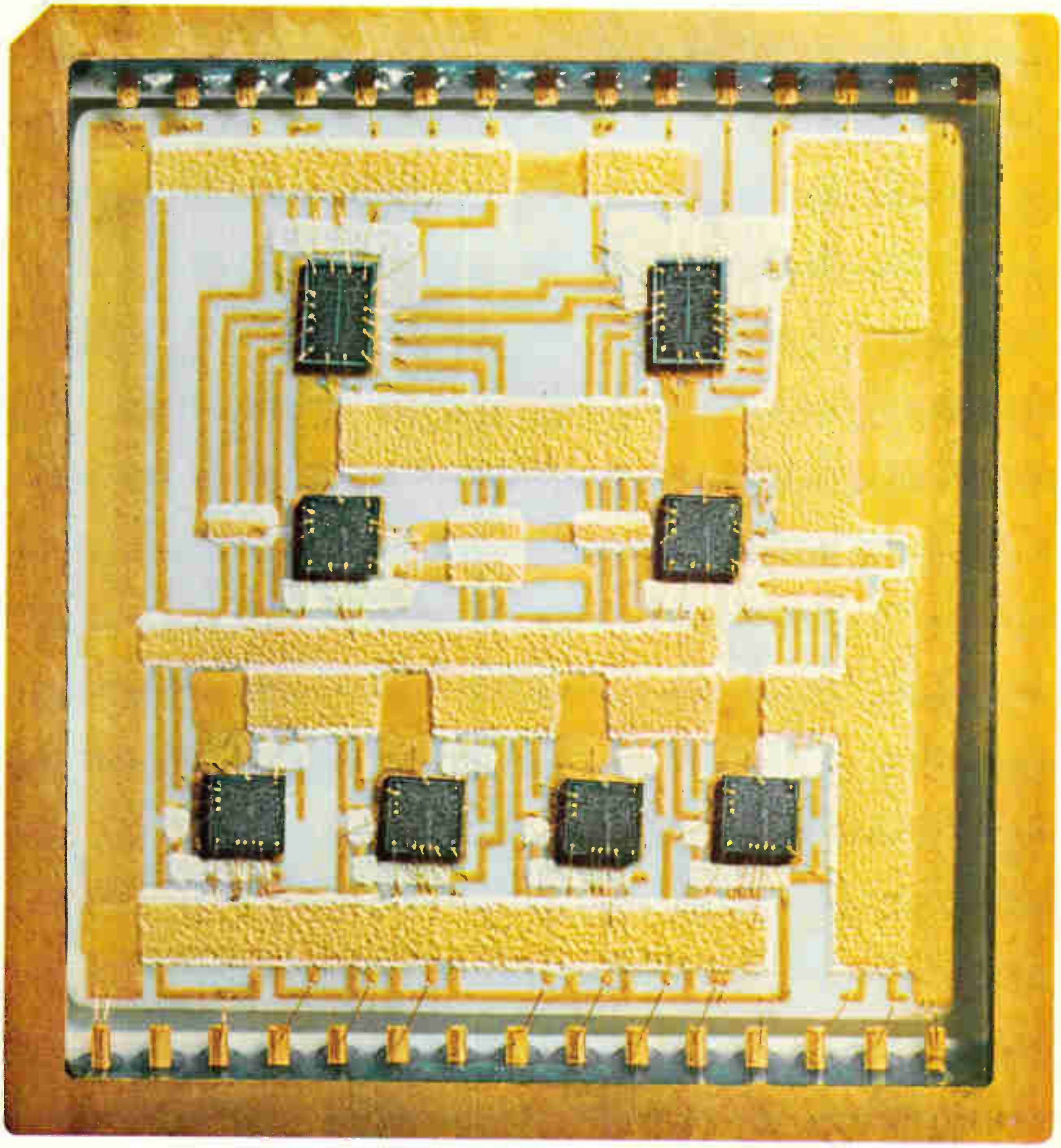
Fairchild can make more hybrids in



an hour than you can use in a month.

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	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
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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

Electronics and medicine: on speaking terms

As one engineer tells it, engineers are going to have to learn to talk like doctors if the field of medical electronics is going to go anywhere. It's a sure bet, he says, that doctors are never going to learn to talk like engineers.

One attempt to lower the language barrier will be made by the first National Conference on Electronics in Medicine, Feb. 14-15 in the Statler-Hilton Hotel in New York. Indeed, one of the sessions, led by John Truxal, chairman of the National Academy of Engineering's committee on the interplay of engineering with biology and medicine, will address itself to this very question.

Potential. Sponsored by *Electronics*, Medical World News, and Modern Hospital magazines, the two-day conference will begin with a keynote address by heart surgeon Michael DeBakey on the potential of electronics in medicine.

Following DeBakey's speech will be a session on computers in medicine, an area where electronics has already made inroads. Joel Cyprus, a Texas Instruments engineer, will deliver a paper on small medical computers. He'll be followed by Dr. Morris Collen, a director at the Permanente Medical Group in Oakland, Calif., and an expert in multiphasic screening, who'll discuss diagnosis with a computer.

An afternoon session on instrumentation will be addressed by Paul Stanley, a Purdue University physicist, and Paul Pumpian, an official of the Food and Drug Administration. Stanley is a crusader for safety standards in electronic equipment, and Pumpian an advocate of the proposed Medical Device Safety Act.

Hardware. The second day of the conference will begin with a panel discussion on the electronic hardware needs of the modern hospital. Also included on the second day's agenda is a session on the systems approach to medical problems.

The final event on the program is a critique of electronics in medicine. Engineers will demonstrate medical electronic equipment recently developed by their companies; a panel of doctors and engineers will then discuss what is right and wrong with the wares. Among the items slated for examination are a new computer from the Digital Equipment Corp. and a xerographic system, developed by Electro-Optical Systems, for mammography.

For more information write Samuel Weber, First National Conference on Electronics in Medicine, 330 W. 42 St., New York 10036

Calendar

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.**

Tactical Missile Systems Meeting, AIAA; Redstone Arsenal, Huntsville, Ala., **Feb. 10-12.**

Transducer Conference (G-IECI), National Bureau of Standards; Twin Bridges Marriott Hotel, Washington, D.C., **Feb. 10-11.**

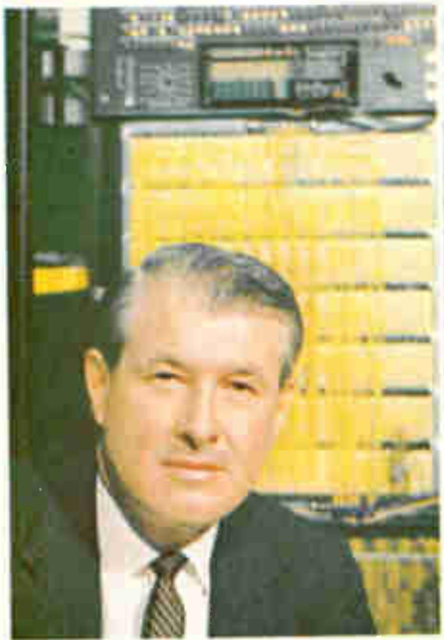
Symposium on Meteorological Observations and Instrumentation, American Meteorological Society; Washington Hilton Hotel, **Feb. 10-14.**

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

First National Conference on Electronics in Medicine, Electronics, Medical World News, and Modern Hospital Magazines; Statler-Hilton Hotel, New York, **Feb. 14-15.**

VTOL Systems Conference, AIAA, American Helicopter Society; Georgia Institute of Technology, Atlanta, **Feb. 17-19.**

(Continued on p. 24)



R. J. Whalen, General Manager, IBM Boulder

Aerial of IBM Boulder complex, looking toward mountains

Assembled tape drive units for Series/360 Computer

IBM: One of the great companies on Colorado's great Front Range.

Profit-minded growth companies are finding their kind of environment in Metro Denver and on Colorado's new Front Range of Science and Technology—the broad span where the high plains meet the Rockies.

IBM is one of them.

In March, 1965, IBM announced it would build a plant to employ a thousand people near Boulder. Today, IBM Boulder includes a product development laboratory in the 640-acre complex of ten buildings that totals over a million square feet of space. Employment is 4,200.

Richard J. Whalen, general manager of IBM Boulder, says, "The decision to locate a major IBM manufacturing facility in Colorado has proved to be a wise one." He cites "the wonderful climate" and the "recreational facilities that will take us years of leisure time to explore," and adds: "The most pleasant of all our experiences has been the success we have enjoyed in finding such highly qualified and dedicated employees. We would not have been able to measure ahead of time the wealth of technical and engineering talent."

Eastman Kodak is coming to the Front Range, too. On June 27, 1968, Dr. Louis K. Eilers, president, announced that Kodak has acquired an option on a 2,400-acre site north of Denver for the manufacture of photographic products.

Target date for the start-up of Colorado operations is set for 1972. "We plan to spend tens of millions of dollars in developing our new Colorado property," said Dr. Eilers.

Other growth companies with blue-chip futures are located on Colorado's Front Range: Honeywell, Hewlett-Packard, Martin Marietta, Ampex, Ball Brothers Research, Shell Chemical, Dow Chemical, Sundstrand Aviation, Bendix, Kaman Nuclear, duPont, Litton Industries, Syntex, Irving Air Chute.

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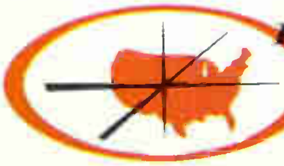

FORWARD METRO DENVER

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Meetings

(Continued from p. 22)

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

West Coast Reliability Symposium, Century Plaza Hotel, Beverly Hills, Calif., **Feb. 21.**

Technological Influences on Communications Conference, IEEE; Washington Hilton Hotel, Washington, D.C., **Feb. 24-25.**

Electric Propulsion Conference, AIAA; Williamsburg, Va., **March 3-5.**

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

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

Second International Laser Safety Conference, Medical Center of the University of Cincinnati; Stouffer's Cincinnati Inn, **March 24-25.**

Semiconductor Device Research Conference, IEEE; Munich, Germany, **March 24-27.**

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

Numerical Control Society; Stouffer's Motor Inn and Convention Center, Cincinnati, **April 1-3.**

Mathematical Aspects of Electrical Network Analysis, American Mathematical Society; Providence, R.I., **April 2-3.**

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

Computer Aided Design Conference, IEEE; University of Southampton, England, **April 15-18.**

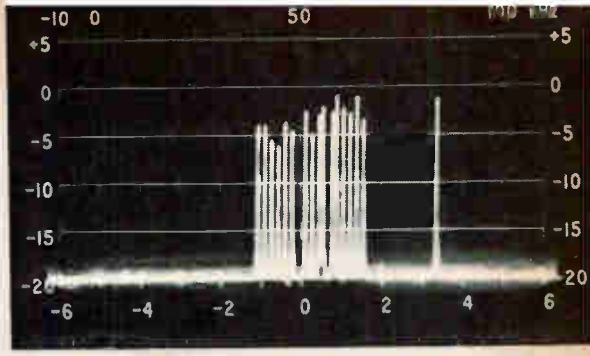
Joint Railroad Conference, IEEE; Queen Elizabeth Hotel, Montreal, **April 15-16.**

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.**

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

(Continued on p. 26)



Three 4-kHz channels of L3 carrier multiplex system. Center channel has teletype subcarriers. Model 360A is in 12-kHz sweep width mode, sweeping from 6.780 to 6.792 MHz.

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Frequency resolution to nearest 10 Hz in phase-locked tuning mode is displayed on flat-plane, high-brightness readouts. Alternative continuous tuning mode presents frequency resolved to nearest 100 kHz.

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Model 305/360 gives you ultra-bright, unambiguous electronic digital readouts of frequency. Built-in counter automatically totals outputs of both the coarse and fine tuning oscillators, reads out tuned frequency with 10-Hz resolution. Attenuator levels appear in three-digit displays, with unique logic and switching circuits combining the levels of the 10-dB and 1-dB per step attenuators. Rear-projection meters with luminous pointers permit parallax-free viewing from any angle with easy resolution of fine-level increments.

Performance features include phase-locked tuning circuits, a single continuous tuning range covering voice frequencies through 32 MHz, and selective bandwidths of 250 and 3100 Hz. You can resolve signals separated by as little as 35-Hz.

Model 305/360 does everything humanly possible to keep foibles from fouling your readings. For the brochure, write Sierra, 3885 Bohannon Drive, Menlo Park, California 94025.

*Average to Very Bright

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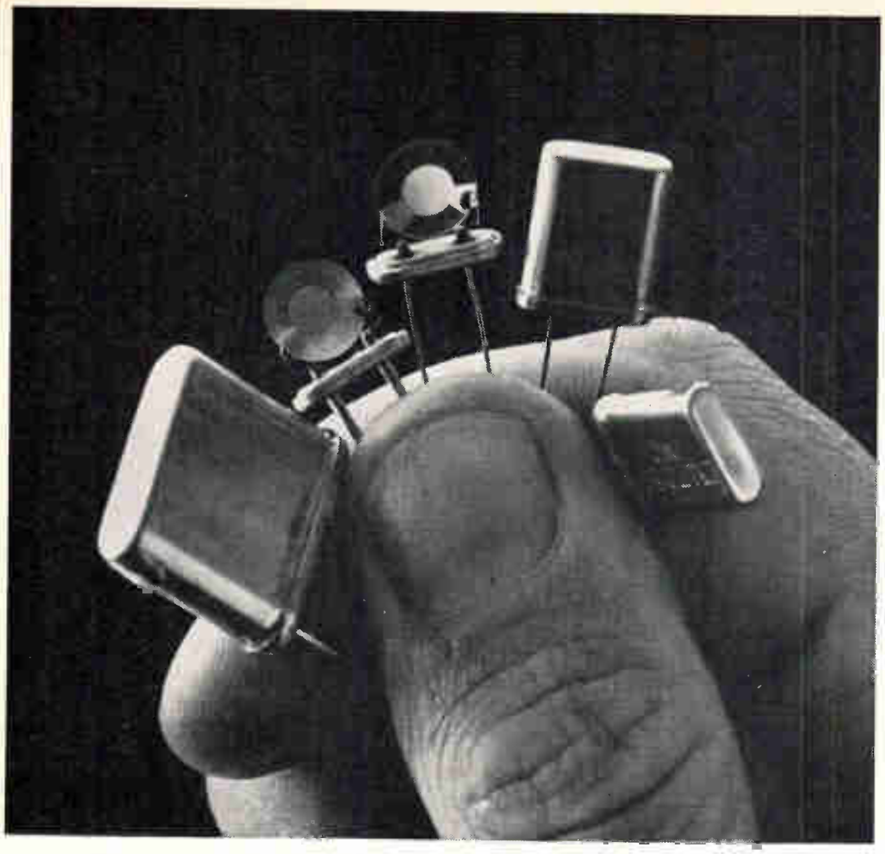


Meetings

(Continued from p. 24)

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.**

Short courses

National Bureau of Standards seminar on frequency and time stability, Boulder, Colo.; **Feb. 18-21;** $150 fee.

Electronic circuit analysis, University of California, Los Angeles; **Feb. 24-28;** $275 fee.

Biomedical engineering materials, University of Wisconsin, Madison; **April 17-18;** $70 fee.

Call for papers

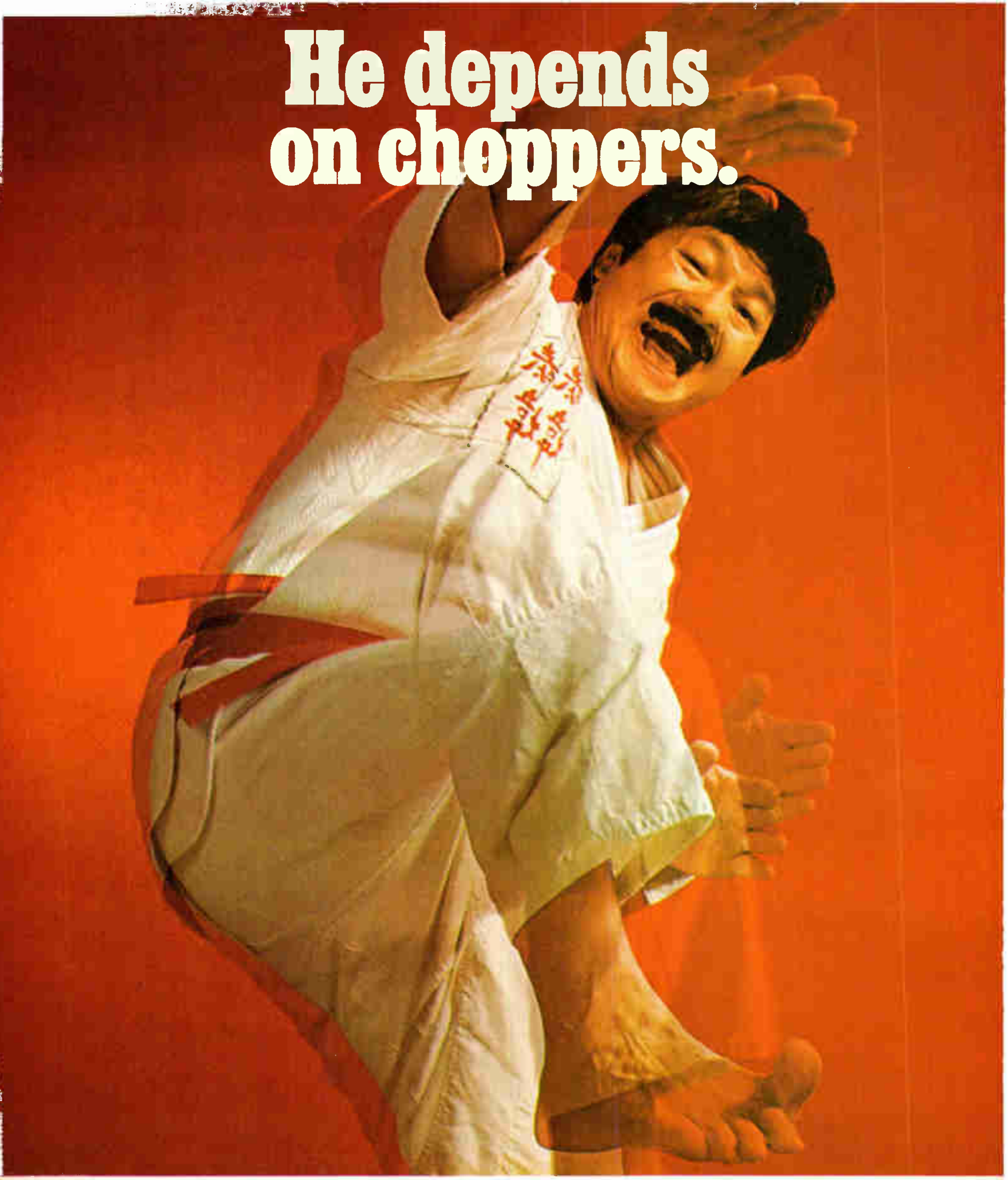
Annual Vehicular Communications Symposium, IEEE; Los Angeles, May 13. **Feb. 10** is deadline for submission of abstracts to A.G. Grimaila, Whittaker Corp., Electronics Division, 9601 Canoga Ave., Chatsworth, Calif. 91311.

Workshop on Applied Magnetics, Sheraton-Park Hotel, IEEE; Washington, May 22-23. **Jan. 24** is deadline for submission of abstracts to O. Kiltie, Ballastran Corp., Executive Blvd., Fort Wayne, Ind. 46808.

Spring Meeting, National Academy of Sciences, National Research Council of the United States of America; Washington, April 21-25. **Feb. 1** is deadline for submission of abstracts to Dr. F.S. Johnson, secretary USNC/URSI, Southwest Center for Advanced Studies, P.O. Box 30365, Dallas, 75230.

Annual Conference & Exhibit, Instrument Society of America; Houston, Oct. 27-30. **Feb. 15** is deadline for submission of abstracts to Vincent J. Giardina, director of technology services, Instrument Society of America, 530 William Penn Pl., Pittsburgh 15219.

Nuclear & Space Radiation Effects Conference, IEEE; Pennsylvania State University, University Park, July 7-11. **Feb. 17** is deadline for submission of summaries to E.A. Burke, AFCRL (CRWH) Stop 30, L.G. Hanscom Field, Bedford, Mass. 01730.



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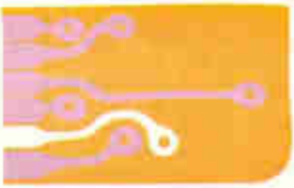

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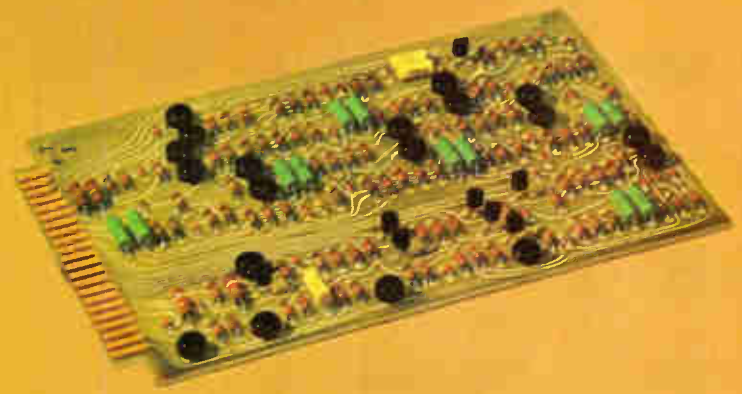
MDS The time reduction achieved by the MDS Data-Recorder method of computer input preparation demands continuously reliable operation. And this in turn demands the highest standards of performance from each and every component.

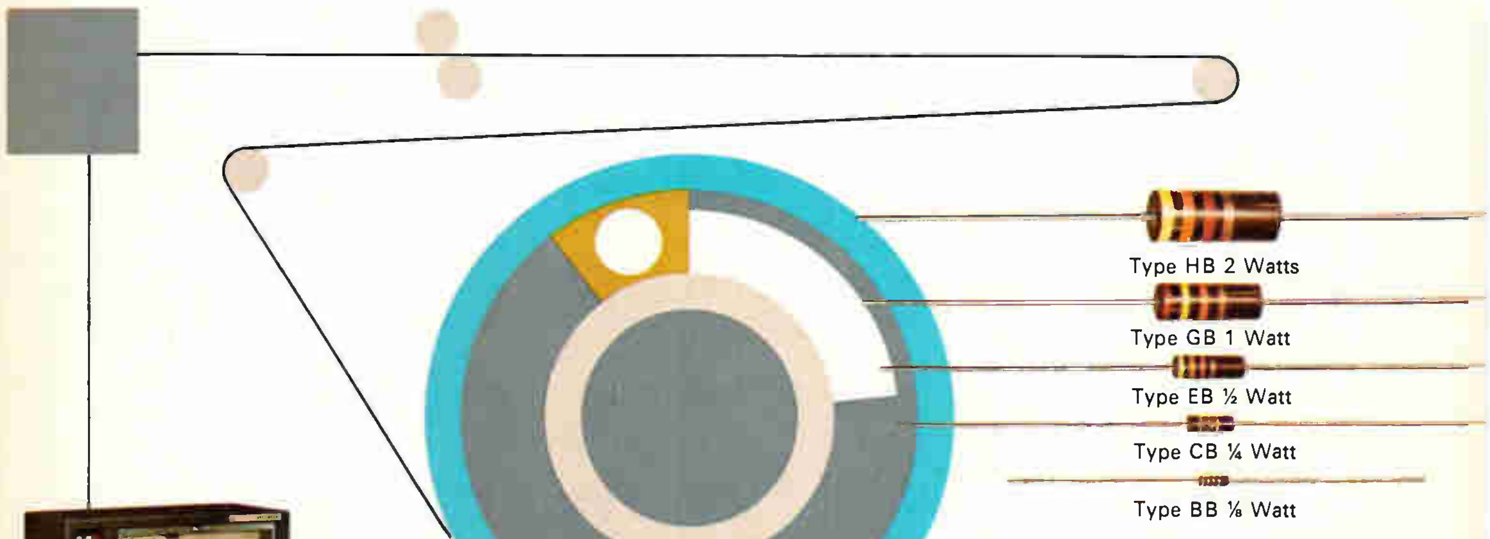
Allen-Bradley fixed composition resistors were a natural selection. Made by an automatic hot-molding technique—developed and used exclusively by Allen-Bradley—A-B resistors afford the ultimate in uniformity. From resistor to resistor—year in and year out—physical and electrical properties are unvarying. Predictable. Always of the highest order.

Performance records are equally excellent. For example, Allen-Bradley hot-molded resistors meet the requirements of the new MIL-R-39008A Established Reliability Specification at the *highest* level—the S level. And this is true for *all* three ratings—the 1 watt, ½ watt, and ¼ watt—and over the *complete* resistance range from 2.7 ohms to 22 megohms.

For complete specifications on this quality line of hot-molded resistors, please write to Henry G. Rosenkranz, and request a copy of 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.



Typical printed circuit board used in the MDS 1101 Data-Recorder, showing the extensive use of Allen-Bradley hot-molded ¼ watt resistors.



A-B hot-molded fixed resistors are available in all standard resistance values and tolerances, plus values above and below standard limits. *A-B hot-molded resistors meet or exceed all applicable military specifications including the new Established Reliability Specification at the S level.* Shown actual size.

Mohawk 1101 Data-Recorder permits transcribing of data from source documents direct to ½" computer magnetic tape.

EC 6821

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Editorial comment

The business to be in

The golden decade would be an apt description of the years 1958 to 1968 from the point of view of the electronics industry. A survey by the Commerce Department shows that five of the 10 fastest growing industries in the U.S. during this period were either in the electronics field or allied to it. Computers led the list with a growth of 511% (compared to the 65% growth of all U.S. industry over the same period). Cathode-ray tubes ranked next at 460%. Sales of semiconductors increased 284% and radio and communications equipment 212%. In addition, radio and tv sets ranked in the top 20 (180%), as did industrial process controls (150%).

Two of these categories ranked among the nation's top five dollar-volume gainers, too: revenue from communications equipment and computers rose by $6 billion and $5.6 billion, respectively.

While the bright decade just past bodes well for the future, planners and developers must gear up for new directions. Emphasis is shifting to a versatile integrated-circuit technology, advanced input-output equipment, optoelectronics, and digital communications techniques. ■ ■

Can the computer manage?

Engineering managers should be among the first to bring the computer to bear wisely upon management problems. Who is more capable of analyzing the computer's strengths and limitations? Furthermore, many engineers have a grounding in the use of computers in design and manufacturing, experience that could be translated to the management area.

However, some engineers are repelled by the glamour currently surrounding "management sciences." They think the concept a fad—if not a fraud. These men view the management "revolution" as unreal, holding that management is an art that cannot be mechanized.

For such skeptics, Carl Thomsen, a Texas Instruments senior vice president, has a warning. Writing in the January issue of Management Accounting, Thomsen says: "An aspiring manager 10 and certainly 20 years from now without substantial training in management systems, management sciences, and the use of computers will not realize his aspiration . . . There will be the inevitable strains of obsolete managers directing subordinate managers who are better qualified at the science of managing," he goes on, but eventually those who haven't received training in management sciences "will be replaced by those who have."

On the other hand, Thomsen warns that those who avidly embrace the concept of applying computers to management may lose sight of the objectives the tools and techniques should help achieve. Management systems are ways of managing, he stresses, not the tools themselves. Furthermore, new computer-oriented managements will fail, Thomsen thinks, if people feel unduly constrained within their environments.

One solution would be to let those managers whose actions are being constrained assist in developing the systems. This should keep the computer subordinate to the primary objective of better management. ■ ■

Guidelines needed

When David Packard was asked to take the post of Deputy Secretary of Defense, he felt he was faced with "an impossible conflict-of-interest problem." Nevertheless, the proposed solution, whereby Packard's stock would be placed in trust during his tenure of office, has met with little opposition. Senators sounded out by incoming Defense Secretary Laird thought the procedure acceptable.

On the other hand, an editorial in the New York Times suggested that "the ties of ownership would not be severed—a fact that would keep alive concern over possible conflict of interest." The Times added: "It is no reflection on Mr. Packard's probity or sense of duty to suggest that he should not enter the Defense Department as a major shareholder in a company heavily engaged in defense work."

There's precedence for both courses: Charles Wilson and Robert McNamara sold their stock before becoming Defense Secretary, but others in high Government posts have simply placed their holdings in trust.

In the case of Packard, whose devotion to civic responsibility and to the most enlightened and respected goals of contemporary management are beyond question, conflict of interest is not a pressing issue. But could the same be said of other holders or seekers of public office?

What is clearly needed is a well-considered policy that allows no options. Congress must take the initiative in fixing such guidelines—and not only for the executive branch but for itself as well. ■ ■

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Who else offers a counter that provides frequency measurements up to 225 MHz for only $1975, plus the options of two plug-ins to boost the range to either 1.3 GHz for $775 or to 3.3 GHz for only $825? That's what you get from CMC with the Model 616 Counter and the new Models 631 and 635 Heterodyne Converters. But that's not all.

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

Already a popular workhorse, the 616 is in common use for alignment of frequencies in UHF communication links, for calibration of high frequency signal generators, for direct monitoring of radio/TV transmitter carrier frequencies, and for production checkout of radio transmitters. But now, with the addition of two great heterodyne converters — and a TIM plug-in if you want it — here's a low-cost, portable family that's hard to beat for application versatility!

For the full specs on the counter and plug-ins, just circle the reader service card. And to arrange for a demonstration, contact your local CMC representative.

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Electronics Newsletter

January 20, 1969

Electronics spending set to increase in '70 budget plan

President Johnson did well for the electronics industry in his final budget proposal. **The Pentagon and FAA budgets were increased; NASA's held its own.**

One big question in the 1970 budget is the fate of the supersonic transport: **new funding was withheld until Boeing finishes redesigning the plane.** The defense budget is set at $80.2 billion, up about $3 billion from 1969. **Almost all heavily electronics budgets are slated for an increase,** including those for electronic-warfare aircraft, missiles, the Advanced Manned Strategic Aircraft, the Airborne Warning and Control System, and other major proposed aircraft programs.

NASA's budget is $3.758 billion, down slightly from $3.85 billion, **but leftover money will make the total about the same.** The budget allows for continued manned exploration of the moon after the first landing and for manned earth-orbit experimentation, and sets increases for unmanned space flight and ground-based research in aeronautics. NASA will again try to get a firm footing for the Apollo applications program and is asking $345 million to get five missions going.

The FAA is to get $947 million, up $74 million from this year.

Budget tightening imperils I/CNI

The Air Force's ambitious Integrated Communications, Navigation, and Identification System (I/CNI) is hanging by its fingernails against huge budget pressures. It isn't yet entitled to a program office within the Systems Command and it's funded for considerably less than $2 million [*Electronics*, Aug. 19, 1968, p. 33]. **Backers of the proposed system are waiting to see how much of this money it gets for fiscal 1969 before they proceed with preliminary design studies.**

Although the idea is in the proposed 1970 budget, it still must run Congressional hurdles. If it survives to become an established program, there is a strong possibility that it could become a tri-service project. **Also, it looks as though the Air Force's 621B navigational satellite program** [*Electronics,* Jan. 6, p. 67] **could be made part of I/CNI.**

Goldilox faces bearish future

Last spring, Westinghouse Electric's announcement of its Goldilox technique for sealing IC's set off speculation that the process would lead the military to reclassify plastic-encapsulated IC's 1-A from 4-F. **And the company planned to use Goldilox in its major IC product lines.** Last month, however, Westinghouse's sudden announcement that its Molecular Electronics division was going out of the commercial IC business [*Electronics,* Dec. 23, 1968, p. 33] **made the military fear that Goldilox would be lost.**

The Naval Electronics System Command had just ordered Goldilox IC's for "mass testing." C.E. Holland Jr., who did the ordering and who's been the prime mover in getting the services and NASA coordinated on plastic IC's, says, "**Right now the whole thing is up in the air. We've reordered the IC's but we don't know if we will get them.**"

A Westinghouse official notes three possibilities for Goldilox: use in certain work in Westinghouse's military systems divisions, licensing in the U.S., and sale of the whole IC division, including Goldilox.

Goldilox processing hermetically seals IC's at the chip level so they aren't affected by **the choice of packaging.** The technique uses silicon-nitride passivation and a titanium-gold bonding scheme and places glass over the interconnections.

Military may fly interim warning net until Awacs arrives

There are those in the Air Force's Tactical Air Command who feel they can't wait five years for the full-fledged Airborne Warning and Control System (Awacs). So the Air Force is considering an interim network called Ataccs, for Airborne Tactical Air Command and Control System, which could be in the air by 1971. **But the Air Defense Command, which would prefer to wait for Awacs proper, feels that Ataccs could siphon off funds from the Awacs program and thus slow it down.**

It was expected that the service's Air Staff Council would iron out the requirements for Ataccs earlier this month and make a decision on whether to go ahead with it or not. But according to one Air Force source, the controversy will continue for at least another month because the council has requested more technical information upon which to base its decision.

Exactly what route the Air Force will take with Ataccs is still unknown. One West Coast source close to the Awacs program says **the Tactical Air Command wants Ataccs so much that it's willing to go without an overland radar and use identification-friend-or-foe equipment instead.** Another possibility being mentioned: installation of the Navy's E-2 avionics aboard a KC-135 transport. But the general feeling is that whatever route the Air Force decides to take, **the aim will be to make Ataccs as much a stepping-stone to Awacs as possible.**

The leading contenders for an Ataccs contract are Boeing and McDonnell Douglas, the Awacs bidders.

All-solid state color television gaining popularity

Producers of television sets predicted last year that Motorola would lose its shirt trying to convince the public to pay a $200 premium for an all-solid state color set.

They've now changed their position. In fact, they're currently working furiously on all-solid state sets themselves. RCA brought out its first all-solid state receiver last fall. And Magnavox and Emerson will each come out with a line of solid state color sets by late spring—**ahead of Zenith, whose efforts appear to be temporarily stalled because of its emphasis on an earlier program aimed at replacing hand-wired sets with a printed-circuit design with quick-disconnect, plug-in features.**

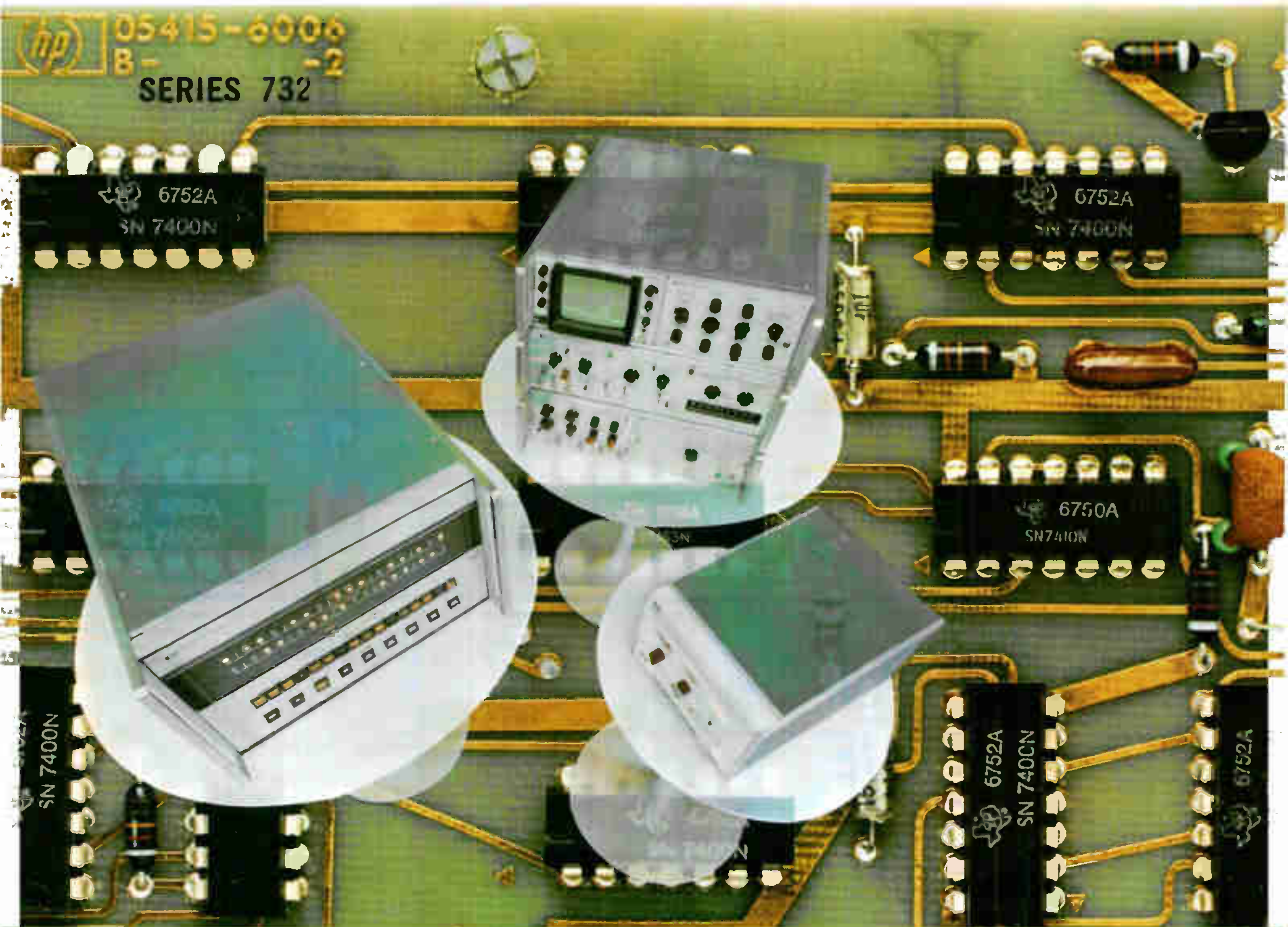
Emerson, which has long held that it wouldn't employ IC's until the benefits could be proven, will now use six of these circuits, more than any of its competitors. And in a related development, RCA this spring will replace the high-voltage rectifier tube in its solid state line with a silicon rectifier.

Air Force questions use of MOS in jobs with radiation threat

Air Force researchers are worried about what they call "the semiconductor industry's commitment to MOS." **Because the radiation resistance of MOS circuits is inferior to that of other IC types, the usefulness of the technology in many applications is being questioned.**

One scientist says his group may soon issue a memorandum to Air Force agencies cautioning them against specifying MOS in systems likely to encounter radiation. **Such expressions of Government concern could slow MOS sales**—only now starting [*Electronics,* Jan. 6, p. 33].

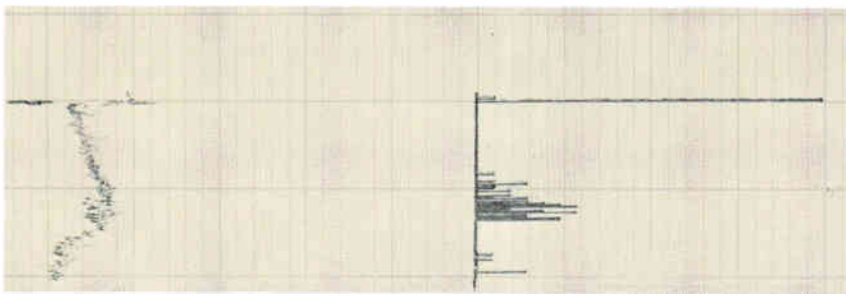
TTL Trends
from Texas Instruments



At Hewlett-Packard, TTL from TI is taking over the tough jobs...in measurement...in computation...in analysis. The following pages tell why, and show how TTL is helping HP better serve tomorrow's customer needs—today!

TI helps Hewlett-Packard...

head off heart attacks before they happen



Recent events have focused attention on the "Cardiac Intensive Care Unit"—one of modern medicine's newest weapons in the battle against heart disease. It is here that diagnosis and prompt treatment enables doctors to effectively head off fatal coronaries before they happen. To serve this need, Hewlett-Packard developed the Model 7822A Arrythmia Monitor—first of a new generation of ultra-high-reliability, compact and low-cost medical instruments made possible with Series 74N TTL integrated circuits from TI.

This instrument "remembers" the normal heartbeat characteristics of a coronary patient, then compares each succeeding beat against the stored norm. If disturbances occur, it provides an immediate warning, enabling hospital personnel to effectively head off catastrophic heart attacks before they happen.

Selling for under $2,000, the HP 7822A uses fewer than 75 TTL plastic plug-in packages, neatly arranged on just four PC boards.

This simplicity underlies the inherent reliability of the instrument. Circuits such as SN7473N and SN7474N multifunction flip-flops plus MSI Counters, Shift Registers and Quad Latches greatly reduce the probability of failure.

And the rugged plastic package was proven—by months of actual hospital field trials and lab tests—to have outstanding durability. For example, one HP engineering testing program subjected the 7822A to 6 months of continuous operation under the most severe hospital environment conceivable: 45°C temperatures and 95-98% relative humidity. *Not a single IC failed during the entire 6-month period!*

Typical use of HP 7822A is shown here. As a focal instrument in today's "Cardiac Intensive Care Unit," it is an important new aid in the prompt detection and treatment of potentially fatal coronaries.

at Hewlett-Packard

TTL takes over the tough jobs

Recently, three divisions of Hewlett-Packard faced three difficult—but totally different—design challenges. Independently, all three solved their problems with Series 74N TTL integrated circuits from Texas Instruments. Here's what happened:

In measurement—many exclusive MSI functions helped drastically reduce package count and interconnections, giving life-saving reliability to HP's new 7822A Arrythmia Monitor.

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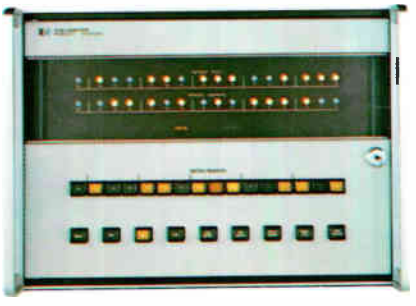
In computation—Over 290 TTL circuits—including high speed Series 74H units—helped HP to halve the size and trim the cost of it's lowest-cost computer by another 31%. The Model 2114A accomplishes all this while retaining 2.0 μsec memory performance and a wide range of input/output options.



In analysis—HP cracked a two-year design deadlock when they zeroed-in on TTL. After two state-of-the-art logic approaches were explored without success, HP engineers tried TTL and that turned the trick. The Model 5400A Multi-Channel Analyzer features 100 MHz clock rate, 1024 channels, and a 2.2 μsec memory . . . all this for $9950. Nearly 400 Series 74N ICs make it possible.

In yet another instance, the same division significantly reduced development time on the Model 5480A Signal Averager by building on experience gained with the 5400A.

TTL added values

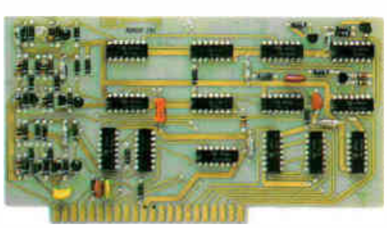
These successes brought bonus benefits. Other HP divisions are now designing new instruments around TTL and achieving lower development expense, better performance, reduced overall costs, and improved reliability.

This mushrooming usage of TTL also brings to HP the advantages of volume purchasing . . . quantity discounts and assured availability. Furthermore, inventory costs are held down because one family of ICs now takes the place of several.

What are your problems? Take a tip from Hewlett-Packard and design with TTL from TI. You'll likely end up with a better product at a more attractive price—and probably increase your profits to boot!

TEXAS INSTRUMENTS
INCORPORATED

Let TI plastic ICs tackle your tough jobs, too.



This circuit board contains 14 of the nearly 1000 plastic integrated circuits used in the Hewlett-Packard products described on these pages.

Hewlett-Packard engineers took a long, hard look at packages as well as circuits when they selected TTL from TI. They considered ruggedness and reliability along with price and availability before deciding on Series 74N TTL.

They weren't alone. More than 1500 other users and OEM's—including such companies as Bunker-Ramo, Systron-Donner and Friden—have put to work more than 20 million TI plastic IC packages during the past three years.

Experience has been so satisfactory that TI plastic is the industry's fastest growing IC package design.

The economy of plastic is only half the story. MSI makes possible even lower costs as well as greatly improved reliability.

MSI means fewer packages, fewer interconnections, fewer circuit boards...in short, fewer things to go wrong in your systems, and fewer things to add to costs.

That's why TI's proven plastic package—along with MSI—assures you the lowest cost-per-function of any logic available today.

Why not decide for yourself? This new IC Catalog Supplement details all TTL/MSI circuits from TI—including flat-packs and C-DIPs as well as the popular proven plastic. Functions run the gamut from decoders to shift registers to active element memories—all told, full specs for 22 MSI devices including 14 completely new types.

For your copy, plus data sheets on other TTL circuits, just drop a note on the back of your business card and mail to Texas Instruments Incorporated, P.O. Box 5012, MS 980, Dallas, Texas 75222. Better yet, simply phone your TI sales engineer or authorized distributor.

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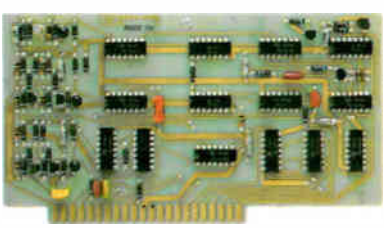

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TEXAS INSTRUMENTS
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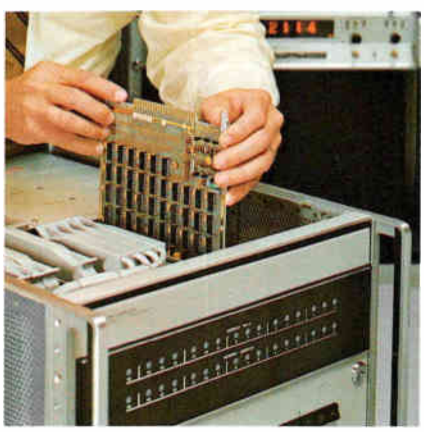
trim the cost of low-cost computers by another 31%



General lab use typifies new low-cost applications for HP 2114A Computer — made possible by TTL technology. Desk-top compactness and easy accessability are IC bonus features.

Cut cost by another 31 percent... reduce size by 50 percent...yet retain virtually all the speed and performance capabilities of the existing HP lowest-cost model. This tall order faced HP engineers when they set out to design a desk-top, third generation computer to serve scientific and industrial markets. Specifically, they wanted the new Model 2114A to sell for less than $10,000.

An analysis of various logic types soon cut the problem down to size. Comparison revealed that TI's Series 74N TTL cost less than half as much and consumed only one-third the power of the logic family then considered standard. Equally important, there were no serious interface problems between TTL and the earlier logic. This assured compatibility with a wide variety of existing HP input/output peripherals and companion accessory equipment.

In the area of performance, HP engineers were pleased to find that standard and high-speed TTL logic could more than fill the bill. And all circuits were available in the same plug-in plastic package.

Furthermore, the single voltage requirement of both standard and high-speed TTL further reduced power supply requirements. And noise margin and other characteristics were also compatible.

Finally, a large selection of MSI functions was readily available. Among more than 250 IC's in the Model 2114A are such key circuits as 7483N Four-bit Full Adders and 7475N Quad Latches. These paved the way to important package count reductions, resulting in lower cost, smaller size and improved reliability.

crack a two-year design deadlock

HP 5480A Signal Averager helps researchers pull weak signals out of overwhelming noise.

HP 5400A Multi-Channel Analyzer typifies sophisticated new generation of analytical instruments—made possible by TTL integrated circuits.

HP engineers liked what they saw when they investigated Series 74N TTL. They had already spent two years trying to develop the 5400A Multi-Channel Analyzer...an advanced instrument which would feature the fastest known A/D converter (100 MHz clock rate), 1024 channels with 10^6 counts per channel, and a 2.2 μsec memory cycle. Two state-of-the-art custom logic approaches had been explored without success.

With Series 74N TTL, HP found a broad selection of standard multifunction circuits, a reliable plastic package, volume availability, and low cost per function – important considerations in a design using almost 400 IC packages and yet carrying a price tag of only $9950.

Performance-wise, the 74N TTL line proved to have almost ideal characteristics—speed, fan-out and noise immunity.

One success leads to another. Experience with TTL in the Model 5400A paved the way for its use in the Model 5480A Signal Averager. This new instrument enables scientists to see low-level repetitive signals literally buried in extraneous noise. It also features a 1000-word, 24 bit-per-word memory, and 100,000-sample-per-second sweep rate.

Again, use of Series 74N TTL logic substantially shortened the overall design cycle. Although development of the 5480A Signal Averager started two years later than the Model 5400A, both reached production at virtually the same time.

at Hewlett-Packard

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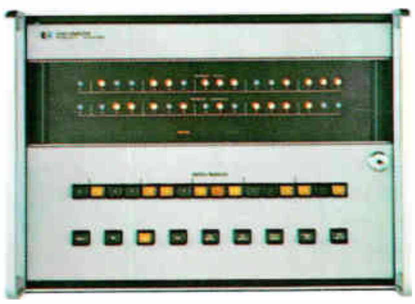

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PULSE POWER

Our PG-13 high output E/I pulser will put out ±**100** volts in the E-mode and ±**2 amps** in the I-mode. PRF 1 Hz to 25 MHz. And with typical 3-I full parameter control to give you more flexibility. Examples: Rise and fall times are independently and continuously variable from 10 ns to 50 ms with greater than 100:1 dynamic range between them. Positive or negative, single or double pulses with the width of each pulse independently variable in the double pulse mode. Amplitude and baseline controls continuous and independent. Delay, first pulse to second pulse, variable from 15 ns to 500 ms.

You can gate the PG-13 or trigger it to 25 MHz or operate it "one-shot" from a front panel pushbutton. Sync pulse, +1V, 15 ns +. Input impedance can be switch-selected for 50 or 500 ohms, and you can vary threshold and sensitivity. Output protected against overloads and shorts; overload indicator.

The PG-13 is solid-state, DC-coupled. Meticulous, advanced design and construction.

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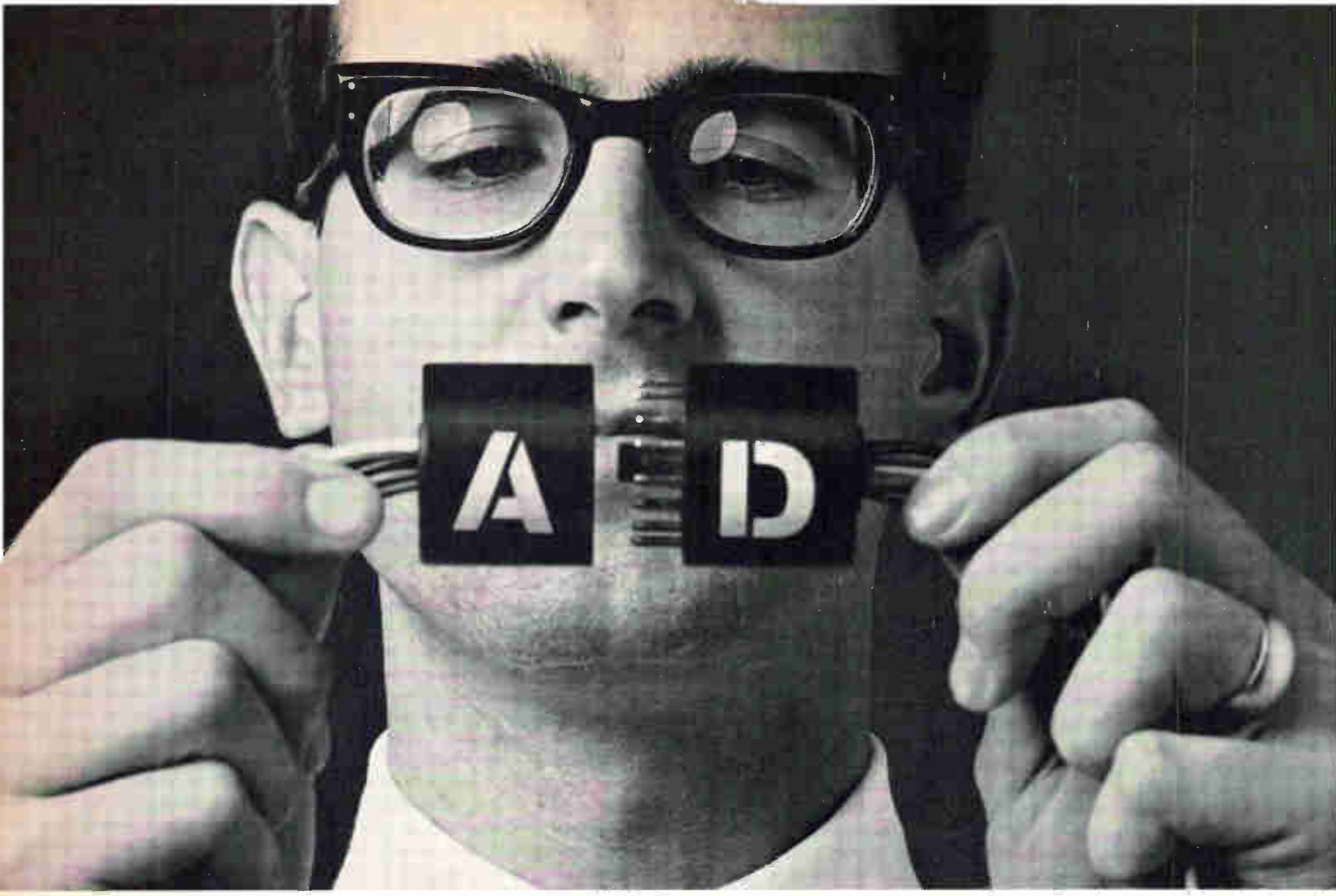
PRODUCTS OF CHRONETICS



Even a digital engineer can interface our new analog instruments.

Analog engineers design analog instruments for analog engineers. Digital engineers aren't usually analog engineers. This leads to problems.

Because we're involved with both D and A, we developed a group of instruments everyone can understand and use.

Before they were put on the market, our systems engineers demanded that analog signals get in and out of digital equipment with blinding speed and stunning accuracy. As a result, here are bold statements about our new line: **Our new instruments are: A.** As fast and more accurate than . . . **B.** Faster and more accurate than . . . **C.** Almost as fast and just as accurate as anyone else's. Whether **A, B,** or **C** applies depends on the instrument you choose.

Here are some of the new ways to get from analog to digital and back again.

Multi-channel digitizers
64 channel high-level multiplexers with sample and hold amp, plus a 15-bit A-D converter in the same chassis. Accuracy: 0.01%. The MD51 has a sample and conversion time of 10 μsec for $8,250 plus $200 for each eight channels. If you can spare another 20 μsec, you'll save $3,050 with the MD41.

Single channel digitizers
15-bit, high-level A-D converters with built-in sample and hold amps. Accuracy is ±0.01%. The AD51 has a throughput word rate of 100 KHz for $5,400. The AD41, though it only costs $4,000, isn't a slowpoke. Throughput is 33 KHz.

Digital to analog conversion
The DA40 is a 10-bit, 16 channel D-A converter. If you need more channels, up to 16 DA40's can be ganged together for 256 analog outputs. Each includes address decode and channel controls, plus a power supply. $375 per channel.

One of the world's fanciest op-amps
Variations on a theme called the HT58 universal operational amplifier include a single-ended op-amp, differential amp, a unity gain buffer and a buffer with gain, all for use with our "T" and "J" series modules. Input impedance of 10^8 ohms and ±40 ma. output current over a voltage range of ±10V. Accuracy: 0.01%. Settling time: 5 μsec. You can adjust the gain, zero offset, and the input offset voltage temperature coefficient. $170.

Our spec sheets meet the same requirement as our new instruments: they're understandable by digital engineers, analog engineers, and anyone else who can understand the specs above. For a complete set of spec sheets contact us digitally, or by using Mr. Bell's analog data transmission device.

SDS
Scientific Data Systems, El Segundo, California

Circle 42 on reader service card

Electronic pressure sensor slated for DC-10's air data computer

Unit gains reliability with a sensitive diaphragm built out of silicon or quarts; six firms, working independently, compete for contract

For several years now avionics suppliers have been aiming at replacing the electromechanical air-data computers in civilian aircraft with more reliable and flexible all-solid state units. This is finally about to happen: McDonnell Douglas is set to award a contract for digital air data computers for its DC-10.

One of the most important elements in the computer—which calculates factors such as altitude, true air speed, Mach number and static air temperature from inputs of static and total air pressures, and temperature—is the pressure-sensing transducer. The mechanical device that's used in conventional analog systems is a major source of unreliability.

Each of the companies that has proposed an air-data system to McDonnell Douglas has taken a different tack in designing a pressure sensor with no mechanical parts or linkages. Generally they use a pressure-sensitive diaphragm that is made of either silicon or quartz.

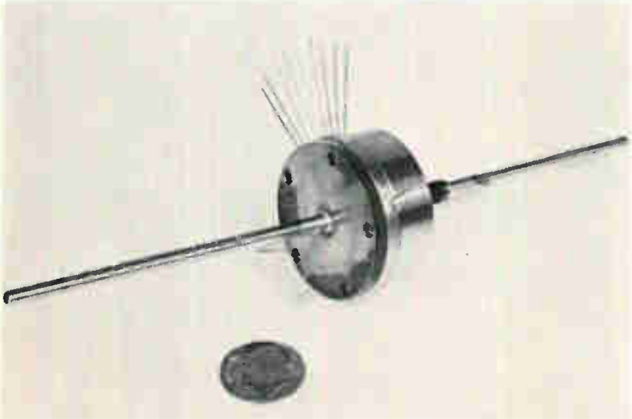
- Honeywell's Aerospace division translates pressure changes into frequency changes by using the distributed resistance-capacitance of piezoresistive strain gages diffused into a silicon diaphragm to control output of a phase-shift oscillator. The frequency output is an advantage, says Honeywell, because information from the sensor isn't affected by noise or the distance over which it's transmitted.
- The Instruments/Controls division of Conrac also uses piezoresistive strain gages in silicon, but the strain elements make up the four arms of a Wheatstone bridge and the output is a varying d-c voltage level.
- The Navigation and Control division of Bendix uses a quartz diaphragm on which capacitive pickoff plates have been placed. The air pressure deflects the diaphragm, affecting the capacitance between the plates, and this, in turn, varies the amplitude of an output a-c voltage.
- The Electronic Systems group at Garrett's AiResearch Manufacturing also uses quartz and capacitive pickoffs, but the output is a varying frequency.

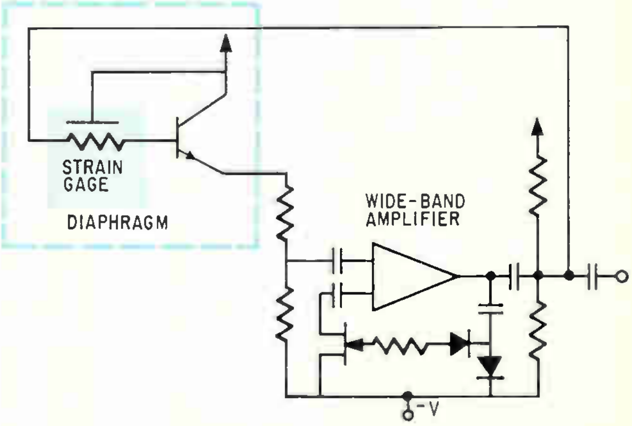
The signal output from the transducer is then conditioned, with either analog-to-digital or frequency-to-digital converters, and fed into the system's computer.

Kollsman Instruments and Sperry Rand are also competing for the award.

These transducers, and the computer systems, are in various stages of development. Conrac and AiResearch are probably furthest along, having promised to deliver test systems to American Airlines by spring. And Conrac developed its piezoresistive pressure transducer, called the Semiducer, about two years ago.

Gain control. Less further along probably are the Honeywell and Bendix transducers. P-type piezo-





Pressure-to-frequency. Piezoresistive strain gage diffused into silicon diaphragm of pressure sensor, left, cotrols the output frequency of a phase-shift oscillator in Honeywell's solid state device.

resistive elements are formed into an n-type circular substrate by standard photoresistive and diffusion techniques, according to Honeywell. The rectangular elements have a strong piezoresistivity measured along their lengths and a distributed capacitance with respect to the substrate that is independent of pressure. Two separate piezoresistive elements and their associated distributed capacitance control the frequencies of two phase-shift oscillators.

An emitter follower is also an integral part of the diaphragm. The diaphragm substrate is the transistor's collector, the diffused strain gage forms the base, and an emitter is added. This transistor is connected to a precision divider network that couples to a wideband amplifier to complete the circuit.

An automatic gain-control circuit using a field effect transistor is added to limit the amplitude oscillations and to improve the oscillator stability.

Just how many of the circuit elements will be integrated into the silicon diaphragm is still being determined by Honeywell. Bendix is relying on a 2-inch diameter quartz, rather than a silicon, diaphragm because it's less affected by temperature.

"We feel we'll get better temperature stability with our quartz sensor than if we relied on strain gages in silicon," says E.J. Hazen, chief engineer of Bendix's Flight Data department. Strain gages are often better thermometers than gages. Honeywell, for example, hopes to correct for temperature and other effects, as well as for unit-to-unit variations, in the digital computer.

Bendix takes the a-c output voltage from the transducer and feeds it into a 16-bit a-d converter. Then the signal goes into a newly designed general-purpose digital computer.

Fuel control. "Our computer is powerful enough to be used in more than just the air-data application," Hazen points out. "We designed it this way so that we don't have to develop a special-purpose machine every time we have something new to design. Right now, we're considering using the computer for electronic fuel control as well as for the air-data job. And a larger version may be used in some automatic ground-test equipment."

The computer has full parallel add, subtract, multiply, and divide capabilities, with a 16-bit word length. It has three separate memories: a nondestructive-readout magnetic type; a diode matrix, and a scratchpad medium-scale integration memory. The computer fits into a 4-by-7⅝-by-4⅞-inch space.

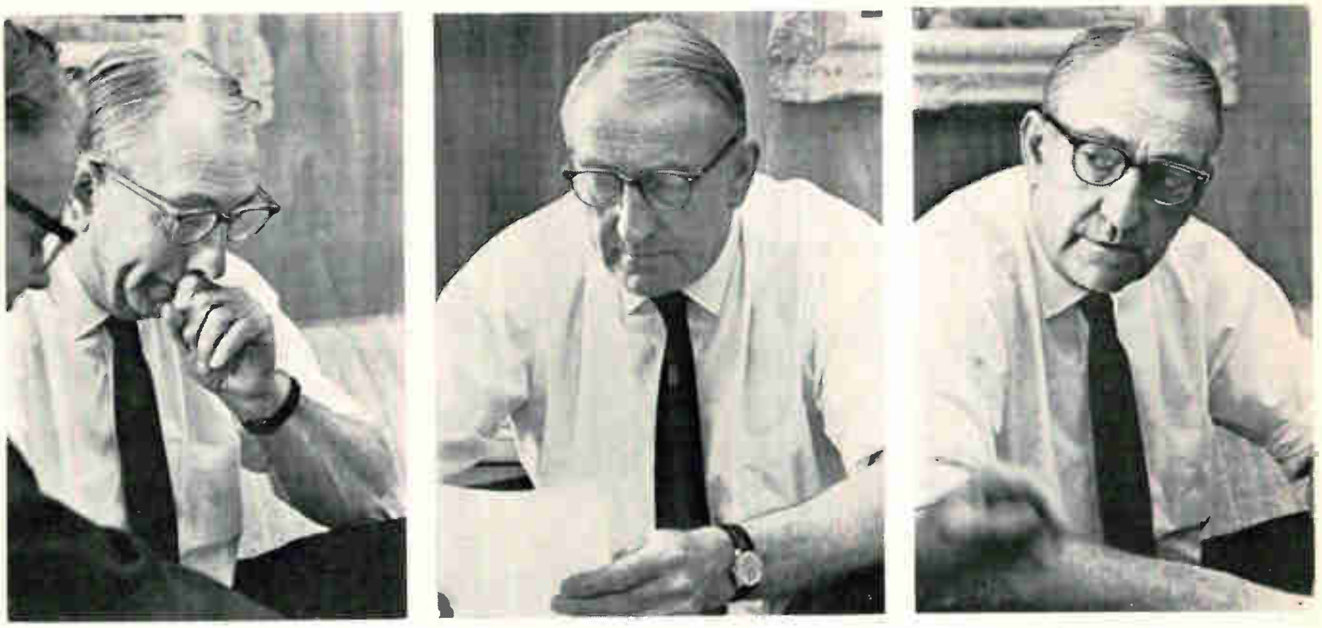
Point of purchase. Up-to-the-minute inventory figures can be calculated with this system, developed by the Kimball Systems division of Litton Industries. When a clerk rings up a sale, he feeds the punched price tag into the machine, which then stores the data collected from the tag. Later the machine transmits the data by telephone to a central computer.

Associative memories

At least three semiconductor companies are now in pilot production on associative, or content-addressable, memory elements. At the International Solid State Circuits Conference in Philadelphia next month, Richard F. Herlein and A.V. Thompson of American Micro-Systems will deliver a paper on a 64-bit MOS memory that their firm is building for NASA's Manned Space Flight Center in Huntsville, Ala. Meanwhile, the components group of Texas Instruments, whose MOS activity is sizzling, has built a 128-bit circuit on a custom contract, and the company is thinking about adapting the technology to produce a catalog item; and Signetics, a subsidiary of the Corning Glass Works, has built sample units of an extremely fast 8-bit bipolar device and expects to announce a product in time for the IEEE Show in March.

Single cycle. Associative memories are attractive because they can elicit all of the words with any given characteristic—such as 1011 in the first four bit positions—in a single memory cycle, whereas an ordinary random-access memory requires that every individual word's exact location be known in advance, and that the location be addressed before the word can be read. Applications range from auxiliary computer memories, where they can be used to increase the apparent speed of main memories [*Electronics*, Dec. 23, 1968, p. 56], to electronic countermeasures equipment, where they could be used to identify r-f signals.

Because these memories require that each cell have logic as well as storage capabilities, the devices tend toward extreme complexity. The AMI circuit, for instance, is on



David Packard: Can he make Pentagon decisions independently of his former business ties?

a huge chip—156 by 144 mils. It contains 1,799 p-channel metal oxide semiconductor transistors, Herlein says. With no d-c power supply at all, the circuit requires one microsecond to write, compare, or read. The firm is building for NASA a breadboard system consisting of 20 chips, plus some TTL circuits, on a printed-circuit board. Each system will have 32 words of 36 bits, plus 3 bookkeeping bits.

Smaller and faster. Texas Instruments delivered its first circuits last month. The chip, at 120 by 90 mils, is smaller than AMI's. And the circuit is faster: 250 nanoseconds to write, compare, and read. If used in a read-write mode only (like a conventional random-access memory), the device has an access time of 50 nsec.

H.B. Grutchfield, manager of product development at Signetics, says that the bipolar memory will probably be released from the pilot line and put in production by mid-February. The circuit has about 100 gates on a 94-by-108-mil chip and consists of two 4-bit words. Chips can be paralleled to form longer words and stacked to produce larger memories.

The Signetics device, known as the 8220, takes 25 nsec to write an address, and 15 nsec to compare and to write out. It may be used as a computer scratchpad.

Military electronics

Packard's choice

Six-foot, five-inch David Packard became a towering figure in the electronics industry as he and partner William R. Hewlett made the Hewlett-Packard Co. into a hugely successful instrument maker (1968 profit of $20.8 million on sales of $268 million). They started H-P in a garage 30 years ago and by making it a model of management turned it into a worldwide company with an excellent reputation. Mostly because of Packard's management capability—and partly because the strong-willed Packard is a self-made multimillionaire in the classic Republican ideal—Defense Secretary Laird tapped him to become Deputy Defense Secretary, the No. 2 post.

As his confirmation came up before the Senate, however, Packard found himself in a king-size controversy. In and out of Congress, there is the question about his appointment resulting in possible conflict of interest. Instead of selling his shares, as former Defense Secretaries Charles E. Wilson and Robert S. McNamara were made to do, Packard offered to put his 29% interest (currently worth about $300 million) in a short-term educational trust. Since one-third of H-P's business is with defense and Government contractors, his decision not to completely divest himself of his interest in H-P openly disturbed some Senators. Senate Armed Services Committee chairman John C. Stennis (D., Miss.) promised a thorough investigation of the "possible conflict of interest."

Larger scale. Packard points out that trying to sell that many shares would have a disruptive effect on the stock market and H-P. Wilson and McNamara, after all, sold stocks worth less than $2.7 million and $1.5 million, respectively.

Packard also offered to resign from the boards of various corporations, institutes, and organizations he belongs to, a standard acceptable procedure. One of them happens to be the General Dynamics Corp., a leading defense contractor and maker of the controversial F-111 swing-wing plane.

Consequently, some observers are raising the question of conflict of interest on a larger scale. Since Packard comes from one of the industries that has a vested interest in keeping military spending in hardware programs high even when the Vietnam war ends, they question whether Packard can make defense decisions that are not influenced by his former ties.

A column by the financial editor

of the respected Washington Post, Hobart Rowen, was headlined bluntly, "Packard Is Wrong Choice for No. 2 Defense Post." Obviously, Packard's every move in the Pentagon will be watched closely by those who fear the military-industrial complex.

In the past, Packard has sharply criticized some military purchasing practices, complaining that the Pentagon worries too much about how much profit a contractor makes and not enough about how good his product is.

Top priority. Packard himself lists the avoidance of a nuclear war as top priority but leaves open whether or not this can be achieved through nuclear superiority with Russia or parity. He's also concerned with bringing weapons systems up to date and working toward arms reduction so that "the U.S. and Russia could maintain stability with a lower expenditure in the military area."

If confirmed, Packard could have a strong effect on Department of Defense research and engineering. An honors engineer from Stanford University, he expresses a particular interest in military research and development.

The effect his departure may have on H-P remains to be seen, but it's doubtful that the solidly managed company will misstep. Packard appears to have bowed out of active management with his appointment. He said he has made no commitment to return to H-P when his Pentagon stint is over.

VAST gets vaster

When the Navy acronym experts came up with VAST to stand for the Versatile Avionic Shop Test System, they also aptly foretold the amount of money that will eventually be poured into the program.

It's now fairly obvious that VAST is turning into one of the big-dollar electronics projects for the Navy. In addition, there's a good chance that civilian applications of this system will mean an additional VAST market.

Right now, PRD Electronics of Westbury, N.Y., a subsidiary of Harris Intertype, holds the biggest VAST orders. The recent award of a $10.2 million letter contract for nine VAST systems swells the amount that this company has earned from VAST contracts to $49.4 million in the past 18 months. This figure includes research and development contracts. This firm has even more money assured from the project: the $10 million is only about half the amount that the Navy will eventually pay for the nine systems. In addition, the contract includes an option for the procurement of seven more systems.

Checkout. The Navy is now installing seven VAST systems that will automatically checkout the Integrated Helicopter Avionics System (IHAS), being developed by Teledyne. The seven systems will be put into operation later this year. PRD Electronics supplied these systems, which use the Univac 1218 computer. However, the nine new systems, which will be installed both ashore and aboard aircraft carriers, and which will be used initially to checkout the Ling-Temco-Vought A-7E, will be using the larger Univac 1219 computer.

The VAST system, according to the Navy, will be able to handle newer carrier aircraft as they come into production, including the VFX and E3C. The Navy stresses, however, that VAST will not afford total automatic checkout: they estimate that the system will handle only about 85% of the avionics electronics.

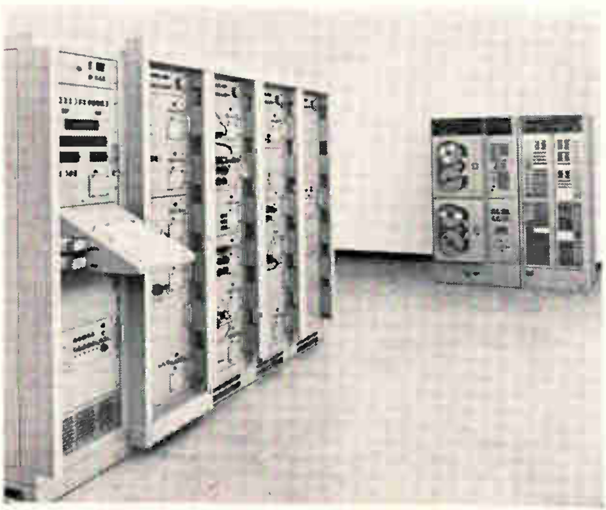
The Navy isn't saying how many systems will be required, since the amount will depend on the deployment of the A7E. However, some Congressional sources report that the Navy has estimated that the cost of VAST will total about $300 million by the mid-1970's.

Over 20 years this system will save $1 billion in avionics support costs, says the Navy, defending its entry into the program. The system not only reduces the number of maintenance personnel but also frees valuable space aboard carriers. The major advantage, of course, is the speed of testing and checkout [*Electronics*, July 12, 1965, p. 49].

No complaints. The Navy reports that it has had no complaints from industry on the requirements that new avionics systems must be designed for VAST testing [*Electronics*, Aug. 21, 1967, p. 42].

Although former Secretary of Defense Robert McNamara pushed long and hard for commonality of equipment between the services, he lost out when it came to the development of automatic avionics checkout systems.

The Air Force and Navy agreed to go their own ways in this field because of different requirements. The Navy equipment is designed mainly for use aboard carriers, while the Air Force's General Purpose Automatic Test System (GPATS) is intended for airbase installation. One of the major fea-



Testing, one, two . . . Versatile Avionic Shop Test System (VAST) is growing into a rather expensive program. Already some $50 million in military contracts have been awarded for its procurement.

Penny-Pincher's Pac

If you're looking for low-cost, high-performance logic that can help you pinch pennies, see how some typical HONEYWELL μ-*PAC* logic module prices have been reduced:

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DN-320	6, multi-input NAND gates	21.00	16.00	2.66 gate
DF-320	8, three input NAND gates	New	20.00	2.50/gate
FF-320	8 basic flip-flops	New	31.00	3.87/flip-flop
FA-320	4 clocked flip-flops	31.75	25.00	6.25 flip-flop
BC-320	6 stage binary counter	46.50	38.00	6.33 stage
SR-321	8 stage shift register	New	54.00	6.75/stage
AP-335	8 half adders	168.00	129.00	16.12 half adder

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Need μ-*PAC* logic modules in a pinch? Ask about our 72-hour Certified Fast Shipment (CFS) plan.

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AUTOMATION

Circle 47 on reader service card

tures of VAST is its relatively small size, which is not a major consideration for the Air Force. Emerson Electric has recently received a $4.5 million order for 10 GPATS. These are in addition to five units that have already been delivered.

Although VAST is a relatively new program, PRD Electronics is already touting it as having numerous applications besides those in Navy line duty. The company says it can be used for in-plant testing of avionics systems that must be compatible with the shipboard VAST system, and can be used for support of third-generation avionics systems on commercial jets.

Companies

Allen-Bradley resisting

"We're not going to roll over and play dead."

A spokesman for the Allen-Bradley Co., the big Milwaukee producer of resistors, other components and motor controls, gives this not-so-subtle indication of the firm's stand on its battle with Uncle Sam over its Negro hiring practices.

The battle went to the desk of Labor Secretary Wirtz last week just as he was cleaning it out to make way for his successor, George Shultz.

Crackdown. The case involves compliance with Executive Order 11246, which forbids racial discrimination by Government contractors or subcontractors. The Department of Labor, which says it tried for four years to get Allen-Bradley to work out voluntary programs to hire more Negroes, cracked down last May. The department's Office of Contract Compliance told the company of its plans to recommend that the company be barred from Government contract work because of biased job practices. Out of a total work force of 6,500 Allen-Bradley employs between 30 and 40 Negroes. There are about 87,000 blacks in Milwaukee—about 11% of the population.

Formal hearings were held, and among those testifying before a three-man panel were black leaders and Father Joseph Groppi, the Catholic priest who led Negroes in open-housing marches for many months. Last month, the panel decided that although the company did not discriminate against any employee because of race, neither did it take "affirmative action" to ensure that applicants are treated equally. The Executive Orders says that Government contractors must take such "affirmative action." The panel said that "affirmative action" may require a contractor "to do something more than to avoid overt discrimination."

The panel recommended that the Secretary of Labor order the Office of Federal Contract Compliance and Allen-Bradley to get together to work out a program of "affirmative action."

But Allen-Bradley, in a response to the panel's findings, did not agree to the recommendation. Nor did attorneys for the Labor Department. Allen-Bradley says it won't comply with a program that it feels violates the law. "Treatment which takes race into account . . . has been condemned by the courts and legislation alike as contrary to the public policy of this nation," says Allen-Bradley. The company feels that a logical development might be that Negroes would be given preference over whites in hiring.

Big issue. The Labor Department lawyers, on the other hand, said that Allen-Bradley had enough time to comply. They recommended barring the company from future Government contracts. If carried out, this could cripple the firm, which does a substantial amount of Government subcontracting.

One of the main issues in the case is how Allen-Bradley carries out its hiring. Up until last year, it's said, almost all new employees were recommended by friends or relatives already employed by the firm. Almost all employees were white, and it's said this tended to exclude recommendations of Negroes. The company did virtually no newspaper advertising for new employees.

This is the first case involving the Executive Order that has gone

this far—and lawyers in the Labor Department feel sure that it will probably wind up in the courts.

"We've been able to work things out with every other company—even in the Deep South," said one department source. "But Allen-Bradley just won't play ball."

Avionics

Drone on

The Navy's drone helicopter program, dubbed Dash, had such serious problems with its telemetry system that the Navy finally grounded Dash and stopped buying the remote-control whirlybirds [*Electronics,* Nov. 11, 1968, p. 74].

However, Dash is rising again, sporting a new name, Nite Panther, and a new look. Nite Panther is a television-guided attack helicopter that delivers bombs, napalm, and rockets at targets that it illuminates with infrared spotlights.

The telemetry problems have apparently been cleared up, according to project sources, during the past six months in a program at the Sperry Gyroscope Co., Great Neck, N.Y.

Sneaky. Because of the covert illumination as well as the fact that the craft is much quieter than helicopter gunships or fighter planes, Nite Panther can, in the words of one Vietnam veteran, "sneak in over a target and attack virtually without warning."

Specifics on Nite Panther are hard to come by because of the Navy's official silence on the project, but published awards indicate that the Gyrodyne Corp. of America in St. James, N.Y., has received contracts totaling about $2 million. Broken down, these awards include $224,388 for a shore-based operations and maintenance system (Dash flew only from destroyers); $498,526 for Jeep-mounted stations for control of the drones; $993,543 for tv camera control, covert illuminator mount, and 1,000-line resolution tv receivers, and $345,867 for an x-y axis camera mount.

Much of the work, which is said to be financed by the Defense Department's Advanced Research Projects Agency, will be subcontracted. Among the firms said to be supplying Nite Panther hardware are Microwave Associates, for the tv receivers; Cohu Electronics, the tv cameras; ITT, the covert illumination system, and Vega Electronics, the telemetry gear.

Nite Panther, an industry source notes, may be only the first of many new remote-control warfare schemes. "We ought to see a flood of requests for proposals this year, with Ft. Belvoir probably leading the pack, and production contracts for several such systems by 1970," he says.

Kibitzer. The aerospace industry, quite naturally, is interested too, and rumors of unsolicited proposals for systems with Nite Panther-like capabilities are rife, with most of these coming from telemetry firms.

Now that the Navy is committed, the Army will probably follow suit with support for similar drone systems. For instance, the Army has for several years been studying a drone system made by General Dynamics' Convair division. This is called Lalo-Peek, and the name, believe it or not, stands for low altitude observations—periodically elevated electronic kibitzer. Its mission would include both tv reconnaissance and electronic intelligence.

The combining of tv-aided remote control, night vision, and weapons delivery is catching on overseas, too, with Great Britain, West Germany, and Israel interested.

Elf to the rescue

Because aircraft direction finders measure the amplitude of the target signal to find the source of the radio transmission, even the best become imprecise when the downed pilot's signal is attenuated by hills or jungle foliage. The Cubic Corp. has taken another tack: it uses two sets of fixed-beam Archimedean spiral antennas to detect the phase of the signal. The result is a direction finder that

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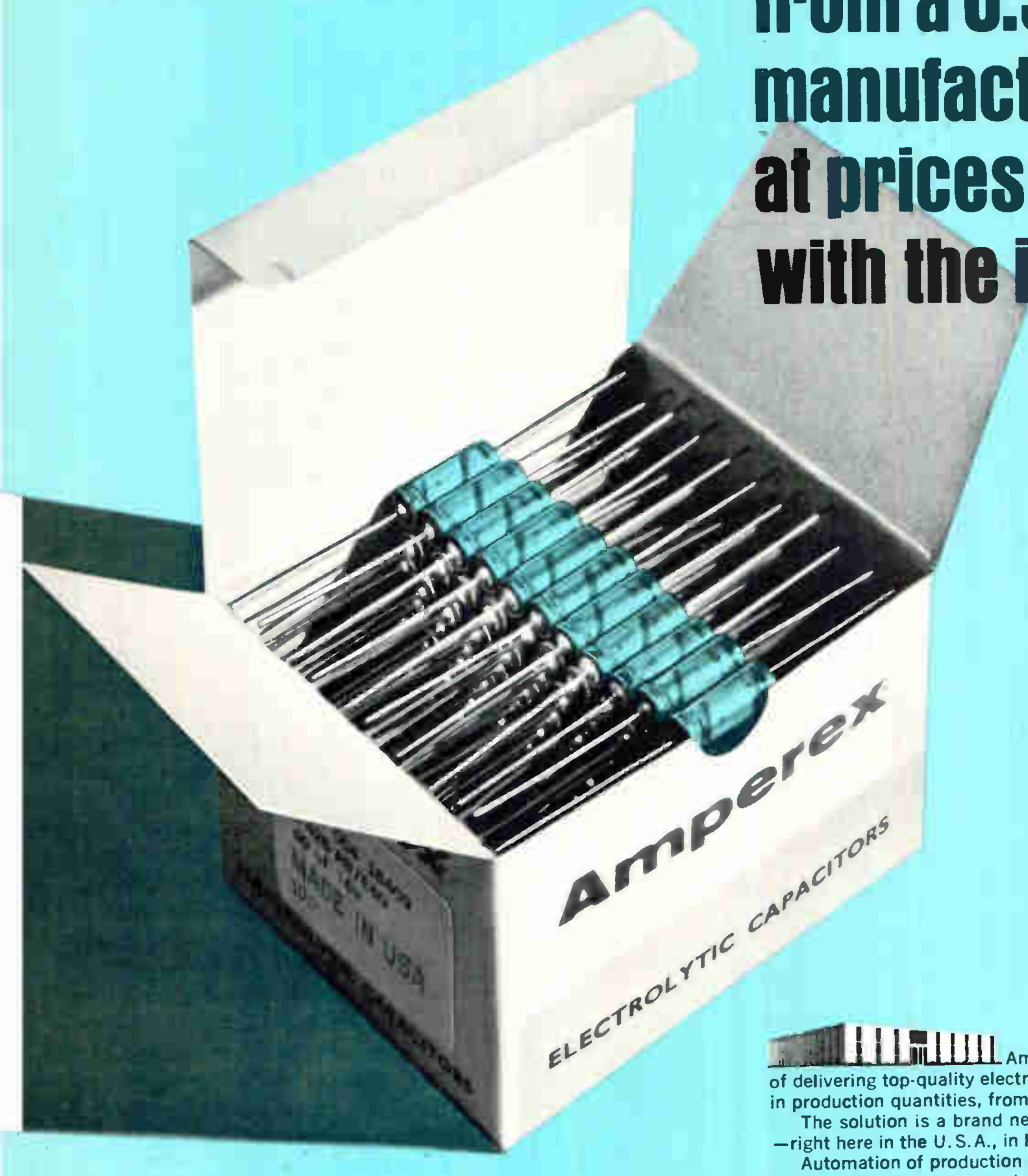

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Cubic says is more sensitive and accurate than conventional models.

During an Air Force test, the receiver, called Elf for electronic location finder, was able to track down a target hidden by dense, wet foliage and high trees from an altitude of 5,000 feet and a ground range of 2.5 miles.

Under less severe conditions, a helicopter-borne Elf has responded to beacons out to 56 miles, according to Richard Keller, the project manager. In one test, he says, the system found a transmitter behind a hill from the helicopter and without a direct line of sight between the antennas and the transmitter.

The Air Force was satisfied with the field tests and plans to order the system, the company says. The unit, developed with Cubic's funds, will cost about $25,000.

Getting closer. Keller says the test flights have shown that pilots can hover their helicopters within an imaginary circle of the beacon signal having a radius of 10 to 20 feet at altitudes of 250 feet—the length of the craft's rescue rope. Keller says this advantage is especially important because helicopter "noise" reflected in the antennas makes conventional direction finders virtually useless within a mile of the downed pilot.

Comparing the phase differences of a received signal is more precise than measuring amplitude. Conventional systems use rotating-loop or parallelogram-type antennas to determine the direction of the signal. With Elf, the slight phase differences between signals arriving at the two sets of antennas (fore and aft and right and left axes) are calculated by a receiver-processor, which is linked to the helicopter's vertical gyroscope to offset errors that result when the helicopter pitches.

Flag down. In the cockpit, an indicator with left-right and fore-aft needles shows the pilot his position in relation to the transmitter. When the signal is first received, a flag on the face of the indicator disappears, telling the pilot to begin

Where are you? Direction-finding gear developed by Cubic Corp. can home in on SOS signal at distances of 2½ miles through dense, wet jungle. The range of conventional gear is limited to a mile.

his search pattern.

The pilot circles until the left-right needle is vertical. Knowing he is on course with the transmitter, he then maneuvers until the fore-aft needle is perpendicular to the left-right indicator. This indicates the precise point at which the helicopter is directly over anyone operating an AN/PRC-28, AN/URC-64, AN/PRC-63, or similar radio.

Elf can be tailored to handle any frequency, Keller says, and is designed to find radio sources regardless of modulation. It's selective enough to distinguish between two beacons with identical antennas, waveforms, and power outputs.

Government

IBM and antitrust

Is 1969 the year the Government decides that IBM is too big?

That's the rumor circulating in Washington and Wall Street. But so far there's been no confirmation. A stony silence greets callers to the Justice Department asking about its plans for an antitrust suit against the giant company.

Antitrust lawyers decline to venture a guess on what form any possible suit against IBM would take. Normally, such suits ask for an injunction against the companies, ordering them to halt all unlawful activities. The department can suggest ways for the company to be reorganized to make its operation lawful. For example, Justice could suggest that IBM be broken into four divisions—manufacturing, time-sharing sales, software production, and computer maintenance.

Triple damages. A suit could be extremely expensive to IBM. If the case is filed and the Government is successful in proving that the company violated antitrust law, all competitors of IBM could file civil suits asking for triple damages. In this case, the court would establish how much a company lost due to IBM's unlawful activities, triple that amount, and assess that sum against the company.

Two firms have already filed their own antitrust suits against IBM: Control Data and Data Processing Financial & General Corp., a computer leasing concern. However, because the legal fees in such a case are extremely high, it is likely that the companies won't pursue them now. They will hope that the Justice Department files in the case and uses Government attorneys to follow it up.

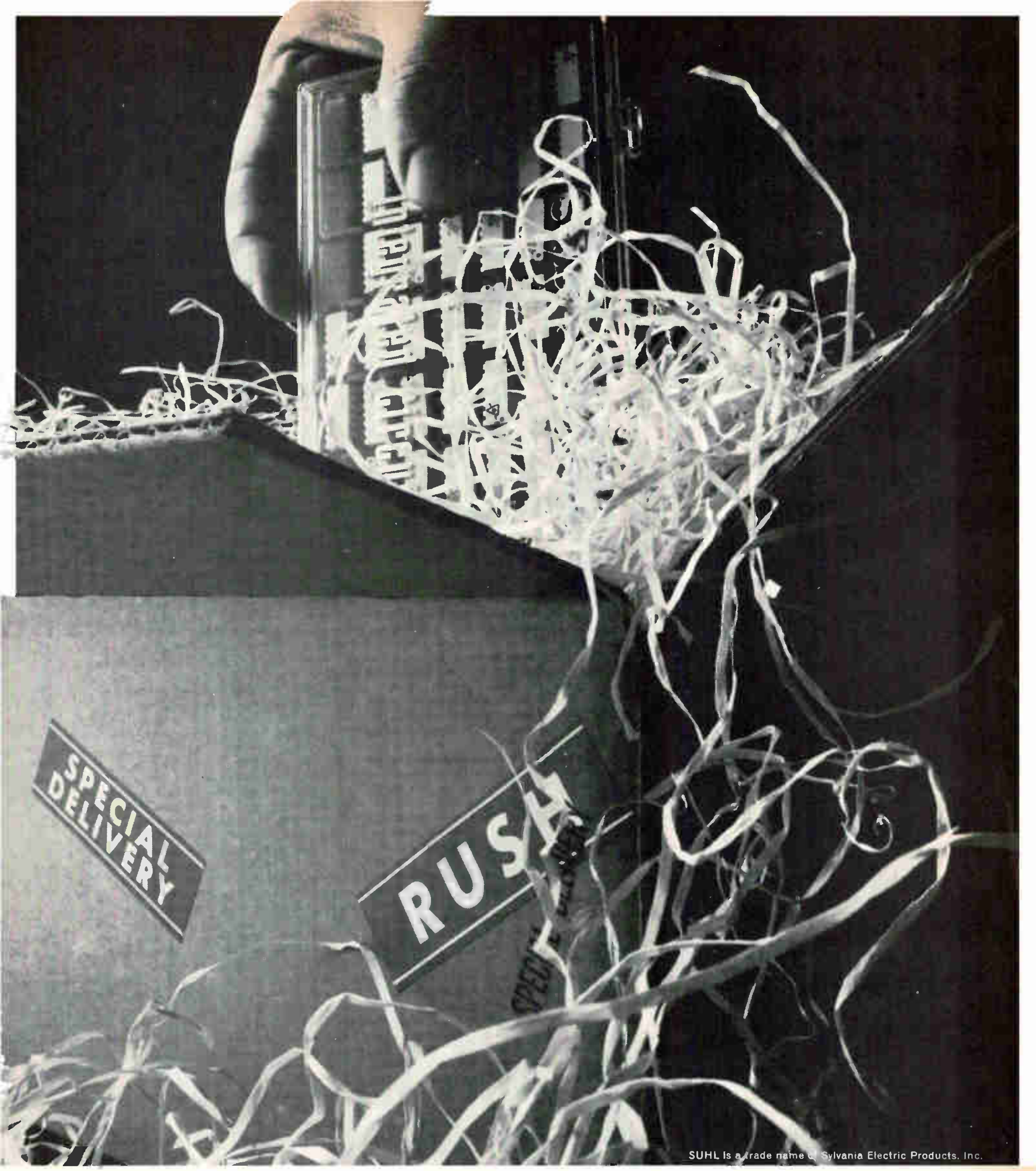
If Justice does file a suit, IBM's strategy may be to seek a consent decree. This would be an agreement between the Government and the company to take some steps that would promote competition. A consent decree doesn't constitute an admission of guilt. Thus the Government's case will not be usable by the companies who file private suits.

IBM is currently operating under a consent decree signed in 1956 at the demand of the Government. The decree forced IBM to sell some of its punch-card facilities to end its alleged monopoly on this business. It also required IBM to offer its machines for sale, not just for rent, and to split off its service bureau from its computer sales and rental operation.

For the record

Three for the money. The Air Force awarded Fairchild Hiller, McDonnell Douglas, and North American Rockwell $9.6 million each to pursue the contract-definition phase of the ZF-15A (FX) advanced fighter development program, thus narrowing the competition to three. A single winner will be chosen in about a year from now.

Hot stove league. Varian Associates has built a microwave kiln for curing tanoak, a hardwood, that until now had defied simple, economic curing processes. The wood, harder than ash, is being used for baseball bats. Previous attempts to cure tanoak required from 60 days to 18 months, and even then the results were uncertain; uneven curing splits the wood. The microwave technique, in which a 30,000-watt klystron is used, takes only four hours. The electronic kiln is being



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On the surface. The Raytheon Co., Lexington, Mass., will develop an airborne phased-array antenna—for communicating with military satellites—that can be mounted flush with the surface of an aircraft's fuselage.

Under an $887,000 contract from the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio, Raytheon's Missile Systems division, has 34 months in which to demonstrate a feasibility model aboard a four-engine KC-135.

Micro State Electronics, Murray Hill, N.J., a Raytheon operation, will help build the solid state transmit-receive modules of the array. Each module will probably also have a diode phase shifter.

Airborne antennas now consist of mechanically scanned reflectors that either protrude from the fuselage or are concealed in a radome. Such designs are not desirable because they add to the aircraft's weight and aerodynamic drag, particularly at supersonic speeds. An antenna that could be built conformally into an aircraft's skin would offer great advantages.

Reportedly, such a design is being considered for an advanced version of the Air Force's Airborne Warning and Control System (AWACS). And it could be useful in fighter aircraft as well.

'Wet NASA.' A massive Government-industry effort to develop and protect the nation's marine environment has been proposed by the President's Commission on Marine Science Engineering and Resources. It called for creation of a "wet NASA"—the National Oceanic and Atmospheric Agency. The new agency would spend about $2 billion a year by 1980 and carry out a broad range of programs. It would take over oceanic programs now scattered among a number of agencies and would absorb the Environmental Science Services Administration and other agencies.

The commission's recommendation called for spending large sums in electronics-oriented programs.

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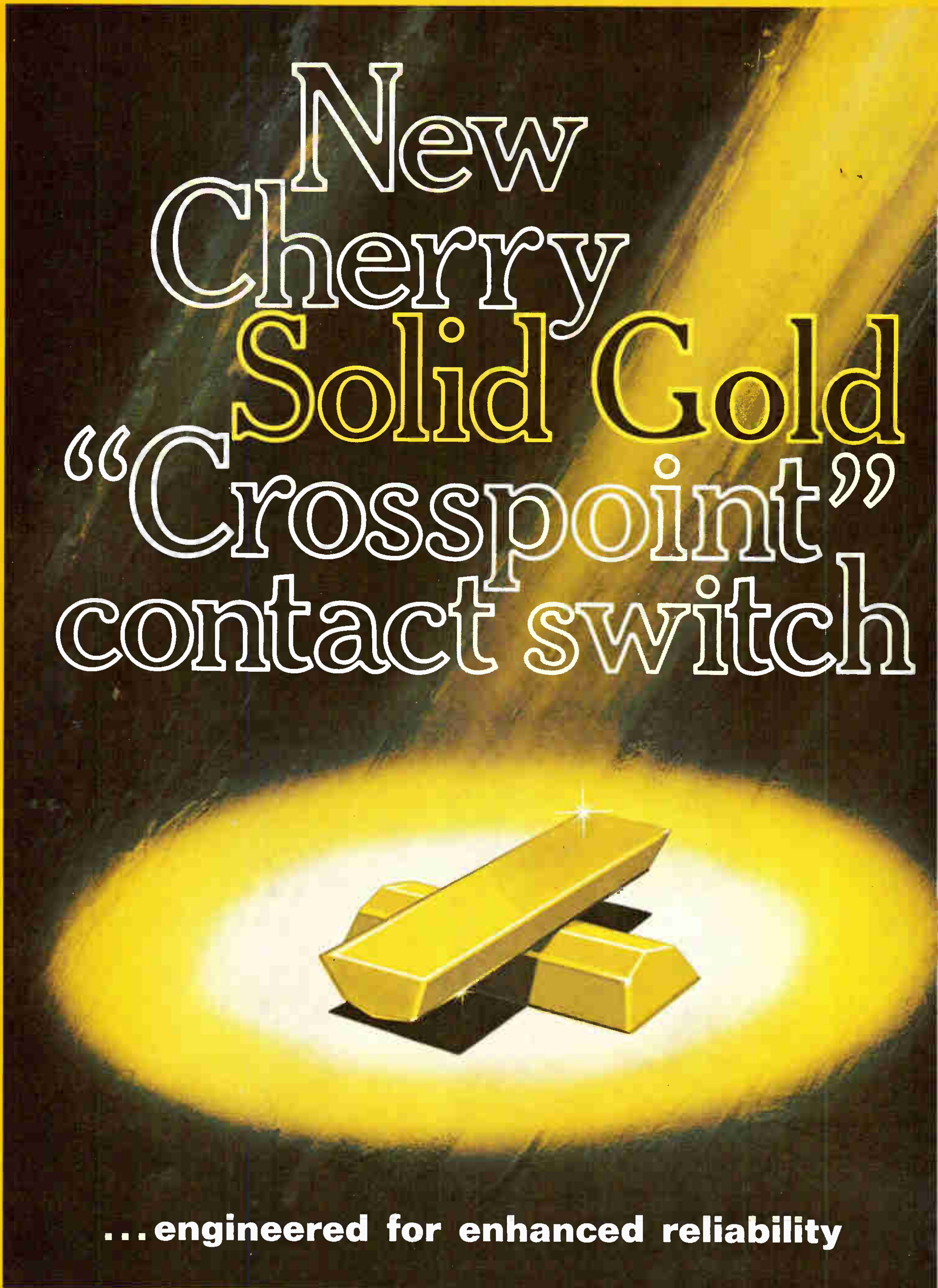
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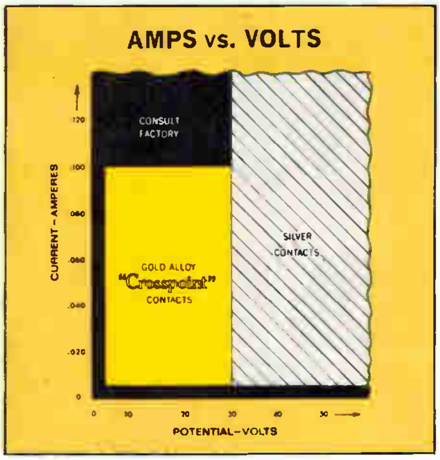

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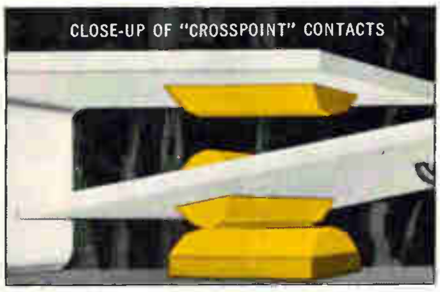

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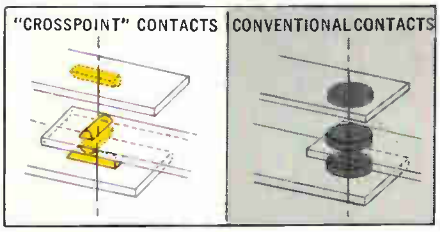

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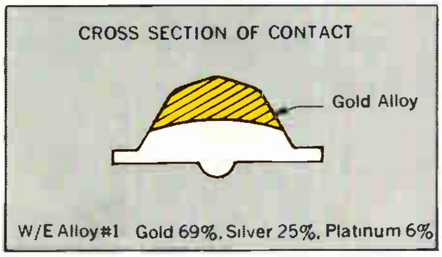

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Yes, we have twelve sizes of HELIAX® elliptical waveguide for the microwave spectrum: 10 in stock, 2 more soon. Coverage from 1.7 to 15.2 GHz. Andrew's unique corrugated construction makes the difference. Makes HELIAX copper waveguide stronger, more flexible. Long continuous lengths are easily fitted to your layout. You save time and money all down the line. Wouldn't you like to know more? Communicate with Andrew.

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Washington Newsletter

January 20, 1969

Navy will furnish Cains for planes

The Navy administrators who wanted the airborne portion of Cains (Carrier Aircraft Inertial Navigation System) to be furnished by the Government have won their tug-of-war with the aircraft manufacturers. **The makers had been battling to subcontract the $250 million aircraft inertial navigation portion separately for the F-14, S-23, and E-2C** [*Electronics*, Dec. 23, 1968, p. 42], but the Naval Air Systems Command has decided to let one manufacturer supply the gear for the three planes. **A two-year development contract will be awarded March 1.**

Because fitting Cains production into these fast-moving aircraft programs calls for tight scheduling, the Navy is overlapping the engineering and production contracts. **The production order will be awarded in mid-1970 with delivery slated to begin in fiscal 1971, even before the engineering-development phase is finished.** The Navy concedes that the same manufacturer may wind up with both contracts. Present plans call for a multiyear procurement, probably beginning with a few hundred units each year.

Cains will use a radio link to align a plane's inertial navigation system with the carrier's inertial system within 5 minutes.

ERTS proposals due from Goddard soon

Earth Resources Technology Satellites are getting closer to the hardware stage; NASA's **Goddard Space Flight Center is putting the final touches on recommendations covering the sensors and experiments to be carried aboard the A and B versions, as well as spacecraft design details.** Space agency officials are expected to go along with the center's proposals, which will be under tight security until they're released in the next few months. However, a Goddard source says the satellites will carry "a predictable composite of the best earth resources experiments proposed over the last few years."

NASA hopes to move quickly on the ERTS program. "We plan to award the construction contract shortly after the requests for proposals are in," says an official, pointing out that many companies have already done a lot of research in this area and are ready to bid for the work on the satellites.

One point still to be resolved is which NASA center will manage the program. Goddard would like it, but officials at the center concede that they're "fat" with programs; several others aren't.

U. S. to join fight against European component standards

The State Department is expected to join the Electronic Industries Association in protesting the common electronic component and equipment standards being drawn up by Great Britain, France, and Germany. **The EIA is so worried about the consequences of a tripartite agreement being arrived at that it has established an ad hoc committee to keep an eye on this problem.** The committee is headed by Leon Podolsky, of Sprague Electric, who is expected to go to Europe next month to meet with the tri-nation group working up the standards. **The EIA maintains that such standards could mean a reduction of as much as 35% in American exports to those nations.**

Members of the EIA who have been pressing for import protection are put in a rather embarrassing position by the three-nation move. In fact, Robert Sprague of Sprague Electric has been one of the foremost protectionist. If the standards are adopted, the American electronics industry could face even tougher barriers than those the American protectionists want to impose against imports.

Data-buoy contract may be let Feb. 15

The national data-buoy system appears to be getting closer to launch. The Coast Guard will probably award a contract Feb. 15 for the system's "concept formulation." **The order, which will cover work on sensor design and data transmission and management, will be relatively small, but 26 companies are bidding in hopes of getting a headstart in this field.**

A $5 million appropriation request for the buoys was rejected last year, but the Coast Guard is now seeking $10 million in the 1970 budget. **The system, a network of buoy-mounted sensing platforms, would transmit data on ocean conditions to satellites for relay to ground stations.**

Privacy issue set for further public airing in House

The special subcommittee on invasion of privacy of the House Committee on Government Operations, **which was so effective in stalling the Bureau of the Budget's proposed National Data Center,** is bent on taking a close look at other computer systems and networks this year. It plans a series of hearings beginning in the next few weeks on existing and proposed applications by credit agencies and state, local, and Federal data banks. **In addition, the subcommittee will check on the use of computerized information by financial institutions and industry.**

Meanwhile, the House group is awaiting the Budget Bureau's revised plans for a National Data Center. Revised proposals for this project will be announced by late spring or early summer; reportedly, they'll incorporate provisions to safeguard the privacy of the individual. A subcommittee staffer says the hearings are designed to determine to what extent the mushrooming use of computers and computer networks impinges on an individual's ability to lead a private life.

Warranty legislation can't be guaranteed

The chances of the consumer-protection bill sponsored by Sen. Warren Magnuson (D., Wash.) appear to have been weakened by the parting shots of President Johnson's consumer adviser, Betty Furness. **The report by her task force on appliance warranties and service said that voluntary steps toward improvement were being taken by trade associations and industry;** it did not come out strongly in favor of legislation aimed at correcting warranty or service faults.

Nevertheless, Sen. Magnuson's Senate Commerce Committee intends to hold hearings on his measure, **which is the same bill he has previously sponsored and which calls on manufacturers to give consumers a complete picture of what they're getting in the way of guarantees, warranties, and service.**

Addenda

The Communications Satellite Corp., still trying to keep the doors open for an aeronautical services satellite, will offer the airlines a package price for the system within the next two weeks. **According to well placed sources in the airline industry, the price will be lower than the estimated $55 million cost of the total system.** . . . Watch for bills in Congress to require that all aircraft carry crash locator beacons. **The FAA investigated the subject last year, but quietly dropped it because of pressure from airlines and private pilots' groups.**

High efficiency/High reliability industrial and lab power supplies

The DCR Series is composed of 34 models — 9 models with power levels of 400 and 800 watts are available, from stock, at 0-40, 0-60, 0-80, 0-150 and 0-300 Vdc in the 5¼″ high package utilized by the model DCR 40-10A.

Other features include: • compliance with RFI specifications MIL-I-26600 and MIL-I-6181D • ± 0.075% voltage regulation for line and load changes combined • voltage *and* current regulation with automatic crossover • adjustable current limiting with automatic recovery • optional overvoltage protection • remote sensing and remote programming.

For more information contact your local Sorensen representative or; Raytheon Company, Sorensen Operation, Richards Avenue, Norwalk, Connecticut 06856.
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63 KEYS TO COMPUTING FREEDOM ARE NOW WITHIN YOUR REACH!

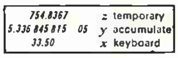
Freedom from waiting to get on the BIG computer;
Freedom from translating your problems into foreign computer languages;
Freedom from starvation-level computing with under-developed calculators;
Freedom from the drudgery of *manual computation.*

The new hp 9100A puts heroic computing power responsively at your fingertips... for the unheroic, one-time-cost of $4900. Fast core memory delivers answers to log, trig and other keystroke functions in milliseconds. And... in seconds you get answers to more complex computations such as roots of a fifth degree polynomial... Fourier analysis... elliptic integrals... Fresnel integrals... real and complex polynomial evaluation... coordinate geometry... regression analysis... three dimensional vectors... numerical integration and many, many, more!

This major computing capability is compressed into one 40 pound package. Its only moving parts are the keys, the switches and one decimal wheel. No noise!

The 9100A is being delivered now along with an extensive—and growing—program library that puts you in control.

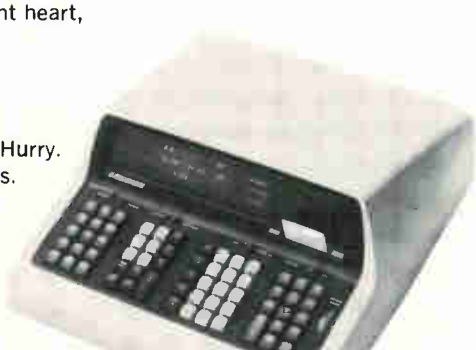
Examine the keyboard. Question every key and switch. Then join the participators! A telephone call or purchase order directed to any Hewlett-Packard sales and service office (located in principal cities throughout the world) will start your liberation from the tyranny and tradition of too BIG, too slow and too weak. If you are still skeptical or of faint heart, ask for a demonstration. It will affirm, assure and delay—but only slightly—your entry into the solid-state of personal computing freedom. Hurry. Being a leader has its advantages. Hewlett-Packard, P.O. Box 301, Loveland, Colorado 80537. Europe: 1217 Meyrin-Geneva, Switzerland.



Dynamic range 10^{-98} to 10^{99}, nearly 200 decades. Observation of math operations on 3 displayed registers. Up to 16 more registers for data storage.

Complex and vector arithmetic simplified with coordinate transformation keys, rectangular-to-polar and vice-versa, in milliseconds.

Trig functions covering all quadrants and any size angle in degrees or radians.



9100A puts answers just a touch away!

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IF $x < y$ **Up to 196 program steps,** each a simple key stroke. "IF" keys permit looping and branching flexibility found only on large computers.

STEP PRGM **Edit programs easily.** Single-step through programs to check and de-bug. Address an individual step and make corrections without re-entering the entire program.

Program from the keyboard. Record and store programs on credit-card-size magnetic cards for repeated use.

Designed for expansion. Printer, plotter, electrical data input/output will become available.

MALLORY CAPACITOR FACTFILE

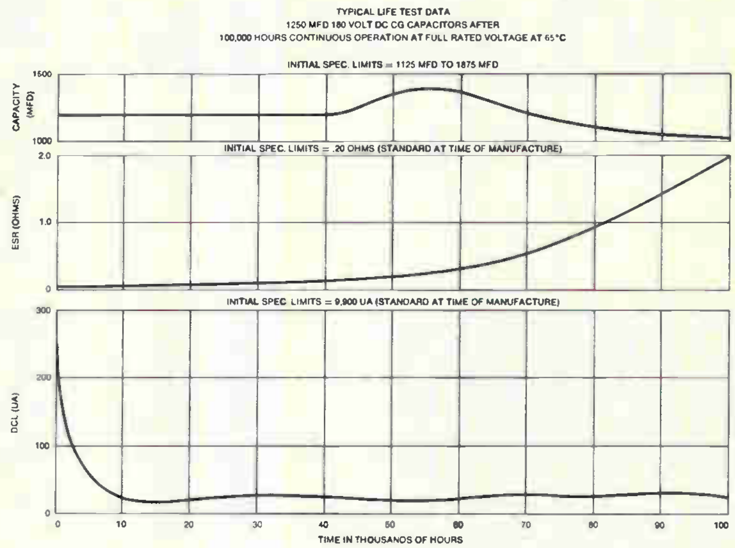
What is the life of a good aluminum capacitor?

Sample #7, shown below, survived 100,000 hours. It is one of a group of computer grade aluminum electrolytic capacitors that we put under test back in 1957.

All capacitors were operated at rated DC working voltage, surge voltage, ripple current and temperature range found in typical computer type power supply circuits.

Sample #7 works almost as well today as it did eleven years ago.

Mallory capacitors enjoy long, reliable life because they are built to exacting standards and tested for surge voltage, vibration resistance, container seal tightness, shelf life, and capacitance, ESR, DC leakage current and electrolyte leakage.



All Mallory CG capacitors should have a useful life of about ten years, when operated at specified conditions. They will last even longer if derated in one or more operating conditions.

Temperature Range

CG capacitors are designed to operate within a range of −40°C to +85°C. They have been tested at 105°C at less than rated voltage without immediate catastrophic failure. Extended operation under these conditions, however, will shorten their life.

Capacitance

Capacity is measured at 120 cps and at 25°C. Tolerance of capacitors rated at 3 to 150 volts is −10, +75%. For capacitors rated at 151 to 450 volts, the tolerance is −10, +50%.

Low Temperature Capacitance

Capacitance of Mallory CG capacitors at reduced temperatures and 120 cps does not fall below the following percentage of nominal rated room temperature (+25°C) capacity.

Rated DC Voltage	Percent of Nominal Rated Capacitance		
	−20°C	−30°C	−40°C
0-15	65	50	30
16-100	80	65	40
101 and up	85	75	50

Equivalent Series Resistance

ESR measurements are made at 120 cps and 25°C. ESR for Mallory computer grade capacitors is very low.

Mallory wants the highest possible rating for its CG capacitors—but not at the expense of long life and reliable operation. The object of all our research and care in manufacturing and testing is to provide our customers with the "best" capacitor. For data, write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

"Freon"® solvents improve reliability and reduce costs.

–Jack L. Steiner, Manager of Assembly Operations, Applied Dynamics, Inc.

Applied Dynamics, Inc., an analog-computer manufacturer in Ann Arbor, Michigan, accomplished more effective cleaning of electronic subassemblies by using "Freon"* solvents. In addition, they improved quality, reliability and reduced costs.

Applied Dynamics uses "Freon" TMC for complete removal of rosin flux after soldering of assembly boards. A two-solvent system, "Freon" T-WD 602 and "Freon" TF, is used for further cleaning of critical modules to completely remove polar soils deposited by plating, handling, etc.

Because of their experience with "Freon" solvent systems, Applied Dynamics is considering additional ones.

Parts are efficiently cleaned in Branson ultrasonic equipment specifically designed for the application and proper handling of "Freon" solvents.

To insure complete cleanliness before the critical modules are inserted into the computer, a three-tank cleaning system is being employed. In the first tank, "Freon" T-WD 602 (a patented emulsion of "Freon" TF, water and detergent), removes foreign matter picked up on the production line. To remove any remaining impurities and detergent residue, boards are then immersed in "Freon" TF. This is followed by a rinse in still a third tank with ultrasonically agitated "Freon" TF.

"These systems insure complete removal of all foreign material and are economical. Since we started this procedure, leakages have been eliminated," says Mr. Steiner.

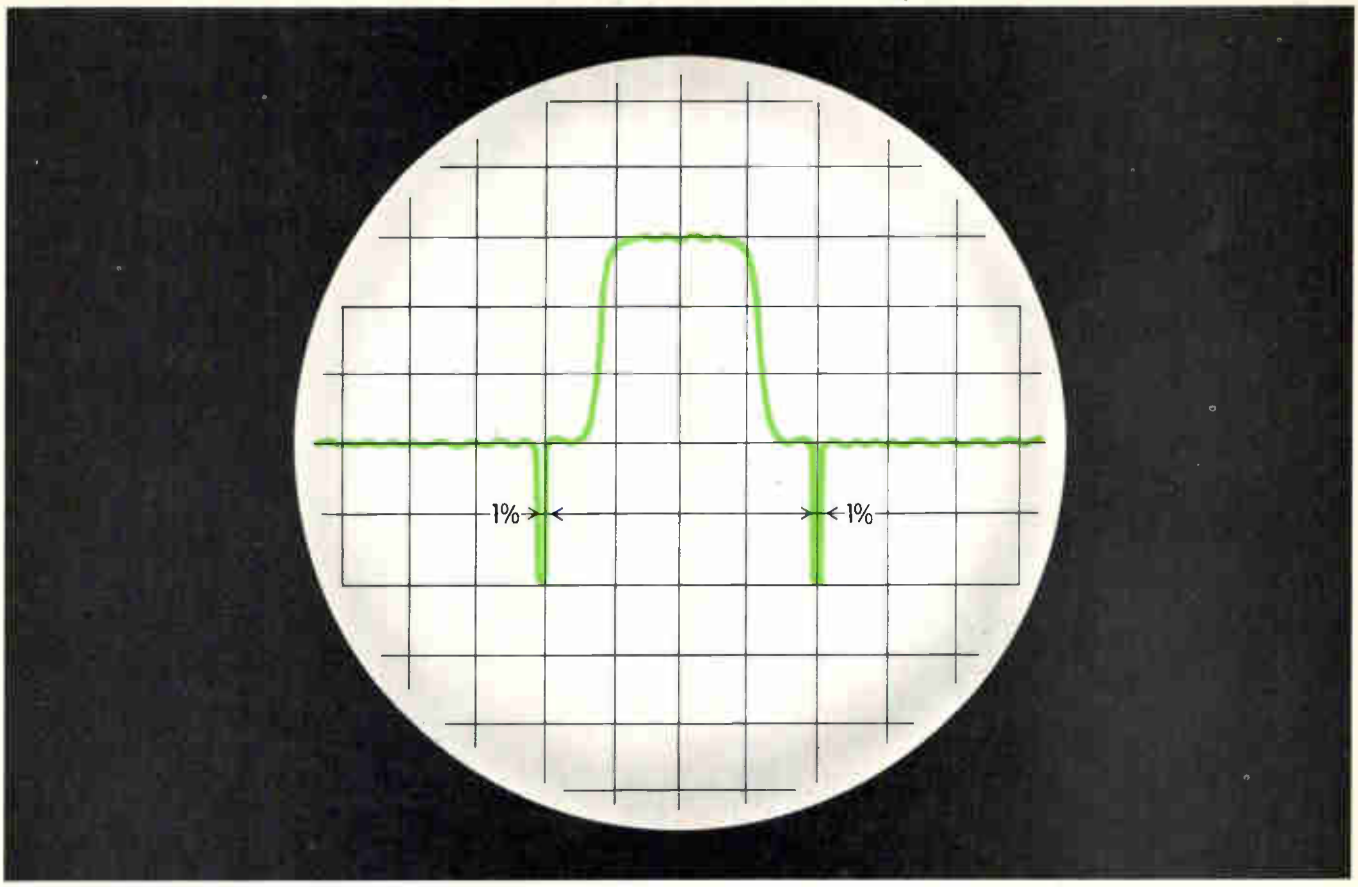
"Freon" solvents may well be able to do similar things for you, too, if you have difficult cleaning problems to solve.

And it can cut your costs, too—because unlike many other solvents, "Freon" needs no inhibitors. So it is easy to clean and reuse.

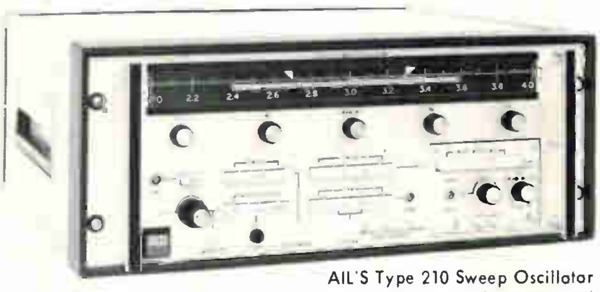
Find out what "Freon" can do for you. Write to Du Pont Co., Room 7238, Wilmington, Delaware, 19898. (In Europe, write to Du Pont de Nemours International, S.A., "Freon" Products Division, 81, Route de l'Aire, CH-1211 Geneva 24, Switzerland.)

*Reg. U.S. Pat. Off. for Du Pont's fluorocarbon solvents.

DU PONT REG U S PAT OFF FREON® Solvents



AIL Type 210 Sweep Oscillator is the only one whose markers are always 1% of swept width.



AIL'S Type 210 Sweep Oscillator provides superior performance and operating simplicity over a broad range of 0.5 to 40 GHz. Main frame price less cabinet: $1525.

On every other sweeper, marker presentation gets wider as bandwidth is narrowed. Result: a loss of resolution when you need it most.

Only our sweep oscillator solves the problem. No matter what range of frequencies you sweep, marker bandwidth is always 1% of the band being swept. Even when bandwidth is extremely narrow.

What's more, our two independently adjustable broadband sweeps, F_1-F_2 and M_1-M_2 are fully interchangeable. On F_1-F_2 sweep, M_1 and M_2 are available as markers. On M_1-M_2 sweep, F_1 and F_2 are the markers. Use this combination to zero-in on an extremely narrow band with unmatched accuracy and resolution.

There's more. An extremely accurate series of 15 ΔF widths gives you calibrated symmetrical sweeps about four separate CW frequencies. With fast, slow, and manual sweep modes.

And we alone provide PIN leveling over the entire range from 500 MHz up to 18 GHz with interchangeable RF plug-ins.

The fact is, these and other features make other sweepers old fashioned. Best way to know is to see the Type 210 in action. Why not call our "hot line" to arrange a demonstration. Dial 516-595-3216 during East Coast business hours.

Or if you prefer, write for our new catalog covering AIL's full line of Microwave Instruments, including specifications on the Type 210 Sweep Oscillator.

AIRBORNE INSTRUMENTS LABORATORY

DIVISION OF CUTLER-HAMMER INC. / DEER PARK, LONG ISLAND, NEW YORK 11729

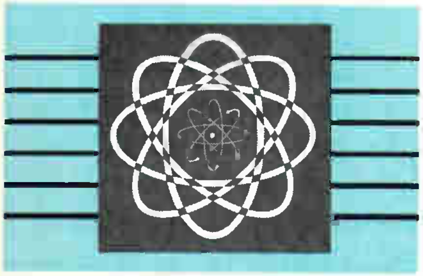
AIL / DIVISION

Circle 69 on reader service card

microtopics

product news from Philco-Ford Microelectronics

Radiation-tolerant IC's now in production



We have developed techniques for producing dielectrically isolated bipolar integrated circuits which can tolerate high levels of transient radiation. Our oxide isolation process has proven reliability. We are now supplying in production quantities.

Prototype quantities of gates, buffers and flip-flops are readily available. Write or call for a consultation on your specific application.

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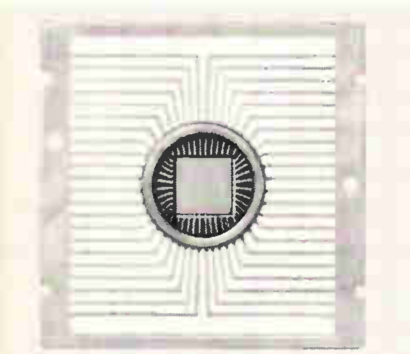
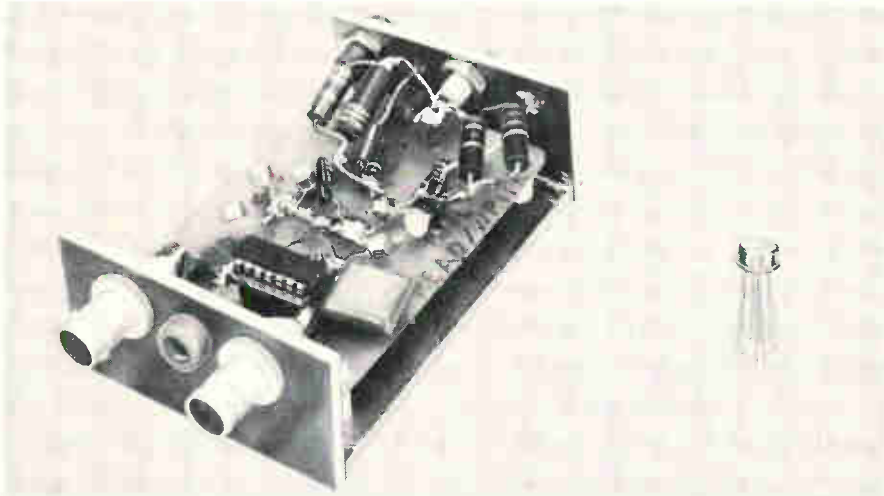
New packages for LSI



Radial flat packs with 34 and 44 leads are now ready for use with LSI circuits. Leads have .050″ spacing. Precision lapped sealing surface to maximize sealing yields. Supplied with brazed sealing ring and isolated metal base. Prototype quantities can be delivered promptly. For data on production quantities, write or call us.

Circle 503 on Reader Service Card



Discrete circuit write amplifier at left was shrunk to hybrid version at right, in TO-5 case.

Microminiaturize your discrete circuits the economical, fast, hybrid way

A write amplifier for magnetic tape, when made of discrete components, used to fill a 2″ x 3″ x 1″ chassis. We converted it to a hybrid microcircuit that fits in a TO-5 case. Four weeks after receiving full circuit data, we had a prototype ready for evaluation. In ten weeks we were producing at a rate of 500 per month.

Performance? The hybrid version is electrically equal, and environmentally superior, to the discrete circuit.

Cost? In volume production, the hybrid circuit cost about the same as the discrete, but its price included REL and qualification . . . the discrete did not.

Hybrid circuits by Philco-Ford are the way to get complex circuits into small packages . . . to provide voltage, current and power output beyond the present abilities of monolithic devices . . . and to do the job quickly, with minimum tooling cost. We've made hundreds of different hybrid circuits. Call a Philco-Ford Hybrid Hunter now, for a consultation on your circuit.

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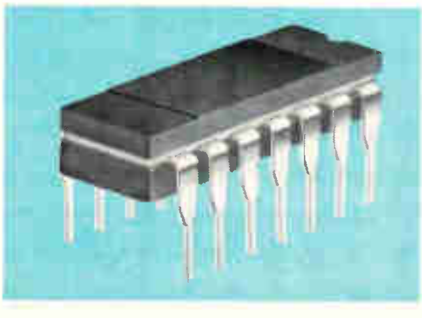
When you go T^2L ...go Cerdip



It pays to buy state-of-the-art logic in state-of-the-art packaging. We make a full line of T^2L gates, expanders and flip-flops, pin interchangeable with SUHL* II. And we supply them in cerdip packages of proved reliability. Both MIL and industrial temperature ratings are available.

For your new logic designs, why settle for less than the convenient, economical handling and assembly of dual inline packaging, with proven hermeticity?

Oh, yes, we also supply T^2L in ceramic flat packs.

*Trademark of Sylvania Electric Products, Inc.

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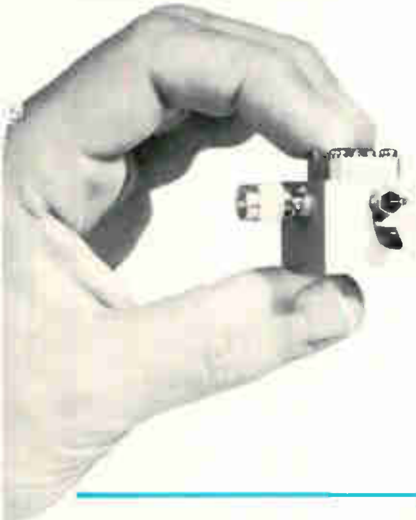
PHILCO-FORD CORPORATION • MICROELECTRONICS DIVISION • BLUE BELL, PA. 19422

New avalanche oscillator X-band source is available from stock



The Philco-Ford P8510 source is now in full production at our Spring City, Pa., plant. And it has more than instant availability to recommend it.

It's highly efficient at low DC input levels. You get 60 milliwatts of X-band power from only 1.5 watts DC. At higher DC input, you can get up to 200 milliwatts out. The secret of its performance is high efficiency Philco avalanche oscillator diodes. Check the specs. Then write to us for data and prices on our complete line of avalanche oscillators from 6 to 16 GHz.

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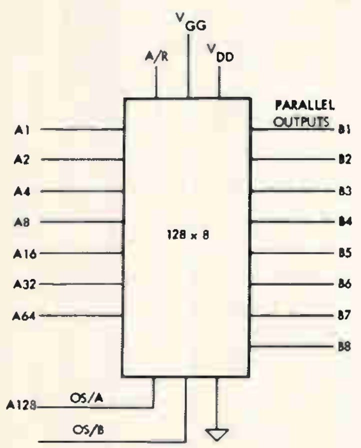
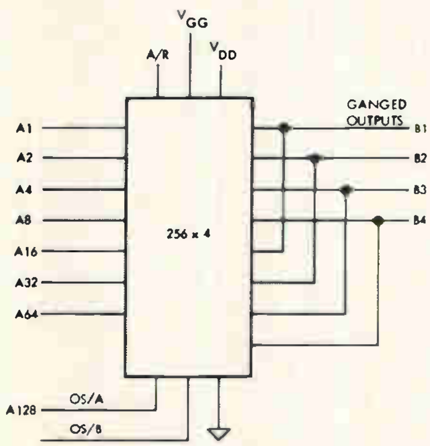
Specifications of the Philco-Ford P8510.
Frequency range (any 5% bandwidth): 6 GHz to 11 GHz
Mechanical tuning: 5% full power to 20% with reduced power
Power output: 60 mw min (CW)
Power input: 80 to 100 VDC, 15 to 25 ma. from constant current source
Efficiency: 3-5%
Weight: 1.5 oz.
Volume: 0.8 cu. in.
Connector: 3 mm miniature coaxial
Operating temperature: −40°C to +85°C
AM noise: typically 110 db per KHz below carrier from 1 KHz to 100 KHz
FM noise: typically 500 Hz rms per 100 Hz from 1 KHz to 100 KHz

MOS 1024-bit read-only memory costs less than 5¢ per bit

Systems designers: get acquainted with the Philco-Ford pM1024 MOS read-only memory . . . then let your imagination run wild. The off-the-shelf pM1024 is programmed with a sine look-up table, and is available for immediate delivery. By use of a custom mask, the pM1024 can be programmed as a look-up table for cosine, tangent, log, exponential or any other commonly used function. Or a synched eight signal waveform generator with a period 128 times basic clock frequency. Stack them up, and you can get character generation, provide microprogramming of subroutines, or solve recurrent equations having variables of known interaction. The fast cycle time of the pM1024 . . . short as 1 microsecond . . . makes many new applications practical.



128 eight-bit word memory



256 four-bit word memory

Pattern organization can be 128 eight-bit words, or 256 four-bit words. Built-in chip select lets you parallel chips to build up memory capacity. Address decoding, memory, and output buffers are all contained on the chip. Output buffers can drive DTL and T^2L directly.

Through the use of computerized software, your custom bit pattern is transferred to the pM1024 with complete accuracy, and with fast turnaround.

Cycle times of 1 and 2 microseconds are available. We supply in full temperature rating, −55 to +125°C; or limited temperature rating, 0 to 70°C.

Circle 507 on Reader Service Card

January 20, 1969 | **Highlights of this issue**

Technical Articles

"The American challenge" to British IC's
page 74

British manufacturers are determined to win a bigger share of the market for integrated circuits in their own backyard. At present, U.S. sources are filling about 75% of the orders. The story of how domestic firms plan to wage the new battle of Britain leads off *Electronics'* special report on the state of the country's IC art. The report continues with three technology articles on how Standard Telecommunication Laboratories integrates its production with computerized layouts of interconnections, a tape-controlled laser to cut masks, and glow-discharge deposition of multilayer insulation. The first technique saves time and money, the second sidesteps problems arising from film distortion and draftsmen's errors, and the third yields good adhesion, fast etching, and limited feed-through resistance. Among topics to be explored in future articles are ion implantation, bulk-effect oscillator modules, and metal oxide semiconductor-bipolar IC's.

A census of i-r detectors
page 91

Among the increasing variety of infrared detectors being offered by manufacturers are doped semiconductor compounds made in single-crystal or multielement configurations. This article discusses what's available and includes a ready-reference table listing 24 detectors with differing performance characteristics operating in the 0.8-to-50 micron region.

Computer memories and semiconductor technology
page 100

The fourth installment of *Electronics'* special report on computer memories zeroes in on semiconductors' position in the technological scheme. The first article in this section catalogs who's making what; the second discusses the two basic kinds of MOS memories that are available, along with their access characteristics; and the third goes into the principal applications of MOS memories, as well as the cost implications of using such arrays.

Coming

Memory adds punch to new calculator

First details on read-only memory that enhances performance of Hewlett-Packard's new desk-top calculator without increasing machine's size. The device, a linear inductive array, stores subroutines.

"The American Challenge" on a chip

U.S. firms hold about 75% of Great Britain's integrated-circuit market, but at least one of the all-British concerns is given to talking about "beating the pants off Texas Instruments"

By Michael Payne
London editor

The salient fact about Britain's integrated-circuit business is that it's dominated by U.S. companies.

There are independent British IC makers, of course, but they must shrewdly nurture their resources, pinpoint their markets, and selectively develop the technology they need. American dominance influences their circuit designs and process techniques, not just their approaches to the market. The responses to the challenge are diverse:

- Marconi-Elliott Microelectronics division of the new General Electric Co.–English Electric Co. combine has set its sights on a large-volume market, fully competitive with American-designed emitter-coupled logic, TTL, DTL, and metal oxide semiconductor devices. The company is dependent on American licenses.
- Ferranti Ltd. and Associated Semiconductor Manufacturers Ltd. have also decided on a volume market (TTL, DTL, and MOS), but with greater dependence on its own technology.
- The Plessey Co.'s semiconductor division, rather than compete directly with the American giants, is developing a capability for medium and small runs of special designs—ECL, RTL, MOS, and bipolar linear circuits.

Something like 75% of the total monolithic IC market (worth about $20 million in 1968) is held by companies that supply circuits made in the U.S. or made in Britain with technology and partly finished material from a U.S. associate. Texas Instruments Ltd. is the biggest, followed by SGS-Fairchild (now simply SGS, but still with the Fairchild technology link), Standard Telephone and Cables Ltd. (an ITT subsidiary), and Transitron. Other companies that distribute in Britain but do not manufacture there include RCA, General Instrument, Sylvania, Signetics, Westinghouse, Motorola, Sprague, and Hughes.

The remaining 25% or so of last year's sales was made by four British manufacturers dependent to a greater or lesser extent on their own technology. Three are completely British-owned: Marconi-Elliott Microelectronics, Ferranti, and Plessey.

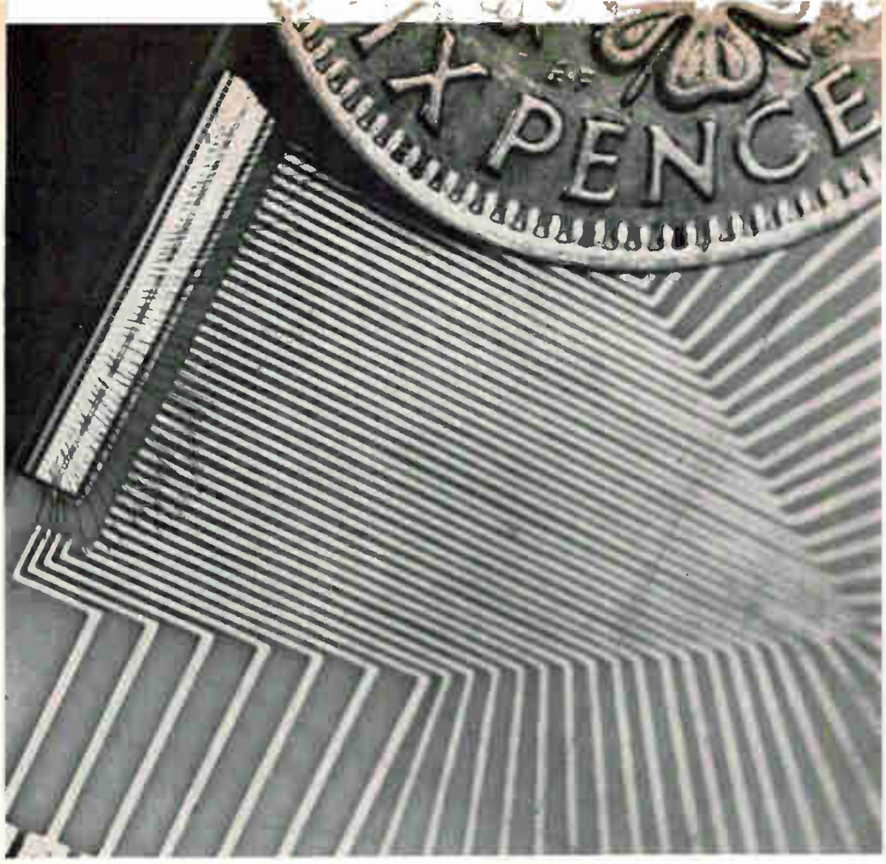
The fourth, Associated Semiconductor Manufacturers Ltd., is owned one-third by the General Electric Co.—unconnected with the U.S. company of the same name—and two-thirds by Mullard Ltd., which in turn is a subsidiary of Philips' Gloeilampenfabrieken NV of the Netherlands. ASM, whose products are sold under the Mullard name, carries out its own research at two labs, and some is done for it, indirectly, by Mullard's British research labs. The Mullard labs, however, are part of the international Philips setup, and work is sometimes taken up by other plants in the Philips group. Similarly, the British ITT labs, Standard Telecommunication Laboratories Ltd., does work for the ITT group as a whole and has no particular formal connection with Standard Telephones, the production side of British ITT operations.

The situation in Britain, of course, is part of the international picture of American technological dominance in electronic technology. In "The American Challenge," for example, Jean-Jacques Servan-Schomber said U.S. firms control 15% of consumer electronics production in Europe, 50% of semiconductor production, 80% of computer output—and 95% of the IC production.

No standouts

In the one-quarter of the market supplied by the four "British" companies, no single company stands out far ahead of its competitors. And the general distribution seems unlikely to change much this year.

All four companies, having opted for some de-



Half a sixpence. MOS photodiode IC being developed by Marconi-Elliott is used to scan ordinary printed characters for recognition at a minimum rate of 2000 per second. Chip is 0.300 inch long by 0.050 inch wide, and contains two linear arrays, each with 48 photodiodes, 48 amplifiers, and 48 output stages. It provides 48 analog outputs representing the light input.

gree of technological independence, have to cope with a far more difficult situation than a U.S. company trying to get established in the microcircuit business. Government money is more difficult to come by, mainly because government spending on military projects is on a much smaller scale than in the U.S. The space effort, never very large, is now negligible. On the other hand, there are fewer firms competing for available money, and the government from time to time assists with loans or grants not tied to specific equipment orders or government R&D projects.

Production orders for most types of microelectronic equipment, for both military and civil use, will always be smaller in Britain than America, so that economies of scale in manufacture will be harder to achieve. Because of the U.S. lead in microcircuit technology, variously estimated at from one to three years, and the sounder economic foundation of the U.S. manufacturing activity, British makers operate at a distinct competitive disadvantage. The U.S. maker, whether he exports directly to Britain or manufactures in a British factory, can usually offer the system builder a more advanced product or an equivalent product with a more extensive reliability record, and can cut prices with fewer qualms. The British maker, however, can count on a small part of the market committed to buying British.

Taking on the Yanks

The British manufacturers attempt to deal with this situation in different ways. Marconi-Elliott intends ultimately to compete with the American high-volume producers of a wide range of standard devices. To save the time and money an independent approach would entail, it depends heavily on Fairchild and RCA manufacturing licenses. At the other extreme, Plessey believes it will compete most effectively with a high proportion of its output devoted to custom design. This means a greater dependence on basic know-how, so Plessey has had to develop its own technology with minimal dependence on licenses, and this, in turn, dictates a limited basic range of devices if effort and expense are to stay within reasonable bounds. The other companies have some position between these extremes.

Marconi-Elliott Microelectronics is the amalgamation of the microelectronics activities of Marconi Co. and Elliott Automation Ltd., resulting from the takeover of Elliott by Marconi's parent, English Electric, in 1967. More than any other British company, M-E has publicly committed itself to high-volume output, with a new 95,000-square-foot factory close to the main Marconi plant in southern England and expansion plans for the original Elliott plant in Scotland. M-E executives are given to talking about "beating the pants off Texas Instruments" and "becoming Britain's leading microelectronics company," and it is clear that the company will either be reasonably successful or lose a lot of money trying.

Results to date derive mostly from Elliott's contributions to the combine: a full-scale production line for 930 series DTL and a pilot production line of 9000 series TTL and 700 series linear devices. (All these IC's derive from a Fairchild license taken out in 1965.)

Elliott has also contributed R&D on orthodox

MOS devices and some work on beam leads based on the original Bell Telephone work. The company made experimental beam-lead bipolar circuits before joining with Marconi, but since the merger the beam-lead effort has been concentrated on use with MOS devices, because M-E believes its biggest future lies with them. M-E researchers hope to make the bond between the lead and the MOS circuit moistureproof by developing the right sort of ion passivation barrier. This would make hermetic sealing unnecessary. Circuits could even remain unencapsulated. Various passivation materials—the only one specifically mentioned is alumina—are being evaluated, but bond testing is a long job and there will be no quick results.

Marconi's pre-merger activity was centered around making circuits for in-house use in Marconi systems, including its own DTL circuit for use in the Myriad process control computer and a range of thin-film devices around which its Mark VII color tv camera was designed. Like Elliott, Marconi was also doing basic work on MOS technology. The company was building a big new plant, but was somewhat vague about how all the space was going to be used.

Since the merger, M-E has started production in its new factory of RCA ECL devices, which will most likely find a market, at least at first, in the bigger System 4 computers designed originally by English Electric's computer division (now part of International Computers Ltd.). The M-E combine has integrated its MOS R&D, and full device production will start this year with a standard range of counters, shift registers, and multiplexers, plus some custom devices for switching automobile instrument control circuitry and others to replace reed relays in telephone exchange switching arrays. Currently, the most complex devices have about 400 transistors per chip. Devices with up to 1,000 transistors per chip are under development. Apart from the beam-lead work, the technology is said to be entirely orthodox.

M-E executives point to two factors they feel will help them get established as high-volume suppliers. First, from time to time the U.S. suppliers companies have fallen down badly on delivery of diffused slices and part-finished devices to their British associates. Since M-E will carry out all processes itself, it feels that it can guarantee delivery. Second, control of all processes will enable it to guarantee quality.

A Texas accent

Ferranti Ltd. is a privately held electrical and electronics company with about two-thirds of its $120 million turnover in process control computers, other control systems, and miscellaneous electronic activities. Like M-E, its microcircuit activity is aimed at the volume market, but Ferranti is depending more on its own basic technology. Production is divided fairly equally between its own design of high speed DTL, known as Micronor 2, and a TTL series built to the same specification as TI's 74 and called Micronor 5. The use of the TI specification indicates the influence the U.S.-associated IC suppliers have on equipment—and consequently IC—design. In the case of this TTL circuit, the role of International Computers was important. International selected TI's series 74 for its small and medium 1900A computers, and set about ordering several hundred thousand circuits. Any company hoping to share in this important order had to produce an equivalent.

Micronor 2 DTL was introduced in late 1965 as an outgrowth of a two-chip DTL device dating back to 1960. The main outlet has always been Ferranti Argus computers. Its claim to fame is a propagation delay of only 9 nanoseconds in the fastest versions and 15 nsec in what Ferranti calls industrial versions. Its high speed is the result of gold doping. The device isn't easy to make, because control of the gold doping is critical for performance and for minimizing the adverse effect of the gold on other chip components (selective doping techniques weren't available when the circuit was designed). The Ferranti DTL is pin-compatible with 930 DTL but more expensive.

Ferranti's design of the type 74 TTL circuits is said to be entirely orthodox, apart from a base-diffusion resistivity of 250 ohms per square; this value is the same as that for Micronor 2 and was chosen to simplify production procedures. Ferranti's range of TTL devices covers about three-quarters of the functions available in TI's own range.

An unusual process

Like everyone else, Ferranti is feeling its way forward in MOS, and has gotten as far as delivering quantities of a custom-built 8-bit d-c static shift register with 61 MOS transistors on the chip. It will operate up to 1 megahertz and has parallel output from each of the 8 bits so that their state can be checked at any time. Each output can drive a load of 15 picofarads, except the eighth, which will drive 45 pf. This is said to be unusually high driving capability. In development are dual 25-bit and dual 50-bit serial-in and serial-out large shift registers that will operate up to 2 Mhz, a quad adder, and a multiplex switch. This has a common terminal and four switches, each with an on-resistance of 400 ohms.

Like Motorola, Ferranti is unusual in using silicon nitride instead of phosphorus-doped silicon oxide as the gate insulator; the nitride forms a more stable barrier. An intermediate layer of oxide a few hundred angstroms thick is inserted between the silicon and the 1,000-Å nitride layer to maintain good MOS characteristics in the device. This process is used on all MOS and is described as a great success.

Plessey's decision to take a different line from all other manufacturers, British or American, and not compete for the high-volume DTL and TTL market has probably brought it, to date, the smallest market share of the British manufacturers. On est market share of the British manufacturers. On the other hand, if the sustained superiority of U.S. competition keeps the DTL and TTL operations of the other three companies from ever becoming economic, Plessey will have to write off that much less investment. Plessey is betting that logic requirements will eventually polarize around ECL, where speed is more important than cost, and MOS, where cost is more important than speed.

Plessey sees the Americans remaining dominant in high-volume standard devices, of whatever format, for a long time to come, so it's developing a relatively large capability in custom design and small runs. At the moment this approach is tougher going than building standard American circuits under license. The Plessey attitude is to bet everything on an assessment of how a British company can best fit in among suppliers of microcircuits to world markets in the long term, not just to British markets in the next few years.

Plessey's method is to use only two production lines to build everything. RTL, ECL and linear circuits are on one line, and all MOS devices on the other. Deposition, diffusion, photolithography, and evaluation procedures remain constant for all devices on each line, and the only variables are the mask patterns used in the photolithographic stage.

The principle behind this method is stated by Derek Roberts, manager of the Semiconductor division: "It is much cheaper to invent a new circuit solution to a problem than to develop, control, characterize, and establish the reliability of new processes."

Looking to the consumer

Plessey says process standardization to this extent works because Plessey IC designers make extensive use of computers to determine the best circuit layout and have access to a large data bank on performance of the processed raw material in all conditions. As might be expected, the greatest stress is being placed on removing communication barriers between the silicon technology specialists and the circuit and device design specialists.

As proof that the approach is fundamentally sound, Plessey points out that it's selling 350-Mhz-bandwidth amplifiers made by its standard process for bipolars. Plessey believes a different process will be required only for linear circuits with bandwidths above 400 Mhz, digital circuits above 200 Mhz, and output voltages greater than 30 volts. The standard MOS process has proved fast enough, says Plessey, for a 24-bit dynamic shift register with a typical speed of 3 to 5 Mhz and a worst-case speed of 2 Mhz; has coped with the complexity of quad 16-bit and single 80-bit d-c shift registers, and is good enough to produce the inch-wide MOS channel needed for an array of six 50-ohm switches.

At present, about a third of Plessey's IC effort is directed to circuits intended eventually for the consumer market; this is probably a higher proportion than that of any other company. Devices developed or under development include:

- A receiver with 1-watt output and all the active circuitry on a single chip that contains about 50 components.
- All intermediate-frequency circuitry except block filters for a tv receiver on a single chip containing about 70 components.
- An audio amplifier for a record player with a 5-watt root-mean-square output.

In the military field, Plessey has a series of chips carrying the radio-frequency, i-f, and audio amplifiers, single-sideband automatic gain control, and demodulator and vogad elements, to which can be added orthodox filters and an r-f power output stage to make up a complete transmitter. There are also some complex digital devices intended for a frequency synthesizer, with about 300 components on the chip.

Like everybody else, Plessey aims MOS activity at the industrial field, and the firm has made photodiode arrays for character recognition, shift registers and memories for computer peripherals, and control logic for experimental electronic telephone exchanges. Research activity includes development of optoelectronic devices—one objective being a solid state vidicon camera—electroluminescent lamp arrays based on gallium phosphide, and semiconductor memory devices, including cheap MOS arrays, silicon-on-sapphire diode arrays for read-only purposes, and ECL high-speed memories.

Imported wafers

Associated Semiconductor Manufacturers diffuses most of the silicon slices it uses, but it also processes imported diffused slices. A little over half of present production by value is TTL to the series 74 specification, sold for computers, telecommunications and instrumentation applications. About one quarter is DTL, mainly similar to the Westinghouse WC 200 design but some custom designed. The balance of IC output is made up of linear circuits, a few MOS devices and preproduction of an

British IC manufacturers

Company	Affiliation
Texas Instrument Ltd.	U.S.
SGS	Italy
Motorola	U.S.
Marconi-Elliott Microelectronics	U.K. (General Electric and English Electric Cos.)
Ferranti Ltd.	U.K.
Plessey Co.	U.K.
Associated Semiconductor Manufacturers Ltd.	U.K. (General Electric Co.); Netherlands (through Mullard Ltd., subsidiary of Philips)
Standard Telecommunication Laboratories Ltd.; Standard Telephones & Cables Ltd.	U.S. (ITT)

emitter-emitter coupled logic circuit (sometimes called emitter squared logic) said to have a typical loaded propagation delay of 2.5 nsec. This circuit is of ASM design and development and is said to combine high speed with low power dissipation.

The linear circuits in production include an a-m radio receiver (without an output stage), currently incorporated in one British domestic portable. The chip contains mixer, oscillator, i-f amplifier, detector, audio preamplifier, and audio driver. The audio output stage is excluded so that the set maker can select the output power level according to his judgment of the market. ASM is essentially a component maker and where possible designs devices to take in the widest market.

Much of ASM's R&D is on MOS techniques. Unichannel MOS IC's in development all use p-channel enhancement mode. A number of devices incorporating static and dynamic shift registers will soon get to the customer evaluation stage. One development project is a 64-bit read-write store in a 16-pin dual in-line pack, with a cycle time of well under a microsecond. The most complex device in development has about 800 transistors on the chip.

Work is also going on in MOS complementary pair logic, but this is still at the research stage. The problems are to obtain yields comparable to unichannel yields and to get the same number of functions in the same amount of space.

All-scale integration

Standard Telephones and Cables is being built up as ITT's leading European producer of monolithic IC's. The bulk of production is currently 930 DTL using slices diffused at ITT's West Palm Beach, Fla., plant. The 9000 TTL is in smaller-scale production, using 2-inch slices diffused in England. Standard Telecommunication Labs, in a long-term R&D program in microelectronics production technology, assumes that different scales of integration will be used for many years to come and seeks to develop production methods common to as many scales as possible.

Computer-aided design methods are being developed that will suit LSI, MSI, and small-scale integration. Some features of multilayer interconnection techniques intended primarily for LSI are being adapted for smaller scale MOS devices.

Other work on integrated electronics at STL is outside the conventional microcircuit field. A long-term research program on solid state bulk effects is seeking to produce—among other things—solid state equivalents of microwave tubes, using extended interaction gain, as in a traveling-wave tube, to obtain high dynamic range and low noise. A parallel program is aimed at producing microwave IC modules incorporating bulk-effect active devices. Present experimental modules use ceramic substrates, but semi-insulating gallium arsenide is being developed as an alternative for frequencies above 30 Ghz.

STL researchers believe that interaction effects between electron, phonons, and photons, particularly electron-phonon interactions, offer ways of cutting integrated system costs. Some passive electro-acoustic devices, such as filters and delay lines, are at an advanced stage of development. Some thought is also being given to the role that solid state lasers, lamps, and detectors might play in integrated systems.

STL meshes its IC production steps, using computerized layout of interconnection patterns, a tape-controlled laser machine to cut the photolithographic masks for metalization and diffusion, and a glow-discharge technique to deposit insulation between the metalization layers. All these steps are described in the three articles that follow. ■ ■

British IC's II

Metalization is designed quickly and inexpensively

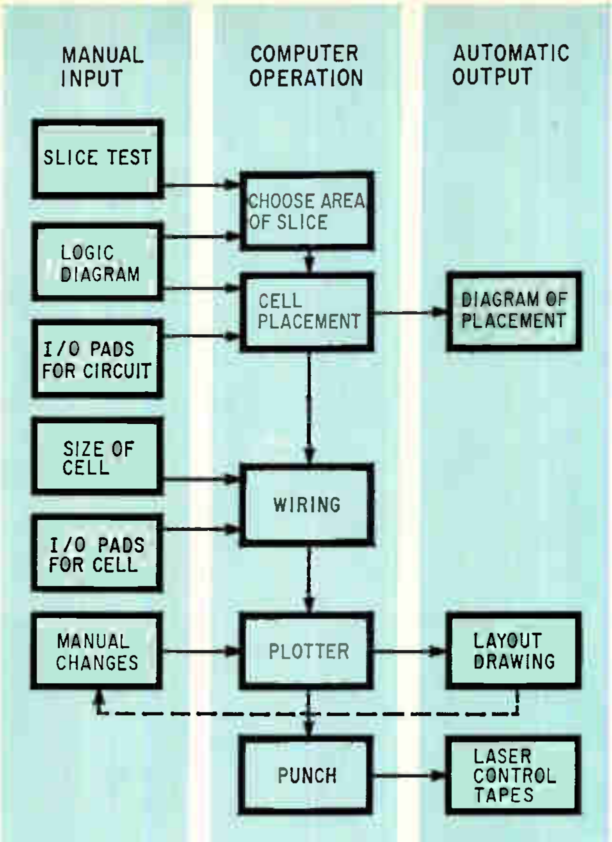
By P.E. Radley, STL

Minimizing lead time and cost has always been a big problem in designing integrated-circuit interconnection patterns. And the problem grows worse as the connections grow more complex. However, at Standard Telecommunication Laboratories Ltd., a British subsidiary of ITT, a suite of computer programs has designed interconnections in a fifth the time and at half the cost of manual methods. In fact, the programs are the only way to lay out the more complex circuits, which simply can't be designed manually.

A 39-gate discretionary layout, for example, was completed by an IBM 360/30 (64,000-byte memory) in about 1½ hours. The computer produces tapes to control a laser mask-making machine. A layout for 75 gates takes about 3 hours. Preparation of the manual data takes typically 3 hours for the 39-gate example. Depending on the availability of the computer, total time for the conversion of the logic diagram to the laser control tapes is two or three days.

The interconnection patterns are in two layers, with most of the wiring in corridors between the gates and flip-flops ("cells") that make up the circuit; only occasionally does wiring pass over these cells (although cells that aren't used in the circuit are used as wiring "real estate"). The final manufacturing information is in the form of four masks for photolithographic processing, defining two dielectric and two metal layers.

The suite of programs goes into action after the



Interaction. Manual inputs and computer operations produce the design and the means of implementation.

silicon wafer containing the cells has been tested electrically. The test results are furnished either as a photograph of the slice, showing bad cells marked with an ink dot, or as a punched paper tape containing data on each cell. The information on the photo must be transferred to punched cards or some other medium the computer can accept.

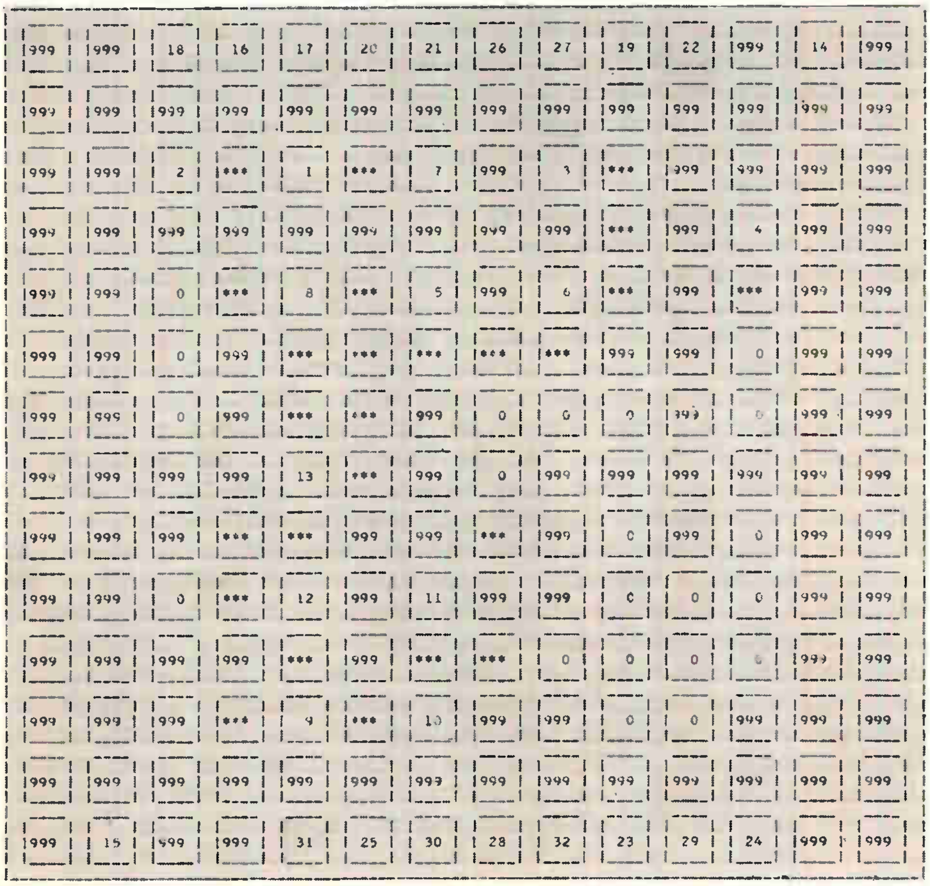
The test results are used to choose the part of the slice that will be used for the over-all circuit. If the interconnection pattern is predetermined, this area can be specified as a fixed arrangement of good cells. If the pattern will be designed specially—discretionary wiring, in other words—an area of a given size encompassing a minimum number of good cells can be specified.

The computer then uses the test results and the specification of the area to be looked for to print out a diagram of the suitable parts of the slice.

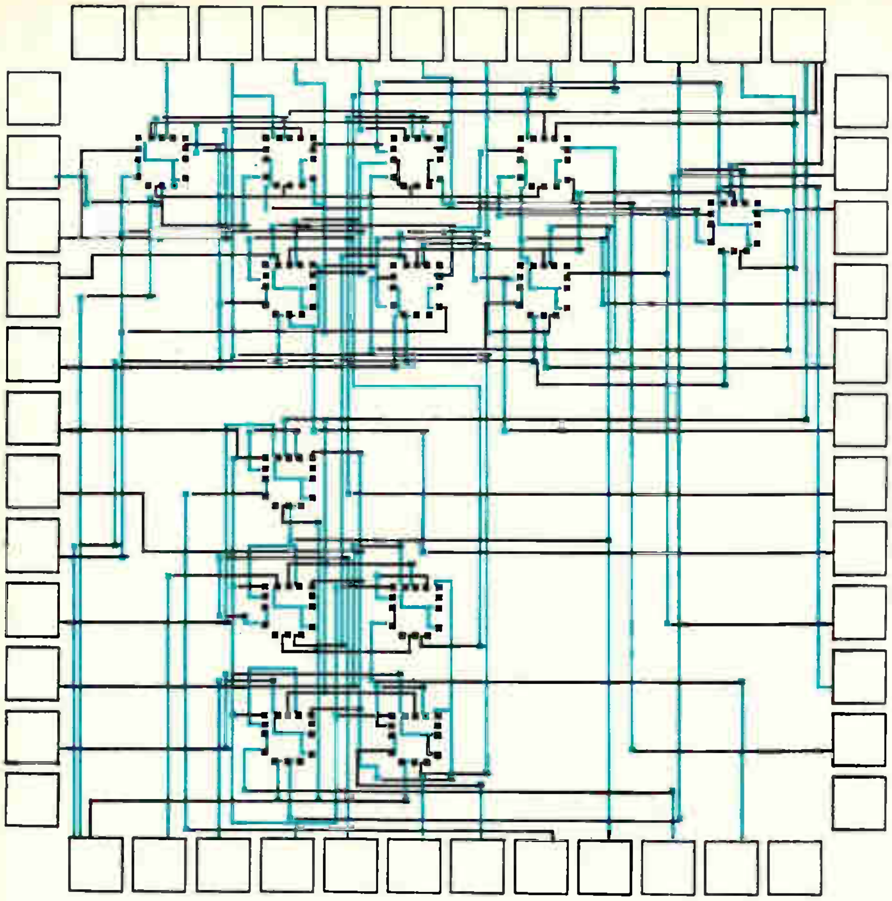
Subsequent computer processing of the design is in three phases:

- Placement—assignment of positions on the slice to the parts of the circuit, based on minimum wiring length.
- Wiring—allocation of a route to each interconnection.
- Output—generation of a layout diagram and four punched paper tapes to control the automatic laser mask-cutting machine.

The placement program requires three sets of input data: a description of the good and bad cells within the chosen area, a specification of the posi-



Placement. The line-printer output of the placement program shows the chosen working cells in dark color and the fixed input-output positions in light color. The positions marked 999 are nonfunctioning cells available for wiring space. The positions marked with stars or a 0 are unused working cells; the starred ones are reserved for wiring space.



Two layers. The computer generates an x-y plot of the interconnection pattern, using a different color for each layer. The small color squares indicate a feedthrough hole connecting the layers.

tions of external connections and any cells whose location the engineer wishes to fix, and a description of where each cell's inputs start and outputs end. This third set, showing the functional relationships of the cells making up the over-all circuit, is coded from the logic diagram. Each gate or flip-flop, its input and output pins, and the wiring connections are numbered. These numbers are combined into a list, each entry consisting of the connection number and all the points that it connects, specified by the cell and pin numbers.

The placement program processes this list to furnish on the line printer a stylized diagram of the area of the slice, page 79, bottom, giving the location selected for each function. The program also punches out a deck of cards describing the wire space available for that placement of functions and a wiring list for the wiring program, expressed as the coordinates of points to be connected.

Routing routine

In addition to the information supplied as the output of the placement phase, the wiring phase must be told the size, in thousandths of an inch, of the cells to be used and the allowable number of wiring tracks across the cell in both the x and y directions. The positions of the input and output pads—the external connections—around the periphery of the circuit must also be described. Each of these is specified by its x and y coordinates with respect to an origin at the bottom-left corner of the circuit.

The output from the wiring phase is a line-printer list indicating the route allocated to each interconnection and a deck of cards describing these routes in detail.

Finishing touches

At the very start of the output phase, the computer displays the route allocation as a two-color diagram on an x-y plotter, as shown at top, each color representing a metalization layer. The designer inspects this diagram and decides whether any changes are needed to prevent, for example, electrical interference between interconnections. At this time, any interconnections needed to join points in the same cell are added manually over the top of the cell.

The line changes are coded on the diagram as additions, deletions, and groups of additions and as the positions where these groups are to be repeated. The "group" and "repeat" functions are used together to specifiy a set of interconnections to form a special function from the several gates, for instance, within one cell and to repeat this pattern at different cells on the slice.

The program is run again to bring the layout up to date and produce another diagram. When the layout finally satisfies the designer, the data is used to produce the punched tapes for the automatic laser mask maker.

The layout shown as on the opposite page is for the 39-gate circuit, using discretionary wiring on a low-yield slice. The suite of programs can be used with equal ease for a fixed, regular array of cells (100% yield of a given area of slice).

In almost every layout the company has done so far, the programs have completely designed the wiring. In only one case has the suite failed to find a route between two points. This was due to an error in the original data, and the connection was easily added manually. ■ ■

British IC's III

Laser cuts masks to size, eliminating most errors

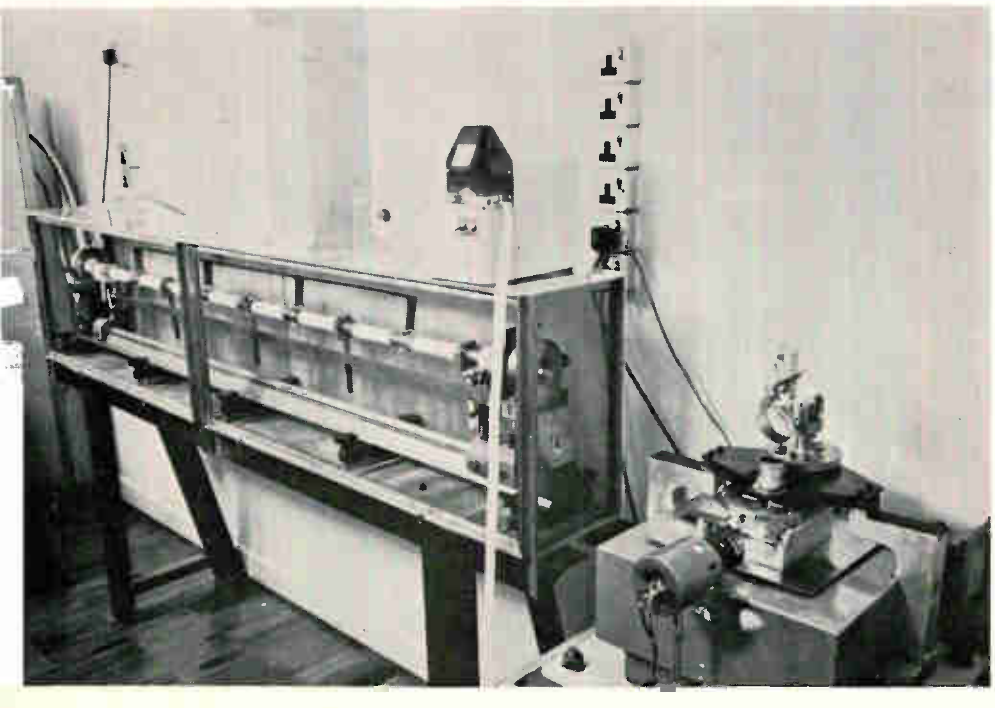
By T.M. Jackson and T.J. Rowe, STL

Combining a laser and a computer has solved one of the trickiest problems in integrated-circuit fabrication: making the masks quickly and accurately. Standard Telecommunication Laboratories' computer-controlled laser mask-making machine generates the intricate photolithographic masks needed for the various diffusion processes and for deposition of the aluminum paths that interconnect groups of cells.

The diffusion masks as made by the laser are the correct size for insertion in the step-and-repeat camera that projects an array of identical mask images on the silicon slice as it scans. The laser masks, therefore, aren't subject to the dimensional errors and distortion introduced by shrinkage in the photographic wet processing required to reduce conventional masks to the correct size.

The conventional method of time-consuming sketching, drafting, and cutting-and-peeling is prone to other errors as well. Identical components can be drawn slightly differently on the composite mask drawing; coordinates can be incorrectly transferred from the drawing to the cut-and-peel material; essential cuts can be omitted, and areas correctly cut may not be peeled. STL's automatic laser mask-making procedure eliminates all these sources of error. Although it's still possible to assign coordinates incorrectly to the features of the mask, errors from this source are substantially reduced with the new method.

The laser is used with a tape-controlled micropositioning coordinate table. The high power density of the focused laser beam etches the mask pattern into an infrared-absorbing surface film on a glass substrate. Lines as narrow as 5 microns can be machined at speeds up to 1 centimeter per second. STL's experience (which so far has been limited to making masks for low-complexity IC's) shows a tenfold reduction in the time required to go from logic diagram to finished masks. The average machining time per mask is about 30 minutes. (Typically, six masks are needed for a circuit: subepitaxial, isolation, base, and emitter diffusion; contact evaporation, and interconnections.) The more complex IC's usually have repetitive blocks



Computerized laser. The automatic mask-making machine can etch lines as narrow as 5 microns.

of patterns; in this case the layout will be partitioned so that the blocks can be laid out as individual units on the substrate.

Machine power

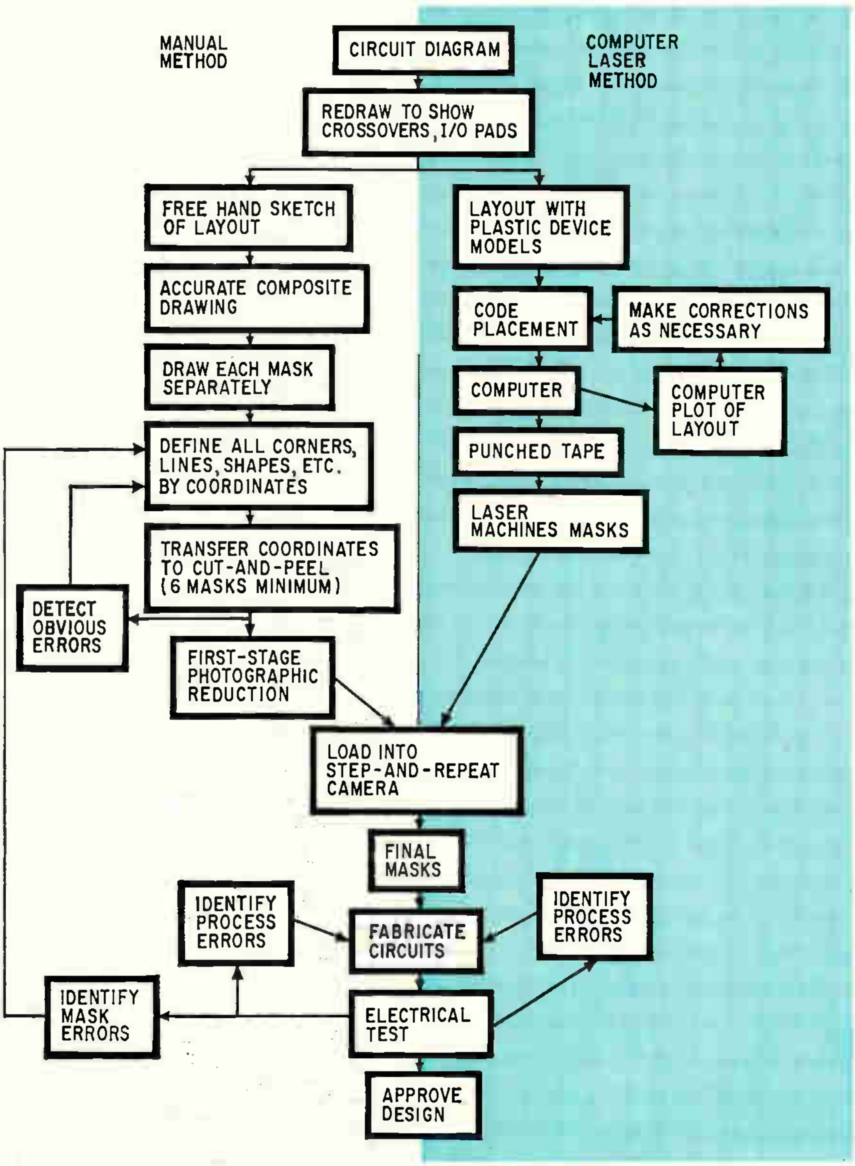
The laser is a pulsed helium-neon gas type with external excitation. It puts out 250 watts of peak power at a pulse repetition frequency of 2 kilohertz, with a wavelength of 1.15 microns. The 1-inch-diameter beam can be focused to a spot variable between 5 and 50 microns in diameter. At the smallest diameter, the incident power density is more than 10^8 watts per square centimeter.

The i-r-absorbing film on the glass substrate is a polymer that is decomposed to carbon by the laser beam, then oxidized in the air to carbon dioxide. The machined area thus becomes transparent. The radiation that emerges on the far side of the substrate quickly becomes defocused and is allowed to disperse naturally.

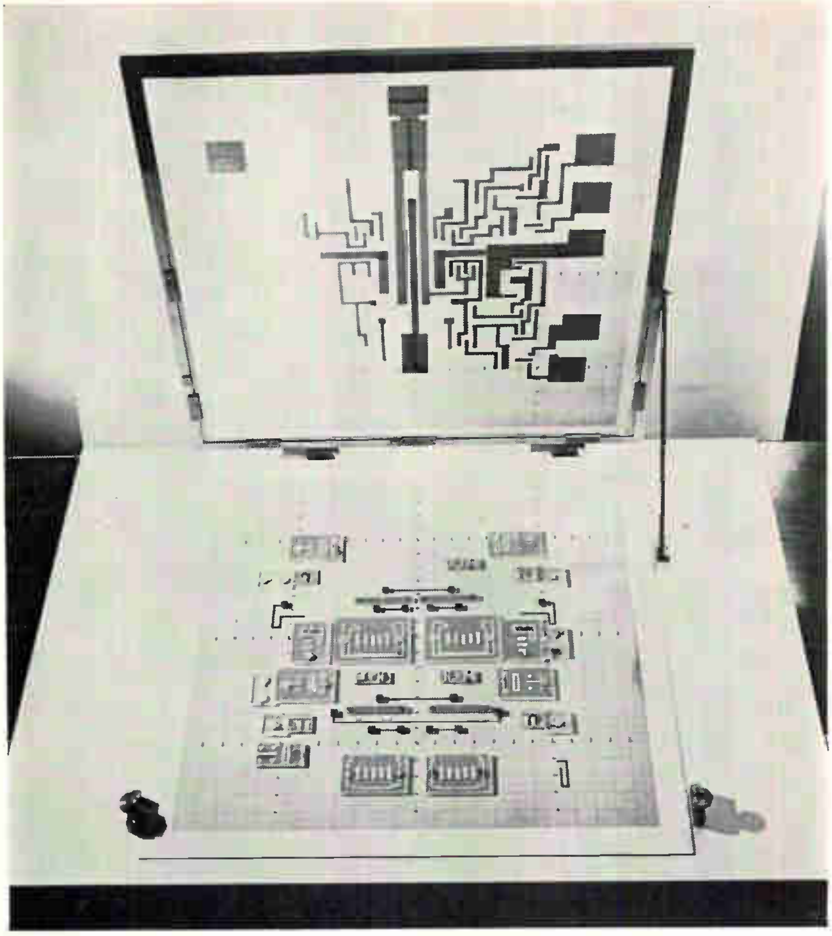
The machining process is independent of the incident power above a certain minimum; in other words, the surface film absorbs the power necessary to decompose it, and excess power is transmitted through the transparent substrate.

The line patterns are actually a series of overlapping dots. The pulse repetition frequency is high enough to ensure clean, straight line edges at the fastest travel of the coordinate table as it moves the substrate under the laser beam.

A tape input provides position information for the coordinate table and switching control for the laser. STL's present coordinate table incorporates an open-loop control system with stepping motors and lead screws. The minimum increment of movement is 12.5 microns, and the positional accuracy is ±5 microns on any programed multiple of the minimum increment. The table can move 2 inches in each of two mutually perpendicular directions. (A new coordinate table is now near completion; this one uses a closed-loop control system and measures its displacement by means of optical grat-



Old and new. The new computerized method eliminates the tedium and inaccuracy of conventional mask making.



Layout table. Before the laser cuts the mask, the layout is designed with models on a coordinate grid. The hinged panel at top permits design of the interconnections.

ings. It will have a minimum increment of 2.5 microns and positional accuracy of ±1 micron. With this table, a mask for a complex monolithic IC can be machined in less than an hour.)

Plastic models

Before the machine can be instructed to cut the diffusion masks, a layout of the IC must be designed. Plastic models of the circuit elements are used for this purpose, scaled to 400X and showing the positions of the contacts but no other details. Each model is coded (for example, transistor T_8) to identify its type and each has a border corresponding to half the width of an isolation channel. For each model, a computer subroutine is prepared; this contains details for the complete set of masks required for the device—up to and including the contact evaporation mask. This need be done only once for each model; after that, when a device is allocated to a particular area of the circuit, it's referred to by its code.

The models are placed on a coordinate grid on a layout table. A second coordinate grid is hinged to the table; this one, etched in a glass sheet, can be set down directly on the models and is used for laying out the interconnection pattern. Even with their large scale, it's important that the coordinate grids register vertically within a small fraction of the minimum grid interval of 0.05 inch.

The models and the overlying interconnection paths (marked with a wax pencil or colored tape) are arranged and rearranged until the layout is satisfactory.

The next step is to code for the computer the locations of all the models and the routing of the interconnections. The model identifications (D_1, T_4, etc.) and the x and y coordinates of its lower-left corner are entered manually on a special form; the data is then punched on cards and fed to the computer. A similar procedure is followed for coding the interconnection pattern, using the coordinates of terminations and changes in direction of the interconnection paths. (This manual coding procedure could easily be automated by a digitizer.) Six tapes are produced: five for the diffusion masks and one for the interconnection mask. Before the computer punches out the control tapes, it plots each mask for checking.

LSI interconnections

The masks for the interconnection patterns for LSI circuits are produced by the laser machine from tapes generated by computer-aided design techniques. Four tapes are required for a complete set of interconnection masks for an LSI circuit, defining:

▪ The openings through the first insulation layer, permitting contact between the individual components or cells to the first metalization layer.

- The pattern of the first metalization layer.
- The openings in the second insulation layer for contact between the metalization layers.
- The pattern of the second metalization layer.

As with the diffusion masks, the computer plots scale drawings for checking, then punches tapes for controlling the laser machine. All these masks are machined to actual size; photoreductions aren't needed. ■ ■

British IC's—IV

Glow-discharge unit makes multilayer deposition easy

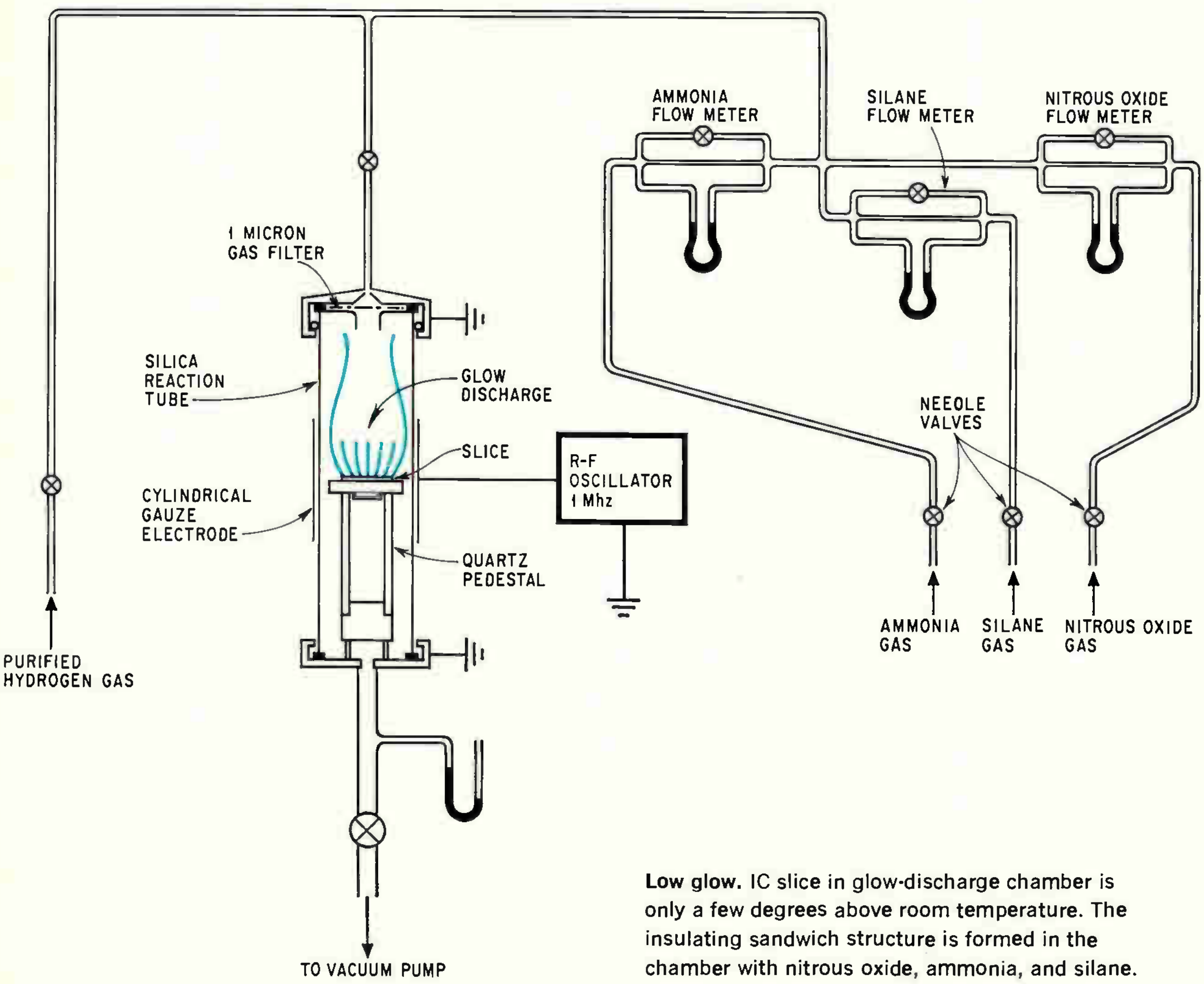
By A.W. Horsley, **STL**

Large-scale integration requires multilayer interconnections; a single metal interconnection layer would have routes too long, devious, and complex. Multilayers are hard to make, however; such problems as poor adhesion of insulating layers and excessive resistance in feedthrough holes are not easy to solve.

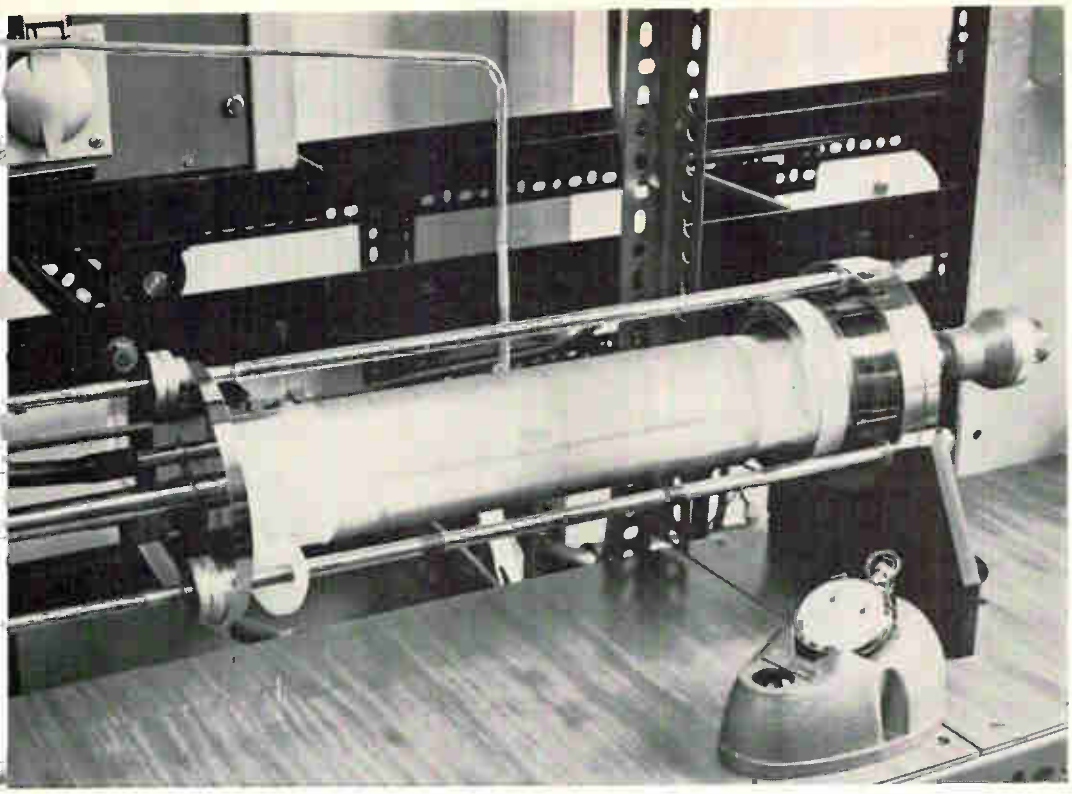
At Standard Telecommunication Laboratories Ltd., glow-discharge techniques have been developed for depositing the dielectric layer between the metal interconnection patterns. The prime advantage of this technique is that it doesn't require high temperatures; deposition takes place at only a few degrees higher than room temperature. The characteristics of the integrated circuit, therefore, aren't altered. The technique also reduces the adhesion and feedthrough-resistance problems to negligible proportions.

The STL system uses aluminum for the metal interconnections and a silicon dioxide and silicon nitride sandwich for the dielectric layer.

It's one thing to build a multilayer system that works when it is first made but quite another to ensure long-term reliability. The STL approach



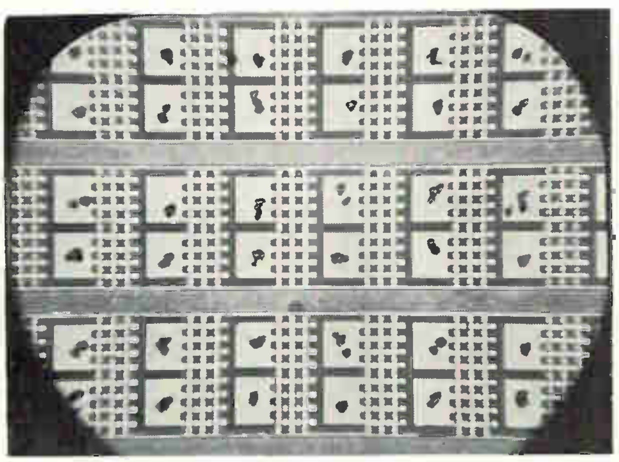
Low glow. IC slice in glow-discharge chamber is only a few degrees above room temperature. The insulating sandwich structure is formed in the chamber with nitrous oxide, ammonia, and silane.



Vertical and horizontal. The initial work was done in a vertical glow-discharge chamber, but a new horizontal machine can process several slices simultaneously.

evidently can withstand the test of time, because tests on the dielectric film have produced these results:

- The adhesion and mechanical stability are sufficient to resist the stress of ultrasonic bonding, which STL uses routinely in circuit fabrication.
- Immersion in liquid nitrogen causes no cracking, peeling, or electrical deterioration.
- Baking at 200°C with a 12-volt bias for 3,000 hours produces no detectable deterioration of electrical characteristics.
- Thermal cycling 200 times between −60° and +100°C has no discernible effect.
- Infrared absorption tests indicate a degree of chemical stability that's surprising in view of the relatively low deposition temperatures.



Test pattern. Reliability of crossovers is measured with specially built test circuits that contain only crossovers. Each lattice-like pattern contains 24 crossovers, and there are more than 400 such patterns on a test circuit.

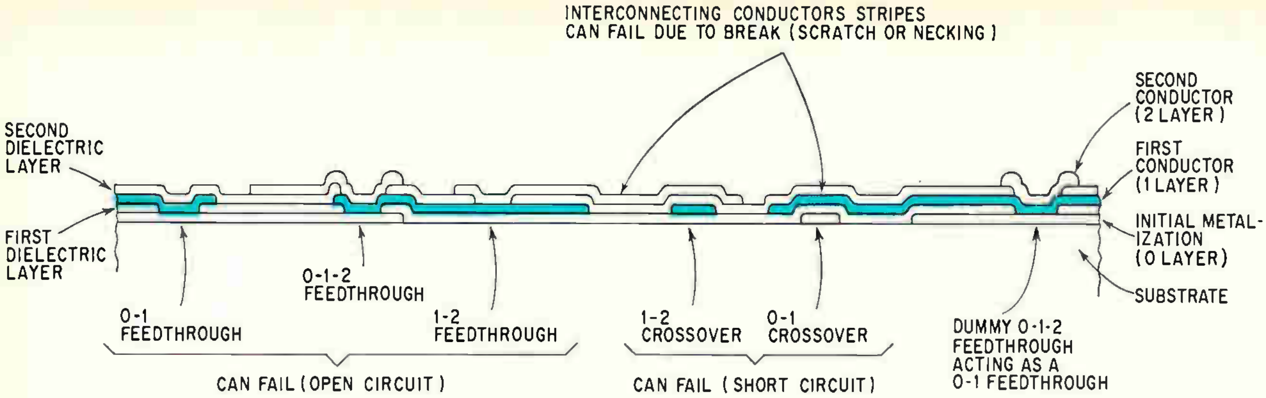
The sandwich itself

Silicon dioxide, the conventional insulating material used to isolate a single-layer interconnection pattern from the silicon below it, is etched rather slowly even by as active a substance as hydrofluoric acid. This is not only a drawback in production but also leads to excessive etching and passivation on those parts of the aluminum interconnection patterns exposed by the feedthrough holes. Such films add unwanted resistance to the interconnections and can even open-circuit them.

Silicon nitride, on the other hand, can be etched rapidly and is compatible with glow-discharge deposition. But it doesn't adhere well enough to aluminum to withstand STL's ultrasonic bonding.

STL combines the advantages of SiO_2 and Si_3N_4 and eliminates most of their disadvantages by using an oxide-nitride-oxide sandwich as the dielectric layer. The total thickness is about 1 micron, most of which is the nitride. All layers can conveniently be deposited in a single reactor.

To form the layers, the reaction chamber is filled with silane (SiH_4). Then ammonia (to produce Si_3N_4) and nitrous oxide (to produce SiO_2) are successively introduced into the chamber, where a glow-discharge plasma at a pressure of 0.1 torr is established by radio-frequency energy capaci-



By the numbers. The initial metalization, which provides contact to the components in the silicon, is designated the 0 layer. The "multilayers" are the 1 and 2 metallizations.

tively coupled from a gauze electrode.

Preparing the slices

STL's original work was done in a small vertical reactor. A larger horizontal version that has since been developed can coat several slices at once. The company has also built a "hot" system in which a coil excites the glow discharge, resulting in a substrate temperature of about 270°C; this heat isn't intense enough to damage the semiconductor, and it tends to increase the stability of the chemical bonds in the oxide-nitride layer. (The i-r tests indicate that the films are more complicated chemically than the simple formulas SiO_2 and Si_3N_4 suggest; they evidently contain N-H and Si-H bonds and are oxygen-deficient. This deficiency tends to decrease after extended baking, but not if the film has been deposited in the hot system.)

A slice spends about an hour in the glow-discharge chamber, for both the deposition itself and the glow-discharge cleaning before deposition that's essential for good adhesion of the film to the aluminum.

To form the feedthrough holes, the film sandwich is photolithographically masked and then etched. It takes 70 to 180 seconds to etch the holes; the longer period is required for films deposited in the hot system. Much of the time is spent etching the thin SiO_2 layers (this is why one troubles to use a sandwich rather than pure SiO_2). The time is still short enough to prevent appreciable etching or passivation of the aluminum, thus ensuring low-resistance feedthroughs.

It's impossible to evaluate an LSI multilayer structure by building circuits and attempting to assess the yield, as is done with less complex circuits. The LSI structure is so complicated that one can't disentangle the various types of fault, let alone estimate their number. A far better approach is to test patterns specially designed to reveal a fault unambiguously. These patterns can be tested in large numbers to give statistical confidence that the required yield has been achieved.

To measure yield of crossovers, for example, STL uses a test pattern containing 10,000 crossovers. Confidence in yield can be established only by testing very large numbers of standard crossovers —not by testing fewer large-area crossovers—since it is at the edge of the crossover that the dielectric is most highly stressed and therefore most likely to fail.

STL proves each crossover test pattern at 36 volts. A cross over passes the test if its leakage current is not more than 10^{-11} ampere, as measured on an electrometer. As a further check, one row is tested at 100 volts.

Yields of crossovers so far have been around 99.99%.

Feedthroughs, however, are much more difficult to test accurately. A four-terminal probe must be used so that resistance can be determined by passing a controlled current through the feedthrough and measuring the voltage drop across it.

Very low testing potentials (only a few millivolts initially) must be used to keep from breaking down a barrier layer and turning a defective feedthrough into a good one. In fact, one of the problems in designing a feedthrough test is deciding what constitutes a bad feedthrough.

There are three types of feedthrough, as shown at top of page, and each behaves differently. The 1-2 and 0-1-2 feedthroughs are much more reliable than the 0-1 type, which has stresses in the upper dielectric layer. This makes a 0-1-2 feedthrough in which the top layer is simply a dummy connection preferable to a 0-1 feedthrough. Using the dummy also simplifies the computer-aided design programs.

A typical feedthrough test pattern at STL contains 300 0-1-2 feedthroughs. Each is individually probed with a low-voltage, low-current source and a digital voltmeter. Feedthroughs cannot be tested in series, since the entire applied voltage will be dropped across a defective feedthrough, probably causing it to break down and appear good. As a result, large-scale testing of feedthroughs is quite tedious.

Yields on feedthroughs as high as 99.8% have been established. ■ ■

Circuit design

Designer's casebook

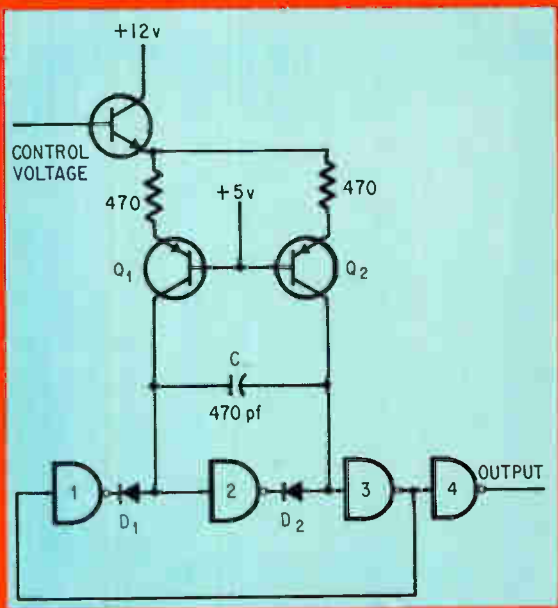
Digital clock operates in low megahertz range

By Peter Westphal
Vienna

A square wave generator built around a single quad 2-input transistor transistor logic gate and a simple transistor circuit works as a 1 to 10-megahertz continuously variable clock for a digital system. Because of its good linearity, it can also be used as a voltage to frequency converter.

The timing network is derived from the emitter-coupled astable, consisting of constant current sources Q_1 and Q_2 and capacitor C. During high levels, the germanium diodes separate the gate outputs from the charging capacitor.

The highest frequency for a given C is determined by the maximum output gate current that will still provide a correct low level output voltage. An SN7400 gate produced an output frequency of 1 to 15 Mhz.



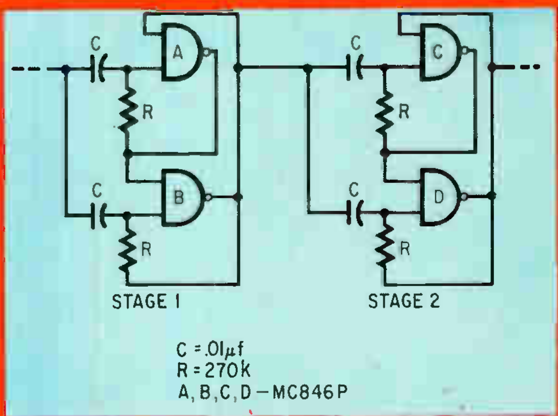
Good timing. The closed loop formed by gates 1, 2, and 3 guarantees the start of oscillation. Gate 4 acts as an output pulse shaper.

NAND gate counter is cheaper to make

By Sholom Kass
Zimmerman-Kass Ltd., Rehovot, Israel

Ripple counters using NAND gates instead of J-K flip-flops can be used if it's not important to achieve high speeds. Two resistors and two capacitors added to a two-input DTL NAND gate make one stage of a ripple counter.

Assume gates B and D are initially high. When B switches from high to low, its negative-going voltage is applied to C and D via the input capacitors. Only the capacitor that was connected to the low output of stage 2, namely gate C, was previously charged. Therefore a considerably larger negative transition is applied to this gate and switches it high. Thus the gate with the low output is switched high, ensuring the counting action.



Flopless. A negative-going voltage is applied to both input capacitors, but only the gate whose output is low switches.

When the first stage subsequently switches from low to high, the second stage is unaffected by the positive signal.

FETs protect differential amplifiers

By S.P. Stranddorf
Radiometer A/S, Copenhagen

Field effect transistors of either polarity can be connected to the inputs of IC differential amplifiers to protect the ICs from positive or negative overvoltages.

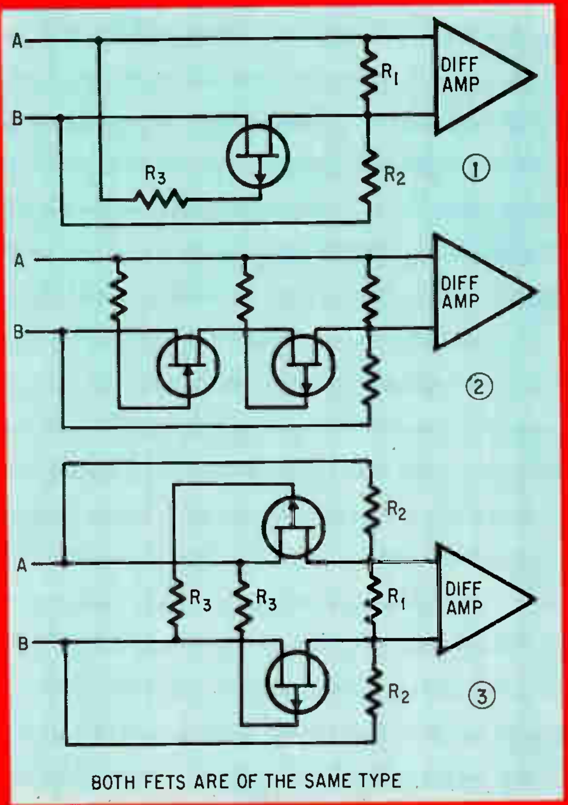
When large differential input voltages of only one polarity can occur, the first circuit protects the amplifier without producing any offset voltage. With a p-channel junction FET, large negative voltages on terminal B will be harmless. When the differential input voltage is larger than the JFET's pinch-off voltage, the drain-source resistance becomes very large, such that the voltage applied to the input of the amplifier will be the differential voltage times the ratio of R_1 to $R_1 + R_2$. R_3 protects the JFET when terminal B is positive with respect to terminal A. If large positive voltages can occur on B, an n-channel JFET should be used.

The following rules should be remembered when designing the input protection:

- the JFET must be inserted in series with the terminal that is to be protected from large voltages.
- a p-channel JFET must be used for large negative voltages, whereas an n-channel JFET must be used for large positive voltages.
- the JFET's pinch-off voltage must be less than the maximum permissible differential input voltage.
- the maximum voltage permitted between gate and source and between drain and source must be larger than the largest differential input voltage that can occur.

The resistor R_2 must be larger than

$$R_1[(V_{diff.\ max.}/V_{i\,max.})-1]$$



Harmless. Inserting a JFET in series with the terminal that is to be protected from over voltages guarantees safe amplifier operation.

where $V_{diff.\ max.}$ is the largest differential input voltage and $V_{i\,max.}$ is the maximum amplifier input voltage allowed.

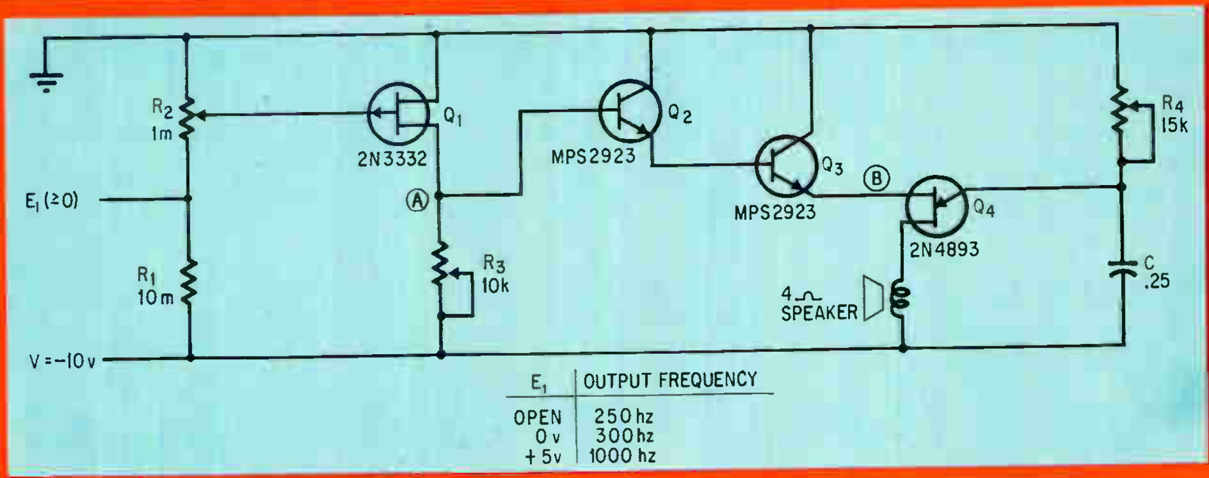
When a condition exists where large differential input voltages of both polarities can occur, the last two circuits should be employed. These circuits are similar to the first circuit. In the last circuit, both FETs are of the same polarity.

ICs are checked faster with audible voltmeter

By Thomas F. Piatkowski
Dartmouth College, Hanover, N.H.

Ears are sometimes more useful than eyes in making electrical measurements. As an example, proper voltage levels in microcircuits can be checked faster using an audible voltmeter. A unijunction transistor discharges periodically through a speaker providing the audible output. The higher the input voltage is to the voltmeter, the higher will be the audio frequency out. The circuit was built to check and debug DTL and TTL logic circuits where visual readout is inconvenient.

The measured positive voltage is applied at E_1. The high-impedance voltage divider, R_2, is adjusted so that the maximum expected input voltage places about 1 volt at the gate of the field effect transistor,



Sounding the alarm. Q_1 is biased to operate in its linear region. Q_2 and Q_3 maintain points A and B at about the same potential while diverting negligible current from load resistor R_3. Q_4 discharges through the speaker, sounding the audible voltmeter.

ensuring its operation in the linear region. Emitter followers Q_2 and Q_3 keep points A and B at about the same potential while letting negligible current flow through the load resistor R_3. The UJT is discharged through the speaker with a period determined by R_4, C, the supply voltage V, and the UJT's intrinsic standoff ratio.

The adjustable resistors R_2, R_3, and R_4 allow this circuit to operate over a wide range of input voltages and output frequencies. R_1 biases Q_1 negatively if E_1 is an open circuit causing a lower output frequency than would occur for a positive E_1.

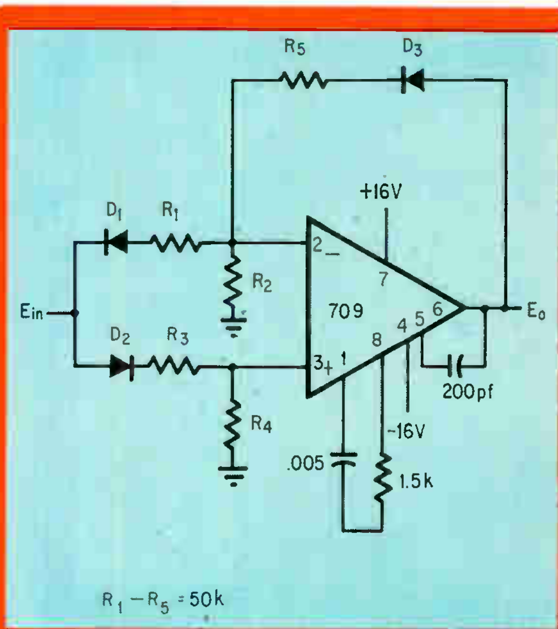
Absolute value circuit needs only one op amp

By Wayne Spani

San Diego, Calif.

Most absolute value circuits contain two operational amplifiers to convert input voltages of either polarity to their absolute value—one in the inverting mode and the other in the noninverting mode. However, only one is really necessary.

A negative input voltage forward biases D_1 and is applied to the inverting input of the amplifier. When the forward resistances of D_1 and D_3 are equal, and $R_5 = R_1$, the transfer function is $E_o = -E_{in}$. When the input voltage is positive, the signal forward biases D_2 and is applied to the noninverting input of the amplifier. The feedback is the same, but the amplifier operates in the potentiometric mode changing the transfer function. If $R_2 = R_3 = R_4 = R_5$, and the forward resistances of D_2 and D_3 are equal, then $E_o = E_{in}$.



Bipolar. The circuit's transfer function is $E_o = |E_{in}|$ for bipolar signals of 0.5 to 15 volts with an accuracy of 0.1% from 0°C to 50°C.

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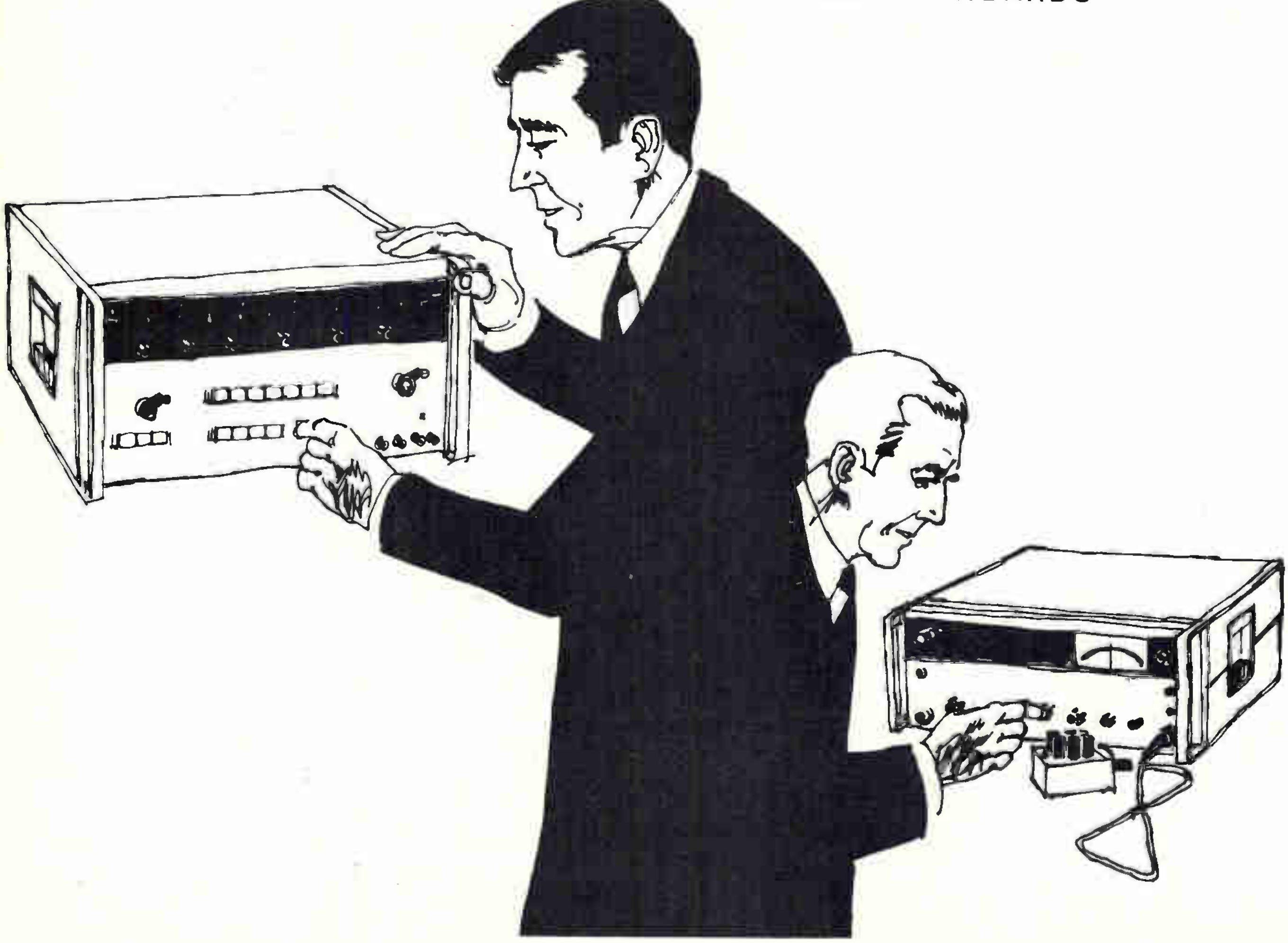
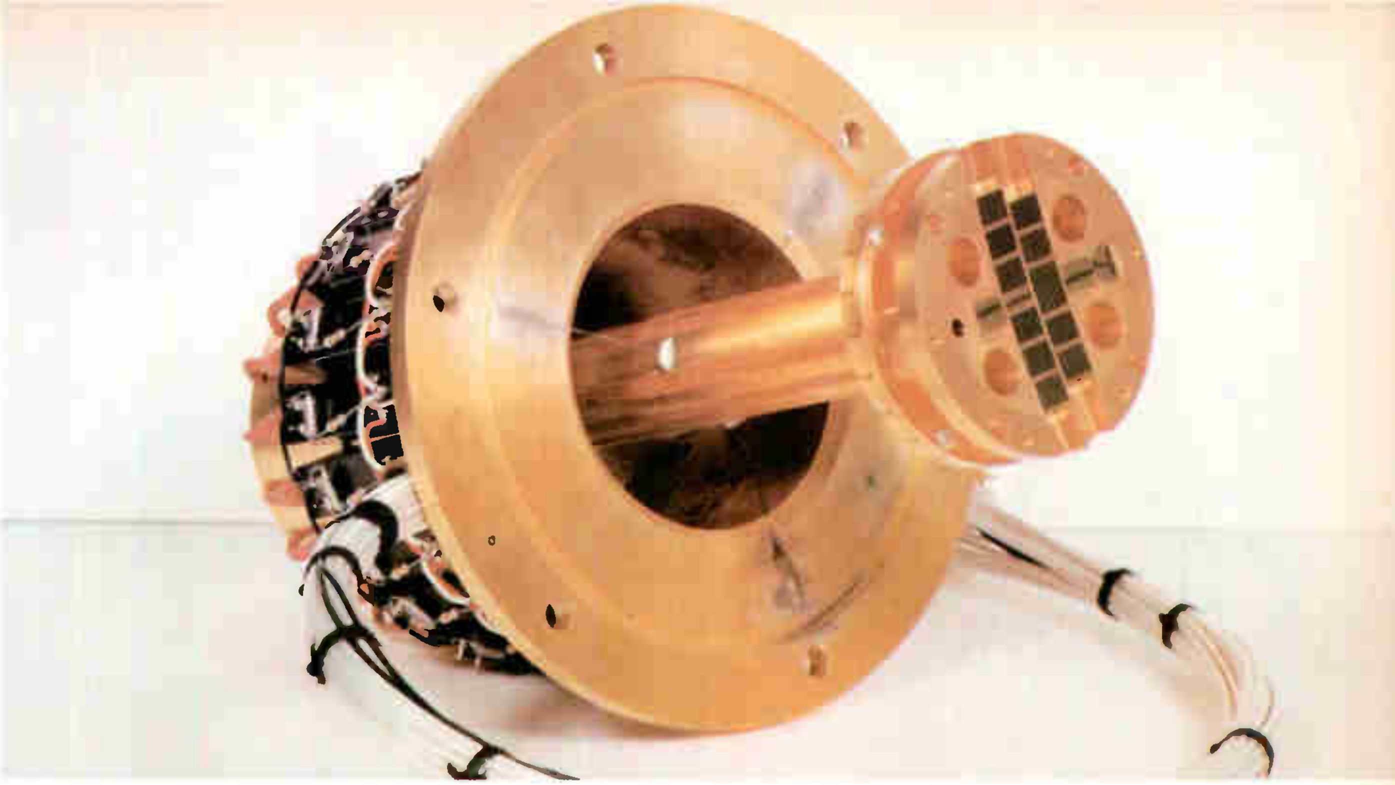
WORKING STANDARDS





Infrared hardware. A mercury-doped germanium photo conductive detector array with reticles, mount and preamps, manufactured by the Santa Barbara Research Center.

Instrumentation

Infrared detector chart outlines materials and characteristics

Survey lists the i-r devices currently available from manufacturers; trend is toward monolithically fabricated, multi-detector circuits

By Philip Shapiro
Aerojet-General Corp., Azusa, Calif.

Advances in semiconductor technology have gone hand-in-hand with progress in infrared systems, each stimulating the other. Semiconductor infrared detectors developed in the past 10 years have included those in mercury-doped germanium, gallium arsenide, silicon, cadmium-doped germanium, antimony-doped silicon, mercury cadmium telluride, and the list is still growing.

The accompanying table records the properties of 24 commercially available photoconductive, photovoltaic, and photo-electromagnetic detectors that have peak responses at wavelengths ranging from 0.8 to 50 microns.

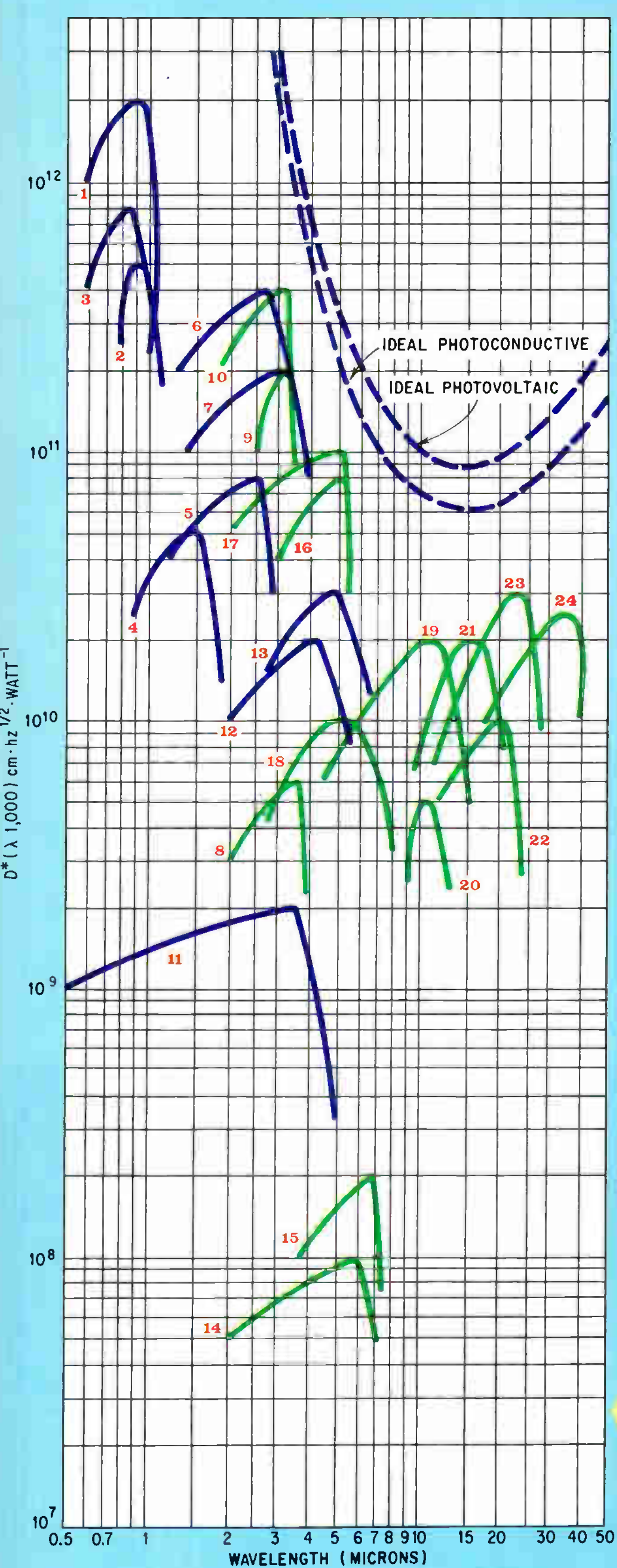
When a device is made by more than one company, the data represents industry averages. Experimental and obsolete detectors have been omitted.

An infrared system's minimum detectable radiant power is inversely proportional to the detector's specific detectivity, D*, defined as

$$D^* = \frac{\sqrt{A \cdot \Delta f}}{\text{NEP}}$$

where A=detector area in cm^2
f=noise equivalent bandwidth in hz
NEP=noise equivalent power in watts, defined as the rms infrared signal incident upon a detector

Characteristics

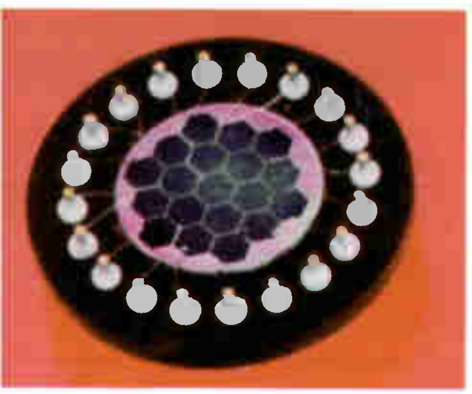


	1	2	3
Detector Material Operating Mode	Si Silicon (pv)	Si Silicon (pc)	GaAs Gallium Arsenide (pv)
Typical Peak D^* (cm hz$^{1/2}$ watt^{-1}) at 1,000 hz modulation frequency	2×10^{12}	5×10^{11}	8×10^{11}
(wavelength, in microns) (field of view, degrees) (background temperature, °K)	0.9	0.9	0.85
Best Measured Peak D^* (cm hz$^{1/2}$ watt^{-1}) (conditions as above)	1×10^{13}	1×10^{12}	
Spectral Range Exhibiting Greater Than 50% Relative Response (microns)	0.6 to 1.0	0.8 to 1.06	0.6 to 0.95
Normal Operating Temperature (°K)	295	295	295
Operating Temperature Limits (°K); 50% peak D^* degradation points	—,320	—,350	
Typical Time Constant (seconds)	5×10^{-7}	5×10^{-6}	1×10^{-6}
Nominal Resistance (ohms)	1×10^{6}	1×10^{6}	1×10^{6}
Area Configuration — Single Detectors: Size Range — Min. to Max. (inches)	.004 to .5	.004 to .7	.004 to .060
Shape (round, square or rectangular)	any	□▭	○□
Typical Package	TO-5/18	Flat Mount	TO 18
Detector Arrays: Minimum Size per Detector (inches) Minimum Size per Space (inches)	.004 .002	.004 .001	
Dimensions — see code	±.002″	±.020″	
Typical Detector Unit Price	$ 40	$ 40	$ 50
Manufacturer(s) — see reference	f,h,m,r,s	k	m

Spectral detectivities of manufactured detectors tested under 60° field-of-view and 295°K background temperature. Theoretical values of peak D^* lie on the dashed curves.

77°K indium antimonide detector by Philco-Ford is designed for infrared tracking

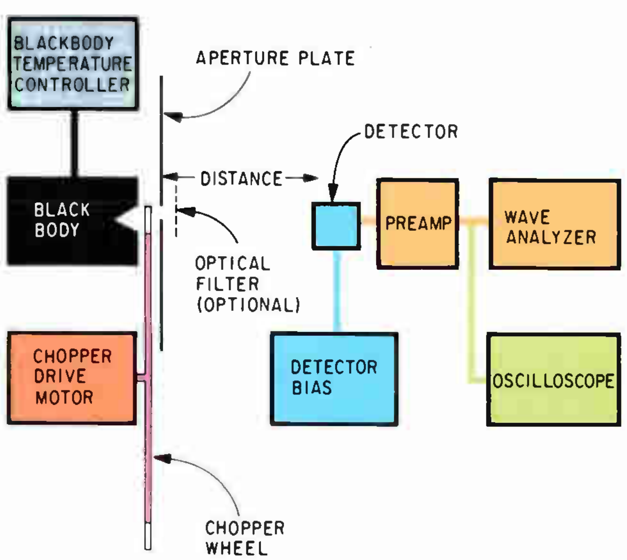
5-element indium antimonide array



19-hexagonal element silicon mosaic

8-element silicon array

4-quadrant silicon mosaic



Typical setup for testing i-r detectors.

which produces a signal-to-noise voltage ratio of unity.

The value of D^* at the detector's spectral peak is of most interest because it allows meaningful comparisons between different detectors when specific radiation sources, atmospheric effects, filters and optics are considered.

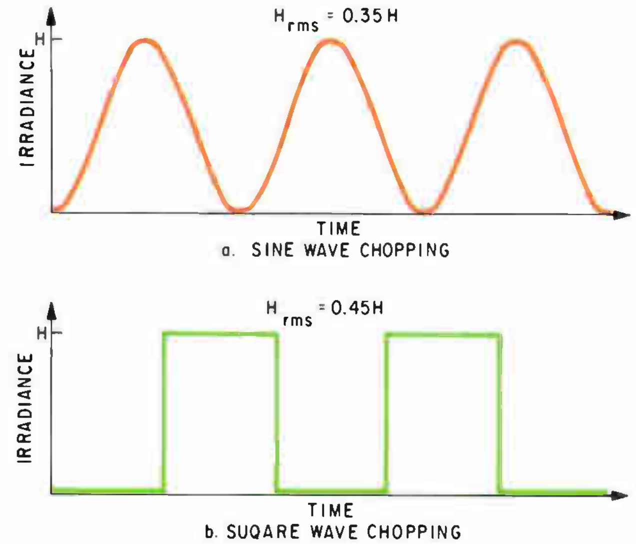
The typical spectral D^* at the peak wavelength is given for each detector operating under uniform conditions -- 1000-hz modulated signal radiant power, 60 degree field-of-view and an external field-of-view environmental temperature of 295°K. The background and field-of-view conditions are noted in the table only for background-limited detectors. With those detectors whose limiting noise is determined by the incident photon flux, considerable improvement in performance in D^* beyond the value listed can be achieved by using cooled narrow field-of-view limiting apertures and cooled spectral bandpass filters. D^* increases as the field-of-view decreases. For the special case of conical field-of-view, which are uniformly radiant, D^* increases according to the cosecant of the half angle.

The prices shown are typical for a single detector with the typical D^* listed and mounted in a standard way. The price of a selected detector with the peak D^* called out as best measured is often more than a factor of two higher in price than a typical detector. For large arrays, the cost per element may drop by an order of magnitude compared with single detectors with similar performance capabilities.

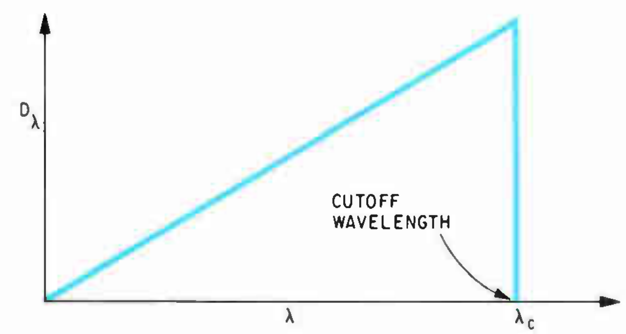
Detectors are usually cooled with cryogenic liquids, or thermo-electric coolers, or Joule-Thompson cryostats, or Sterling cycle coolers. Many companies supply thermo-electric coolers for the 195° to 273°K region. For temperatures of 77°K, manufacturers are now supplying detectors in rugged metal Dewars.

Also listed are detector temperatures at which peak D^* is degraded by 50%. This information is useful when ideal cooling conditions are not practicable.

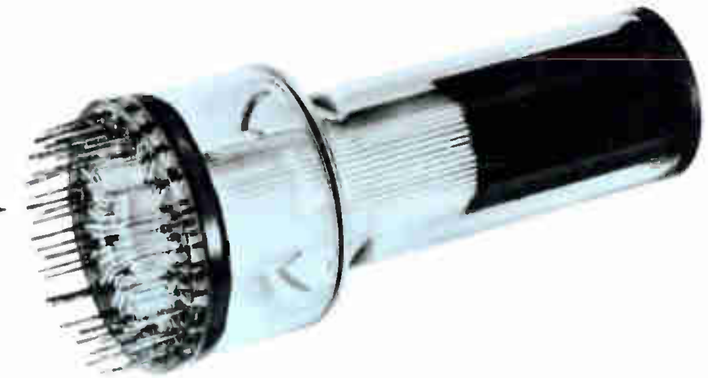
The resistance presented is for an average size detector (1 millimeter square). Reactances such as occur in photovoltaic cells have been disregarded. Biasing in photovoltaic detectors permits control over various parameters that are fixed in photoconductive detectors. By controlling the bias, both in magnitude and polarity, the detector's impedance, time constant, spectral response, and peak D^* can be influenced.



Chopped i-r. Modulation from sine and square "wheel."



Ideal. Spectral response of theoretical photon detector.



Mosaic. A lead selenide 56-element detector array, made by Santa Barbara Research Center, packaged in a Dewar.

New techniques in multi-element detector fabrication have come to the forefront in recent years as a result of new requirements in systems design. Individual elements have been reduced to about 0.003 inch square for single crystalline detectors and 0.001 inch square for thin film detectors in one and two dimensional arrays. Monolithic fabrication methods are well developed for both photoconductive and photovoltaic devices. Linear arrays of hundreds of detectors are now practicable.

The mercury cadmium telluride detector is a recent device. Its spectral response can be tailored to the 8 to 14 micron region, while requiring cooling to only 77°K. Information on this detector can be obtained from its manufacturers, Honeywell, Santa Barbara Research Center, Texas Instruments, and SAT in Paris.

Peak D^* can be much higher than indicated when a background limited detector is operated with low incident radiant flux. The peak D^* of impurity activated germanium and silicon detectors, for example, improves significantly under such conditions. When operated as such, the detector's resistance increases, so to preserve electrical bandwidth, it is necessary to reduce associated capacitances by moving the preamplifier and detector closer together. A cryogenic preamplifier that operates as low as 4.2°K has been developed to allow the two to be as close together as possible.

Two intrinsic photodetectors, lead tin telluride and lead tin selenide are presently receiving attention as developmental devices. Advanced work on these two detectors, especially lead tin telluride, is being carried on at the Lincoln Laboratories of M.I.T.

For very long wavelengths (beyond 100 microns) work is being done with extrinsic photoconductors. Boron doped germanium and gallium doped germanium are two such detectors. Indium antimonide has also been found to display photoconductive effects at these long wavelengths by changes in mobility rather than the usual change in carrier concentration.

# of available infrared-region detectors

4	5	6	7	8	9	10	11	12	13
Ge Germanium (pv)	PbS Lead Sulfide (pc)	PbS Lead Sulfide (pc)	PbS Lead Sulfide (pc)	InAs Indium Arsenide (pv)	InAs Indium Arsenide (pv)	InAs Indium Arsenide (pv)	PbSe Lead Selenide (pc)	PbSe Lead Selenide (pc)	PbSe Lead Selenide (pc)
5×10^{10} 1.5	8×10^{10} 2.5	4×10^{11} 2.7 60 295	2×10^{11} 3.1 60 295	6×10^{9} 3.5	2×10^{11} 3.2 60 295	4×10^{11} 3.1 60 295	2×10^{9} 3.4	2×10^{10} 4.1 60 295	3×10^{10} 4.8 60 295
	1.5×10^{11}	7×10^{11}	4×10^{11}	1×10^{10}	3.5×10^{11}	7×10^{11}	2×10^{10}	5×10^{10}	5×10^{10}
0.9 to 1.7	1.2 to 2.8	1.3 to 3.2	1.4 to 3.8	2.0 to 3.8	2.5 to 3.4	1.8 to 3.8	.5 to 4.2	2.0 to 5.3	2.7 to 6.3
295	295	195	77	295	195	77	295	195	77
	–,310	160.250	–,160	–,320	–,210	–,180	–,310	–,230	–,160
1×10^{-7}	3×10^{-4}	5×10^{-3}	3×10^{-3}	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	5×10^{-7}	2×10^{-6}	3×10^{-5}	4×10^{-5}
2×10^{5}	1×10^{6}	1×10^{6}	2×10^{6}	3×10^{1}	5×10^{4}	5×10^{5}	2×10^{6}	5×10^{6}	5×10^{6}
.004 to .5	.001 to 1.0	.001 to 1.0	.001 to 1.0	.004 to 0.1	.004 to 0.1	.004 to 0.1	.003 to .3	.003 to .5	.003 to .5
any	□▭	□▭	□▭	○	○	○	□▭	□▭	□▭
TO 5/18, BNC	Flat Mount	Glass Dewar	Glass Dewar	TO 5/16	Glass Dewar	Glass Dewar	Flat Mount	Glass Dewar	Glass Dewar
	.001 .001	.001 .001	.001 .001	.003 .002	.003 .002	.003 .002	.003 .002	.003 .002	.003 .002
	✢ ↕ .001″	✢ ↕ .001″	✢ ↕ .001″	✢ ↕ .002″	✢ ↕ .002″	⚋ ↕ .002″	✢ ↕ .001″	✢ ↕ .001″	✢ ↕ .001″
$ 100	$ 40	$ 600	$ 600	$ 175	$ 600	$ 600	$ 100	$ 900	$ 900
h,m,r	e,g,j,o,q	g,j,o,q	g,j,o,q	c,h,m,r	c,m,r	c,o,r	j,o	j,o	j,o

14	15	16	17	18	19	20	21	22	23	24
InSb Indium Antimonide (pem)	InSb Indium Antimonide (pc)	InSb Indium Antimonide (pc)	InSb Indium Antimonide (pv)	Ge:Au Gold-Doped Germanium (pc)	Ge:Hg Mercury-Doped Germanium (pc)	(Hg-Cd)Te Mercury Cadmium Telluride (pv)	Ge:Cd Cadmium-Doped Germanium (pc)	Si:Sb Antimony-Doped Silicon (pc)	Ge:Cu Copper-Doped Germanium (pc)	Ge:Zn Zinc-Doped Germanium (pc)
1×10^{8} 6.0	2×10^{8} 6.8	8×10^{10} 5.3 60 295	1×10^{11} 5.1 60 295	1×10^{10} 5.0 60 295	2×10^{10} 10.5 60 295	5×10^{9} 10.6 60 295	2×10^{10} 16 60 295	1×10^{10} 20 60 295	3×10^{10} 23 60 295	2.5×10^{10} 36 60 295
3×10^{8}		1×10^{11}	2×10^{11}	2×10^{10}	5×10^{10}	2×10^{10}	4×10^{10}	2×10^{10}	5×10^{10}	5×10^{10}
2.0 to 7.0	3.6 to 7.3	3.0 to 5.4	2.0 to 5.4	3.0 to 7.5	6 to 14	9 to 13	11 to 20	12 to 23	15 to 27	20 to 40
295	295	77	77	60	27	77	4.2	4.2	4.2	4.2
		–,95	–,105	–,80	–,40	–,100	–,26	–,10	–,20	–,6
2×10^{-7}	1×10^{-6}	6×10^{-6}	$<1 \times 10^{-6}$	1×10^{-7}	2×10^{-7}	$<1 \times 10^{-8}$	1×10^{-7}	1×10^{-7}	5×10^{-7}	2×10^{-8}
1×10^{1}	2×10^{1}	1×10^{4}	1×10^{5}	1×10^{5}	1×10^{5}	2.5×10^{1}	1×10^{5}	7×10^{6}	1×10^{5}	2.5×10^{5}
.015 to .040	.040 to .1	.003 to .1	.003 to .1	.003 to .1	.003 to .1	.020 to .080	.003 to .1	.004 to .1	.003 to .1	.003 to .1
□	□▭	□▭	□○	□▭	□▭	□▭	□▭	□▭	□▭	□▭
Metal Cont.	Flat Mount	Glass Dewar	Glass Dewar	Glass Dewar	Metal Dewar	Glass or Metal Dewar	Metal Dewar	Metal Dewar	Metal Dewar	Metal Dewar
		.003 .002	.003 .002	.003 .002	.003 .002	Developmental	.003 .002 .002″	.004 .004	.003 .002	.003 .002
		⚋ ↕ .001″	⚋ ↕ .002″	⚋ ↕ .002″	⚋ ↕ .002″		⚋ ↕ .002″	⚋ ↕ .004″	⚋ ↕ .002″	⚋ ↕ .002″
$ 400	$ 90	$ 750	$ 600	$ 800	$ 2,500	$ 4,900	$ 3,000	$ 2,500	$ 2,500	$ 3,300
h,i,j	d,i	h,i,l,m,n,o	b,c,l,m,o,r	c,m,n,o	a,m,n,o,r	p	n,o,r	a	a,m,n,o,r	o

Detector manufacturers

a.	Aerojet-General Corp.	Azusa, California
b.	Avco Corporation, Electronics Div.	Cincinnati, Ohio
c.	Barnes Engineering Co.	Stamford, Conn.
d.	Block Engineering, Inc.	Cambridge, Mass.
e.	Catron Electronic Corp.	Geneva, Ill.
f.	E. G. and G.	Boston, Mass.
g.	Electronic Corp. of America	Cambridge, Mass.
h.	Electro-Nuclear Laboratories, Inc.	Menlo Park, Calif.
i.	Honeywell Radiation Center	Boston, Mass.
j.	Infrared Industries, Inc.	Waltham, Mass.
k.	Mithras, Inc.	Cambridge, Mass.
l.	Networks Electronic Corp.	Chatsworth, Calif.
m.	Philco-Ford Corp.	Spring City, Penn.
n.	Raytheon Co.	Waltham, Mass.
o.	Santa Barbara Research Center	Goleta, Calif.
p.	SAT — Paris, France; (U.S. Representative: Elteck Corp.)	Larchmont, N.Y.
q.	Sensor Precision Ind.	Medfield, Mass.
r.	Texas Instruments Inc.	Dallas, Texas
s.	United Detector Technology	Santa Monica, Calif.

pc — photoconductive mode pv — photovoltaic mode pem — photo-electro magnetic mode

Array dimension code

- linear ⟷
- 2-dimensional ✢
- linear staggered ⚋
- space between rows ↕

Electronics' guide

Slowdown!

(and read about the world's fastest IC adder.)

Signetics announces a no-kidding leadership device: the 8260 Arithmetic Logic Element, latest addition to our DCL family.

The 8260, now available in volume, is a monolithic gate array incorporating four full adders structured in a look-ahead mode. The device may be used as four mutually independent Exclusive-NOR or AND gates by proper addressing of the inhibit lines. Here is a device which in typical application increases speed three to four times, greatly reduces package count and appreciably lowers over-all system costs.

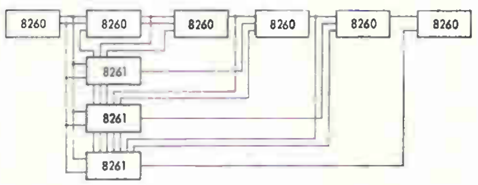
As a four-bit adder, the 8260 permits parallel addition of four sets of data and features simultaneous (look ahead) carry on each bit within the package. Extension of the look-ahead feature for 16 bits or more is facilitated by the 8261 Fast Carry Extender.

Access to the 8260 from previous stage(s) is provided through five OR-ed channels, and inhibition of carry-in-data and bit-to-bit carries is accomplished by a true (active high) logic level of C_{INH}.

The "carry-outs" available are: Internally Generated ($\overline{C_G}$); Propogated (C_P); and Ripple ($\overline{C_R}$). This gives the 8260 complete flexibility when used in Ripple Carry or Anticipated Carry Adder systems.

The 8260 is available now in 24-lead flat pak, −55° C to +125° C and 0° C to +75° C, and will soon be available in both full MIL and commercial DIPs.

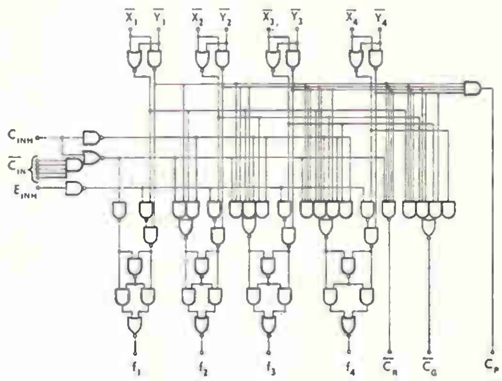
For complete information on the world's fastest adder write Signetics, 811 East Arques Avenue, Sunnyvale, California 94086. Fast!



24-bit Fast Adder System; 9 packages; minimum external connections.

No. of Bits	Package Count 8260	8261	Quad 2-Input NAND Gates	Addition Time per Bit (ns)	Total Addition Time Input to Output (ns)
16	4	1	–	3.3	52
24	6	3	–	3.3	52
32	8	3	–	2.0	64
48	12	6	1	1.3	64
64	16	7	1	1.2	76

Increased speed and reduced package count far exceed what is attainable with any other IC family.



The 8260 Arithmetic Logic Element.

Signetics Integrated Circuits
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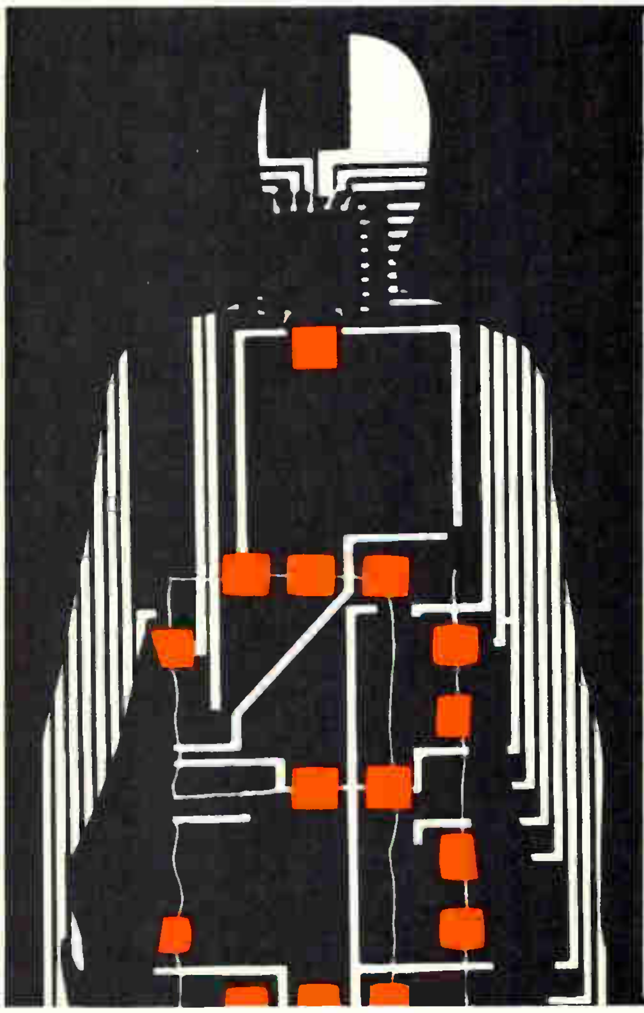

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Semiconductor arrays get bigger and denser

By Ury Priel

Signetics Corp., Sunnyvale, Calif.

Memory circuits are being offered as standard products by almost all semiconductor manufacturers. These products now cover a wide range of speed, both read-write and read-only functions, serial and random-access operations, and such special designs as content-addressable organizations. Furthermore, the capacity per chip is steadily rising as both chip size and element density increase.

Custom-designed storages are still much in demand, but they no longer dominate the market for semiconductor memories. The shift to volume production of standard memories stems from the built-in affinity of semiconductor technology for batch fabrication, which, in turn, is well suited to turning out arrays of identical cells that are characteristic of all memories.

Metal oxide semiconductor and bipolar circuits will soon be fabricated on chips measuring 150 mils a side or more—against the now standard sizes of under 100 mils square. MOS circuits are decreasing in price and increasing in density almost daily, while bipolars are benefitting from better yields and better circuit design.

As noted in an earlier article [*Electronics*, Dec. 23, 1968, p. 54], bipolar circuits' major advantage over MOS in memory applications is speed. Because their elements cannot be as closely packed as those of MOS circuits, bipolars will continue to be used in small arrays requiring high speed. The large-memory field, however, is monopolized by MOS.

Within speed limits

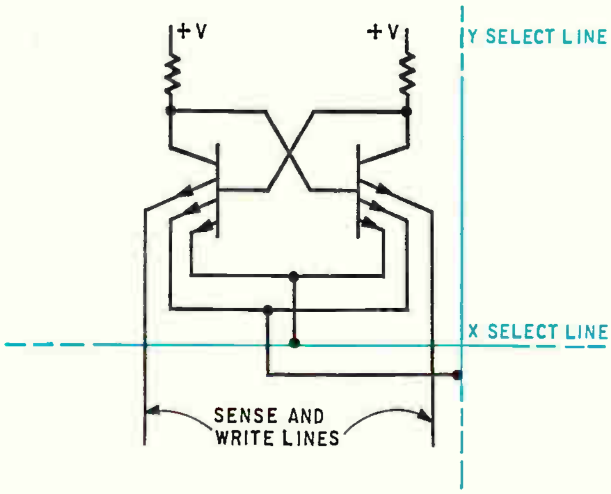
Computer designers have come to rely heavily on read-only memories as sequence controllers, code converters, character generators, look-up tables, and even program storages in some cases. A read-only memory cell is an inherently simple device for which MOS technology is ideally suited—provided the cycle time isn't less than 100 nanoseconds. Built-in capacitance precludes the operation of individual devices at higher speeds.

American Micro-systems Inc. and the General Instrument Corp. have both developed a read-only memory with 2,048 bits on a chip measuring 84 by 106 mils. The memory dissipates 130 milliwatts when operating at 2 megahertz (500-nanosecond cycle), and its outputs and inputs can be connected directly to transistor-transistor, diode-transistor, or MOS logic circuits.

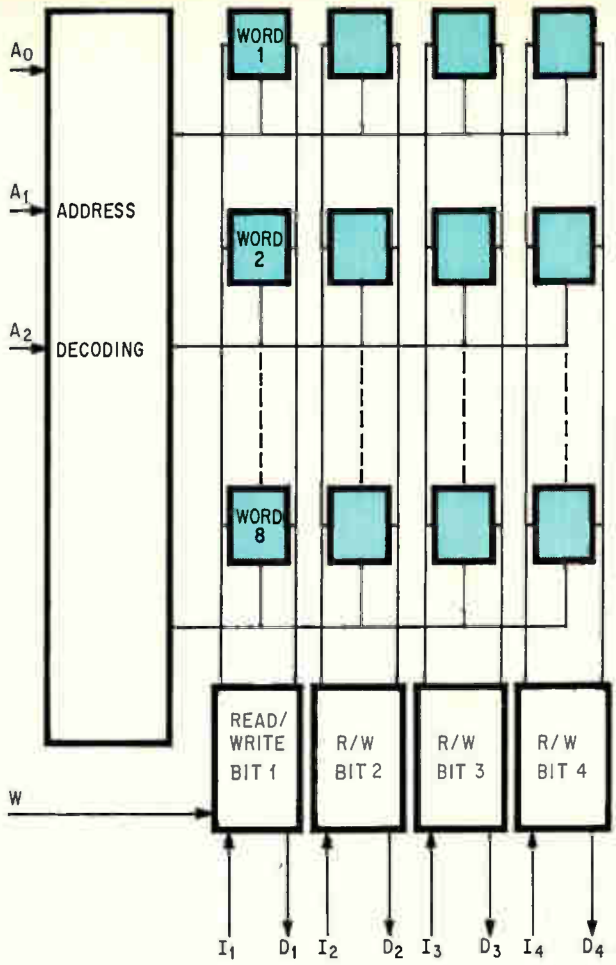
Philco-Ford Corp., Texas Instruments, and the Fairchild Semiconductor division have each brought out a 1,024-bit read-only memory, and other manufacturers are expected to join the club.

For higher speeds, bipolar circuits must be used, but only with increases in size, cost and power dissipation. Radiation, Inc., offers a 100-bit read-only memory in the form of a 10-by-10 diode matrix, and Motorola Inc. is working on a 128-bit memory. The Signetics Corp. is developing a 256-bit read-only memory that works with DTL or TTL and can be programed either at the factory or by the user.

Signetics is using a fusing link approach; the customer defines the data stored in the memory by melting away certain metal interconnections, or links, corresponding to stored 0's. In this new organization, access to each link can be gained with fewer external connections than earlier fusing link designs required.



Standard. Originally a custom design, this bipolar circuit is now being used routinely by several manufacturers.



Scratchpad. This 32-bit memory is one application of the circuit shown schematically on page 100.

TI is working on a 512-bit bipolar read-only memory having a 30-nsec delay from the word driver input to the external detector output; the interconnections are made with a computer-controlled discretionary-wiring technique, and, in general, no two chips are wired alike. The aim here is to utilize all the good cells on a large chip and none of the bad ones. This approach, which is unique to TI, can be applied to any kind of large chip, but it offers a special advantage in read-only memories. Cells defective because they're open-circuited can often be included in the wiring as 0's, while short-circuited cells can be included as 1's. The approach thus has the potential to improve yields.

Long shift registers can be used as serial memories in much the same way as acoustic delay lines or even magnetic drums are used. [An article comparing the virtues of shift registers and delay lines as serial memories will appear in a future issue of *Electronics*.] To get a sufficiently long delay, the shift register must contain dozens or hundreds of bits, and only MOS technology provides the necessary packing density on a chip of reasonable size. Bipolar shift registers are being manufactured, but their bit capacities are low and their applications lie in processing and control rather than in the memory field.

Of the MOS shift registers now being marketed for memory applications, American Micro-systems is offering three different units. One has three 66-bit registers on a single chip—with the three externally connected to one another if desired—another has two 40-bit registers, and the third has a pair of multiplexed 213-bit registers.

Philco-Ford has a 256-bit dynamic shift register from which the stored data disappears if the shifting action stops. And the National Semiconductor Corp. offers a dual 100-bit dynamic shift register and dual 32-bit and 64-bit static registers.

But none of these wholly MOS memories work to advantage with high-speed logic circuits. To offset the technology's speed limitations while realizing its savings in space and cost, MOS must be combined with bipolar, either by putting both types of circuit on one large substrate or by mounting the two circuits on separate chips in a hybrid package. This approach is being investigated by Amperex, the Solid State Scientific Corp., and Signetics, and Siliconix has already marketed a monolithic MOS-bipolar analog switch, which proves the feasibility of this approach.

Random happenings

Semiconductor technology—both MOS and bipolar—holds out as much promise in the field of random-acccess memories as in the read-only types. Up to now, most of the emphasis in this area has been on scratchpad memories—small, fast units that act as buffers between a processor and a large random-access memory.

MOS scratchpads now on the market include a 32-bit memory from American Micro-systems, another of 32 bits from General Instruments, and a 64-bit unit with a 300-nsec access time from Philco-Ford. Motorola and TI are each developing 256-bit MOS random-access memories.

Bipolar scratchpads have generally been developed as custom circuits and later marketed as standard products. One example is a 16-bit memory using a coincident selection scheme and TTL circuits, shown opposite. This unit is now available from the Transitron Corp., Sylvania, and Fairchild. And Motorola has successfully combined the TTL saturated cell with nonsaturating current-mode sense and write circuits in a 16-bit memory that's said to cycle in as little as 50 nsec and to dissipate only 250 milliwatts.

Fairchild has developed a 64-bit scratchpad element that has 16 four-bit words. The words are accessible in about 30 nsec, but the chip requires external decoding. Signetics has an eight-bit memory with address decoding on the same chip, and it is developing a similar 32-bit unit that will be integrated on a 100-by-100-mil chip, shown above. The individual cells are essentially the same as those opposite, except that there are three address lines instead of two. The three-bit address picks out one of eight four-bit words, and is decoded through the multiple-emitter structure at the cell; the box labeled "decoder" in the diagram is actually only a bank of inverters. The 32-bit memory's access time is about 20 nsec.

These developments point to the eventual development of larger bipolar memories that will rival MOS memories in terms of density and cost, but exceed them in terms of speed. These improvements will result both from circuit innovations and from adaptation to the "terrain" of an IC.

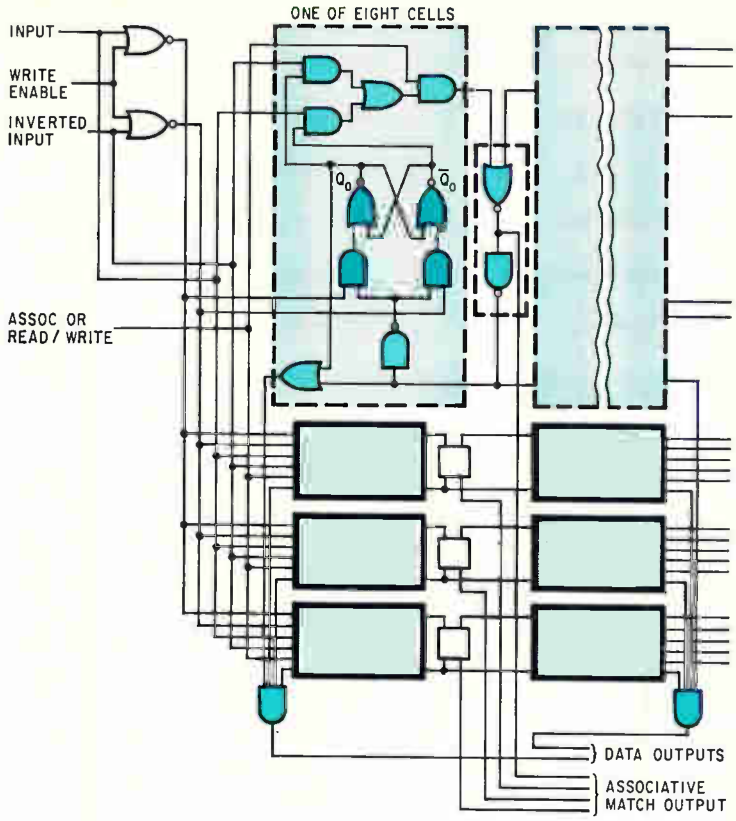
Today's largest MOS circuits are shift registers holding a couple of thousands bits on a chip 100 mils square; the largest bipolar circuits are on chips of a similar size but are limited to about 100 bits—bits, however, that are randomly accessible. Thus, MOS density is now about 20 times that of bipolar circuits, but carries a penalty in the form of serial versus random access.

By the end of 1970, it should be economical to put a thousand or more bits on chips 150 or 200 mils square, and gain access to these bits in as little as 20 nanoseconds through bipolar circuits.

One of the major merits of integrated circuits is the easy implementation of combinations of memory and logic—in content-addressable, or associative, memories, for example. In an associative organization, the memory is presented with a bit pattern, or key, that may or may not be as long as the words in the memory. The entire array is searched in parallel, and those words whose bits match those in the key are taken out.

These memories can be used for list processing, information retrieval, language translation, and air traffic control. They will also offer a hardware solution to complex software problems when their costs are reduced.

Signetics is developing the TTL associative memory shown at right. It contains four two-bit words on a 100-by-100-mil chip, and it can get at any of these words in 20 nsec. It dissipates 420 milliwatts.



Associative. Any of these four two-bit words, all on a chip 100 mils square, is content-accessible in 25 nsec.

Future developments will result in more complex but lower-cost semiconductor devices. These developments include improvements in the isolation between circuits on a chip, the use of complementary transistors on a single substrate in both bipolar and MOS technologies, increases in yield, and greater reliance on computers in design. ■ ■

Memories X

MOS random-access arrays

By Burton R. Tunzi

American Micro-systems, Inc., Santa Clara, Calif.

Large-scale integration through MOS technology promises to enhance the performance and cut the cost of random-access memories. Larger and larger chips are being designed every day, and they are leading to larger memories assembled from many chips on a common substrate, driven in parallel or separately as required by the memory's capacity.

The circuits on these chips can be either static or dynamic. The dynamic type requires refreshing from time to time, but its elements can be densely packed and it therefore lends itself to memories of large capacity. Both kinds of circuits can include decoding transistors on the same chip; the address decoding can be partial or complete, but the more complete decoding often involves a speed penalty. With or without the decoding, both circuits can be made compatible at input and output with diode-transistor and transistor-transistor logic circuits.

A typical single chip contains 256 individually addressable bits, which may be considered 256 words of 1 bit each. A memory with a longer word, say of 16 bits, could be assembled from 16 of these 256-by-1 chips driven in parallel. Or a memory with a larger number of one-bit words, say 4,096, could be made from 16 chips driven separately.

Organized either way, 16 chips can be packaged in about 1.5 cubic inches, and will dissipate about 2.4 watts supplied from sources of +5 and −12 volts when operating.

Two modes

Data is stored in MOS memories in either a conventional cross-coupled pair of d-c NOR gates or in the form of a charge on a capacitor in a dynamic circuit. The charge is maintained by periodic refreshing. Such dynamic circuits dissipate very little power and can be packed densely on a small chip.

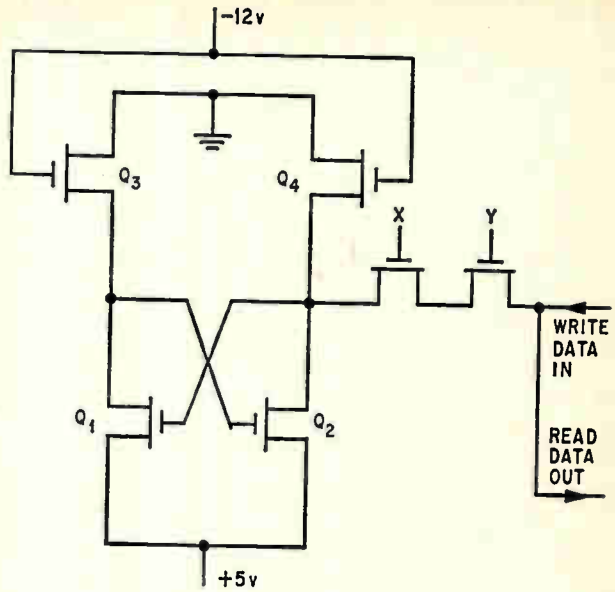
Either kind of circuit may be produced by American Micro-systems' proprietary low-threshold-voltage process, which yields transistors with turn-on thresholds of only −2 volts. Conventional processes produce transistors with thresholds of 5 to 10 volts.

In the d-c storage element at right above, transistors Q_1 and Q_2 are the cross-coupled elements of the flip-flop and have relatively low impedances. Transistors Q_3 and Q_4 have higher impedances and serve as load resistors. As their gates are permanently connected to the −12-volt supply, they are always on. The circuit's output is the drain of Q_2 coupled through decoding transistors Q_5 and Q_6 to a sense amplifier. This point is also the circuit's input; data to be written comes in through the decode transistors and forces the flip-flop into the desired state.

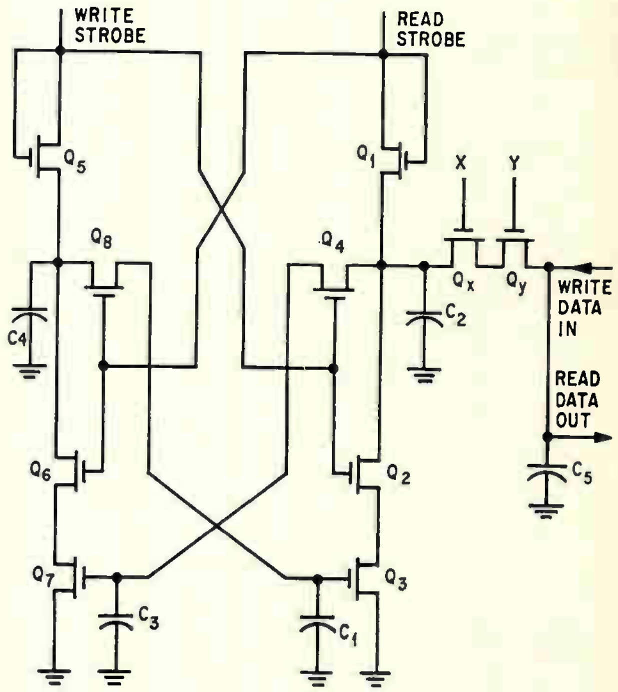
This cell, with addressing lines, takes up about 40 square mils of silicon and dissipates less than 1 milliwatt of power.

The dynamic storage circuit at right below is essentially a one-bit shift register that continuously circulates upon itself. The recirculation requires strobe pulses, but they can have a relatively low frequency—a few kilohertz—and need be only a couple of hundred nanoseconds wide, for a duty cycle of less than 0.1%. These same pulses initiate the read-write action in the dynamic cell. Power dissipation is roughly proportional to the strobing frequency, and can be as small as 100 nanowatts per bit at slow strobing rates.

With no d-c current paths in the circuit, all the transistors can have the same impedance. This impedance can be relatively high, and the area occupied by each transistor small. Furthermore, the same line can be used for both reading and writing, saving still more area.



Static. The cross-coupled transistors retain a stored bit indefinitely without refreshing.



Dynamic. Parasitic capacitance store data but require refreshing; the entire circuit can be quite small, however.

Data is stored in this cell as a charge on capacitor C_1, which is actually only the parasitic capacitance on the line to which it is shown connected in the diagram. Transistor Q_3 is biased on if the charge on C_1 is negative.

The drain of Q_1 is normally maintained at +5 volts, but a read strobe pulse appearing from time to time momentarily drops it to −12 volts, thus turning on Q_1 briefly. During this short interval, capacitor C_2, which is also simply a parasitic capacitance, charges to the −12-volt level.

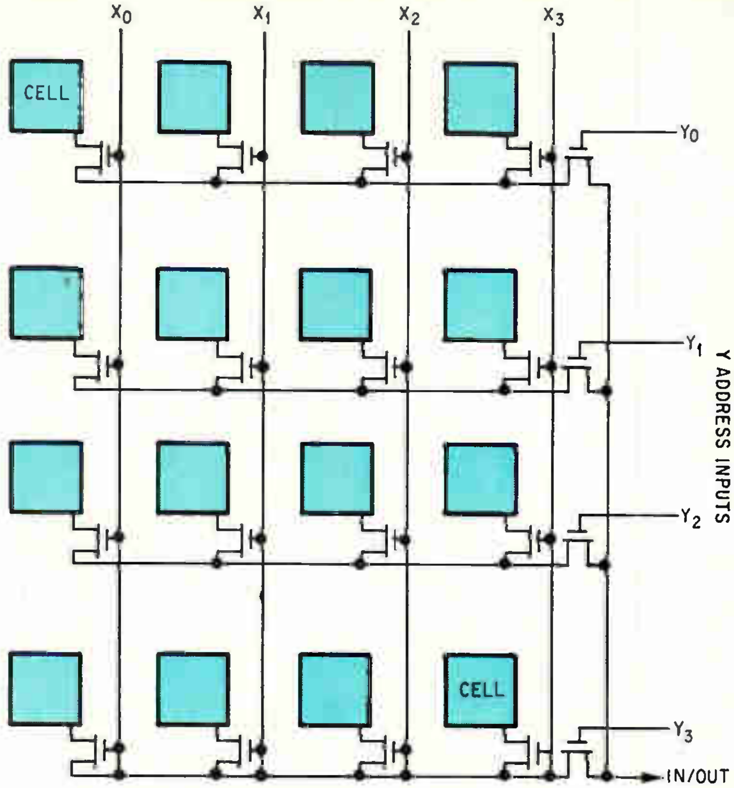
Some time before the next read strobe occurs, a write strobe turns on Q_2. (In the absence of other activity, the read and write strobes occur alternately about 500 microseconds apart.) Because C_1 has Q_3 biased on, C_2 discharges through Q_2 and Q_3 to ground. After the write strobe, therefore, C_1 and C_2 are oppositely charged.

Besides discharging C_2, the write strobe discharges C_3 through Q_4—biasing Q_7 off—and puts a negative charge on C_4. The following read strobe turns on Q_6 and Q_8; with Q_7 off, nothing happens in Q_6, but the negative charge on C_4 is transferred through Q_8 to restore the level on C_1, which may have leaked off somewhat since the last read strobe.

The two halves of the circuit are obviously identical, and their operation is exactly reversed if C_1 is initially discharged. The capacitances are small, as are the resistances of the transistors biased on, so that the charging and discharging can occur very quickly.

Between the read and write strobes, C_2 is always charged to −12 volts and therefore contains no useful information. But between the write and read strobes, the charge on C_2 represents the data stored in the circuit. At this time, therefore, the address decoding transistors, Q_x and Q_y, can be turned on, transferring most of the charge on C_2 to C_5. The latter is the parasitic capacitance on lines external to the circuit and is as much as two orders of magnitude larger than C_1 and C_2. The voltage on C_5 is therefore much smaller than the one on C_2, but it is still well above the threshold of an ordinary sense amplifier.

If transistors Q_x and Q_y are turned on at the time of the write strobe, C_2 and C_3, instead of discharging, acquire whatever voltage level is impressed on the output line and on C_5 by a write driver. The following read strobe transfers the newly written information to C_1—discharging it if C_3 is charged, charging it if C_3 is at ground.



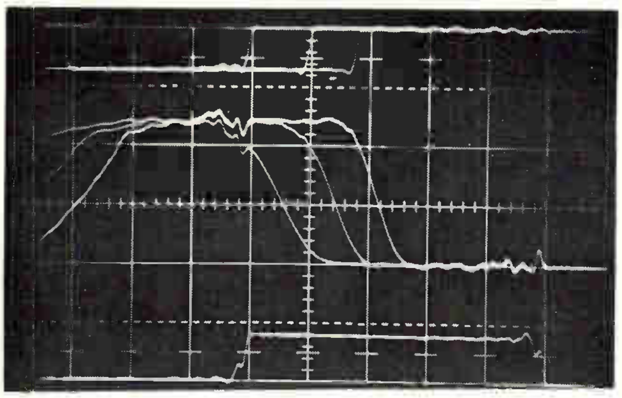
Common address. Single transistor to access full row increases array density and decreases output capacitance.

These dynamic circuits are examples of two-phase clocked circuits, but other versions require more or fewer phases. Where, for example, four-phase clocking is employed, the phase pulses often relate to different stages and overlap in various ways to improve circuit operation. These multiple phases, however, place an additional burden on the systems designer, who has to provide properly timed phase pulses over a wide area.

Two-phase dynamic storage elements have been laid out on silicon slabs as small as 16 mils square —less than half the area required by the d-c cell. With such a small area, a 256-bit array can be fabricated on a chip only 100 mils square; and a 512-bit random-access array and 2,048-bit associative memory are not far off.

Although the diagramed d-c and dynamic circuits include both x and y addressing transistors, only one such transistor is actually needed for each cell in the array. The other can serve a whole row of cells, as shown above. Using two transistors on every cell not only unnecessarily increases the area of the whole array, but means that all the cells must produce an output on a single common line, presenting a large capacitive load.

In the 16-by-16 cell array, any one cell can be addressed by driving one of the x and one of the y lines. This partial decoding method requires a minimum of silicon area and achieves the maxi-



Slower when hot. Traces are, top to bottom, input, memory output, and load output, repeated at −55°, +25°, and +125°C. This unusual slowing, characteristic of MOS, follows because circuit is an RC network with positive temperature coefficient of resistance.

mum possible speed. However, it also requires 32 address input leads, and the external decoder that selects two of these 32 leads as an address must have a supply voltage greater than 5 volts because the gate of an MOS transistor must be at least 5 volts more negative than the source and drain if the device is to turn on. But the drain voltage in the decoder equals the gate voltage in the array because the two are electrically common; if the array operates from a 5-volt supply, therefore, a higher voltage is needed in the decoder.

Full decoding on the chip permits selection of the x and y lines from a single binary input address—eight lines in the case of the 256-bit array. This setup can be driven with TTL-compatible input signals, but the extra circuits dissipate more power, add about 100 nsec to the access time, and take up space on the chip. The most straightforward decoder would use 32 four-input NOR gates and eight inverters to generate the address-line complements. A more sophisticated decoding matrix would use fewer gates but add delay. ■ ■

Memories XI

Cutting systems costs with MOS

By Lee Boysel

Fairchild Semiconductor, Mountain View, Calif.*

The great strides made in the past year in developing metal oxide semiconductor memories—both read-write and read-only forms—reflect the technology's potential for cutting costs.

Read-only memories are taking on many applications, including control as well as pure storage functions; and automated mask-making simplifies the task of reworking a read-only memory.

Read-write memories are built of pure MOS or bipolar assemblies, or in hybrid arrays containing both types of circuit, and are available in a wide range of capacities and speeds.

Large dynamic MOS read-only memories are now available in sizes from 1,000 to 5,000 bits and at projected volume prices of a half-cent a bit. These low costs should give these arrays jobs as microprogram sequencers, hard-wired memory subroutines, tables of data, and alphanumeric character generators. They may also create interest in the relatively unexplored area of random control logic.

This form of logic includes distributed controls and common bidirectional data buses. The latter route data from any register in a group to any other, with appropriate input and output gating to control their paths rather than separate connections between every pair of registers.

Distributed controls represent a new departure from control techniques in conventional digital systems—a departure that is becoming feasible only with large-scale integrated circuits. The collection of logic gates in the system that control timing and data routing would be controlled in turn by signals that are additional inputs to the chips, where they're decoded internally. The technique requires a number of redundant gates, duplicated on different chips, but it sharply reduces the number of interconnections; in LSI, interconnections cost money, but gates don't.

Both of these techniques reduce the number of pins per package and give gate-to-pin ratios as high as 10 or 15 to 1—thus simplifying the problem of partitioning the system into modules.

Decentralized control

Read-only memories are ideal means for implementing random control logic, particularly in an LSI system. For example, a read-only memory acting as a sequencer can drive a bank of eight parallel memories, each containing 256 words of 64 bits each. The bank's output is thus a long word of 512 bits, each of which is an input to one or more standard logic blocks in a data-flow path.

Such decentralized control memories typically contain about 10 bits for each gate they replace, representing at least 90% of the total control logic and 40% to 50% of the system's components. The

* Now with Four-Phase Systems, Inc., Palo Alto, Calif.

Read-write memories

Type	Bits	Access Time (µsec)	Full Cycle Time (µsec)	Power Per Bit (mw)	Power Per Chip (mw)	Pads	Chip Size (mils)	Probable Volume Price Per Bit (Cents) 1970	1971-72
Static p-channel	32	1	1	2	64	14	65x65	20-30	10-15
Static p-channel	64	2	2	2.5	160	16	90x90	15-25	7-12
Static p-channel	128	3	3	3	470	17	125x125	—	10-15
*MOS/bipolar drive & sense	64	0.2-0.3	0.2-0.3	1	32	24	70x70	8-10	3-5
*MOS/bipolar drive & sense	128	0.2-0.4	0.2-0.4	1	64	32	90x90	8-10	3-5
*MOS/bipolar drive & sense	256	0.2-0.5	0.2-0.5	1	128	40	120x120	8-10	3-5
*MOS/bipolar drive & sense	512	0.3-0.6	0.3-0.6	1	256	56	170x170	8-10	3-5
4φ dynamic	256	1	2	0.2	50	20	95x95	4-5	3-4
4φ dynamic	512	1	2	0.15	80	22	125x125	5-7	2-3
4φ dynamic	1,024	1.5	3	0.1	100	24	150x150	—	2.5-3.5

*Hybrid subassembly

remaining control logic is combined in an array of conventional logic gates—the same kind as those used in the data-flow path.

This approach to random control has three benefits. First, at a half-cent per bit for the memory and 10 bits per gate replaced, the cost is 5 cents per effective control gate, compared to 10 to 20 cents per bipolar logic gate.

Second, in a system designed around a read-only memory, a 2,000-bit memory can replace a 200-gate LSI array with many fewer interconnections, greatly reducing hardware and assembly costs.

And third, meeting customer demands involves merely specifying the contents of a read-only memory—an easy job with small risk of error, simple documentation and testing, and no rework. Turnaround on an order for such a circuit can be as little as six weeks, compared to several months for a complete custom circuit.

Read-only memories as random control devices have their disadvantages, too, of course. The biggest of these is the fact that errors can't be corrected by the addition of wire jumpers, or the clipping of something out; a whole new mask has to be made. Consequently, the wise course is to simulate the system's operation on a computer before the mask is made, or to first build the memory out of discrete diodes and to then convert to an MOS read-only memory after debugging. Even with this precaution, occasional reworking is inevitable.

To minimize the reworking, most MOS manufacturers either have a fully automated mask-generating system or are planning to install one. When such a system is available, the customer supplies the data that the memory is to contain on punched cards or on a Fortran coding form that the manufacturer converts to punched cards. These cards are then fed into a computer that cuts the working mask on a plotting table and draws a copy on Mylar. This copy is numbered for documentation and checking purposes because it's very difficult to verify a pattern on a working mask directly. The computer also prints the data in tabular form, prints coding errors if the input is in Fortran, and generates paper tapes for automatic LSI testers.

These computer-controlled systems generate masks rather quickly at very low cost. They keep initial memory development costs as low as $500 on small-quantity orders and permit the customer to receive his complete shipment only a few weeks after placing his order. They also very nearly eliminate masking errors and circuit reworks.

Since read-only memory wafers are essentially identical, they can be mass-produced and stockpiled in readiness for the gate mask and tester code pattern that adapt them to a customer's requirements. Using this approach, the manufacturing lines can produce a single high-volume item with standard packages, test fixtures, and other accessories at very low costs.

Static and dynamic

MOS read-only memories come in static and dynamic forms. Static memories read out and hold indefinitely the word addressed by the input without clocks or strobe pulses; their projected costs during the next few years, with the high-volume techniques described above, are about 1 cent per bit. Dynamic memories have outputs that must be continuously restored at some minimum clock rate, and it's their costs that are expected to drop to about a half-cent per bit.

In a static memory, the address decoder and the memory matrix itself must be made of NAND/NOR gates with large fan-ins and resistances. The matrix as a whole looks like a large capacitance when

Read-only memories

Type	Bits	Access Time (μsec)	Power Per Bit (μw)	Chip Size (mils)	Pads	Words x Bits	Probable Volume Price Per Bit (Cents) 1970	1971-72
Static	256	2-3	250	75x75	16	64x4	5-7	2.5-3.5
Static	1,024	3-4	120	90x90	20	128x8	1.5-2.3	0.8-1.3
Static	2,048	8-10	80	125x125	22	256x8	—	1-1.5
4φ dynamic	2,048	0.7-1	50	90x90	24	Variable	0.5-1	0.3-0.5
4φ dynamic	4,096	1	20	125x125	24	512x8	1-2	0.3-0.5

viewed from the input. Charging the capacitor through the resistance takes time, so that access is gained to a static memory in 3 to 4 microseconds. These arrays also dissipate something like 150 microwatts of power per bit.

At the present state of the art, a 1,024-bit static memory can be fabricated at lowest cost on a chip 90 mils square cut from a 2-inch wafer. A memory with twice the number of bits on a somewhat larger chip is feasible, but its greater parasitic time constant would slow its access time to about 10 μsec. Furthermore, a 90-mil-square chip gives the maximum yields per bit under present production-line conditions. A memory twice as large could be built on a chip 120 to 130 mils square, but this size isn't expected to be economical until the early 1970's.

Dynamic read-only memories typically provide twice the bit density, five to 10 times the speed, and a quarter the power consumption of static memories. The 90-mil chip can hold 2,048 bits; again, a larger chip with more bits is feasible, but it will cost slightly more per bit. In applications where pin count, size, and power dissipation are critical, however, the extra cost is justified.

Storing and fetching

Read-write MOS memories come in three major forms: complete assemblies of p-channel MOS devices, p-channel storage cells addressed by bipolar decoders and containing bipolar sense amplifiers, and complementary systems using both p-channel and n-channel devices. And they come in three performance levels: high-speed scratchpad memories of a few bits with access times of a few nanoseconds; medium-speed, medium-capacity memories; and rather slow bulk-storage units.

The applications of high-speed scratchpads, the oldest form of semiconductor memory, generally justify costs of a dollar a bit. Bipolar integrated circuits dominate this area at present, though, and probably will continue to do so.

Medium-performance memories are most practical at today's state of the MOS art. In the range of 32 to 256 bytes (256 to 2,048 bits), bipolar circuits are prohibitively expensive and magnetic memories are inefficient. Typical MOS costs of 25 to 50 cents a bit are therefore justifiable.

Fairchild Semiconductor recently announced a static p-channel read-write memory with 64 bits on a chip 90 mils square. Each bit is accessible in 2 μsec and dissipates 2 milliwatts. This unit is priced at 25 cents a bit in large quantities.

The third level—bulk storage—is the most attractive for solid state technology in terms of potential profit, but it's also the most difficult to attain because of the entrenched position of ferrite cores and other competitive technologies. The most common approach in this class is an array of MOS flip-flops driven by bipolar decoders and sensed with bipolar sense amplifiers. However, the bipolar circuits dissipate considerable power, and the MOS chips require a large number of leads because they must be on separate chips within a hybrid package.

One solution to these problems lies in the use of a quasi-static four-phase circuit with dynamic decoding on the chip. This circuit requires a four-phase clock and continuously circulates data bit for bit within itself. To the outside world, though, the memory as a whole looks like a d-c circuit—hence the designation quasi-static. The cell itself occupies only about a third the area of a static flip-flop, but the chip area is about two-thirds that of a static memory with an equivalent number of bits because of the space taken up by the decoding circuits. This size reduction, together with the eliminated bipolar circuits, halves the cost—but at another price.

That price is in performance. A dynamic read-write memory is limited to a 1-megahertz clock rate, corresponding to a 1-μsec access time; its full cycle time is just twice its access time because the data has to be regenerated after being read out. Nevertheless, just such a memory, holding 256 bits, dissipating 0.2 milliwatts per bit, and containing all decoding read-write controls and two bidirectional input-output buses, is now available. Its price for delivery this year is about 7 to 10 cents per bit, but this is expected to drop to about 4 or 5 cents in 1970. The MOS-bipolar system's cost is two or three times as much.

These figures, along with those quoted for speed, may seem conservative when compared with some recent optimistic forecasts. However, they will appear on data sheets in the foreseeable future and are therefore quite realistic. ■ ■

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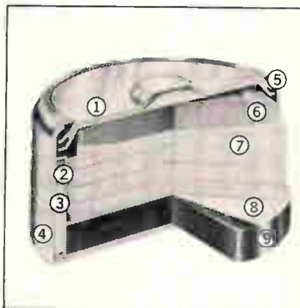

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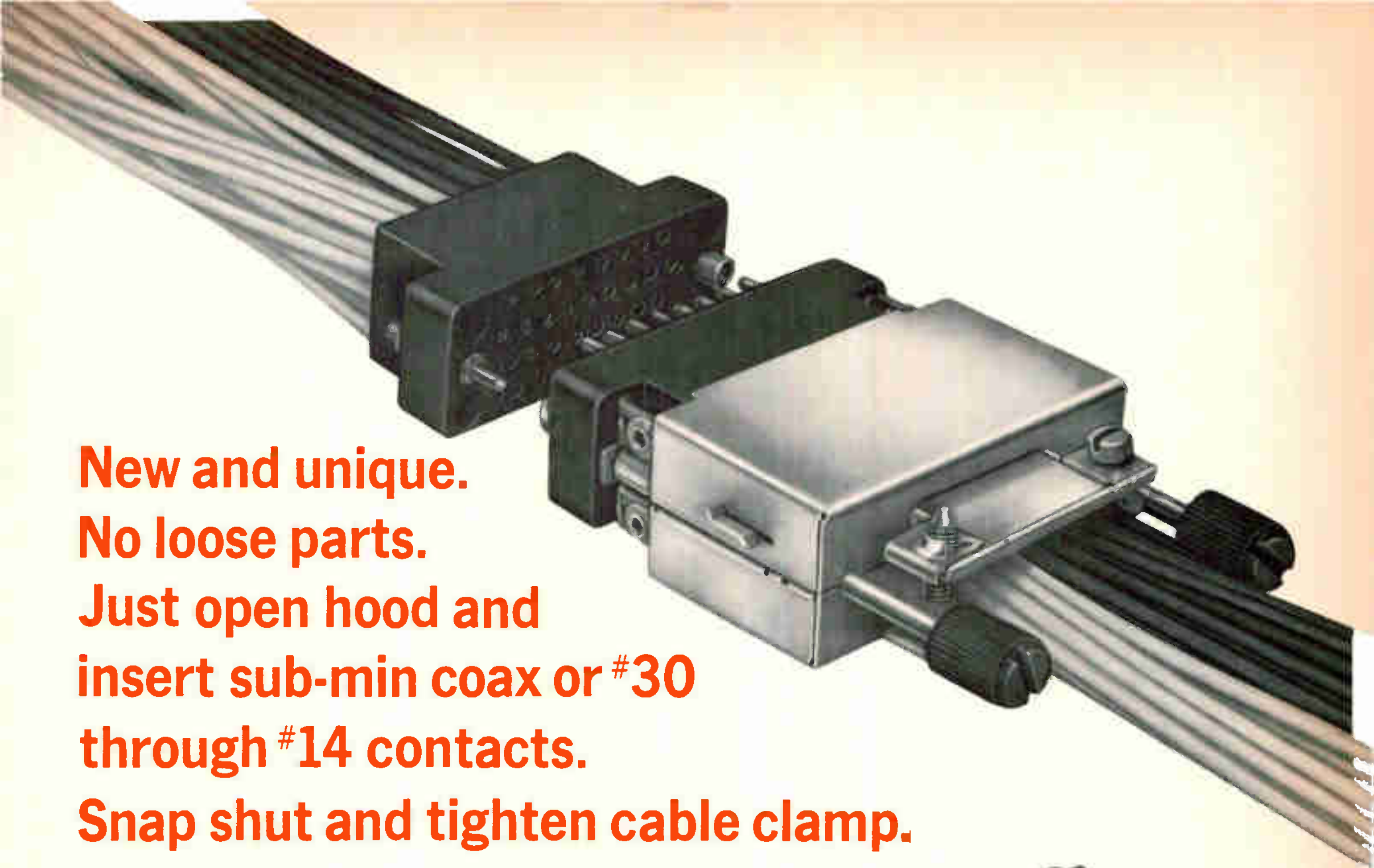

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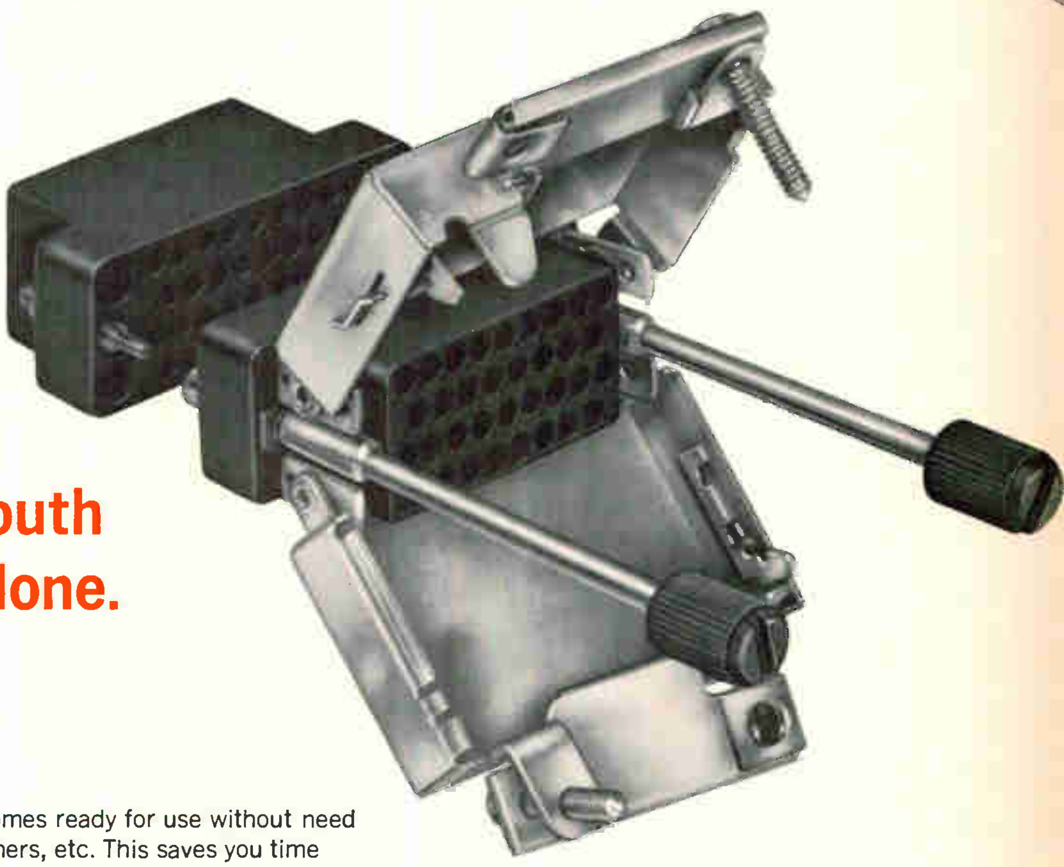

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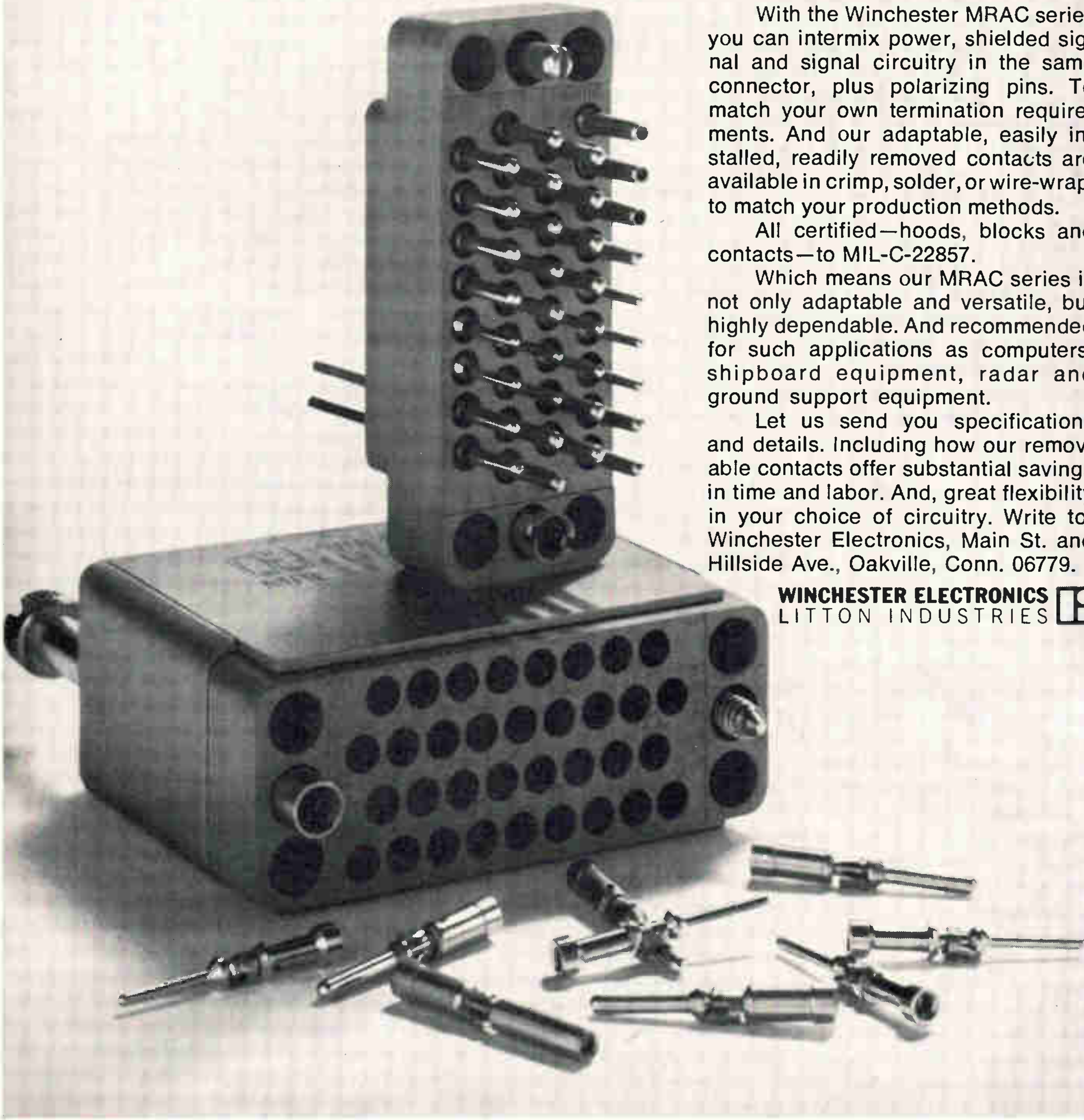

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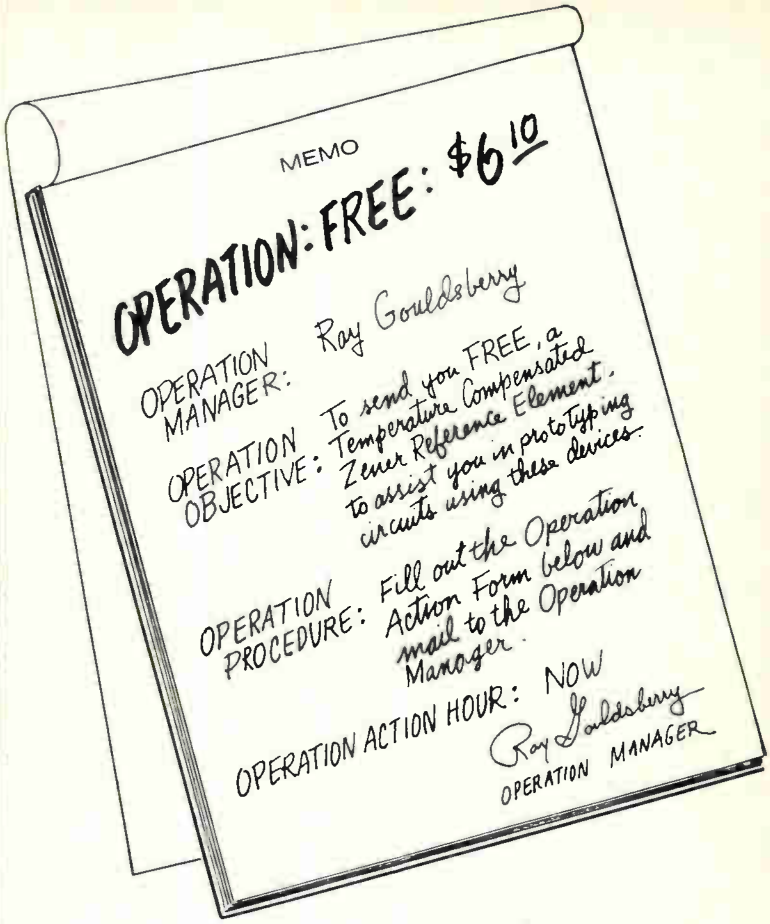

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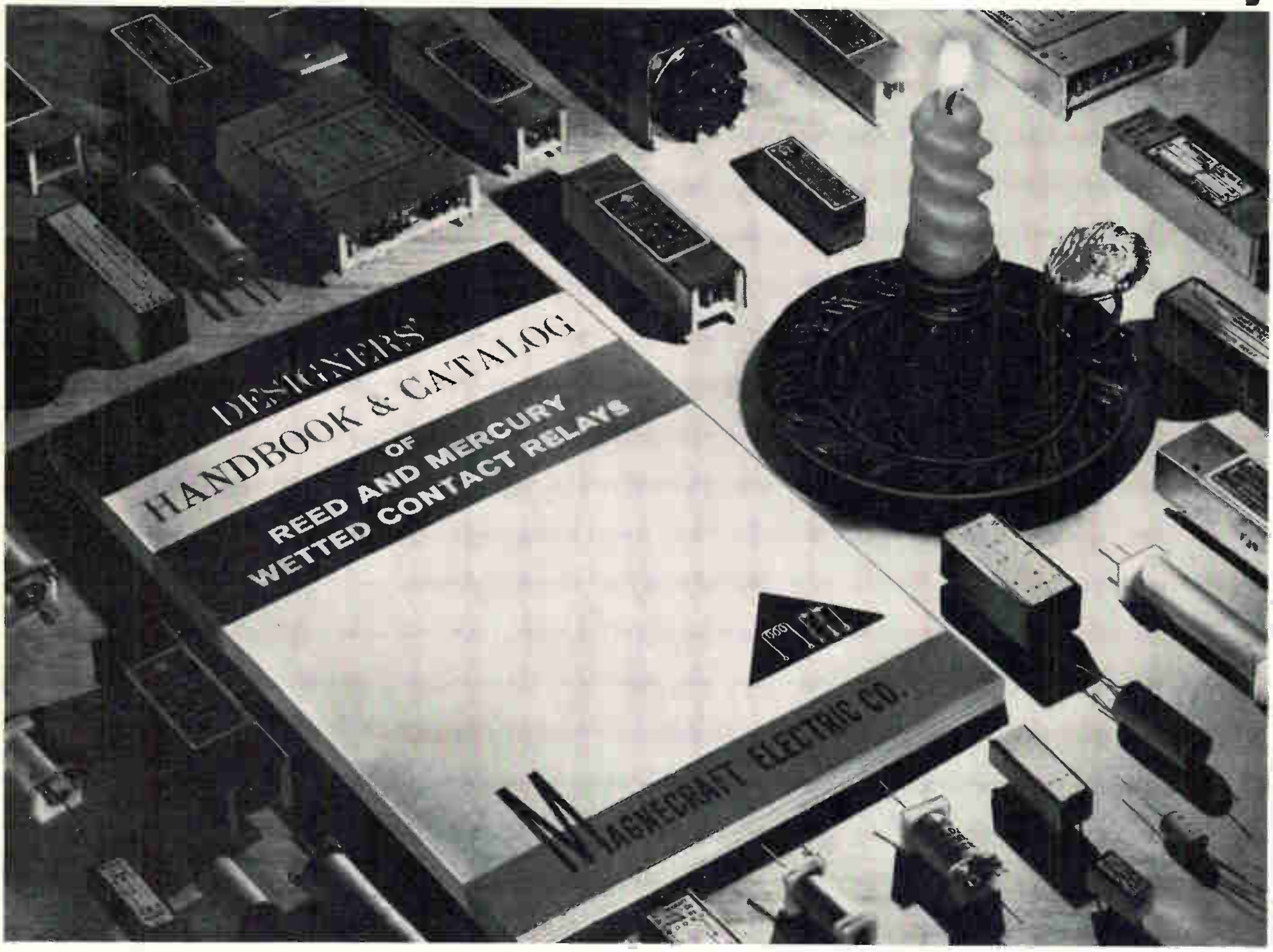

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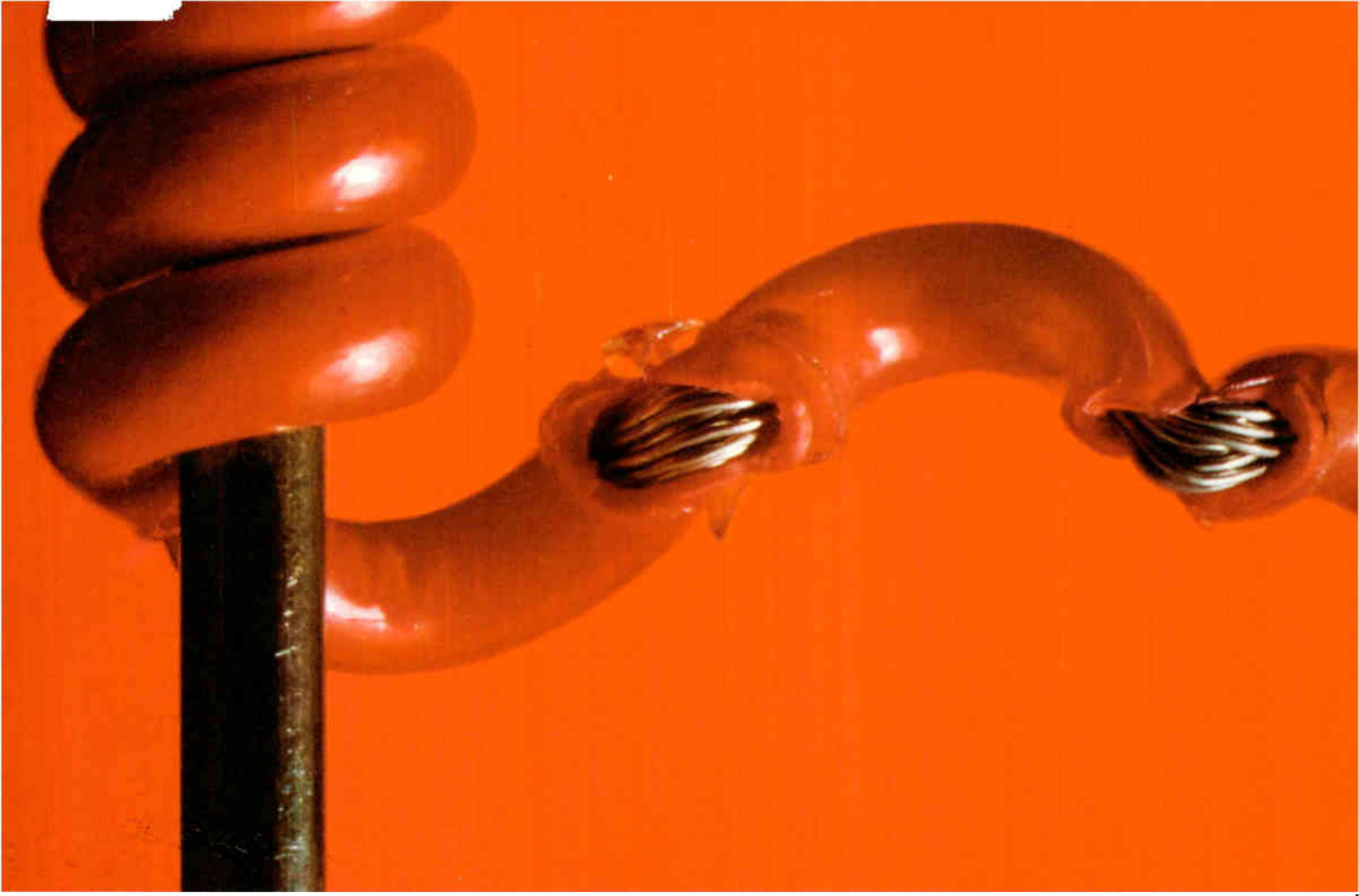

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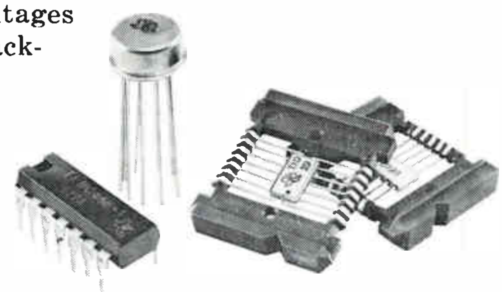

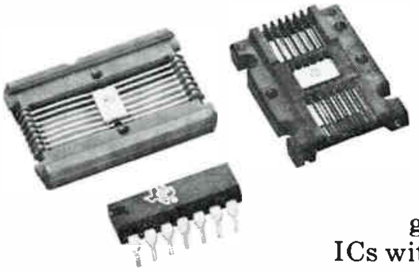

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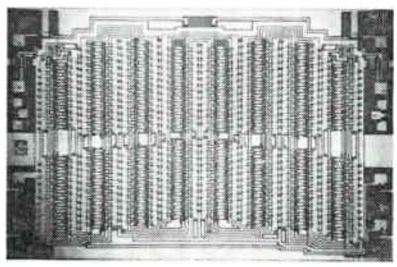

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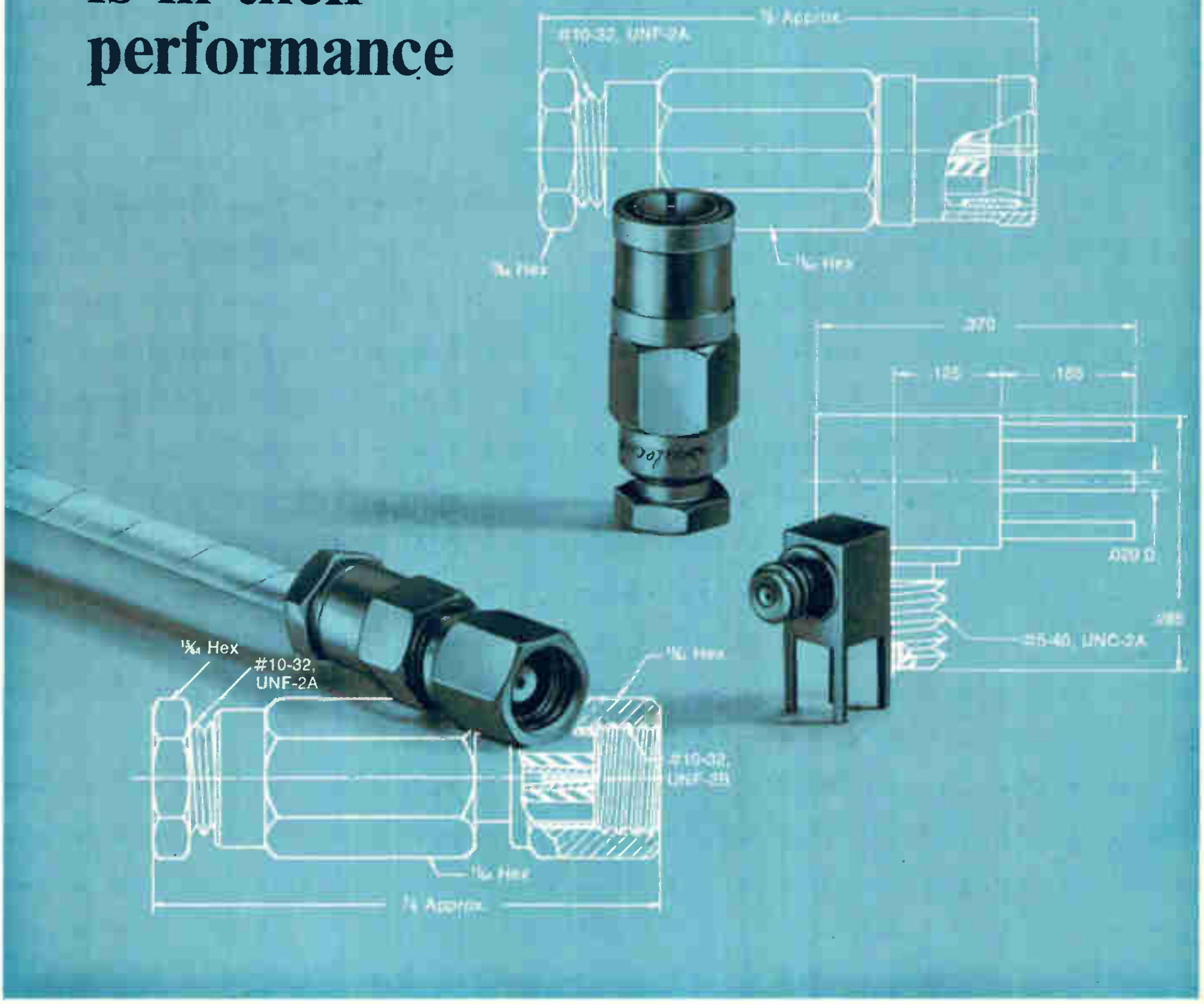

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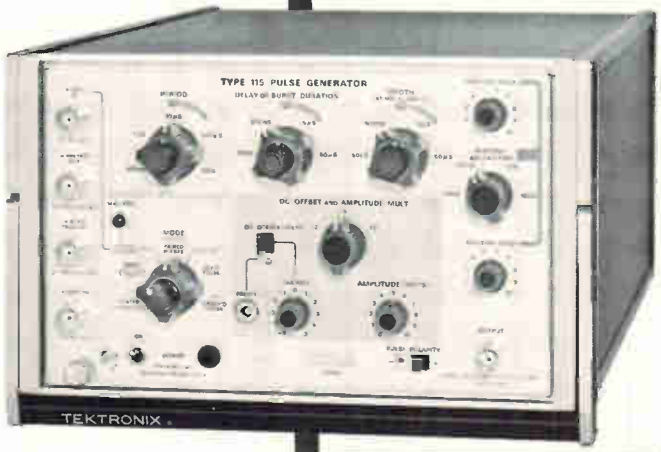

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Getting more mileage from computers

SRI group is developing an experimental system to bridge capacity gap that's attributed to users' limited experience with advanced equipment

By Wallace B. Riley
Computers editor

The computer field, for all the advances in speed and performance that have been recorded during recent years, still has a way to go in realizing the full potential of machines and associated hardware and software over a broad range of applications. In a nutshell, the systems design art has outstripped the ability of owners and operators to make the best use of what's available to them.

That's the opinion of Douglas C. Engelbart, who's doing something about the situation, as well as others in the field. He heads the Augmented Human Intellect Research Center at the Stanford Research Institute in Menlo Park, Calif. Since the early 1950's, Engelbart and his colleagues have been addressing themselves to this capacity gap, which, he says, is largely attributable to lack of experience. At the moment, the center's crew has designed and assembled an impressive and complex system of hardware and software that represents a sort of halfway house on the road to the solution of the problem.

The center's work is being underwritten by the Pentagon's Advanced Research Projects Agency, the National Aeronautics and Space Administration, and the Air Force's Rome Air Development Center. Earlier, the Air Force's Office of Scientific Research was a participant.

Most observers applaud Engelbart's efforts and give high marks to his ideas and progress to date. And, in the main, such criticisms as are advanced are from traditionalists or those who express preferences for different individual hardware elements.

The principles and goals of the center's work are abstruse enough for Engelbart, himself, to resort to analogy when outlining them. For openers, he compares the state of the computer art to transportation around the turn of the century, when only a few automobiles were chugging about the countryside. Their usefulness was limited because roads were scarce and service facilities were largely confined to blacksmith shops. By contrast, today's cars, which come equipped with all the equipment and instructions needed to operate them satisfactorily, are the beneficiaries of a vast support network that includes superhighways, rules of the road, filling stations, mechanics, parking lots, and the like. A great deal of practical experience has accrued from the evolving designs of automobiles, says Engelbart. Partly because of hothouse growth, the same is not true of commercially available computers.

Foreshortening. Engelbart's organization is working toward plugging the breach. To this end, they've integrated a computer system that includes, among other things, an unusual display presenting the contents of a file, a standard typewriter keyboard along with two other input devices for modifying the file, and a set of functions that permits a user to add, delete, or change information in the file almost as fast as he can think—and far faster than an observer looking over his shoulder can follow.

A user can work comfortably and efficiently for hours with the system. He can compose new material and study data already on file, modifying or displaying it to various depths—a procedure that's analogous to looking at labels on file drawers, labels on folders in one of the drawers, headings on the papers in the folders, or the contents of the papers. In addition, the operator can edit, move big chunks of data around quickly, and make as many copies as he wants, either in the computer or as paper printouts, more readily than he could with typewriter, pencil and paper, or other media. An operator can also work with vectors and alphanumerics to draw pictures and

Chairman. Douglas Engelbart, who heads SRI computer project, sits in special console-equipped chair developed by Herman Miller for experimental system.

. . . most definitions of the user system are almost laughably inadequate . . .

diagrams in the file.

"The true measure of any kind of system is its value to the user," says Engelbart. By this yardstick, the center's set-up appears very valuable indeed—at least to those unburdened by traditional ways of thinking about intellectual processes. But the center's track is by no means completely clear. Returning to his transportation analogy, Engelbart points out that "traffic jams" could prove a serious problem for interactive computation. "However, transportation systems are inherently limited to two dimensions—three in the case of air transportation," he says. "Computer systems have the potential for multidimensional expansion, with no limit in sight today."

Virtually all computer experience accumulated to date centers on equipment and associated services, including software. What's needed, Engelbart believes, is a vast body of user-related knowledge to extend the level of interaction with the system. He finds most definitions of the user system almost laughably inadequate. And, he says, the same is true of the interface between the user system and the computer system.

Old school ties

For example, a great deal of work has been done to develop equipment and techniques that combine advanced electronic equipment with the most primitive data-manipulation methods. These include various kinds of pens and tablets for "drawing" on a cathode-ray tube—a situation that ties electronic manipulation of data to traditional pencil-and-paper techniques. This procedure is grossly inadequate, says Engelbart, because the data rate is necessarily several orders of magnitude slower than the user's train of thought.

Test case. The kind of problem that must be solved in designing a user system and its interface with a service system is illustrated by an analysis of what's involved in inserting a character in a word or adding a word in the middle of a sentence. The task includes three elements—the command, "insert," the entity to be inserted, and the place to insert it. To design such a capacity into a system, along with dozens of related functions, requires thinking several levels above the user-system/service-system interface and even further above specific hardware or software design details.

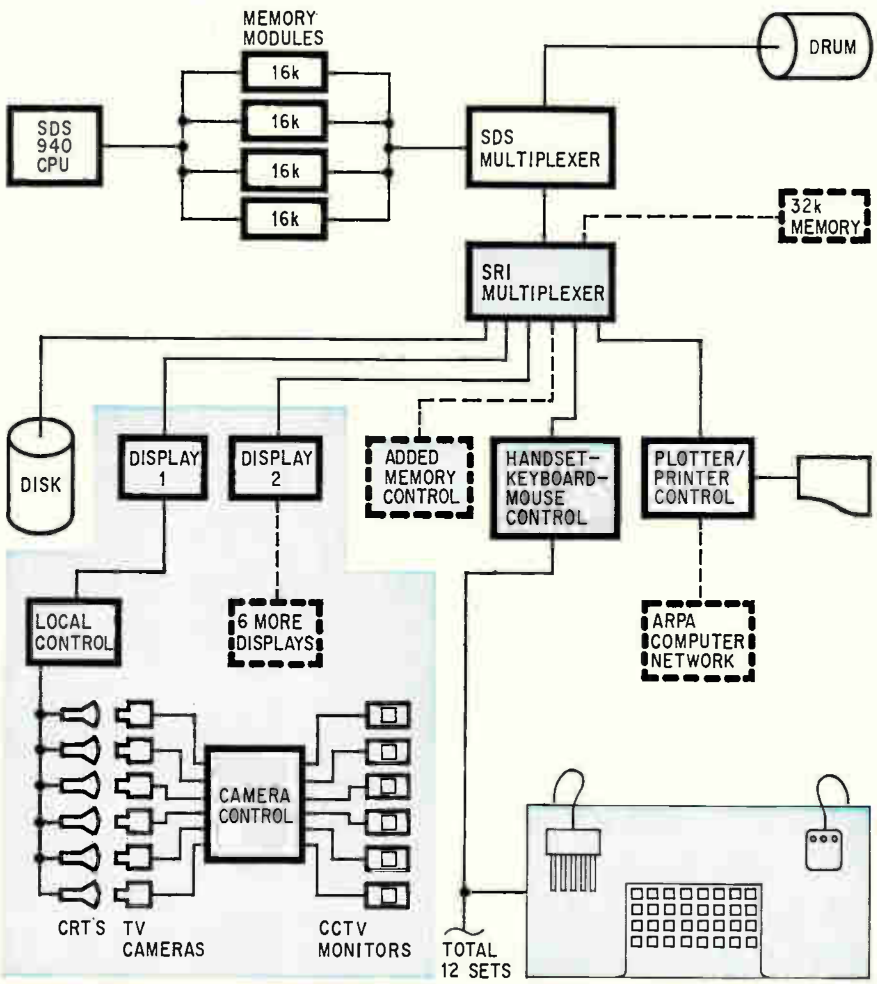
At the outset, Engelbart faced the problem of just how to begin. He realized that neither engineers nor users could adequately define an entire system that would prove to be most useful. Fortunately, his research team included individuals with a wide range of interests, aptitudes, and skills. Engelbart's happy inspiration was to use his staff, which now numbers 17, as its own subject group—building, experimenting, asking "why not . .?" and then trying something else in a heuristic bootstrapping operation. The staff thus develops the tools and techniques required to carry out its assignment, living up to the project's goal of augmenting human intellect.

Conglomerate

In their working system, Engelbart and his research team have used some quasi-conventional hardware and software, together with some unusual new design—originated at the institute or borrowed from other organizations working in the computer field.

At the heart of the center's project is a Scientific Data Systems 940 computer with four memory banks of 16,384 words each. Controlling the 940 is a time-sharing program developed at the University of California at Berkeley and later made commercially available by SDS.

One of the 940's distinguishing features is its double memory bus,



Double bus. The SRI system's computer memory is simultaneously accessible from the processor as well as special and conventional peripheral equipment.

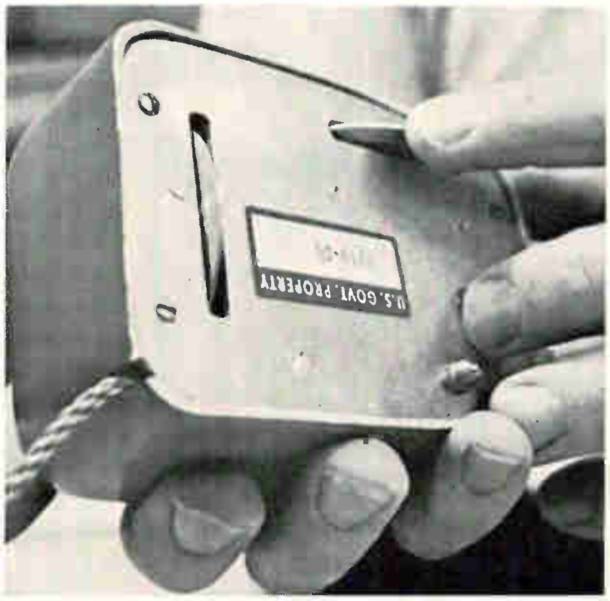
which permits the central processor and peripheral equipment to use memory simultaneously in most cases without interfering with one another. Only when the data sought is in the same module must one or the other give way.

With the double bus, the displays can be refreshed without loading down the central processor. Since displayed information is usually in one module, while the processor is working with another, refreshment can be handled directly from the main memory without an intervening buffer.

Bus schedule. All the conventional and off-beat equipment is connected to the second bus. The former includes a fast magnetic drum, a disk file, and a line printer, as well as provision for eventual connection to the Advanced Research Projects Agency's nationwide computer network [*Electronics*, Sept. 30, 1968, p. 131]. This apparatus has to be multiplexed onto the second bus. The standard SDS multiplexer doesn't have the capacity for this, so it handles only the drum and another special multiplexer designed and built by the center staff. A complex priority scheme wired into the multiplexers decides which device gets access to the memory when two or more conflict.

One of the unusual devices in the system is a crt display with a closed-circuit television link. A controller in the multiplexer drives six conventional display systems, which include the necessary character and vector generators, digital-to-analog converters, and the like. The crt in each display, however, measures only 5 inches in diameter and faces a television camera that transmits the image over a coaxial cable to a receiver, which replaces the usual display. The tv camera has 875-line, rather than 525-line, resolution. In addition, such equipment is cheaper than a scan converter.

Good deal. This approach has several advantages. The 5-inch crt's are much cheaper than larger units of less precision. Some of the saving on the tube cost goes for the tv setup, but there are other benefits that could be realized in no other way. One of the most important is that the crt's need be refreshed only 15 times per second. This slow rate causes a flicker on the crt display that is severely fatiguing to watch—for direct viewing a refresh rate of 30 per second is a minimum and 60 per second is preferred.



Inputs. Conventional keyboard is in parallel with 5-key handset, whose combinations correspond to individual keys. At user's right hand is a "mouse," the movements of which on any smooth surface are duplicated by a spot, or "bug," on the display. Shown inverted at left, the mouse has two wheels and a ball bearing for three-point support.

The slow refresh rate, however, permits a single controller to generate separate displays on several crt's, and the flickering is absorbed in the tv camera's vidicon. A vidicon image remains nearly constant for a short time before beginning to drop off—as contrasted with the nearly exponential decay of the crt phosphor. Broadcast tv cameras are adjusted to minimize this lag time; the center's cameras are adjusted to maximize it. As a result, the image is retained long enough so that the flicker in the tv receiver is hardly noticeable to most persons, except where parts of the display change rapidly.

Another advantage is that only a single coaxial cable is required from each television camera to its receiver; five cables would be needed to drive a remote display directly. And finally, a simple switch in the tv control system inverts the polarity of the signal. As a result, the display is black on white, rather than the white or green on black that is typical of most displays.

Animal kingdom.

The principal input device in the system is an ordinary keyboard, of the same type used with many crt displays. Characters, words, or statements, "typed" on the keyboard, appear on the display. They may show up at the top or at a point indicated by a "bug," a spot serving as a pointer, controlled by a "mouse," which is a small device resting on the tabletop near the user's right hand. The mouse is supported at three points—two wheels on perpendicular axes and a ball bearing for stability. As the user pushes it this way and that on the table, the wheels turn; analog sensors detect the motion, causing the bug to move on the screen, in tandem with the mouse's table track. When moving rapidly, the bug seems to have a long tail; upon close examination, however, the bug is seen to move in a series of small jumps, leaving a fading footprint, which creates the illusion of the tail. The lag time in the vidicon causes this; it's the only really noticeable effect and has no serious consequences on the system's operation.

Most of the commands in the system are represented by combinations of two or three characters. When issuing commands from a

Remote pickup. Closed-circuit tv provides low-cost precision display.

standard keyboard, the user must move his hands around on the keyboard and take his eyes from the display. Both actions tend to generate confusion and fatigue. To overcome these difficulties, the center staff has designed a small five-key handset that duplicates nearly every function on the keyboard. There are 31 ways to depress the five keys (not counting the "all-up" combination). These correspond to the 26 letters of the alphabet plus five special characters in an easily memorized code. With his left hand on the handset, his right hand mov-

. . . the mouse is slated for more human engineering . . .

ing the mouse and operating three control buttons on top of it, and his eyes on the screen, the user can work for hours with minimum fatigue.

At ease. One recent development that pleases Engelbart and his staff very much is a swivel chair that includes the keyboard-handset-mouse setup; it was developed by Herman Miller Inc., a leading furniture company that has become interested in the center's activities. Lounging in the chair with a tv set before him, a user can work creatively in comfort.

The center staff has ambitious plans for the future. For example, it expects to enhance the system's memory capacity through the special multiplexer and to add six more displays. Further experimental work has also been done with several new versions of the basic five-key handset. One staffer has even suggested a special glove with miniature switches in the fingers. More human engineering on the mouse appears likely as well. At the moment, it's basically comfortable to work with, but the three control buttons are awkwardly located for some functions.

More importantly, the center hopes to refine the system for group interaction, including multiple access to files for both reading and writing information. Since members of the groups may not be in the same room—they may even be continents apart—this requires computer-controlled audio circuits. Furthermore, with the closed-circuit tv in the display system, computer-controlled picture juggling should be possible—complete with such effects as split screens and superimposed images so that different files can be compared.

One of Engelbart's more exotic ideas is to have a tv camera on the display itself, pointing at the user and transmitting a shot of his features to the central system. This would permit members of an interactive group to see each others' faces—a potentially important feature since in personal meetings much information is often transmitted through gestures and facial expressions. ■ ■

Engineers accept the risk of layoffs as part of the game in defense field

Attempts to form union make little headway; contractors and Government are standing pat although the high turnover boosts costs and lowers efficiency

By Peter Vogel

Assistant editor

Shortly after Robert Talbott was laid off by the Lockheed Missiles & Space Co. in Sunnyvale, Calif., he noticed that one of his sons had developed a forced laugh. "It made my hair stand on end," Talbott says. He knew where the boy had picked up the habit: from Talbott himself. "I laughed at the boss's jokes, I laughed at the possibility of being laid off, and I laughed at the possibility that I might not be able to find another job if I were."

At home. Robert Talbott has been trying to organize an engineers union since he was laid off by Lockheed over a year ago. His efforts to date have proved unavailing.

A year later, at 37, Talbott is still looking for a job as an aeronautical engineer. Though he was subsequently rehired after being surplussed, Talbott spent much of his time trying to organize a union among Lockheed engineers, and was fired for cause—recruiting on company time.

Talbott's response to being surplussed, however, is not particularly typical in his profession. Most engineers, probably because of the relatively high pay scales, accept the insecurities of working on defense contracts as a necessary evil. Talbott and others have found that engineers apparently aren't ready to accept unionism as a panacea for their problems.

Talbott claims he's been blacklisted as a result of his attempts to form a union—the American Association of Scientists and Engineers. But for the thousands of other engineers in the defense field who simply cash their severance checks and move on, the situation isn't quite as acute. New jobs are found—sometimes in their own communities, sometimes at the other end of the country. Nonetheless, there are great difficulties involved in having an essentially transient engineering population. And they've received more and more attention since the mass layoffs of the 1962-64 period.

For one thing, layoffs at Pentagon contractors deplete the value of the defense dollar. It costs an average of $3,000 for a company to recruit an engineer and pay his relocation costs. These outlays are written off to the Pentagon as overhead.

A study prepared for the Pentagon three years ago by the Stanford Research Institute concludes that the high turnover in the defense industry's salaried personnel and the associated expenses are "a major factor in the inflation of research and development costs." The SRI report also charges that the comings and goings of engineers contribute substantially to inefficiency in the defense industry. Richard S. Ostberg, a group manager with the Electronic Systems division of Sylvania Electric Products in Waltham, Mass., spells this out: "When the end of a contract is in sight the better people often leave for a more secure job." Robert Kutz, a digital design engineer at LTV Electrosystems in Dallas, agrees. "Once rumors of layoffs get started, the whole plant runs scared," he says. "Production

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Who gets the ax?

Engineers often get the uneasy feeling that their employers regard them as pawns on the corporate chessboard, worth using to gain an advantage but expendable when the game calls for a sacrifice. And they may not be wrong. Israel Katz, dean of the center for continuing studies at Boston's Northeastern University, believes that engineers are ill-used by top managements who generally don't understand their importance in the corporate scheme of things.

"Managers often don't appreciate the engineers' role in expanding a company's horizons," he says. "As much as 10% of their investment should be allocated to risky, speculative projects that could open up new outlets. At the same time, engineers should also stretch, upgrading their abilities. It's a two-way street."

Poor grades. Katz characterizes management performance in layoff situations as "miserable" when it comes to determining who will go and who will stay. "There's no practicable method of determining technical competence," he says. "As a result, managers take refuge in myths, regarding their older personnel as obsolete and expendable. They believe their younger staff know all the latest things and can get the company into new areas at less cost because of their lower pay scales."

In reality, says Katz, it is the older engineers, the leaders in their fields, who have the contacts and know the customers. "A company generates its own competition and may well lose accounts when it lets a seasoned hand go," he says. "Younger engineers have had a theoretical education, but because of experience gaps, they lack the know-how to contribute creatively. You learn on the job, not at school."

Katz says that present methods of evaluating performance are ineffective because they rely on such variables as personality or the ability to "be a good team member." Katz has compiled a scholarly—but practical—list of measures for determining the contribution of an engineer to business, as well as for gauging his potential for growth. Katz's criteria, which are quantitative rather than qualitative, cover such general areas as activity, peer-group recognition, and acceptance by customers and superiors, as well as such specifics as the number of patents held, number of proposals submitted, and frequency of contacts with customers. "This sort of evaluation takes more time. And it's more work than most want to take on, so it isn't often used," he says.—**Gail Farrell**

goes to pot, and you can't help worrying about when you are going to be axed."

Personal bias. Efficiency and costs are not, however, the overriding concerns among the engineers who are laid off. For example, Lockheed's total employment dropped from 30,126 last February to 25,500 in October, as the Poseidon missile program moved from development to production. Between 800 to 1,000 persons were laid off; the rest of the drop was due to attrition. Talbott is still bitter: "We were surplus. Like something that's traded on a commodity exchange."

Many engineers have to move to find new jobs. Israel Katz, dean of the center for continuing studies at Northeastern University in Boston, points out that they consequently cannot put down roots. "What about the communities in which engineers live?" he asks. Those who don't expect to remain in one spot, he says, will not take part in community activities—even though their education and experience qualify them to assume leading roles. A transient will not be as ready to vote for, say, school bonds. The excellence of education in a given area may seem irrelevant to a man who may sooner or later be forced to move his family.

Getting the message. There is evident pride among corporate officials that mass layoffs, like those that occurred in 1962-64, have not been repeated. However, this doesn't necessarily mean that engineers are any less migratory. Now they're quitting before they're fired. Sources at the Hughes Aircraft Co., Culver City, Calif., put the matter delicately: "The need for mass cutbacks among professionals is usually alleviated by attrition as a result of prior knowledge of contract termination or cancellation."

Hughes officials also cite "pressures from Congressmen and others on behalf of their constituencies" as a factor now working to stabilize the engineering work force. Nonetheless, R.P. Loomba of San Jose (Calif.) State College, a professor of electrical engineering who has specialized in the employment problems of EE's, points out that the change in Administrations in Washington in 1963, after the assassination of President Kennedy, played havoc with the regional allocation of defense funds.

Data compiled by both SRI and the Manpower Group at San Jose State indicate that as many as 23% of all engineers leave their jobs because of terminations. (The figure does not include those who leave a job voluntarily before they can be terminated. And many managers consider it too high.) "The problem is fundamentally economic," says Mac C. Adams, deputy executive for the Avco Corp.'s Government Products group in Everett, Mass. "The Defense Department would have to provide funds to prevent ups and downs in the aerospace industry, but R&D money has been curtailed by the fixed budget and war production. There can be dry spells during which no new weapons systems are coming along. Under such circumstances, companies can't afford to keep people on. There's no magic way of avoiding this. Government and industry are very conscious of the problem but have learned to live with it; it's part of the nature of things." However, Adams concedes, "we could all manage better."

A source at LTV Electrosystems agrees. "Better long-term planning and scheduling by both companies and Government procurement agencies could reduce the number of layoffs," he says. A similar suggestion comes from Sylvania's Ostberg. "One of the traditional gripes in the industry is the stretchout between proposal and decision," he says. "If DOD were quicker to grant awards, things would be better." Companies are caught in a squeeze, he notes, when a proposal they submitted has not been funded but the engineering staff they've assembled for the project has to be kept intact.

"Suppliers have brought this situation to the attention of Government officials, but they seem powerless to act," says Ostberg. In Washington, however, sources at the Office of the Secretary of Defense see things somewhat differently. "What we're looking at is a normal process—normal private enterprise," says one. "There isn't a crucial problem."

Passed buck. A spokesman in the Office of the Deputy Assistant Secretary of Defense for Installations and Logistics says, "I don't think it's a DOD problem. We make an effort to maintain as many ongoing projects as we can. When engineers are out of work, you might say that nature takes care of it."

What it comes down to is that the Government has done very little to help stabilize the engineering work force. But then, this doesn't appear to be a principal policy objective. "Current Pentagon procurement practices are lessening the stop-and-go aspects," says an official. "But the big idea is not to soften the impact of terminations for engineers and communities. It's to get lower costs and higher quality for the DOD."

Defense agencies now spread a buy over several years, purchasing a portion of their requirements annually. However, follow-on awards are generally put up for grabs. Thus, a contractor may win one year, lose the next, and be forced to make layoffs anyway. The Pentagon also has economic adjustment procedures for large-scale contract terminations. These were put into play at the community level when the B-52 run and the F-105 contract ended. By and large, however, the Defense Department seems not to have heeded the conclusion of the SRI study—for which it paid—that the high turnover of engineers was an area to which planners might "profitably address some systematic attention."

Self interests

Such efforts as have been made to stabilize the engineering work force are largely attributable to managements, acting in their own best interests with an eye to both expense and efficiency. However, as Sylvania's Ostberg says, "There's not much industry can do because we really have only one customer." The net result is that less has been done to stabilize the situation than to make the engineers' migration easier. The root causes of the inefficiency and cost inflation that attend high engineer turnover remain largely untouched.

For example, both the General Motors Corp.'s AC-Electronics division in Milwaukee, and Honeywell Inc. in Minneapolis, go all out to retain their engineers and scientists. If a layoff is inevitable, these firms will try to place affected employees in other divisions or departments. If this fails, AC and Honeywell let other companies in the same geographic area know what kinds of engineers and scientists are available. And when an intercompany transfer is offered, according to both firms, a salary boost is almost always included. But this doesn't mean the transfer is a promotion or will necessarily move an individual to a spot for which he's suited by training and experience.

Lend lease. Lockheed also tries to shift its surplus engineers within the company before letting them go. In addition, the firm has a unique, if modest, plan that permits engineers (especially EE's) to go with another company while waiting for another Lockheed job. The program, dubbed LEND (Lockheed Engineers for National Deployment), covers only 20 or so people at present. But engineers have been placed temporarily with, among others, Dalmo Victor, Philco-Ford, and Stanford University while remaining on the Lockheed payroll.

Talbott, sitting among the stacks of mimeographed papers that outline the objectives of his American Association of Scientists and Engineers, says: "The DOD and defense contractors could do something about engineers' job stability if they wanted to. But nobody has put enough pressure on them."

But Talbott has no illusions about what a union could do immediately. As a long-range objective, he hopes the AASE will be able to win better job security for engineers of all ages. Right now, however, he would settle for some standards by which an engineer could know where he stood in a company. At the same time, Talbott is aware of the problem cited by a realistic colleague: "We need a strong professional union, but it seems to be too lower class or some such thing for engineers to become interested. They'd rather take their paychecks and shut up than be associated with labor."

Allies

Talbott has been trying hard to sign up the 30% of the Lockheed engineering staff needed to get the National Labor Relations Board to hold a representation election at the company. He has, however, refused to accept help from either the AFL-CIO or the Teamsters, "If you play ball with them, they end up calling all the shots," he says. "Right now, DOD and corporate managements do this. And there's no sense trading."

Talbott has gotten a lot of support from San Jose State's Loomba, whose studies of employment patterns among engineers since 1960 have convinced him that layoffs are not the results of "acts of God or natural calamities over which man has no control." Along with Talbott, Loomba has concluded that layoffs are the work of men and establishments throughout the country and that engineers need an organization with collective-bargaining powers to secure more control over their destinies.

Expert testimony. Loomba cites a joint meeting of the California Society of Professional Engineers and the California State Employment Relations Agency two years ago which concluded: "Engineers should use collective bargaining to solve problems with the employers when other methods are found to be ineffective."

In addition to working toward greater job security for engineers, Talbott's AASE would attempt to get transferrable pension plans and to retain other company-vested benefits for engineers when their assignments are shifted or terminated. The interruption of pension plans forced by moves from company to company "may deprive the industry of the experience and leadership of older men," says Northeastern's Katz. He believes engineers may leave the defense field for more secure jobs when they begin to be concerned about post-retirement benefits. ■ ■

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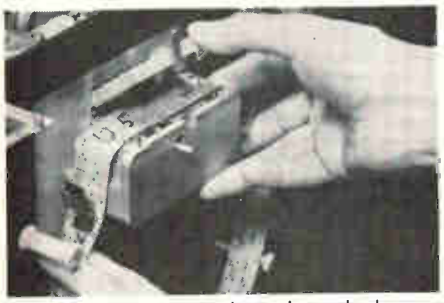

Instructions from an 8-channel punched paper tape provide the logic-input to the assembly machine relay gate that employs both 6- and 12-pole IBM wire contact relays.

machines have been widely used, often on a round-the-clock, three-shift basis, in IBM's electronic assembly operations.

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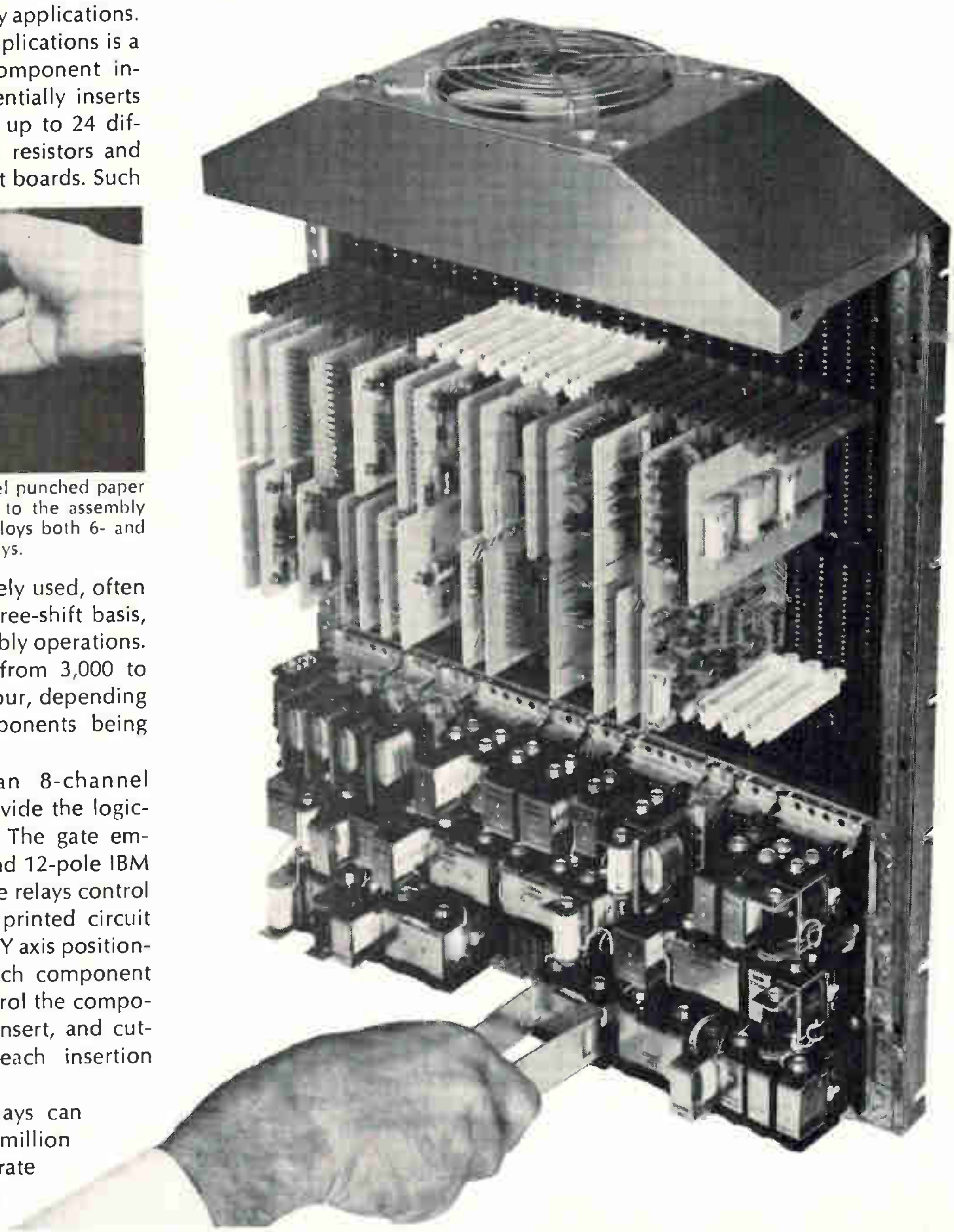
Instructions from an 8-channel punched paper tape provide the logic-input to the relay gate. The gate employs three rows of 6- and 12-pole IBM wire contact relays. These relays control the movement of each printed circuit board through the X and Y axis positioning of the board for each component insertion. They also control the component feed, component insert, and cut-and-clinch cycles for each insertion operation of assembly.

IBM wire contact relays can perform in excess of 200 million operations with an operate speed as fast as 4.5 ms, a release time of 5 ms maximum. The product line includes 4-, 6-, and 12-pole Form C relays, 4- and 6-pole latch models, all with compact, solderless, pluggable mountings...with coil-voltages up to 100 VDC.



☐ Compact packaging system reduces costs

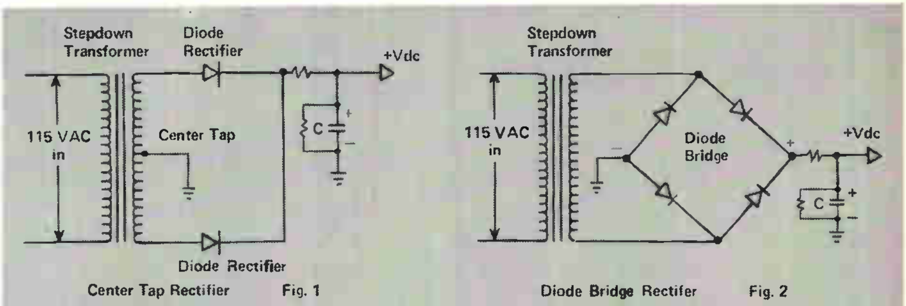
Performance Measurements Co., Detroit, Michigan, reports significant savings in packaging their new electronic recording system. The packaging method previously employed required two gates to mount the components in the main console. Now, with IBM's modular packaging, only one gate is needed. That's because the IBM technique makes the most efficient use of console space with compactly mounted and connected circuit boards, relays and hardware.

Mounting time has been saved, too. Pluggable components, low-cost card receptacles and interlocking card guides have so simplified the packaging job, that Performance Measurements now saves 70% on the cost of mounting hardware. Fewer and shorter wires are needed in the compact console—eliminating three feet of 1½-inch cable and shortening a second cable by eight inches. The modular chassis gives designers freedom to experiment freely with various mounting configurations. It also permits easy access for servicing and diagnostic analysis.

The same design freedom, plus significant hardware and labor savings are available in many applications.

IBM components and packaging can help you in timing control, digital logic testing, telemetering, process or numerical control.

IBM's pluggable components, low cost card receptacles and interlocking card guides allow design freedom, simplify packaging and make servicing easy.



In some cases a bleeder resistor should be placed across the capacitor; for example, to keep the proper voltage level to all relays under conditions of minimum current draw (as with only one relay energized).

☐ Simplified power supply drives relay systems

IBM wire contact relays operate by direct current. This type of current is preferred to alternating current in most switching applications because it offers several advantages, including:

- High speed: a requirement in many logic circuits.
- Smaller size: for compact packaging.
- Ease of arc suppression: diode suppression can be used.
- Safety: non-dangerous voltage levels are commonly used.
- Compatability with transistor circuitry.

The supply of DC power to the wire contact relays may be obtained from a simply-made rectifier, as shown in Figs. 1 and 2, either type being acceptable.

Capacitor size for a given current draw on the supply can be determined by the following equation:

$$C = \frac{I}{V}(15{,}000)$$

Where C is in microfarads
V is in volts
I is in amperes

A guide to the selection of rectifiers and transformers can be found in the electronic manufacturers' manuals describing such devices. In some cases entire bridge circuits may be purchased in one compact package.

"Image-wise, how would it be if the competition found out there was some infighting going on here?" That from George Korecht, Public Relations, who was looking very sincere in a sincere dark, vested suit. He toyed slowly with horn rimmed glasses, waiting.

"Infighting is a little strong, George," puffed Eldredge Oldadt, Senior Engineer and Group Elder Statesman. "I realize you public relations types are looking for words with sizzle, but we're seeking more than a word. What we want is a proper statement that will exactly describe our insuperable technical capability without resorting to polemics and without getting boxed in by too many parameters."

"Gad. Look, El. I got an eight megabuck potential going and I need an ad. And you give me a klutzed up R&D nostrum." With that, Bart Selitall, Product Manager, slammed his notepad on the table. An aggressive, thirtyish cum laude ME from the Nevada Institute of Technology, Bart always wanted action. And quite frequently got it.

"Gentlemen, please. Let's get back to the problem congruency-wise." Korecht again. "We have several magnificently great products to cover here. And our first hang up seems to be in describing our terminal, feed-thru and programming blocks. In our headline we need, what we in the trade call a grabber. How would you describe them?"

"Adequate."

"Fantastically preeminent over anything else."

The Connector Thing

in which the correct product benefit words are sought after to inform, excite and mollify.

"Enhnhnhnhn."

"Who's the enhnhnhnhn?"

"Us. We in R&D feel that anything that has finally been committed to production is but a megapossibility of what..."

"Okay. Okay. Forget that jazz. You El. What's with the adequate bit. Have we or haven't we?"

"George, of course it's an excellent product. With highly imaginative parameters. But we feel with a few improvements..."

"Hey, El. Cut it out!"

"Bart?"

"Look guys. We got the greatest way to interconnect wires in the business. Now why don't we say so? Do you bums read your reports? Or ever look at what the competition does or doesn't have?

"While people are taking the time to screw down or solder connections, all they really have to do is plug them in if they use our modules. And ours lock. There's a little retainer doohicky in the block that really latches onto that contact. It can't wiggle out. And the contact is really snug. You guys sit around and dream perfection all you want, but what more do you want? This terminal junction system design has been selected by the military as the best design for them. Period. And why? The rated voltage is 1 kVAC at sea level and 375 kVAC at 100,000 feet in the environmental models. With the shock and vibration guarantee of 20 G's, 2,000 Hz. The rated current is 20 amps/buss in the size 16 contacts, and 10 amps/buss in the size 20. And you can get as many as seven bussing arrangements as standard. And we'll even make special arrangements. With these things we can give people a lot greater design flexibility. And tremendous weight and space savings. So anywhere anybody needs to have wires tied together, we got the greatest thing going and you pussyfoot over a word."

"Come on guys, let's agree on an adjective. Bart? El?"

"Fantastic."

"R&D?"

"Well, a modified, qualified fantastic in your terms, that is."

"Fine, I think we can put that one to bed."

"Now, gentlemen. The coffee break is almost on us. And we know what that all does morale-wise. So let's get on briefly with the next shot. Twist/Con."

"Well, hasn't everything that can be said about our micromin pin and socket connection been said?" That's Bernard Weyout, R&D. "I mean economical. High density packaging of contacts on 0.050" centers. That's up to 420 contacts per square inch. And it's got a helical breathing spring that gives it 100% wiping action. The contacts are protected. And it's highly reliable. So what's to be talked about again? Frankly, I'm sick of it. Seems every time I pick up an..."

"Look, Bernard. We're tremendously sympathetic to your problem. We realize that in R&D you're theorizing on one-kay and up contacts on the head of a pin, but until NASA has a requirement, let us get our licks in first. All right?"

"You production cats really bug me, you know. What do you know about creativity? All you're interested in is money and..."

"Cool it, Bernard. Now what can we say about Twist/Con. El?"

"Well, without going out on a limb, George, we could really talk about our quality and delivery. Oh, I know those are a couple of hacked up words, but look, we've shipped thousands of connectors in the last three weeks and not one of 'em has come back.

"I hear people have complained about some pretty sad wares. Including cracked insulation. And poor workmanship. Even the wrong orders. But not from us.

"You know that sub min connector is really something. A lot of people don't realize that our Twist/ Con pin contact is formed with a breathing helical spring and it really works better under vibration than any other design.

"So Twist/Con is really more than acceptable as connections for IC's, interconnecting of PC boards, and on modules with connectors welded to hybrid circuits. Twist/Con is adaptable to 22 AWG to 30 AWG standard wires."

"Well, could you call our Twist/Con superior? Highly economical?"

"Well, George, both those descriptive words are relative. We in the scientific world look on superiority as..."

"Jam it El, baby. I need a sales piece. I've seen our specs and I've seen competitors. Our Twist/Con is great. I vote for using superior and economical."

"Agreed."

"All right, it's almost lunch time anyhow."

"Well, with qualifications..."

"Look, team, thanks. It's really been great, you know, the participation. The bedrock. The nitty gritty. Now, next month we'll be talking with Ben Efitts from personnel and some new sales engineers about multi-pin connectors and terminal modules. Uh, Bernard, that's a meeting I don't think we need R&D represented at. Thanks, fellows.

"Hello, Brenda. Will you get me advertising? Thanks, Hon. Hello, Harry. Look, the ad's are okay. Both. Look, use terrific on the terminal, programming and feed-thru modules. What? Right, terrific. Sure. I got an unqualified adequate out of Product Management and if that isn't terrific I don't know what is. And, uh, superior and economical on the Twist/Con. Look, do you know any other sub min you can get contact density like 420 per inch and at such a price? Okay. And neither does anybody else. Print it.

"And put in the line to write for catalogs for the modules and Twist/Con.

"Man, like $400 bucks an hour to wrestle over three words. Why don't they just leave it up to PR in the first place? Then we could come up with something like Microdot... because."

MICRODOT INC.
220 Pasadena Ave., South Pasadena, Calif. 91030

Circle 133 on reader service card

Zipping through the harness maze

System tests a 1,000-wire cable in 2 minutes and pinpoints short circuits in 5 seconds; control is by hand or by tape

Time, an ohmmeter, and a technician with a lot of patience once were all that were needed to test out a wiring harness. Meters have changed little and technicians have as much patience as they've always had, but harnesses are becoming more dense and more complex. Companies that make them don't want to spend a lot of time testing and they can't tolerate the inevitable human mistakes. Besides, some harnesses are so dense and complex that they defy testing by the man-and-meter technique.

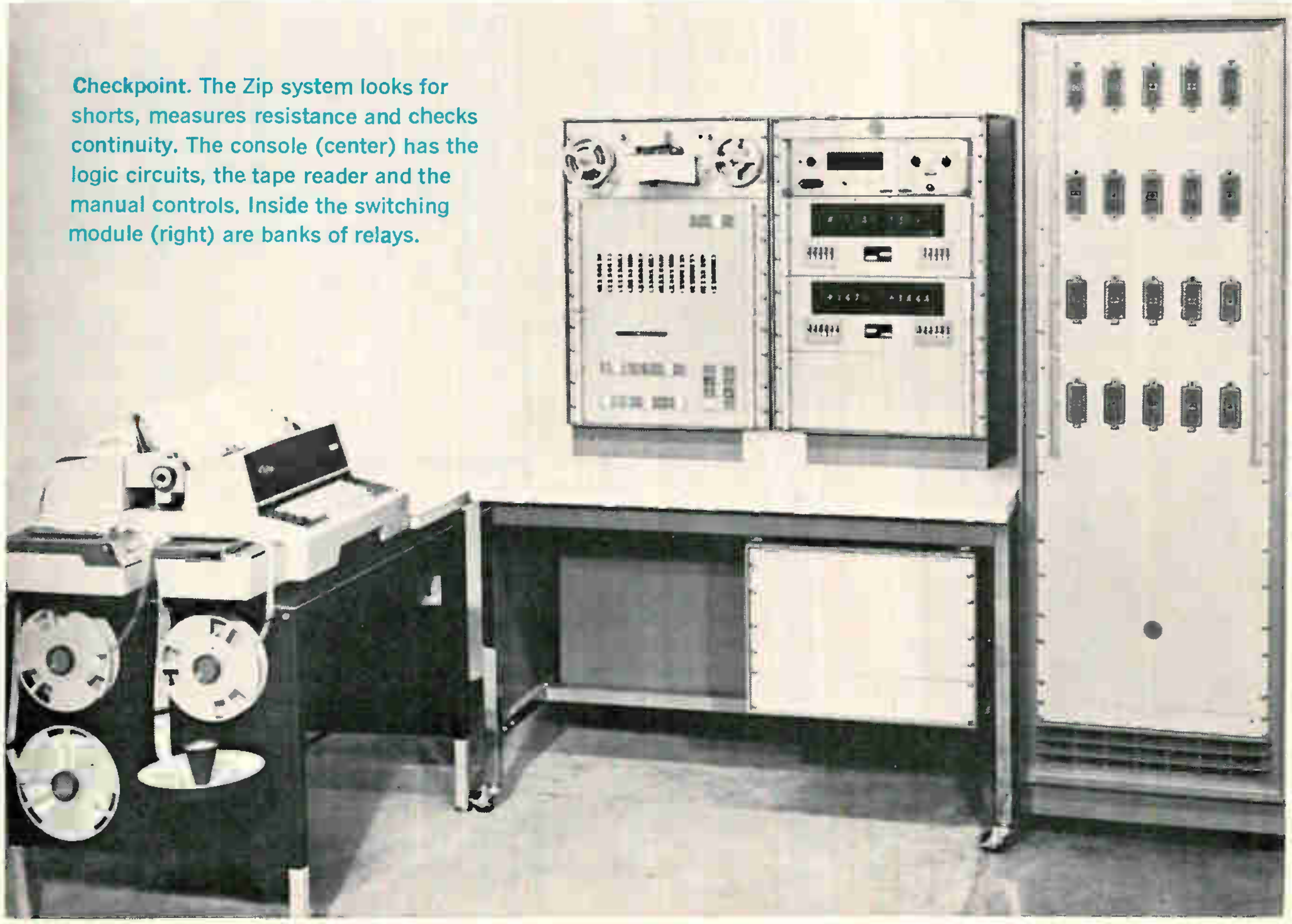
The result of all this has been the development of automatic checkout systems. Many are built in-house, but a few companies are starting to turn them out as standard products.

The latest from Automation Dynamics, one of the companies making commercial testers, is Zip III, a system that can perform a test every 10 microseconds and check out a 1,000-wire cable in 2 minutes.

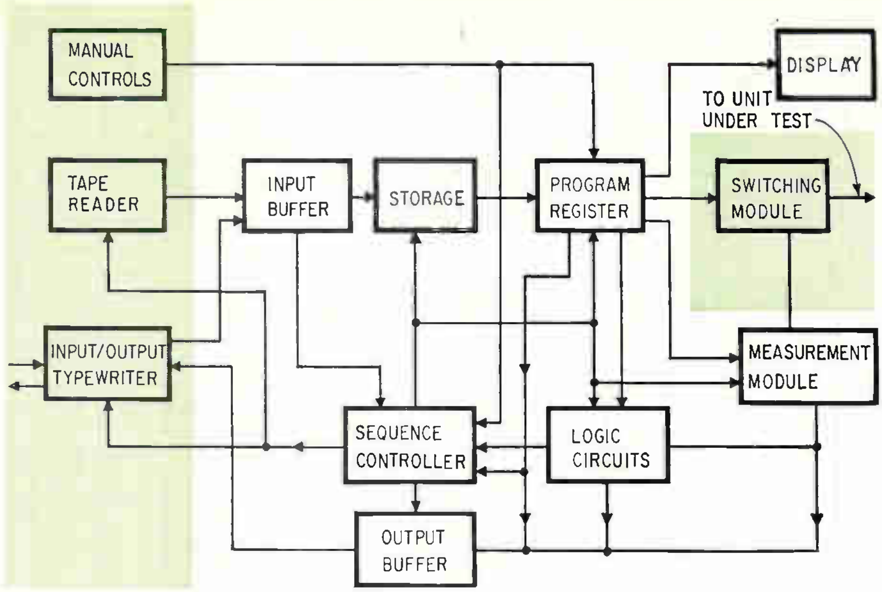
Among other things, Zip measures resistance, makes go/no-go decisions, looks for shorts, and checks continuity. And the system can be run by hand or by tape.

The pieces. Zip comes in three parts—an input/output typewriter, a console, and a switching module. Inside the console are the measuring instruments—bridges, voltmeters, and comparators—plus circuits that process inputs and outputs, and send commands to the switching module. On the console's face are the tape reader, the operator's control panel, and two digital displays that show which terminals in the harness under test are connected to Zip at any given time.

The switching module consists of relay banks that step the system



Checkpoint. The Zip system looks for shorts, measures resistance and checks continuity. The console (center) has the logic circuits, the tape reader and the manual controls. Inside the switching module (right) are banks of relays.



Looking for trouble. After receiving inputs from manual switches, tape or the typewriter, the console sends commands to the module.

through two switching stages—group transfer and point to point. The module has two 100-point switching matrices, each with 100 reed relays, and two group-transfer matrices, each with 40 electromechanical relays.

On the switching module's face are rows of connectors, enough to handle 2,000 terminations. Zip can be expanded in 1,000-termination steps, and the console can handle 100,000 terminations at one time.

The harness under test is connected to Zip through these connectors; the module, which is on wheels, is connected to the console by a long cable. The result is that the operator can take the test system to the harness, rather than dragging the harness to the tester.

And Zip can be multiplexed—programed to work with one set of modules for a certain period of time, another set for another period, and so on. This feature is valuable if setup time for a harness is long, if Zip is being used at more than one point on a production line, or if more than one type of harness is being tested.

Checks. Zip does a variety of tests. For one thing, it makes continuity checks, using a bridge connected to an analog go/no-go reference. With a constant-current generator, a digital voltmeter, and a two- or four-wire circuit, Zip measures resistance and then checks to see if the resistance is within tolerances.

In testing for shorts, the system measures the low resistance path between one termination and ground while all terminations outside the loop are grounded.

The insulation resistance of each conductor is obtained by measuring the leakage current from the conductor to ground. Again, all terminations except those in the same loop are grounded. Voltage is set to 100, 250, or 500 volts d-c and current is limited to 0.5 milliamp.

When there are diodes in the harness, forward and reverse voltages are measured with a dvm.

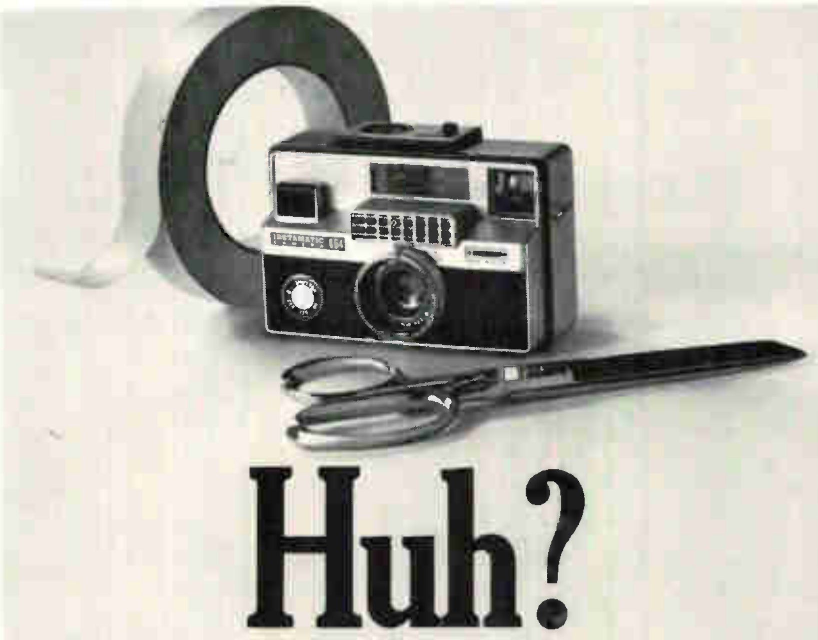
Ways to run. Zip has five operating modes. In manual, all tests are performed one at a time on command from the operator.

The auto-sequence mode allows high-speed continuity testing. For example, in this mode Zip checks a 1,000-wire cable for continuity in 15 seconds.

When Zip is in the tape-programed mode, an analyzer inside the console reads the punched-paper or Mylar tape and commands the system to check continuity, look for shorts, measure insulation resistance, or do all three, depending on the program. Zip makes go/no-go decisions, and advances the tape to the next command if the decision is go. If it's no, the analyzer commands that information about the failure be printed, and then either stops the test or advances the tape.

The search mode is used after a

Tools of the drafting trade.



Strange looking drafting tools? When you know how to use them with KODAGRAPH ESTAR Base Films, you can save hours of creative drafting time.

Take the camera. With it and ESTAR Base Film you can make a photodrawing. As the name implies, a photodrawing is simply a combination of a photograph and a drawing. You just photograph an existing part, assembly, model—no matter how complicated—and combine the photo with drawings on ESTAR Base Film. Extra detail, such as connecting lines, can be added easily on the outstanding matte drafting surface of the film.

Tape and scissors? "Scissors drafting," of course. With KODAGRAPH ESTAR Base Films you can delete and add components of a drawing by cutting and taping—not redrafting the whole job.

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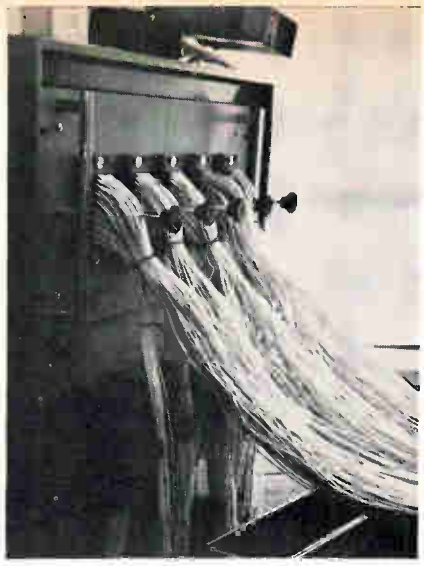
Kodak

DRAWING REPRODUCTION SYSTEMS BY KODAK



Probing. Cables connect the harness being tested to the switching module, shown above.

short has been discovered. Zip automatically isolates the fault by checking the low resistance path between the conductor under test and all other wires in the harness. The exact location of a short can be found in 5 seconds.

Zip can even help to write its own program. A harness that has been previously tested and approved is connected to the switching module, and the system is put into the self-program mode. The system prints out a list of loops inside the harness. Using this list and a function code, the operator can quickly write a test program.

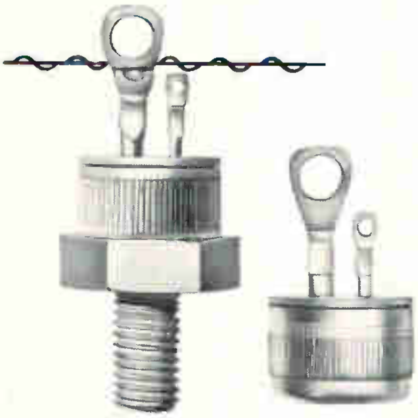
Three choices. There are three models of the Zip system: QC-440, QC-442, and QC-444. All can do the tests described previously. The 440, 442, and 444 differ in the resistances that can be measured, limits that can be set, accuracy, and test voltages that are available.

Both the 440 and 442 operate in the manual, sequence, tape-programed, and search modes, while only the 444 has in addition the self-programing capability. The 444 also comes with the teletypewriter, a tape output, and a digital display of the reading of its dvm. And with the 444, tolerances can be changed during the test on command from the tape.

The 440 costs $33,000, the 442 is priced at $40,000 and the 444 at $54,000. Additional 1000-termination modules sell for $8,800. Delivery time on any of the three is 30 to 60 days.

Automation Dynamics, 35 Industrial Parkway, Northvale, N.J. 07647 [338]

This 40 Amp TRIAC really controls power



2N5441 and 2N5442 press-fit types give you:

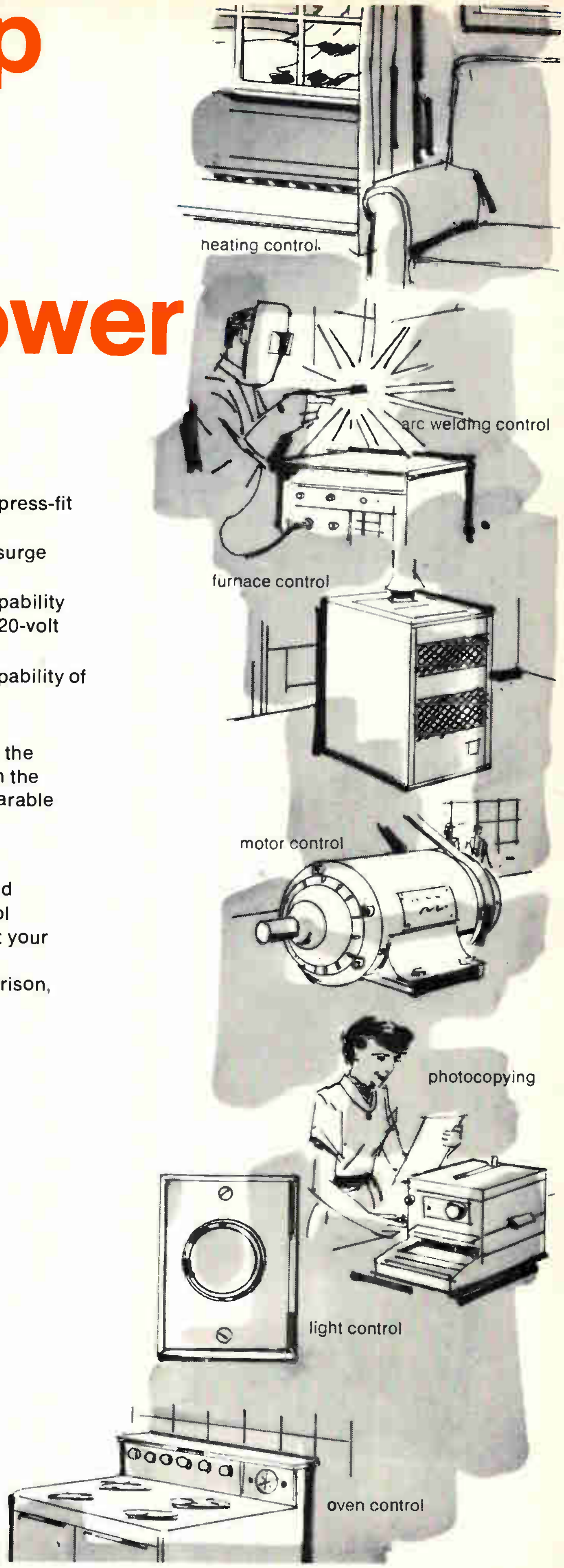
- 300 amp full cycle surge capability
- power handling capability of 5,000 watts for 120-volt operation
- power handling capability of 10,000 watts for 240-volt operation

Because a Triac can do the job of two SCR's back-to-back, the 2N5441 or the 2N5442 can virtually replace any two types in the 2N690-series or the 2N3873-series in circuits having comparable voltage and current ratings—and with fewer components.

2N5444 and 2N5445 stud types also available.

Please give your RCA Field Representative a call if you need application assistance in applying Thyristors to your control problems. Ask him, too, for pricing information—or contact your RCA Distributor. For technical data, write RCA Electronic Components, Commercial Engineering, Section R-N-1-2, Harrison, N. J. 07029.

RCA

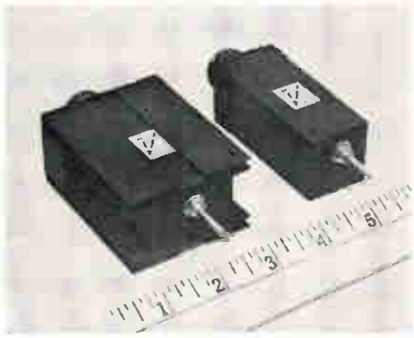


Controlling power without interference

Zero-crossover device uses a bank of SCR's to handle up to 1 kilowatt

Just before a movie starts, the projectionist reaches for a rheostat and turns down the lights, a standard procedure in ground-based theaters. But these days the Roadrunner and Sister George are being screened in airliners flying at 30,000 feet. And airplane designers want a controller that doesn't waste energy the way a rheostat does.

The search for an efficient way to control power without generating electromagnetic interference was going on before the days of in-flight movies, of course. Leading the hunt have been designers of military planes, which are usually loaded down with sensitive guidance and communications systems.



In control. The SPC has both triggering circuits and SCR's. The smaller CSO doesn't have rectifiers.

But the word from a small electronics house in Marietta, Ga., is that the search is over. The company, Omnionics, has developed a 5-ounce controller that continuously adjusts power up to 1 kilowatt. And as important as its light weight, says the company, is the fact that the controller generates hardly any electromagnetic interference.

With or without. Called the SPC-300-1, the controller is packed into

From The Antenna Men at TRG...

...a comprehensive capability in microwave antennas and antenna systems

TRG Parabolic Pencil Beam Antenna, a linearly polarized type, operates over the full waveguide band of 26.5 to 40 GHz. Has unique scalar feed for broadband operation without adjustment. Send for bulletin.

If your microwave system calls for specialized antennas in the 300MHz-300GHz range, The Antenna Men at TRG can supply what you need. Control Data Corporation offers in-depth capability for the design, development, and production of antennas that meet exacting performance specifications. They are available with linear, dual linear, dual frequency, circular, or multiple mode polarization and are fabricated to quality standards required for the most sophisticated communications, radar, radiometry, telemetry, countermeasure, or surveillance systems. Control Data specialists are also uniquely qualified to design complete antenna systems for you or to assemble systems to your specifications. If specialized antenna procurement poses problems for you, contact The Antenna Men, Control Data Corporation, Boston Space and Defense Systems Operation, 404 Border Street, East Boston, Mass. 02128. Tel: 617-569-2110.

CONTROL DATA
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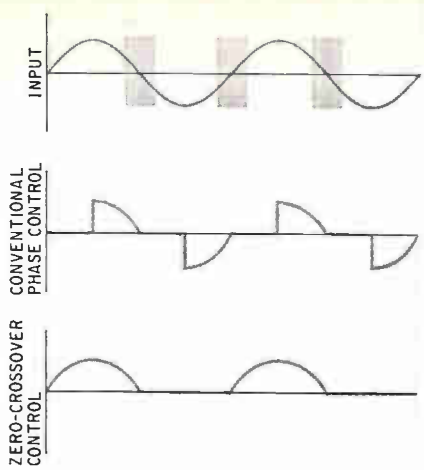
SPACE AND DEFENSE SYSTEMS

Circle 141 on reader service card



Zeroing. Turning SCR's on and off as input goes through zero eliminates the transients and interference caused by sudden voltage changes.

a black box that's 3 by 1.4 inches by 0.5 inch and connected between the power source and the load. The box contains triggering circuits and a bank of silicon controlled rectifiers; coming out of the box is a potentiometer shaft that's used to adjust the output power level.

For designers who prefer to use their own SCR's or who want to keep the SCR's separate from the control circuitry, Omnionics is offering the CSO-300-1, which is the SPC minus the rectifier bank. Both models are available in 60- and 400-hertz versions.

Besides their duties aloft, these controllers should find work anywhere else power has to be adjusted without interference. They may be used, for instance, in telemetry stations or environmental test chambers.

Pick one. Until now, says Dan Matthias, an Omnionics sales engineer, designers looking for power controllers have had to choose either a rheostat, which is inefficient, a variable transformer, which is heavy, or an SCR phase-control system, which is light and efficient but which radiates interference and puts transients into the load.

The SPC and the CSO are phase-control systems, but they use the zero-crossover technique to fire the SCR's. Also, the position of the triggering pulses can be adjusted, further reducing interference.

SCR's need a certain holding current to keep them in the conducting state. To hold interference to a minimum, the turn-on transient

THE CHANGING INTERFACE

...an IC/Systems Seminar

March 28, 1969 – Park Sheraton, New York

Conducted by the Electronics Management Center

The new generation of integrated circuits is producing a serious communications gap in electronics design. The complexities of LSI and its implications for systems design are shaking the traditional relationships between components suppliers and systems builders.

Engineers in every function from research and development to final packaging must come to grips with the continuing merger of circuit design and process technology.

Companies considering sweeping new product directions are aware that immediate steps must be taken to minimize risks.

At the CHANGING INTERFACE Seminar, the men who create, produce, market, and use components and systems will gather to examine the important questions together. Questions such as:

How can the systems design capabilities of the user be coupled more effectively with the supplier's device design know-how?

Is the emphasis shifting from circuitry to systems design?

How can design automation reduce the gap between systems and technology houses?

Will LSI become largely a custom market, or will standard off-the-shelf items be developed?

How will design changes be provided for?

What is the testing interface? Who is responsible, for how much?

The CHANGING INTERFACE Seminar has been scheduled on the day following the annual IEEE Convention to make efficient use of your time. Plan ahead. Make your trip to New York this March a little more productive. Send your reservation request to:

THE ELECTRONICS MANAGEMENT CENTER
330 West 42nd Street, New York, New York 10036
An Information Service of McGraw-Hill, Inc.

... interference at half power drops 37 db ...

should be as low as possible, which means that switching should be done as close to the crossover point as possible. With these controllers, the timing of the firing pulse can be adjusted to assure a minimum turn-on transient consistent with load impedance and holding-current requirements.

How much the new units reduce noise depends on the nature of the load. In one test, Omnionics engineers replaced a phase-control system that doesn't use zero-crossover with an SPC in a system where a 1.4-kilowatt source was feeding a bank of incandescent lamps. The system's 20-kilohertz interference dropped 37 decibels at half power and 25 db at quarter power.

Nothing new. The company acknowledges that the zero-crossover technique isn't new, but claims that the SPC and CSO are the only commercial controllers that employ it. According to Omnionics, currently available zero-crossover switches are all on-off devices. And, a spokesman adds, the circuitry providing flicker-free adjustment of lights in a 400-hz system without the aid of digital counting circuits is unique and is being patented.

The SPC's nominal input is 115 volts rms and 9 amps, and it can take a 400-volt surge or a 60-amp single-cycle surge. Power dissipation is 3 watts.

Those 60- and 400-hz versions of the SPC that operate at up to 33°C cost $210; units working to 70°C are priced at $233.

According to Omnionics, the CSO works with most commercial SCR's, and the company can build interface circuits to precisely match controller to load and power source or to meet unusual triggering requirements.

Like the SPC, the CSO takes 115 volts nominal and 400-volt surges, and uses 3 watts. Price is $173.

Both units draw operating power from the power source, so neither needs a separate supply.

Delivery time for both models is four weeks.

Omnionics, 1111 Mountain View Dr., Marietta, Ga. 30060 **[339]**

Circle 145 on reader service card

Cable weight takes a dive

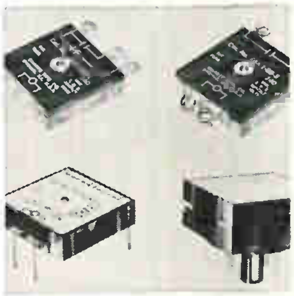
Foamed Teflon material is used as the dielectric; cable can be bent and stands up well to temperature shifts

For nearly a decade, Teflon has been used in solid form as a dielectric for coaxial cables. Because it stands up to rough handling and high temperatures, it has been designed into many systems.

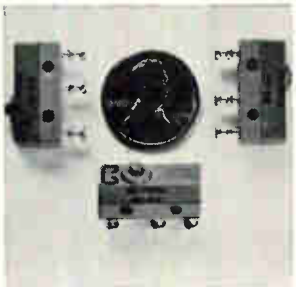
But solid Teflon has the disadvantage of being heavy. The scientific research group at Microdot Inc. has found a way to make Teflon lose weight without losing its virtues. Using a unicellular foaming process, the company makes a spongy version of Teflon called Micro-cell, whose first appearance is in a new coaxial cable. The company calls the cable the lightest heat-resistant cable on the market. A length of 1,000 feet weighs 19.1 pounds, about one-third the weight of a comparable cable having a solid-Teflon dielectric. In Micro-cell, small cells of inert gas occupy about one-half the total volume of the dielectric material.

Besides low weight, Micro-cell has, according to the company, the lowest permittivity of any available dielectric—1.4, compared, for ex-

Bidirectional push-button rotary switch called Space-Saver comes in 8, 10, or 12 positions in all standard codes. Life characteristics include 100,000 cycles (a cycle consists of 720° rotation). It carries 3 amps continuous, makes and breaks 0.125 amp resistive at 28 v d-c and 115 v a-c, 0.05 amp inductive at 28 v d-c. Janco Corp., 3111 Winona Ave., Burbank, Calif. [341]

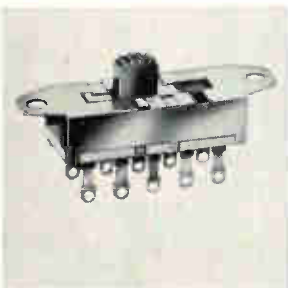


Solid state relay SSA withstands extreme environmental conditions of shock, vibration, heat and acceleration. It offers a predictable threshold voltage for pull-in and drop-out. The contacts always close when a minimum of 3 v is applied to the coil, and will always open when applied voltage is reduced to less than 3 v. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. [342]



Sealed subminiature switch for military and industrial applications is completely protected against water, oil, flux and other harmful elements within its environment. It is available in long life (over 5 million operations), low force (150 grams max.) ratings, handles 10 amps and has standard terminal configurations. Hi-Tek Corp., 2220 So. Anne St., Santa Ana, Calif. 92704. [343]

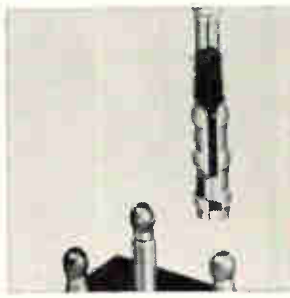
Active bandpass filters series DE500 with integral detector cover the 1 hz to 10 khz frequency range. Out-of-band rejection is greater than 60 db. Input signal is 1 to 5 v rms. Input impedance is 600 ohms. Operating voltage is 12 to 15 v d-c at 100 ma. Size is 1 x 2 x 3 inches. Price is less than $150. Diversified Electronics Co., 154 San Lazaro Ave., Sunnyvale, Calif. 94086. [344]



Slide switches models G141-S (double pole, 4 position) and G140-S (single pole, 4 position) are 1.377 in. long and mount in 0.100-in.-diameter clearance holes on 1.187-in. centers. Travel of switch actuating knob through all 4 positions is 0.470 in. and from position to position is 0.155 in. Continental-Wirt Electronics Corp., 26 W. Queen Lane, Philadelphia 19144. [345]

High Q r-f coils for communications equipment and filter circuits come in values of 0.1 to 100,000 μh in a 10% series and tunable over a $\pm$10% range. The magnetically and electrostatically shielded package is moisture sealed for military requirements. Q values of 140 to 160 are typical for inductors of 0.18 to 330 μh. Coil-Craft Inc., 340 Bronxville Rd., Bronxville, N.Y. [346]

Female terminals, designated Claspcon 1929 and 1881-2, speed p-c board connections. They feature an offset seam that prevents distortion or loss of electrical contact, even after multiple connecting operations. The 1929 mates with a 0.045 in. square wire post; the 1881-2, with a round 0.093 in. bead pin-type terminal. Molex Products Co., 5224 Katrine St., Downers Grove, Ill. [347]

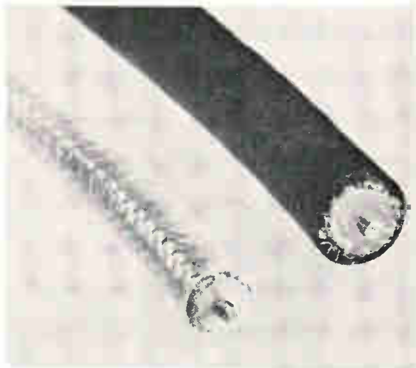


Electronic time delay relays are offered in plug-in, plastic enclosures. Transistorized circuitry consists of an R-C timing network having a solid tantalum capacitor triggering a unijunction transistor whose function energizes an internal dpdt electromechanical relay having gold-plated, silver-cadmium oxide contacts. Vanguard Relay Corp., 225 Cortland St., Lindenhurst, N.Y. [348]

ample, with 2.2 for solid Teflon. And the permittivity is constant over wide temperature swings. The operating range is —65°C to +200°C.

Bends and squeezes. Foamed materials have been used in coaxial cable before but, says Microdot, none has the strength of Micro-cell. This dielectric won't crush if a user squeezes the cable between his fingers or if he bends it. And, adds Microdot, a user can solder the center conductor and the shield without worrying about melting the dielectric.

Micro-cell cable with 50-ohm impedance is available with center



Foamy vs. heavy. Micro-cell cable, left, is one-third the weight of cable whose dielectric is solid Teflon.

conductors of 19 to 33 AWG tinned copper; the shield is 36 AWG tinned copper.

The price is about $180 per 1,000 feet. Microdot says that solid-Teflon cable with similar properties costs $140 per 1,000 feet.

The capacitance of the cable is 25 picofarads per foot, and attenuation of a 400-megahertz signal is 11 decibels per 100 feet.

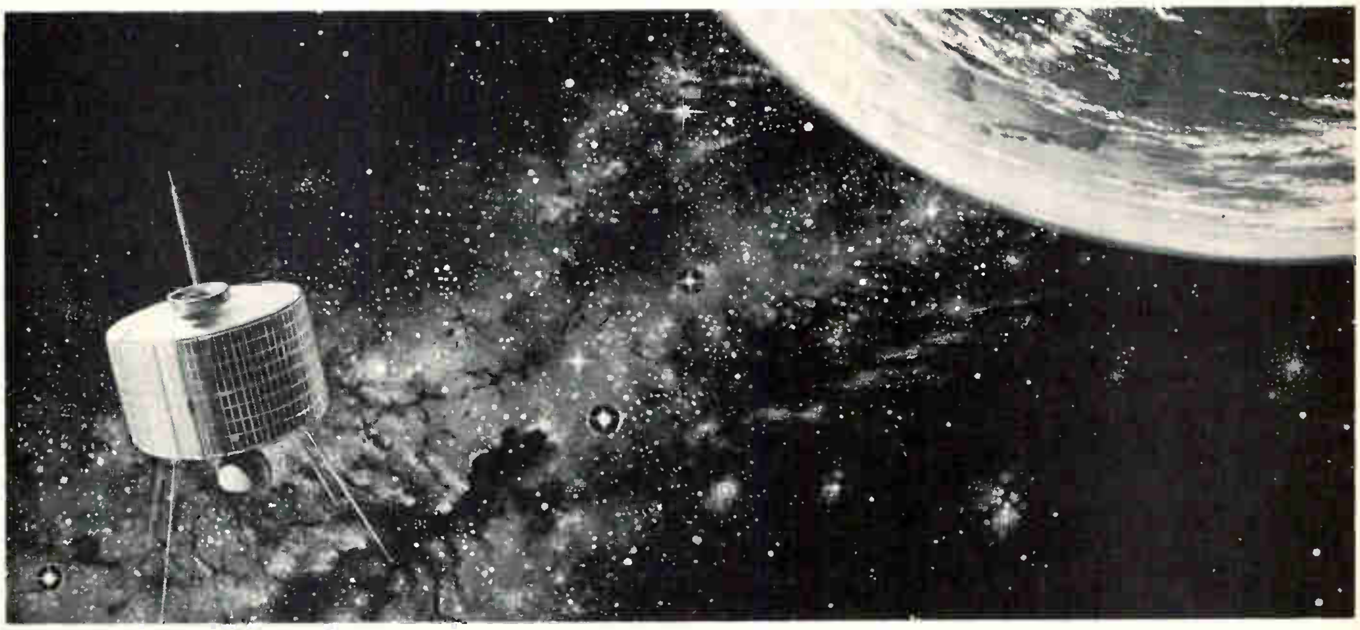
The diameter of the dielectric is 0.094 inch, the diameter of the shield is 0.117 inch, and the diameter of the jacket is 0.140 inch.

Microdot is looking at aerospace companies as the ones most likely to use the Micro-cell cable. Teflon cable is in many airborne systems now, and Microdot feels this lightweight version will increase the use even more.

Delivery ranges from off-the-shelf to 30 days, depending on the type of cable ordered.

Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif., 91030 [349]

VOICES IN OUTER SPACE ...



another step ahead in the development of satellite communications.

Last September K.D.D. of Japan decided on FUJITSU as the most qualified expert to develop and manufacture a new PCM-TDMA COM SYSTEM. This system employs pulse-code multiplexion with a transmission speed of 50 million bits/sec.; TASI, a time assignment speech interpolation system which increases channel capacity; a time-division multi-access controller and a phase-shift keying device.

The resulting 700 channels per band—which is more than conventional FDMA can boast—provide distortion-free voice communication, larger per-band capacity and lower per-channel charges.

For us, it's another step toward our goal of a better tomorrow for everyone. For humanity, it's another step closer to the stars.

FUJITSU LIMITED

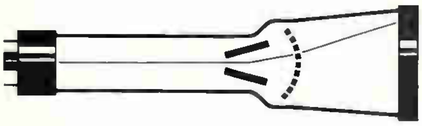
Communications and Electronics

Marunouchi, Tokyo, Japan

MAIN PRODUCTS: ☐ Telephone Exchange Equipment ☐ Telephone Sets ☐ Carrier Transmission Equipment ☐ Radio Communication Equipment ☐ Space Electronics Equipment ☐ Data Communication Equipment ☐ Computers (FACOM) & Peripheral Equipment ☐ Automatic Control Equipment (FANUC) ☐ Telemetering & Remote Control Equipment ☐ Electric Indicators ☐ Electronic Components & Semiconductor Devices ☐ Auto-Radio & Car Stereo (TEN) ☐ Marine Radar ☐ Nuclear Measuring Equipment

They Don't Make CRT's Like They Used To...

Thank Goodness! Better resolution, faster writing rates, larger display all depend on the CRT. It is in this area that HP has made important innovations—in fact, HP has made most of the important contributions to improving CRT's over the past six years! And these improvements add up to the two most important benefits to you — greater accuracy and easier operation.

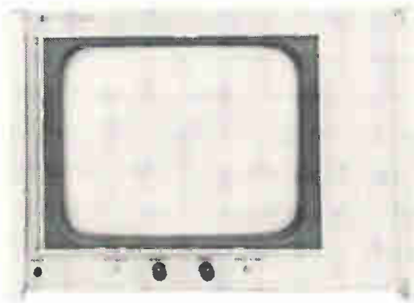


HP uses the post-acceleration technique in the HP 180 scope system to provide fast writing rates, bright traces, and a lower-powered, more easily controlled amplifier—all contributing to the accuracy of the display. A further improvement in CRT techniques has provided a deflection system with unmatched linearity and no compression. Add the internal graticule and you have a CRT with accuracy limited only by the human eye.

But HP is not stopping there! A further improvement in CRT techniques will soon bring bandwidths for measurements of 200 MHz—300 MHz *real time*—and even higher!

For years, the vertical display of a high frequency scope did not exceed 4 cm—and you probably have some of these scopes still operating in your lab. Obviously a larger display means easier viewing, higher resolution and greater accuracy—but how do you get a larger display? You could lengthen the CRT to increase the distance from the electron gun to the CRT face—or increase deflection power and decrease sensitivity.

Or, you could use the mesh dome magnification technique as HP has for the 180 scope system. A wire mesh dome is used as a precision "diverging lens." Voltage applied to the dome creates an electrostatic field that electronically "bends" the beam. In the 180 series, this gives you a vertical swing of a full 8 cm at 50 MHz and 6 cm at 100 MHz—50 to 100% more than you get in other scopes—and the CRT is shorter than the normal 22-inch rack depth! More accurate, easier-to-see displays? You bet!

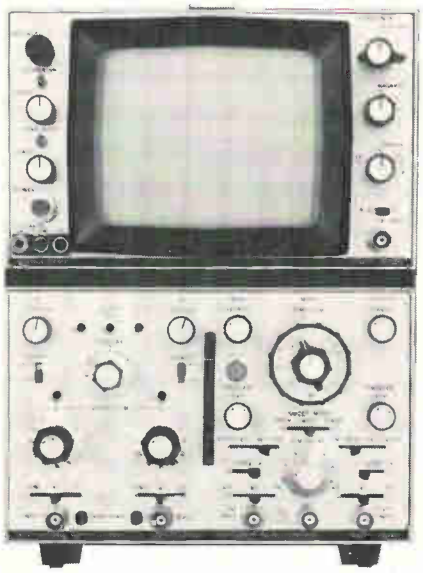


Recently, HP perfected dome mesh technology to the point of producing a high frequency display monitor that offers a full 8 *inch* x 10 *inch* display area in a tube *only 18 inches long!* Remarkable for its size, this post-accelerator CRT has a deflection factor of only 14 volts per inch at the 20 MHz bandwidth and a rise time of 20 ns. Some CRT's require as much as 10 volts to rise 0.8 cm!

It was a logical next step for HP to use the mesh idea in their storage CRT's—to bring you a single CRT that offers conventional viewing, variable persistence of the trace, and full storage. A second mesh that "remembers" the electron beam trace is used next to the phosphor. At the twist of a knob, you can adjust the mesh memory span from 0.2 second to minutes—to hours—to days. The mesh doesn't "forget" even when you turn the power off!

Why did HP use the mesh storage CRT? We could have built a mono-accelerating bi-stable tube—but they would offer only storage or conventional use—no variable persistence. And there is an annoying flicker each time a bi-stable tube is flashed with an erase pulse. The HP mesh storage tubes have 200 ft-lamberts of brightness—20 to 100 times greater than bi-stable tubes—and the HP system is far less susceptible to permanent burns—minor burns can be easily erased.

Whether you choose a conventional or a storage CRT for your 180 system mainframe, you get the same performance from any of the 180 plug-ins. At HP, storage does not mean a sacrifice in performance!



Take a good look at the field-proven HP 180 Scope System. You'll agree CRT's are better than ever! Check your HP Instrumentation Catalog for full specifications and prices on the 180 scope system mainframes and plug-ins. Or, for recommendations on a complete line of instrumentation to complement the 180 system, call your nearest HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

089/4 A

STEP FORWARD

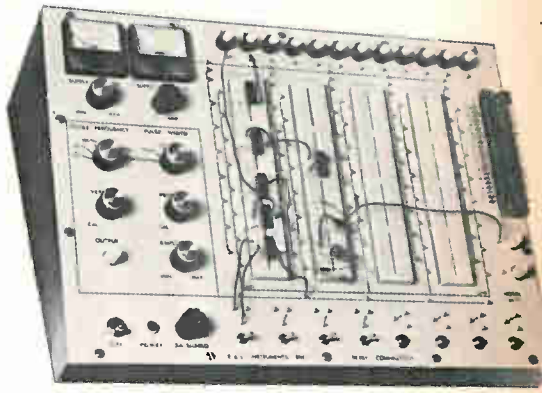
HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

New instruments

Taking the mess out of design

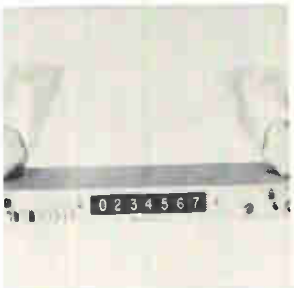
Lightweight breadboard has power supply, pulse generator, lights and drivers, and switches; it handles up to 32 IC's



Wires all over the workbench; an exasperating search for the right sockets; the wait until another engineer finishes a test so that his pulse generator can be borrowed; the transistor burnt out by a wayward soldering iron. In too many cases these are regular, though unwanted, parts of the circuit-design process.

But a new system from a new company, the LBB-32 dynamic breadboard from E&L Instruments Inc., may take a lot of the scavenging and soldering out of digital design work. The engineer makes his circuit by plugging the called-for components—integrated circuits in dual in-line packages or cans, resistors, capacitors, diodes, tran-

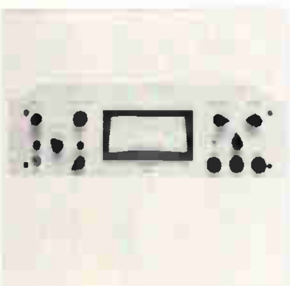
Audio-frequency microvoltmeter type 1346 is a metered, calibrated attenuator that can be used as a self-contained low-level d-c source and, in conjunction with an appropriate oscillator, as a source for any a-c waveform from 0.1 μv to 10 v with a spectrum up to 100 khz. Output impedance is 600 ohms. Price is $250. General Radio Co., West Concord, Mass. 01781. [361]



Modularized electronic counter/timer model 2802 has a range of d-c to 12.5 Mhz. It features an input sensitivity of 10 mv from d-c to 5 Mhz and 30 mv from d-c to 12.5 Mhz with a 250 v overload protection. It also offers simplified push button switching, dual input channels, and remote programing capability. Price is $455. Atec Inc., 1125 Lumpkin St., Houston 77024. [362]

Rugged construction and simplicity of the OS-12 oscilloscope make it suitable for universities, laboratories and production use. Simple operation is achieved by using the minimum number of controls and by automatic synchronization of the time base. Bandwidth is d-c to 30 khz. Unit is 5½ x 7½ x 10 in. Texscan Technical Products, 7707 Record St., Indianapolis. [363]

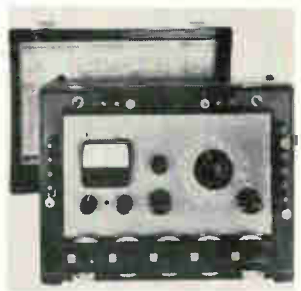
RC generator/indicator type SUB is for simplifying bridge measurements and filtering out noisy signals. Owing to the logarithmic indication over a range of more than 80 db, adjustment of sensitivity during bridge measurements is not required and voltage changes from 50 mv down to 1 μv are easily detected. Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J. 07055. [364]



Picophotometer model 18 measures current from photomultiplier tubes and other current sources. Current measuring capability is 10 μa to 1 pa full scale, permitting resolution of 10^{-14} amp. The unit contains a negative high voltage power supply variable continuously from zero to —1,500 v. Price is $760. Pacific Photometrics Instruments, 3024 Ashby Ave., Berkeley, Calif. [365]

R-f multimeter RFM-1's capability includes d-c and r-f millivolts from 3 to 1,000, db from 0 to 60, and vswr in two ranges from 1 to 3. Swept frequency vswr measurements at low levels are facilitated by an internal video amplifier with switchable gain to 50 db and 200 khz bandwidth. Price is $98.50 with accessories. Radiation Devices Co., P.O. Box 8450, Baltimore 21234. [366]

Three-in-one Wheatstone bridge WB-110B features ±0.025% accuracy of reading. It combines in one instrument an ultrasensitive Wheatstone bridge, a chopper stabilized readout amplifier and a bridge voltage power supply. It measures from 1 ohm to 110 megohms in 8 ranges with amplifier sensitivity of 1 mv full scale. Precision Standards Corp., Box 8361, San Marino, Calif. [367]



Potentiometric voltmeter-bridge model 300A has 5 d-c voltmeter ranges to 511.10 v with 1 μv minimum steps, 8 ammeter ranges to 5.1110 amps with 10 pa minimum steps, and 10 resistance ranges to 511.10 megohms with 10 microhm minimum steps. Size is 14.5 x 7.2 x 11.3 in. Price is $995. Electro Scientific Industries Inc., N.W. Science Park Drive, Portland, Ore. [368]

. . . a circuit with 32 IC's can be breadboarded . . .

sistors—into the LBB's pegboard. The components are interconnected with solid #22 hookup wire which plugs, without soldering, right into the board.

According to Ronald Portugal, president of E&L, all that an engineer needs to design and test a digital circuit is the LBB, a wire cutter, and a wire stripper. "He doesn't even need a scope; we all know what the outputs of logic devices look like," he adds.

Besides a pegboard, the LBB includes:

- a 2-amp power supply whose output is variable between 2 and 10 volts;
- a pulse generator;
- 12 lamps with driver circuits;
- four toggle switches and four pushbutton switches.

And when the job won't or can't come to the engineer, he can pick up the breadboard and go to the job. The LBB is 4¼ by 11 by 15 inches, weighs 10 pounds, and draws 25 watts from a 115-volt input.

Makeup. The LBB's pegboard, four long connectors mounted in the middle of the front panel, can hold, for example, 32 14-pin dual in-line packages.

The upper left-hand corner of the front panel contains a voltmeter and an ammeter which display the output of the LBB's power supply. Running across the top of the panel, to the right of the ammeter, is a dark line. The four sockets on this line are the power supply's output terminals.

Also above the pegboard is a row of 12 lights, and under each a socket. Input resistance at each socket is 4,700 ohms. A voltage greater than 1.5 volts turns a light on, and voltage falling below 0.5 volt turns it off.

Under the power supply meters are the controls for the pulse generator, whose output can range between 1 volt and 6 volts. Width is adjustable, in steps, from 1 microsecond to 100 milliseconds, and frequency, in steps, from 10 hertz to 1 Mhz.

The output sockets for the pulse generator lie along a dark line that runs under the pegboard. And

mounted with the controls is another output plug, a BNC connector.

Also below the pegboard is a row of switches—four toggles and four pushbuttons — with access sockets.

On the right side of the board is a 22-pin connector with a column of sockets. This is particularly useful if the circuit being designed is to be put on a printed-circuit card.

Below this connector are two BNC connectors with sockets, used to tap signals off the board.

The LBB costs $650 and delivery time is 30 to 45 days.

E&L Instruments Inc., 61 First St., Derby, Conn. 06418 **[369]**

New instruments

Package deal for ECM firms

Amplitude comparators for tracing radar signals offered as complete units

The amplitude comparators used in tactical aircraft to indicate the direction of enemy radar signals are usually assembled by makers of electronic countermeasures equipment. They buy or build the component parts—essentially a detector, video amplifier, and video comparator.

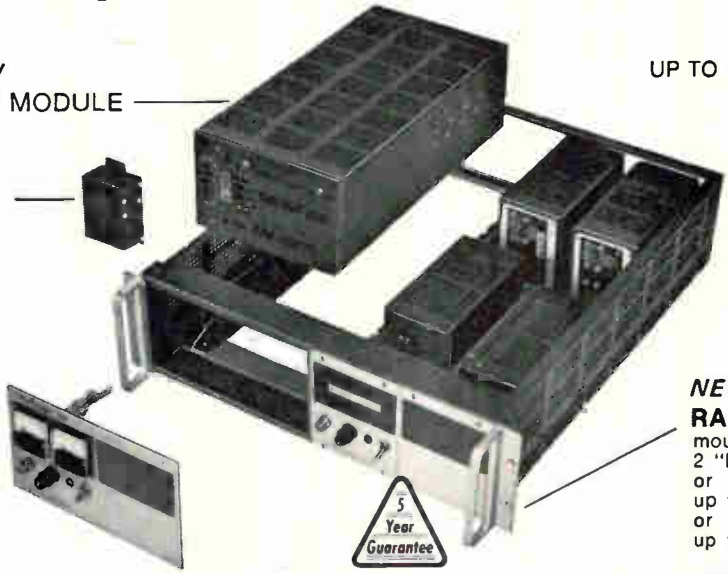
But Raven Electronics Inc., anticipating a large market for these devices, is offering them as complete units. William Whistler, Raven's vice president for engineering, says that purchased separately, the detectors alone can cost as much as $75, and the amplifiers have to be built from scratch. Raven will sell the complete instrument for $275 in quantities of 500.

On the side. In its countermeasures application, the amplitude comparator is linked through a receiver to antennas on each side of the aircraft. The device amplifies and compares the radio-frequency waveforms from each antenna to determine on which side of the plane the signal is stronger.

The company is offering three

LAMBDA ANNOUNCES
the new EE power package
with the highest power available in a half-rack module!

UP TO 150 VOLTS/UP TO 33 AMPS/
ONLY $320



NOW THERE ARE 7 VERSATILE 5 YEAR-GUARANTEED CONVECTION-COOLED LM SERIES MODULES—IN STOCK—ONE DAY DELIVERY

FEATURES OF NEW "EE" POWER PACKAGE

- **MEET MIL. ENVIRONMENT SPECS**
  Specify Lambda with assurance of meeting military requirements
  - RFI—MIL-I-16910 • Vibration: MIL-T4807A
  - Shock: MIL-E-4970A Proc. 1 & 2
  - Humidity: MIL-STD-810 Meth. 507
  - Temp. Shock: MIL-E-5272C (ASG) Proc. 1
  - Altitude: MIL-E-4970A (ASG) Proc. 1
  - Marking: MIL-STD-130 • Quality: MIL-Q-9858

  Fungus Proofing (optional):
  all models available with MIL-V-173 varnish for all fungi nutrient components at $10.00 surcharge.
- **THERMALLY PROTECTED AND SHORT CIRCUIT PROOF**
- **NO VOLTAGE SPIKES OR OVERSHOOT**
  on turn-on, turn-off, or power failure.
- **WIDE INPUT VOLTAGE AND FREQUENCY RANGE**
  105-132 VAC, 45-440 Hz with 10% derating for 50 Hz operation. (205-265 VAC, optional at no extra charge).
- **LINE REGULATION:** .05% + 4mV
- **LOAD REGULATION:** .03% + 3mV
- **RIPPLE AND NOISE:** 1mV rms; 3mV p-to-p
- **TEMP COEFF.:** .03% /°C
- **HIGH PERFORMANCE OPTION**
  All models available with these specifications at $15.00 surcharge:
  LINE REGULATION: .01% + 1mV
  LOAD REGULATION: .02% + 2mV
  RIPPLE AND NOISE: 0.5mV rms; 1.5mV p-to-p with 60 Hz input
  TEMP COEFF.: .01%/°C

NEW ACCESSORIES FOR "EE" PACKAGE

- **Rack Adapters**
  LRA-7 • 5¼"H x 19"W x 21"D. Price $70.00
- **Chassis Slides**
  Add suffix "-CS" to LRA Model number and add $50.00 to price.
- **Panels**
  5¼" x 8⅜" Metered panel MP-50. Price $55.00
  5¼" x 8⅜" Non-metered panel P-50. Price $35.00
  Add $10.00 for fungus proofing.
- **Overvoltage Protectors**

LM-OV-7	3-8V	4 7/16"H x 2 13/16"W x 1 13/16"D	$75.
LM-OV-8	6-20V	4 7/16"H x 2 13/16"W x 1 13/16"D	75.
LM-OV-9	18-70V	4 7/16"H x 2 13/16"W x 1 13/16"D	75.

Package EE 4 15/16" x 7½" x 17"

WIDE RANGE

Model	ADJ. VOLT. RANGE VDC	MAX AMPS AT AMBIENT OF: (1) 40°	50°	60°	71°	Price
LM-EE-0-7	0–7	16	13.5	11.2	9.2	$320
LM-EE-0-14	0–14	10.2	8.6	7.3	6.1	320
LM-EE-0-32	0–32	5.2	4.4	3.8	3.2	320
LM-EE-0-60	0–60	2.7	2.45	2.15	1.85	320

FIXED VOLTAGE

Model	ADJ. VOLT. RANGE VDC	MAX AMPS AT AMBIENT OF: (1) 40°C	50°C	60°C	71°C	Price(2)
LM-EE-3	3 ±5%	33.0	29.0	25.0	20.5	$320
LM-EE-3-P-6	3.6±5%	32.0	26.0	22.0	18.3	320
LM-EE-4	4 ±5%	32.0	26.0	22.0	18.3	320
LM-EE-4-P-5	4.5±5%	31.0	24.6	20.8	17.3	320
LM-EE-5	5 ±5%	31.0	24.6	20.8	17.3	320
LM-EE-6	6 ±5%	30.0	24.6	20.8	17.3	320
LM-EE-8	8 ±5%	28.0	23.5	19.7	16.5	320
LM-EE-10	10 ±5%	24.0	20.4	16.8	13.8	320
LM-EE-12	12 ±5%	21.0	19.0	16.1	13.2	320
LM-EE-15	15 ±5%	19.0	18.0	15.5	12.7	320
LM-EE-18	18 ±5%	16.5	14.8	12.4	10.1	320
LM-EE-20	20 ±5%	15.2	13.7	11.8	9.7	320
LM-EE-24	24 ±5%	14.0	12.5	10.8	9.0	320
LM-EE-28	28 ±5%	13.0	11.5	9.8	8.2	320
LM-EE-36	36 ±5%	10.4	9.8	8.6	7.1	320
LM-EE-48	48 ±5%	7.7	7.1	6.5	5.4	320
LM-EE-100	100 ±5%	3.3	3.0	2.5	2.1	350
LM-EE-120	120 ±5%	3.0	2.7	2.2	1.9	350
LM-EE-150	150 ±5%	2.2	2.0	1.75	1.50	350

NOTES:
1 Current rating is from zero to I max. Current rating applies over entire output voltage range. Current rating applies for input voltage 105-132 VAC 55-65 Hz. For operation at 45-55 Hz delete 40°C rating. For operation at 360-440 Hz consult factory for ratings and specifications. For 50 Hz operation derate 10%.
2 Prices F.O.B. factory, Melville, N. Y. All specifications and prices subject to change without notice.

Write, wire, or call to order direct, for information, or for new Lambda Power Supplies catalog. LAMBDA Electronics Corp., 515 Broad Hollow Road, Melville, L. I., New York 11746, TEL. 516-694-4200, TWX 510-224-6484.

LAMBDA

Circle 155 on reader service card

models, all with the same specifications except for frequency range. The CA-104 operates from 2.7 to 5.4 gigahertz, the CA-105 from 4 to 8 Ghz, and the CA-106 from 8 to 12 Ghz. Each has a recovery time of 2 microseconds, which Whistler maintains is particularly good when combined with the unit's dynamic range of 35 decibels at radio frequencies. The quick recovery stems from the use of completely d-c coupling in combination with a stabilized feedback.

Strength counts. Input-output delay is about 50 nanoseconds, depending on signal strength. "Low-level signals stretch the delay range," Whistler explains, "while strong ones shorten it." Amplitude error is 0.7 decibel rms, tangential sensitivity is –45 decibels above 1 milliwatt, and operational sensitivity is –35 dbm.

Each of the amplitude comparators is 0.75 by 3.16 by 5.16 inches. Whistler says the next version will have thin-film hybrid components and will be only about 0.5 by 1 inch by 2 inches.

Raven Electronics Inc., 101 West Alameda Ave., Burbank, Calif. [370]

New instruments

Pulses come cheap from small source

Low-priced generator is 4 x 3 x 2 inches; output goes to 1 Mhz

One way to keep money in your pocket is to put a pulse generator in there too. This suggestion comes from Willard McKinney, sales manager at R.H. Dempsey Mfg., who points out that many engineers are spending up to $200 for pulse generators for test and repair work. These are usually much too fancy for the application, McKinney says, but they're the only generators around that can do the job.

Now Dempsey is offering a $40 generator whose output is continuously adjustable between 40 kilohertz and 1 megahertz and whose pulse width ranges between 50

That's right—
It's a signal generator without a dial.

Instead, the frequency you set is displayed on a digital Nixie® display—to *four significant digits* of accuracy and resolution. We call this feature **ddc**™—direct digital calibration.

Using a unique, patent-applied-for circuit, **ddc** automatically, directly, and continuously measures the frequency to an accuracy better than 10 PPM, and displays it to 0.01% . . . 100 PPM, or about 100 times more precisely than any dial.

These frequency measurements are crystal-clock-referenced, at *all* settings, and the display is direct-reading, *always*, including decimal point and units . . . kHz or MHz. *The frequency you see is the frequency you've set—always.*

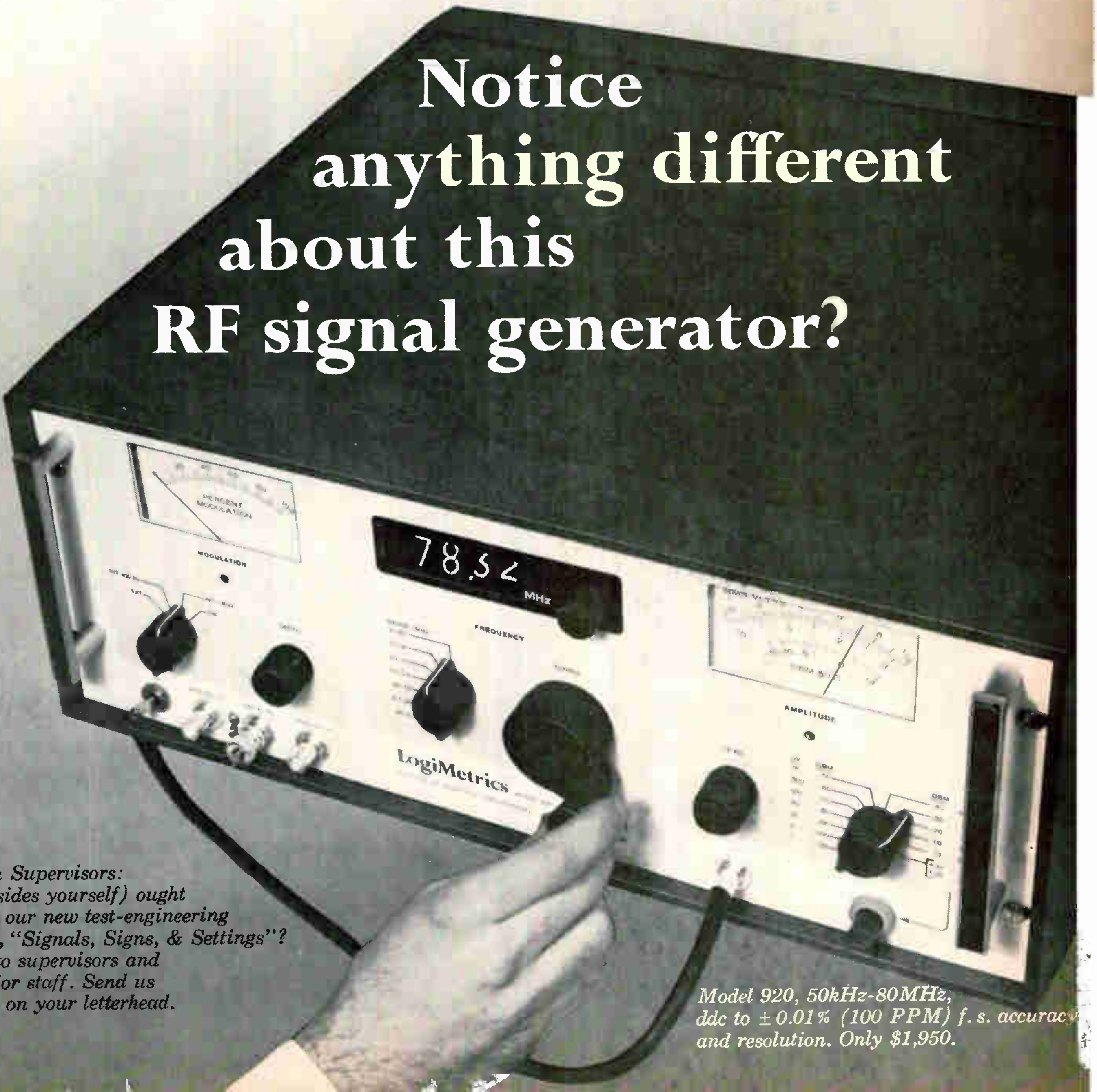
That's not all. These new all-solid-state designs provide for complete digital-system compatibility—programming of both frequency *and* amplitude, printout, computer control, etc.

Bulletin 900-10A reviews the theory and application of Series 900 signal generators from 50kHz-230MHz. To get your copy, check the reader-service number below . . . or call or write directly.

LogiMetrics

DIVISION OF SLANT/FIN CORPORATION,
100 Forest Drive, Greenvale, N. Y. 11548;
Phone: (516) 484-2600;

Notice anything different about this RF signal generator?



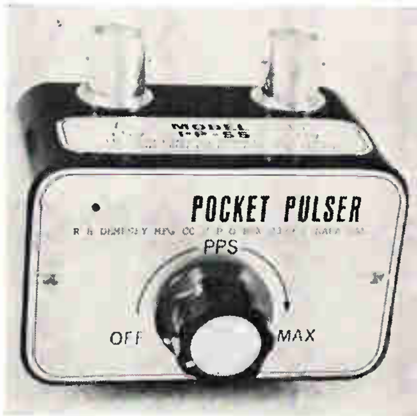
Attention Supervisors: Who (besides yourself) ought to receive our new test-engineering quarterly, "Signals, Signs, & Settings"? It's free to supervisors and their senior staff. Send us your list, on your letterhead.

Model 920, 50kHz-80MHz, ddc to ± 0.01% (100 PPM) f. s. accuracy and resolution. Only $1,950.

nanoseconds and 2 microseconds. It's called the pocket pulse generator, or PP-55, because of its size, just 4 by 3 by 2 inches. The PP-55 is a blocking oscillator with a feedback loop, encapsulated in epoxy and then packed in a Bakelite case. Power comes from a Mallory TR 177 battery.

The amplitude of the output pulse is +5 or −5 volts; and the frequency range can be extended down to 1 hertz by attaching a capacitor to terminals on the back of the device.

Low drift. Rise time of the output depends on the load; at 1 megohm it's 10 nanoseconds, and at 50 ohms it's 30 nsec. Dempsey engineers haven't yet measured fall times. They haven't specified long-term drift yet either, but the company says that this drift is low because tantalum capacitors are used in the generator. At 18 khz, short-term drift is 10 hz/hour.



Helper. The pocket-size PP-55 is designed for repairmen and for engineers testing circuits.

The PP-55 is the civilian offspring of the TG5R, a generator that the company has been building for the Navy since Dempsey's founding three years ago. Sailors use the TG5R to trigger a plan position indicator during repair work.

Among the things that the PP-55 can help test, says McKinney, are cable terminations, photocouplers, and tunnel diodes. He adds that the generator can be the input to a circuit under design or the trigger for such devices as binary logic circuits and multivibrators.

Delivery time is 30 days.

R.H. Dempsey Mfg., P.O. Box 2339, Napa, Calif. 94558 [371]

Whether you want a wave analyzer or a spectrum analyzer, the ambidextrous HP 3590A does the job. This flexibility is achieved through the use of automatic amplitude ranging, electronic frequency sweeping, and linear or log X-Y outputs for graphic display.

But this dual capability is only the start of the HP 3590A's measuring ability. Add to this versatility the >85 dB dynamic range, highly selective bandwidths, ac and dc programmability, and a frequency range of 20 Hz to 620 kHz. The sum of all these improvements is increased performance and accuracy at speeds previously unattainable. Why settle for less? With the HP 3590A, you get the measurements you want—when you want them—faster and easier.

To provide the additional advantages of a special balanced input with selectable terminating impedances of 75, 135, 150, and 600 Ω—the new HP 3591A selective voltmeter is now available. Multiply this highly useful input capability by the fact that the 3591A is calibrated to indicate properly in either dB or dBm regardless of the terminating impedance selected. One result—an analyzer capable of making noise and level measurements on balanced voice frequency circuits, or on carrier systems up to 120 channels. And this example is only one of the many applications of an instrument designed with you in mind.

The 3590A mainframe is $3200. The 3591A mainframe is $3350. Three plug-ins are available: 3592A low cost slave and program unit when used in second 3590A, $80; 3593A with 3-digit mechanical display, $1100; 3594A with 5-digit electronic counter frequency display, $1600.

To get complete information on either the HP 3590A or the HP 3591A, call your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

099/6

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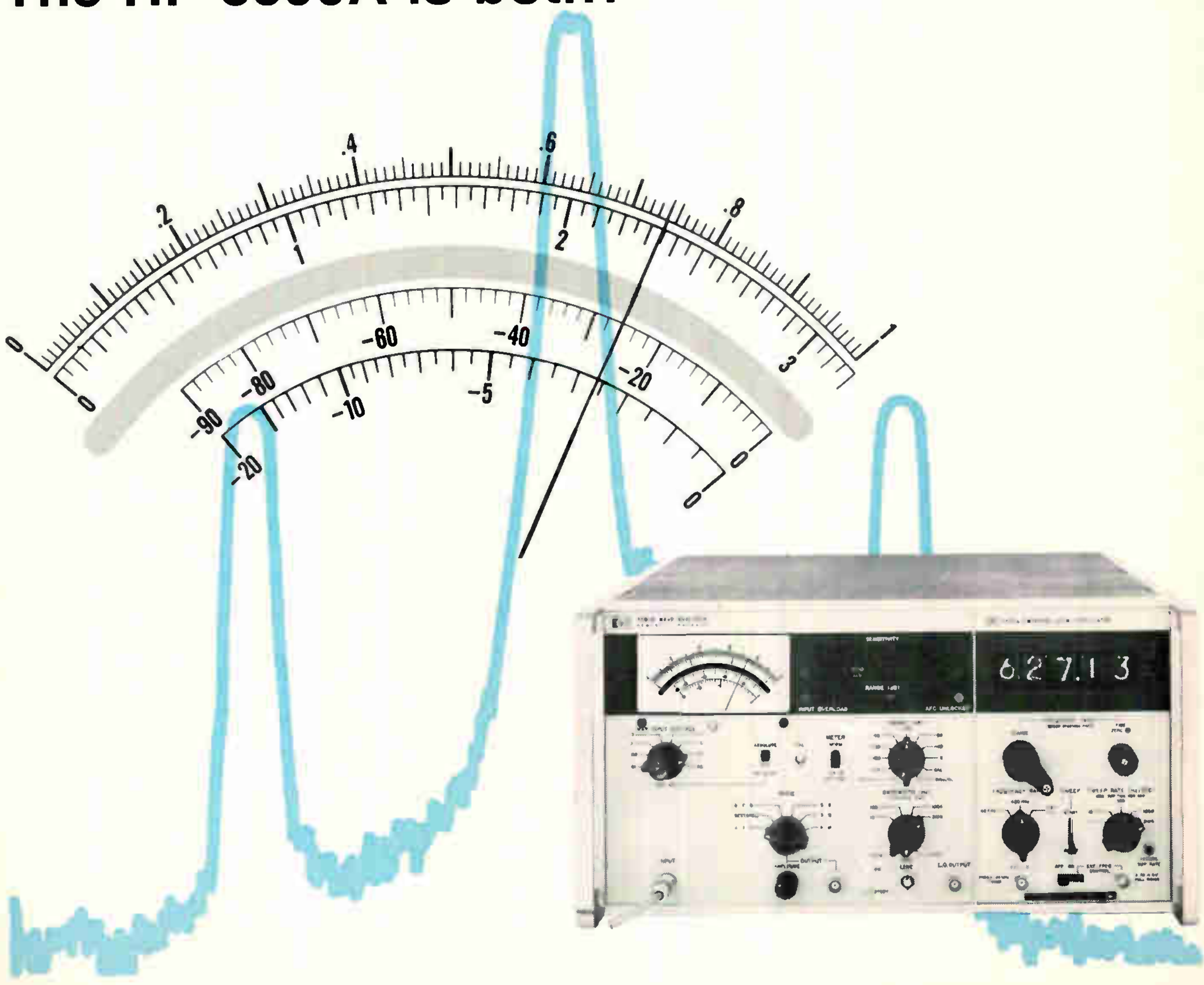

Circle 159 on reader service card

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Computer display is highly readable

First all-British remote terminal has 15-by-11 matrix and sells for $6,000; production line in Canada is planned

The proliferation of computer peripheral equipment has been, up to now, principally a U.S. phenomenon. But Ferranti Ltd. next spring will start delivering what it describes as the first wholly British-designed and -manufactured remote display terminal.

Price of the stand-alone terminal in the U.S. will be about $6,000, and Ferranti claims this makes it the least expensive unit of its kind in the world in terms of cost per character. The price in Britain and on the Continent hasn't yet been determined. The company attributes the low price to use of integrated circuits and novel methods of character generation.

Sharp image. The displayed characters are more legible than those generated by most displays because the sub-raster is defined by a 15-by-11 matrix, each position of which corresponds to a bit in computer memory. Conventional units use a 7-by-5 matrix.

The terminal has 64 characters in its magnetic storage. The unit includes a keyboard and a new crt. A message of up to 2,048 characters can be displayed on the crt, then edited and transmitted over

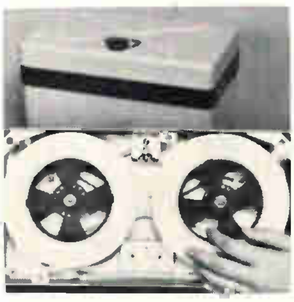
IBM-compatible tape recorder model 70C is designed for a maximum speed of 25 ips continuous operation, and is also available at speeds of 5, 12½, and 18¾ ips. It will accept up to 20 commands/sec and has the optional capability of search forward/reverse at 75 ips. Price range is $1,650 to $3,200. Cipher Data Products Inc., 1219 Morena Blvd., San Diego, Calif. [421]

Data sets designated modems 4400/20H and 4400/20L are based on a narrowband technique of transmission. They transmit two separate high-speed, 2,000 bit-per-sec messages at the same time over a single telephone line. EDP users with multistation networks can realize cost savings of up to 50% on leased transmission lines. International Communications Corp., Miami, Fla. [422]

Pictorial/graphic digitizer can translate pictorial source material into computer language and record it directly to computer tape ready for data processing. It features resolution up to 1,000 lines per in., accurate gray level encoding, adjustable scanning aperture, and bandwidth compression for graphic inputs. Aeroflex Laboratories Inc., S. Service Road, Plainview, N.Y. [423]

Scanner-A/D converter 013-022 is designed for use in automatic check-out equipment and data acquisition systems. The standard, 10-channel model is capable of 400 conversions/sec. Pin board allows programing of 4 functions/channel. Accuracy of A/D converter is 0.025% of full scale ±least significant digit. A. D. Data Systems Inc., 830 Linden Ave., Rochester, N.Y. [424]

Bulkhead-mounted, single line punched tape reader model 3100 is designed for loading computers, controlling test equipment, and similar uses where a small tough unit is required. It will withstand 2 g vibration from 5 to 33 hz, and 25 g shock. Operating temperature is −40° to +70°C. Price is $1,190. Electronic Engineering Co. of California, E. Chestnut Ave., Santa Ana, Calif. [425]



Digital tape recorder model DS-4130 is a compact, cartridge-loaded unit featuring IBM-compatible hub for rapid, post-flight data processing. It includes incremental recording capability for RZ or NRZ (1) inputs with a 200 bits-per-inch density and a character transfer rate to 200 steps/sec. Unit measures 6 x 7 x 13 in. Sanders Associates Inc., 95 Canal St., Nashua, N.H. [426]

Programable data comparator series 800 provides monitoring of up to 100 points, with point scanning frequency of 200 khz. Programing is sequential, requiring only a single advance signal input to move from point to point. Data word length is 4 BCD digits, plus signal. Peak-to-peak amplitude of input signals is 10 v max. Systems Research Corp., 2309 Pontius Ave., Los Angeles. [427]

Analog-to-digital converter model HS-810 will assign up to 10 million 8-bit binary numbers/sec to wideband analog signal. Codes available are straight or offset binary, 1's or 2's complement, or Gray. It has a maximum error of 0.2% ±½ least significant bit and a maximum aperture time of 0.4 nsec. Computer Labs, 1109 Valley Park Dr., Greensboro, N.C. 27403. [428]

On line. First all-British terminal displays computer-generated data.

a data line. Or the terminal can be coupled to a regular telephone line and used to interrogate a computer from a remote site.

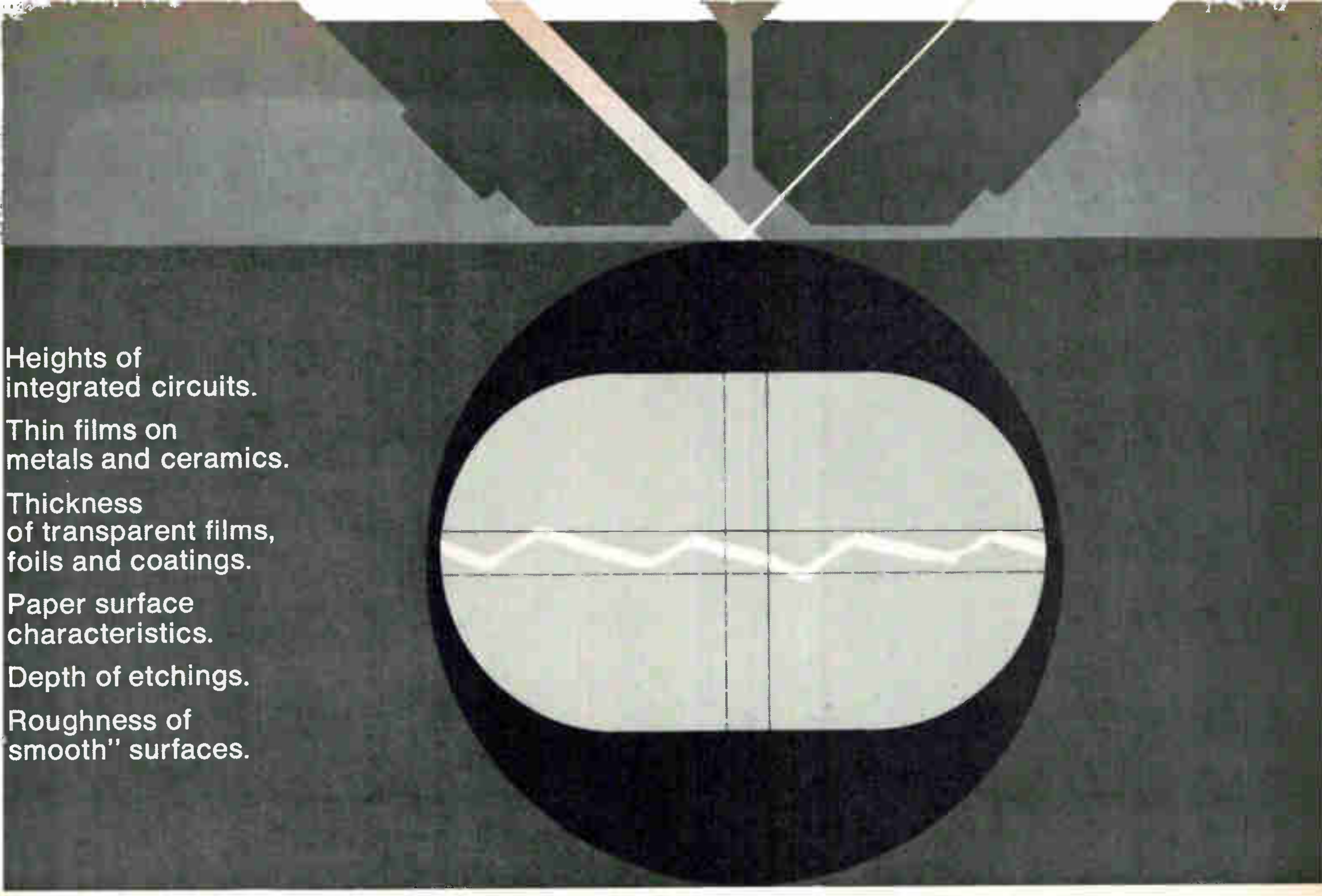
The flicker-free screen measures 240 by 180 millimeters and uses a new long-life phosphor developed by Ferranti. It can display a message of up to 32 rows of 64 3-mm-high characters. The refresh rate is 50 hertz. Equipment for graphical displays can be added, Ferranti says.

Video version. A second version of the display terminal uses a full-raster television scan with broadcast standards instead of the subraster system. Both systems operate with standard codes. A range of character sizes permits text, captions, and graphic displays to be inserted into an existing video-modulated raster.

The television type will be marketed as a monitor for closed-circuit tv systems. The remote computer terminal was designed for use in computer-controlled communications systems at airports, railroad terminals, supermarkets, and theaters.

First deliveries will be limited to Britain, but the company says a second production line will be set up in North America, probably at Ferranti Packard in Toronto.

Ferranti Ltd., Moston, Manchester, England [429]



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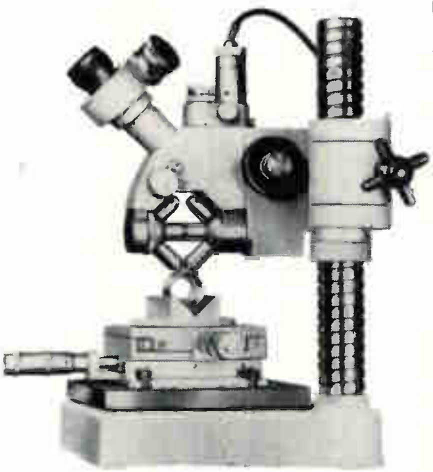

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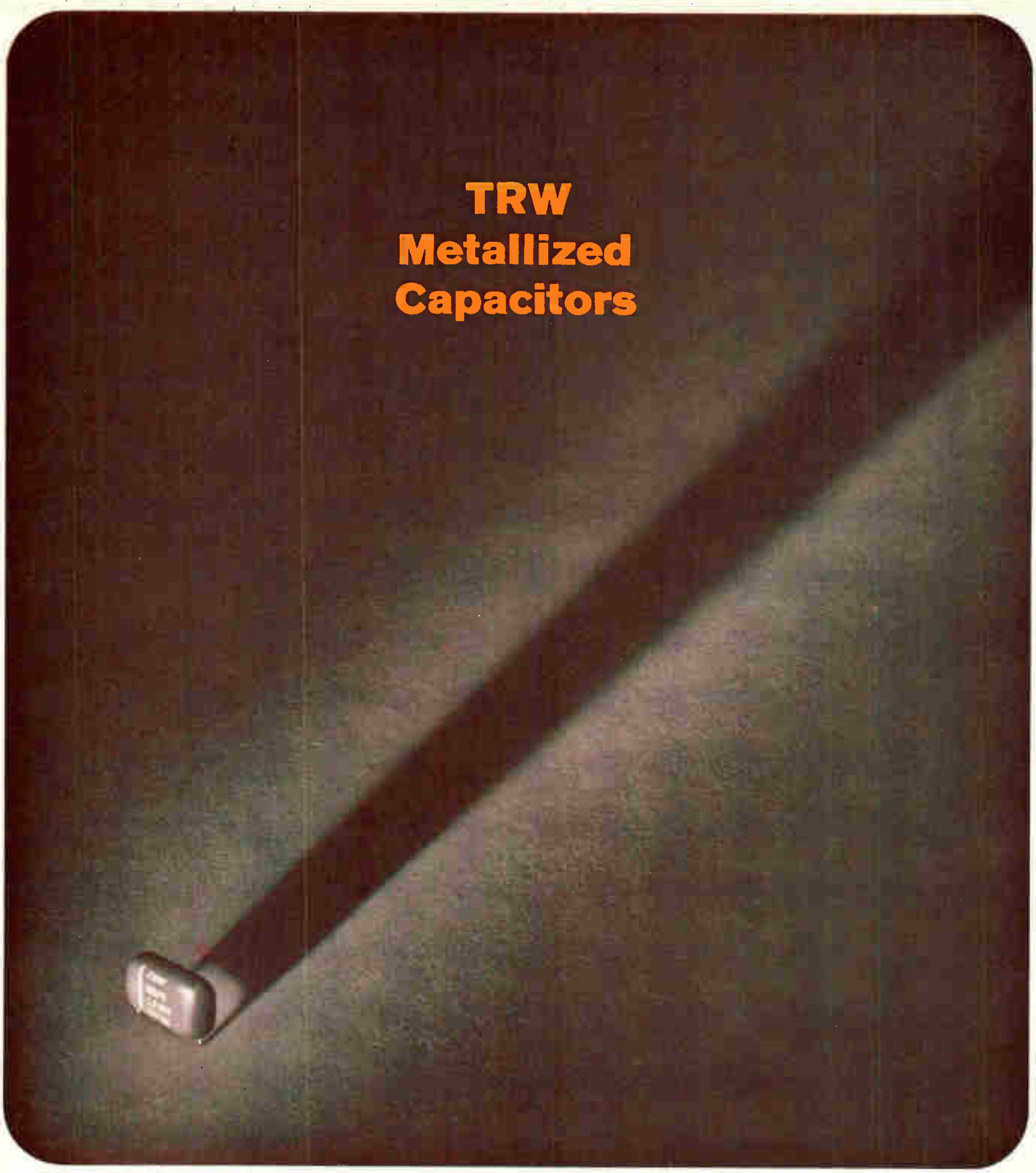
Circle 163 on reader service card



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Mini-magnetron delivers 1-kw pulses

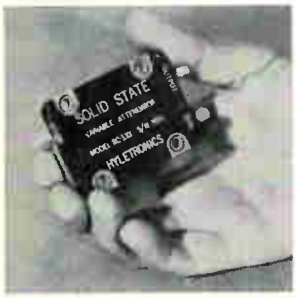
Positive-pulse design is used in a 11.5-ounce source developed for radar, fuzing and transponder applications

By capitalizing on a design technique known since the early 1950's, Microwave Associates Inc. has developed the smallest, lightest Ku-band magnetron yet, the MA-287. Applying a positive-pulse design, the firm has built a tube weighing only 11.5 ounces and measuring 1.5 inches on a side. Small as it is, the MA-287 emits pulses of 500 watts to 1 kilowatt at fixed freqencies around 16 gigahertz.

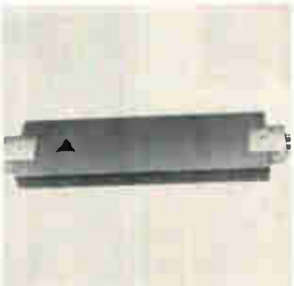
Magnetron sales manager Jerry Simpson says that the tube is among the most rugged available, that it can achieve pulses only 20 to 30 nanoseconds long with nanosecond rise time, and that warmup takes only a few seconds. And he ascribes all these features to the positive-pulse design.

A company spokesman says the next smallest tube is a classified device, 2 inches on a side and 1 pound in weight. From there, weight increases to 18 to 22 ounces in commercial magnetrons which are negative-pulse devices.

The difference. A positive-pulse magnetron differs from the com-



Variable attenuators cover the range from 0.5 to 11 Ghz with essentially the same curve for bias current versus attenuation for all frequency bands. Insertion loss at zero bias is 0.8 db from 0.5 to 7 Ghz and 1 db from 7 to 11 Ghz. Attenuation of 60 db for any octave bandwidth can be attained with 20 mw of bias power. Hyletronics Corp., Ainsworth Rd., Wilmington, Mass. [401]

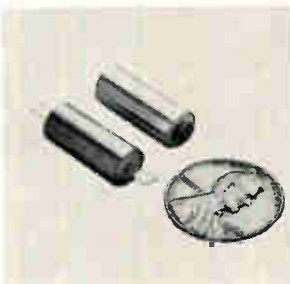


Microwave acoustic delay line with 10 μsec delay and 50 db loss operates at 50 w peak and is designed for L-band. Vswr is 3:1, bandwidth is 20%, spurious response 20 db. For S-band, loss is 65 db; for C-band, 90 db. Applications are radar checkout, altimeters, fuzes, and similar equipment. Cost is under $3,000. Andersen Laboratories Blue Hills Ave., Bloomfield, Conn. [402]

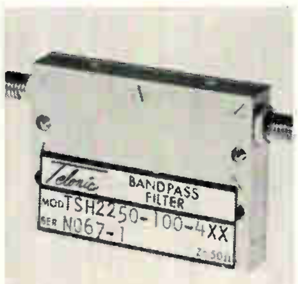
Preselector network is remotely driven to preselect channels to an accuracy of ±1 Mhz in X-band. It is an electromechanical device which, upon command, activates the motor drive circuit to tune the 3 preselectors to the desired channel. The unit is temperature compensated and hermetically sealed. It weighs 27 lbs. Gombos Microwave Inc., Webro Road, Clifton, N.J. 07012 [403]

Ferrite 3-port circulators cover 10% bandwidths. Matching waveguide flanges from 3.7 through 15.4 Ghz, these units have 25 db isolation, vswr's of 1.07 through 1.13 as standard with insertion losses generally less than 0.2 db. Magnetic shielding is available on all 17 models of the series. Portchester Instrument Corp., 114 Wilkins Ave., Port Chester, N.Y. 10574. [404]

Computer designed DB-X-358 interdigital and comb-line microwave filters are available with center frequencies from 200 Mhz to 15 Ghz with 0.5% to octave bandwidths. Typical vswr is 1.20. Typical insertion loss is 1.0 db. Price is $200 to $400 depending on specifications and quantity. DeMornay-Bonardi Div., Systron-Donner Corp., 1313 N. Lincoln Ave., Pasadena, Calif. [405]

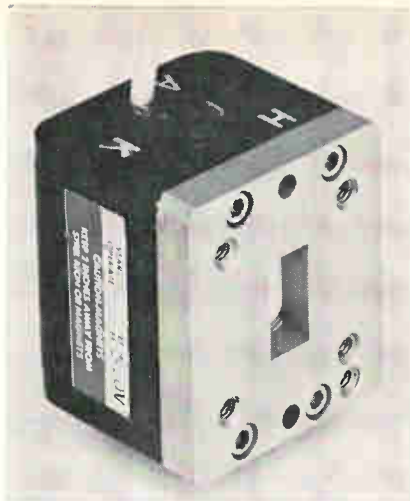


Connectorless attenuator cartridges are for direct inclusion in stripline modules or transmission lines. They are available in several attenuation values, up to 30 db. Units operate from d-c to 10 Ghz and can be provided with stripline, disk or other mating configurations. They can also be incorporated into co-ax components. Microlab/FXR, Livingston, N.J. 07039. [406]



Miniature bandpass filter model TSH is for telemetry applications in the 2.2 to 2.3 Ghz transmission band. It exhibits a wide stop band with rejection greater than 40 db from d-c to 1.980 Ghz and 2.475 to 8 Ghz. Rejection skirts are typically similar to 0.1 db Chebyschev ripple. The unit measures 1 21/32 x 1 5/32 x 5/16 in. Telonic Engineering Co., Box 277, Laguna Beach, Calif. [407]

Double balanced mixer-preamplifiers series DMP offer r-f coverage from 100 Mhz to 1 Ghz with local oscillator to r-f isolation of 30 db minimum. Output capability of +10 dbm at less than 0.5 db compression at i-f's of 30, 60, or 70 Mhz is standard. The unit measures 4 x 2⅜ x 1 9/16 in. Price is $695. RHG Electronics Laboratory Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735. [408]



Powercube. Magnetron only 1.5 inches on a side can put out a kw pulse.

mon negative-pulse types in that almost all of its components—cathode, magnetic pole assembly, heater, and external supports—are at ground potential. Only the anode is positively pulsed to draw electrons from the cathode. In negative-pulse tubes, the cathode must be isolated from other tube parts by shields to prevent arcing.

Since the MA-287's cathode can't discharge current to any part of the tube except the anode, everything can be (and has been) compressed into a smaller, lighter package. Magnetic pole pieces are brought closer to the interaction space between anode and cathode, giving a more uniform field and reducing the amount of magnetic material needed.

The magnetic pole pieces themselves can be used to support a new sort of cathode structure, one supported from both ends instead of at one end of the vacuum envelope. Spacer washers within the magnetic pole pieces grip the cathode tightly.

Fast warmups. The assembly is rigid; the new tube passes MIL-E-5400 shock and vibration specifications with ease. At the same time, the cathode's support is lighter, and it thus presents less mass for its internal heater to warm up; the tube's turn-on time is a quick 10 seconds or less. Warmups of less than 7 seconds have been measured in the lab.

Having the heater at ground potential eliminates the usual need for a bifilar transformer in line-type modulators. And obviously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. . . anode can be biased for very short pulses . . .

there's no problem of capacitance between ground and heater transformer. In negatively pulsed tubes, both these effects limit rise times and add jitter. But the new tube's minimum rise time is estimated to be less than 1 nanosecond and jitter less than 10 nsec.

Since there's no danger of arcing, the anode can be biased to allow very short pulses. "Negatively pulsed tubes tend to get gassy when biased," says Norman Balmuth, the firm's manager of magnetron engineering. "But the 287 has no problem here. One of our customers biases the anode at 80% of the voltage needed to trigger a microwave pulse, and by adding that 20% when needed, he can get pulses as short as 20 nsec —an important feature when high range resolution is wanted, say in radar or fuzing."

Retrofits? Simpson suggests transponders as another possible application for the MA-287. "It's possible that transponder tasks now performed at X band may be moved upward to Ku band along with other military systems requirements. There could be a retrofit market here, and though we couldn't drop the 287 into an X-band socket, we'd like to sell to builders who might make replacement subassemblies."

These builders would be able to buy the MA-287 in lots of a thousand in about 6 months. Microwave Associates is aiming the tube at original-equipment manufacturers and thus doesn't even have a small-quantity price. "But the 287 should cost about $700 in OEM quantities," says Simpson.

The firm may decide to offer a tuner so that output frequency could be varied; this could boost the price 50%.

More likely is an isolator built into the tube's output waveguide flange. This would raise the price about $50, but Balmuth says the added cost would be offset by better tube protection, reduced pulling (a type of frequency shift), and savings in external waveguide hardware.

Microwave Associates Inc., Northwest Industrial Park, Burlington, Mass. **[409]**

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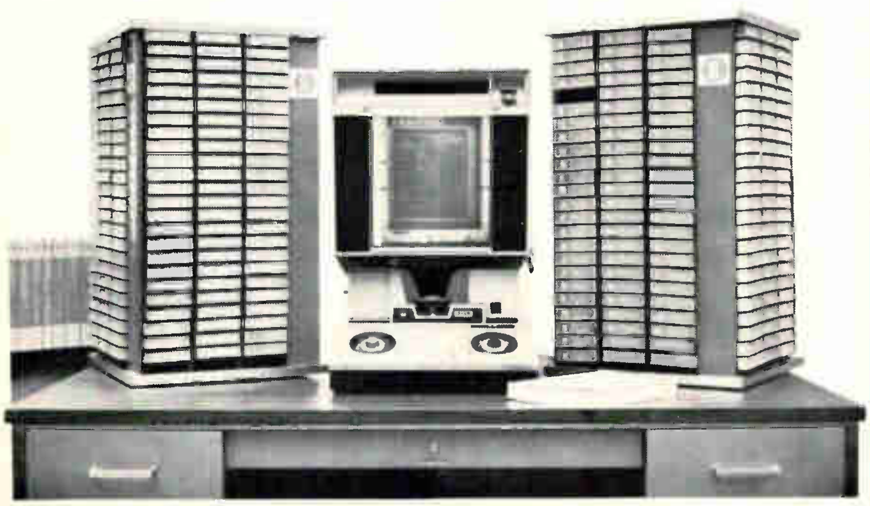

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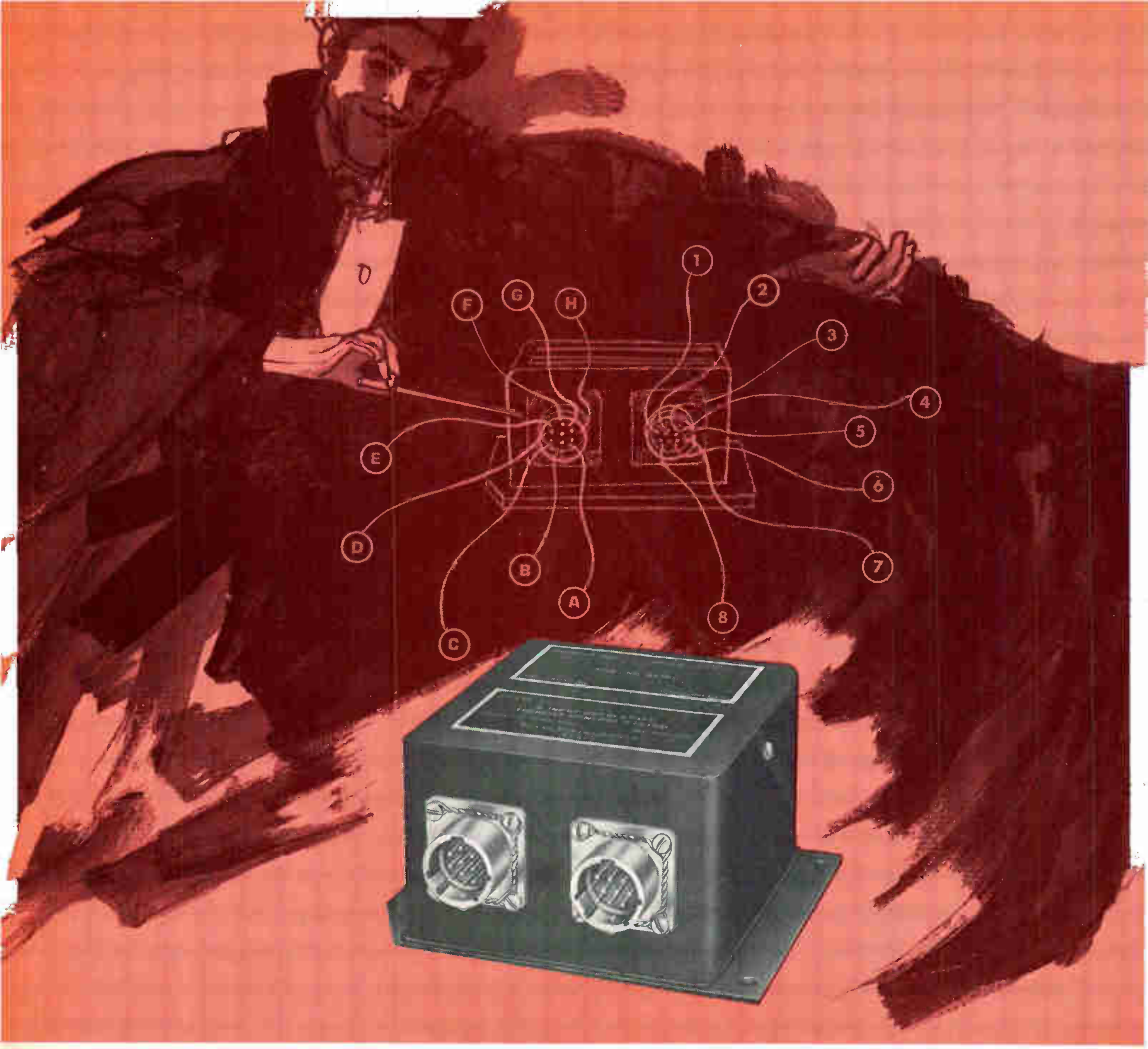

Introducing THE THERMAL LOGICIAN for monitoring several temperatures in several locations...simultaneously.

This feat of magic is performed by a new TI multi-channel thermal switch. It's the heart of a missile's environmental control system. Each channel accepts input from one or more sensors and performs logical switching functions to initiate rapid warning or control response. With an MTBF of 75,000 hours, it's one of the most reliable thermal switches ever devised.

This particular switch happens to have five channels. It could have fewer or many more. Other options include single or three phase design and SPST or SPDT switching action.

This example of innovative electronic circuit design suggests that TI's thermal magicians can solve your next complicated (or simple) temperature control problem. How about it? Write for literature to TI Control Products Division, Attleboro, Mass. 07203, or phone (617) 222-2800, Ext. 318.

TEXAS INSTRUMENTS
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Circle 170 on reader service card

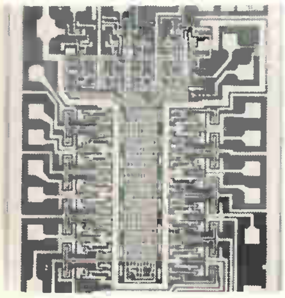
IC does four jobs in f-m stereo

Besides separating audio channels, monolithic device acts as muting circuit, automatic switch, and lamp driver

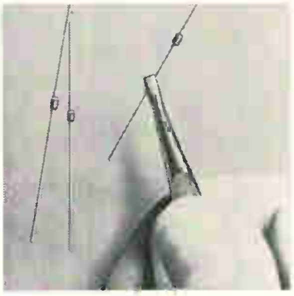
The multiplex demodulator in most commercial f-m stereo radios performs the sole function of separating the two channels of a stereo broadcast and routing them to their separate audio channels. But most modern f-m stereo radios that provide over 30 decibels of separation also require further devices with additional discrete circuitry. Most sets use a lamp driver, for example, to indicate on the tuning dial when a high-quality stereo signal is being received.

But an integrated-circuit f-m stereo multiplex demodulator making its debut this month provides four functions on one 60- by 71-mil chip—and at prices competitive with or lower than those of discrete devices that can deliver the same performance. Officials at Motorola's Semiconductor Products division believe their MC1304 is the first such device available in monolithic form.

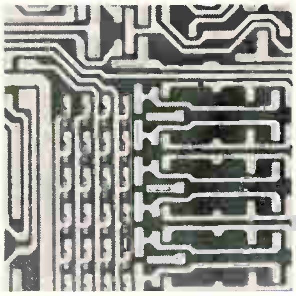
Clay Tatom, manager of product planning for linear IC's, claims the circuit "will be a real winner in the consumer market." He says



Digital decoder 9311 features a built-in enabling capability and high speed (20 nsec through delay). The circuit is designed to convert four digital inputs into one of 16 mutually exclusive digital active-level low outputs. Price is from $11.40 to $34 each, depending on quantity, package, and temperature range. Fairchild Semiconductor, 313 Fairchild Dr., Mtn. View, Caiif. [436]

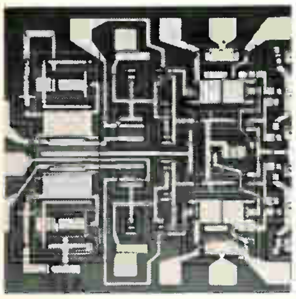


Silicon zener regulators series C4011 are 400 mw microminiature units suited for use in both commercial and industrial products. They meet or exceed MIL-S-19500. The series is available in 19 zener voltages, ranging from 6.2 to 36 v. Pricing is as low as 15 cents in large quantities. Centralab Semiconductor Div., Globe-Union Inc., 5757 N. Green Bay Ave., Milwaukee 53201. [437]



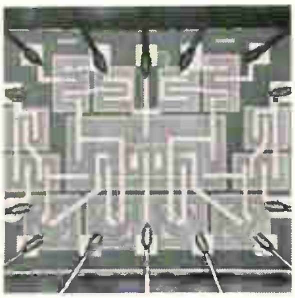
Bipolar 128-bit read only memory XC170 economically provides 16 custom 8-bit words and is supplied in a fast turn around cycle. Address times are less than 45 nsec. Unit is supplied in the Unibloc 16-pin dual-in-line package for operation over the 0° to 75° C range. Price is $9.95 in 100-up quantities. Motorola Semiconductor Products Inc., Box 20924, Phoenix 85036. [438]

Six-ampere SC141 and ten-ampere SC146 plastic triacs have applications in control circuits for major appliances. They feature a molded gray silicone package, round leads for easy handling and mounting, a solid copper heat sink for low thermal impedance (2° C/w), and a glass passivated triac pellet insuring hermeticity. General Electric Co., 1 River Road, Schenectady, N.Y. [439]



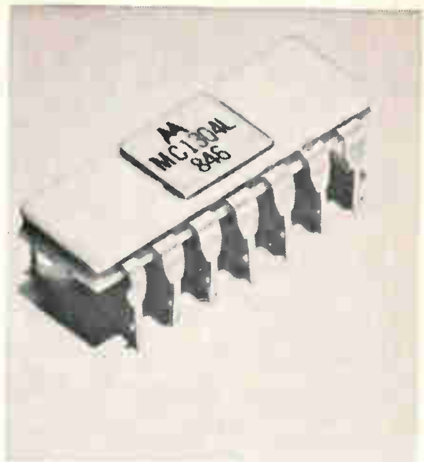
Dual differential-input amplifier L120 consists of 14 MOS FETs and 12 bipolar transistors on a single chip, 55 x 65 mils. Suited for sample and hold, integrating and fast voltage comparison, it is unity gain stable with no external components. Typically, input bias current is 20 pa, input resistance is 2 x 10^{11} ohms. Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. [440]

Solid state relay R160, a replacement for electromechanical relays, combines semiconductor and IC technology. Packaged in a ¾-inch press-fit case, it is available for actuating voltages of 6, 12, and 24 v d-c at a gating current of 35 ma. The unit will control a power circuit of 16 amps rms at 120 v, 50 or 60 hz. Hunt Electronics, 2617 Andjon Drive, Dallas 75220. [441]



Monolithic quad voltage translator IC model 1026 is designed to interface between standard current sinking logic and MOS multiplexers, and has negligible power dissipation in the "output high" condition. Allowable range of the negative supply is from −4 to −60 v, and the output pull-up may be returned to 64 v more positive. United Aircraft Corp., Trevose, Pa. 19047. [442]

C-w avalanche oscillator diodes series MA-4900 are designed to accomplish a one-step conversion from d-c to microwave energy, thereby eliminating complex circuitry. Typical performance is represented by the MA-4980 which operates over the 8.2 to 12.4 Ghz range with minimum output of 10 mw and efficiency of 1 to 2%. Microwave Associates, Burlington, Mass. [443]



Four-in-one. IC multiplex demodulator does extra jobs in stereo sets

at least one manufacturer of stereo receivers has bought the MC1304. It provides more than 40 db separation at 1 kilohertz. Kenneth Wolf, product manager for consumer IC's and designer of the circuit, says this is 6 to 10 db greater separation than the best high-quality f-m stereo multiplex demodulators in discrete form provide. And the MC1304's price—$4.80 for quantities of 100 or more—compares favorably with a $5 to $6 cost for similar discrete systems, according to Wolf.

The other three things the MC-1304 does are:

- An audio muting circuit squelches the interstation hiss when tuning between f-m stations.
- A built-in stereo switch automatically switches from stereo to monaural when the signal level drops below that required for high-quality stereo reception.
- A built-in driver delivers up to 40 milliamps to a lamp on the dial face.

The device is housed in a ceramic dual in-line package, but may be offered later in a plastic case.

Tatom says it is difficult to obtain stereo separation greater than 35 db using discretes. A monolithic IC allows better matching in the demodulator because all the transistors are on one chip, and matched transistor pairs are critical in this application, he says. "You can get stereo separation using other methods—by using a diode matrix, for example—but it's hard to get a good match between parts in the demodulator section when

using discretes," he says.

The built-in switch, by converting a weak stereo signal to monaural, eliminates much of the noise and distortion. These occur because of the greater susceptibility to selective fading in the wider-bandwidth stereo signal.

Besides offering a system that has greater capability than can be obtained with discrete systems, Motorola engineers believe the unit's total harmonic distortion, which is typically 0.5%, is also important. Also, the device can reject a frequency without external filters, and its power dissipation is less than 150 milliwatts. Says Tatom, "That's pretty low for a circuit that performs all these functions."

Frequency rejection at 19 khz is 25 db; at 38 khz the figure is 20 db. Wolf says these levels are comparable to those of discrete systems for "storecast" reception—piping the signal into a business establishment. Frequency rejection at 67 khz is 50 db, which Wolf maintains is better than is possible using discrete systems. He says external filters probably won't be required for storecast reception.

The MC1304 will operate with power supplies rated at 8 to 14 volts d-c.

Motorola Semiconductor Products, Inc., P.O. Box 955, Phoenix, Ariz. [444]

New semiconductors

Toshiba joins consumer FET race

Junction-type pre-amp and dual-gate MOS unit are initial entries

Increased emphasis on field effect transistors in Japanese-made equipment is underscored by the decision of Tokyo Shibaura Electric Co. to market two types of FET's that were designed for consumer products.

A junction type for audio amplifiers features a high breakdown voltage and a low noise figure. The second FET is a dual-gate MOS

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type for use in television tuners and similar applications up to about 500 megahertz.

The audio type, designated the 2SK30, has a maximum voltage rating of 50 volts and a noise figure of about 0.5 decibel. The noise figure is measured at 120 hertz with a signal-source impedance of 100 kilohms. Neither figure is startling, but Toshiba considers the combination of the two as unusual. The company says that the devices will sell for about the same price as low-noise silicon transistors, and that it expects to be making about 300,000 devices per month by the second half of 1969. They could be used at the input of a preamplifier or main amplifier, in the tone control circuit, or as a load for a low-noise pnp input transistor in a preamplifier.

In this last-named application, they act as a high load impedance and increase the gain of the input transistor.

Since each channel in a stereo set might use one of these FET's at the input to the preamplifier, two in the tone control and one at the input of the main amplifier, a Toshiba engineer speculates that six or eight might be used in one set.

A typical application for the MOSFET is as an r-f amplifier in the very-high-frequency tuner of a tv set. Two gates of the device are in a cascode configuration, similar to a dual-gate MOS unit developed by RCA. One gate is used for signal input, the other for automatic-gain-control input. The second gate can also be used for the oscillator input connection in mixer applications.

Toshiba expects to market, by next Spring or Summer, a tv set using this FET. By the second half of 1969, the company hopes to push the price down to where it will compete with bipolar r-f transistors at the same frequencies.

The company predicts that, during the second half of 1969, production of the MOSFET's will reach between 100,000 and 150,000 units a month.

Tokyo Shibaura Electric Co., 2, 5-chome, Ginza-Nishi, Tokyo [445]

Iowa's Quiet Industrial Explosion

A state that's made one of the most successful agricultural-to-industrial transitions in history proves there's more to prosperity than just tall corn.

A scant fifty years ago, before the advent of mass communications, traveling vaudeville troupes were careful to keep their material on a popular level. Each mildly sophisticated new gag brought the same reaction — "Sure it's funny, but will they get it in Dubuque?" The implication was that if the humor was broad and obvious enough for the rubes in Dubuque, it could safely be used on any stage in the country.

America has changed since those innocent rural days and nowhere is the change more evident than in Iowa. In 1951, for the first time in her history, Iowa's industrial output exceeded her still-soaring agricultural output.

To the leaders in Iowa, this tipping of the scales represented the culmination of years of guidance and hard work. Because this industrial era in Iowa didn't just happen — it was carefully and deliberately planned.

As World War II drew to a close, the farm states of the Midwest found themselves in a peculiar position. Technological and biological advances, necessitated by the needs of the war, had made it possible for one farmer to farm more land than ever before The result — fewer and fewer farm jobs. With the prospect of mass unemployment in the future, Iowans began luring industry to their state.

Year by year, step by step, the state's industrial capacity grew. At no time did the unemployment level go above the national average.

As the years passed, Iowa's industrial recruitment methods achieved a high level of sophistication. Iowa's governors have traditionally taken a close personal interest in industrial development — many a vacillating board chairman has found himself receiving calls from the governor's mansion in Des Moines. Iowa trade missions composed of state business and political leaders have jetted abroad, seeking out new markets for Iowa products.

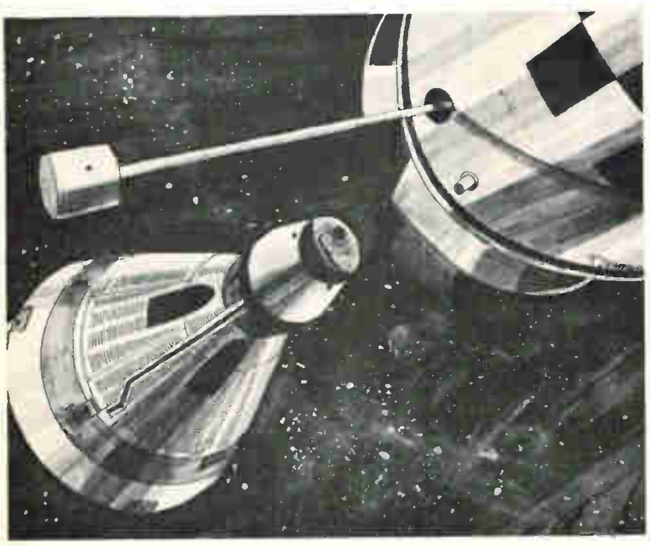
Probably her biggest asset, however, is her people. Iowa colleges and universities graduate more Ph. D.'s per capita than any other state in the union. Her work force is intelligent, educated and endowed with typical Midwestern pride in work. Personnel Directors privately admit Iowa plants are generally more productive than sister plants in other states.

If Iowa has a serious problem, it's her image. Progress has been so rapid, the state's industrialization is not generally known. To many industrialists, particularly in the East, Iowa is still one vast cornfield.

But this problem, too, is being met with typical Iowa ingenuity. Iowa's leaders have attacked the image problem in a unique way: by thinking of Iowa as a corporation. High level brainstorming sessions have produced some startling ideas. A convincing battery of Expo-type visual presentations are being developed for foreign and domestic trade missions. On the theory that the best way to dispel a sterotype is through personal acquaintance, the state's tourism budget has been radically expanded. A huge regional airport capable of handling the yet-to-be-developed giant SST's is under discussion. The possibility of a state professional football team has been raised.

Thus, with her industry booming, Iowa sets out to amplify her accomplishments. And, if you've ever been to Iowa or talked to Iowans, there can be no doubt of her ultimate success.

Have you overlooked Iowa as an industrial site? For details write Iowa Development Commission, 250 Jewett Building, Des Moines, Iowa 50309.



The vast Collins Radio complex in Cedar Rapids has played a significant part in America's space program. 124 of the 500 top U. S. companies have 446 modern plants in Iowa.

Far-sighted Iowans are already at work planning for a Midwest air terminal in their state capable of landing the new supersonic transports. Iowa is midway between Chicago, Minneapolis, Omaha and St. Louis.

Cultural activities are very much a part of life in Iowa. Every major city has an Art Center.

Circle 177 on reader service card

New Books

Right wavelength

Frequency Modulation Receivers
A.B. Cook and A.A. Liff
Prentice-Hall Inc., 527 pp. $15

If you would like less noise and more signal from books on f-m receivers, pick up this one and thumb through its pages. There are plenty of waveforms, graphs, and circuits with good, descriptive captions. Slanted toward the communications engineer and professional service technician, this book can serve as a reference on a variety of topics related to receivers; the chapters needn't be read in sequential order.

Because it deals primarily with commercial receiver design, it is vacuum-tube oriented, although field effect transistor circuits are described. Equations in the text are kept to a minimum; all necessary derivations are included in appendixes at the end of each chapter.

Modulation techniques are compared, and the effects of noise and very high frequencies are covered in three chapters. The remaining sections deal with the building blocks of an f-m receiver, such as mixers, amplifiers, limiters, detectors, squelch circuits, and tuning indicators.

Since detectors form the fundamental difference between a-m and f-m receivers, f-m detection is treated in great detail. Good explanations are given for phase-shift detectors, such as the Foster-Seely discriminator, which are more widely used than slope detectors, such as the Travis detector, because they are easier to align. However, since both types require some form of prelimiting, because they respond to a-m as a result of noise, the ratio detector, also a phase shift type, is presented as a better choice. This circuit has built-in limiting.

Also interesting are the chapters on tuning indicators and stereo broadcasting. Proper f-m tuning has become essential for good channel separation and is more difficult than a-m tuning because the operator must listen for least distortion rather than maximum volume. Tuning devices fall into three

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New Books

major categories: tubes that make use of fluorescent screens; neon bulbs that indicate correctness of tuning by changes in brightness, and meters that read peak voltages or give null readings. Diagrams and circuits of all the tuning indicators are shown and discussed extensively.

Profitable tools

Active Integrated Circuit Synthesis
Robert W. Newcomb
Prentice-Hall Inc., 292 pp., $11.95

Linear integrated circuits have developed very rapidly in recent years, but their developers have relied little upon mathematically oriented theories. However, the geometry and electrical properties of IC's are such that somewhat advanced theoretical tools—the state-variable theory and nonreciprocal network synthesis methods, for example—can be profitably employed. Such linear-circuit methods are the basis of this text, which evolved from research conducted at Stanford University.

State-variables make it possible to synthesize an IC with low sensitivity to component variations from readily available operational amplifiers using a minimum number of capacitors. In addition, nonreciprocal network synthesis is useful for designing active-filter IC's based on gyrators and negative-impedance converters.

A discussion of the prime elements of integrated components and generating elements of basic gain blocks leads off the text. State-variable theory, active and passive RC synthesis which includes feedback circuits are also treated. Element replacement, method comparison, distributed networks, and quasilossless time-variable synthesis follow in the text.

The text is also supplemented with illustrative examples and problems. Among the features are descriptions that reduce advanced theories to practical form by stressing the circuits and techniques available for solving design problems. Another quality is the logical expository presentation of the latest research results.

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Circle 181 on reader service card

Technical Abstracts

Light bounce

Laser rangefinders—from laboratory to field
E.J. Woodbury
Hughes Aircraft Co., Culver City, Calif.

Because of their extremely short wavelengths optical radars offer higher resolution than those transmitting at microwave or millimeter frequencies. Since lasers are highly collimated and can be made monochromatic they were ideal for radar applications. As a result, systems have been designed for tank rangefinders, gun laying, and ballistic delivery in aircraft. These systems should be in production in about seven years.

In the meantime, production has started on a low repetition rate ruby laser rangefinder. Both the IEEE and ASTM have formed committees to set standards for laser radar components and measurements.

Lasers can also be used to profile terrain with very high accuracy from planes flying at low altitudes, map harbor bottoms, and determine the height and structure of clouds.

While the optical and mechanical components associated with the laser in optical radars don't present any unusual development or packaging problems the laser itself does.

Part of the difficulty stems from the laser's poor efficiency. Of the lasers used in radars, argon ion is a few hundredths of a percent efficient, Q-switched ruby a fraction of a percent, Q-switched neodymium: yttrium aluminum garnet nearly a percent, and Q-switched CO_2 five percent. However, the last laser is still in the research stage and its use depends on the development of practical 10.6 micron detectors.

These low efficiencies mean that lasers must dissipate most of their input energy as heat. Ruby lasers are most affected by heat. At low temperatures their gain increases sharply, making it difficult to maintain a single pulse output; at high temperatures their efficiency drops. Nd lasers are less sensitive to temperature changes; argon ions la-

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sers are even better in this respect, partially compensating for their low efficiency. CO_2 lasers, on the other hand, are affected by the temperature of the plasma tube's walls and must be cooled to or below room temperature.

At low repetition rates, both ruby and Nd lasers require average input powers typically less than 20 watts, permitting thermoelectric cooling. But at repetition rates exceeding five a second, more efficient cooling becomes necessary, making it difficult to use ruby lasers. Nd lasers then have the edge because they usually can dissipate heat above the upper temperature specified for successful operation. Nevertheless, a completely satisfactory coolant remains to be found.

Temperature changes also affect optical alignment, thereby changing the laser's mode pattern, threshold, slope efficiency, and beam divergence. Known as thermal lensing, these effects can be compensated for if the laser operates continuously. But if the laser is pulsed, complicated techniques, such as programing the resonator, are required. As long as the temperature remains static, or even if the laser is vibrated, optical alignment can be controlled.

Low efficiency also affects the operating life of some of the laser's critical components. High loading increases the failure rate of flashlamps, for example. Significant development remains on the design of this component.

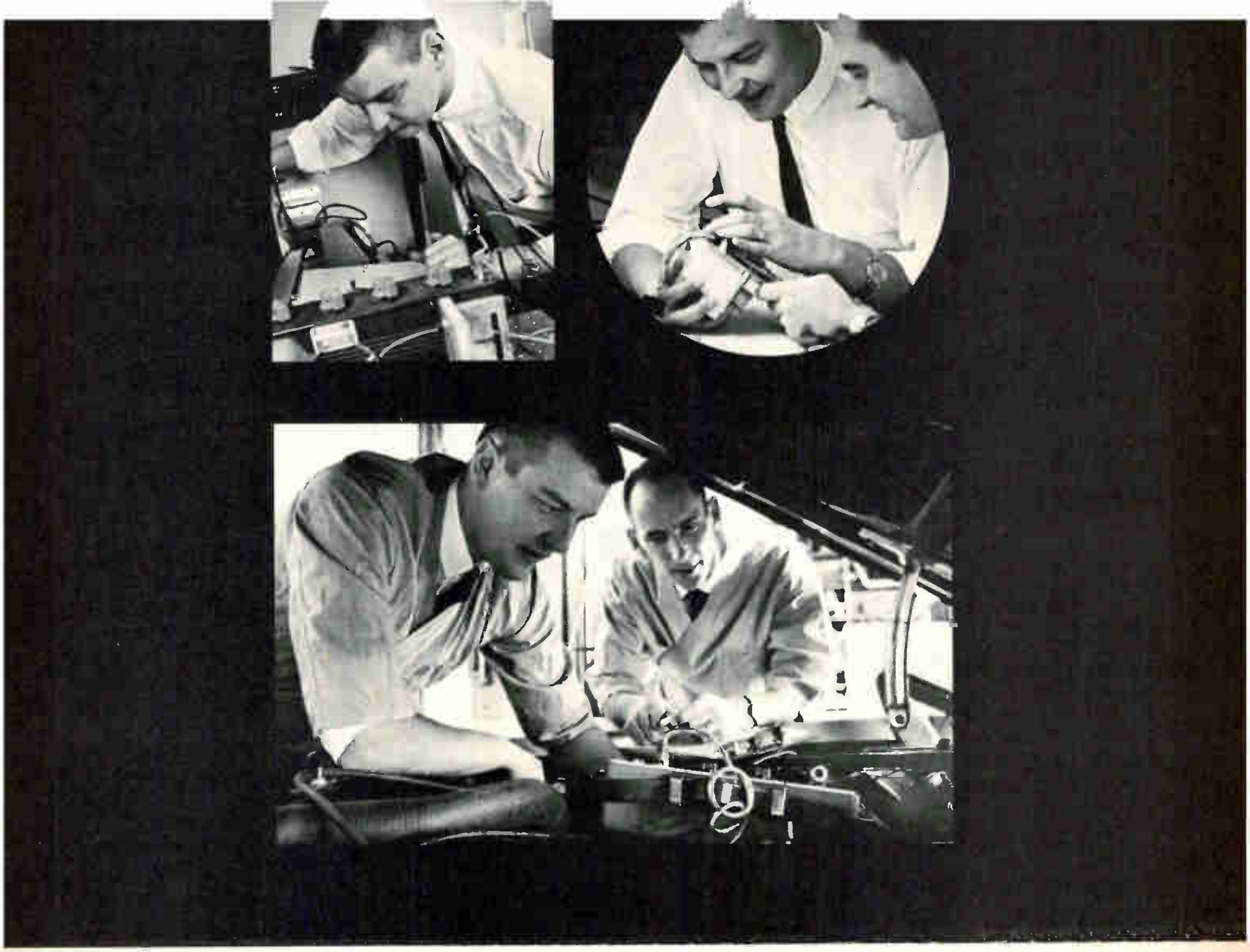
Presented at Nerem, Boston Nov. 6-8

Efficient anomaly

Power generation with avalanche diodes

Kern K.N. Chang
RCA Laboratories
Princeton, N.J.

While experimenting with silicon avalanche diodes, researchers at RCA Laboratories found that the behavior of the devices differed from that of other impatt diodes. They discovered that these "anomalous mode" diodes can generate hundreds of watts of pulse power with efficiencies greater than 25%.



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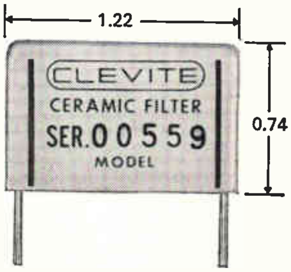

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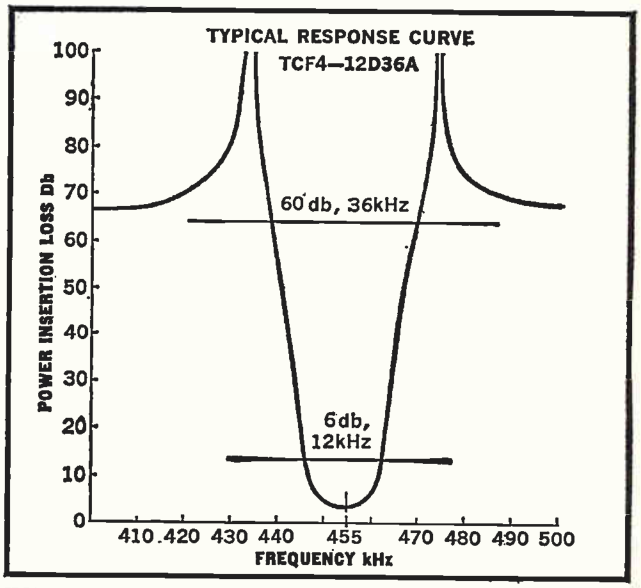

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TCF6—30D55A	30kHz	55kHz
TCF6—35D60A	35kHz	60kHz
TCF6—12F36A	12kHz	36kHz (90 db)

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CLEVITE

Technical Abstracts

In fact, many of these diodes have been built and tested, and several have achieved efficiencies of 60%. The experimental results indicate that the anomalous avalanche diode might make an excellent source of high-power pulsed energy from 200 to 1,500 megahertz.

The RCA team says the rise time of the r-f pulse depends mostly on the circuit used, not on the diode. What they considered well-fabricated diodes produced pulses with rise times of from 50 to 100 nanoseconds in a properly tuned circuit. Also, pulse delay times of 100 to 200 nsec were attributed to the pulser and the bias network used to drive the diode.

The researchers, who concede that the physical model of these diodes is sketchy, found two major differences between them and other impatt devices. First, the anomalous diodes oscillated with transit-time angles as low as 0.3 radian, instead of the normal value of pi radians. And the efficiencies were almost twice those predicted for other impatt diodes.

The anomalous diode is a p^+nn^+ structure. The n region has a resistivity of approximately 5 ohm-centimeters, is 8 to 10 microns wide, and has a breakdown voltage of 160 volts. A depletion region extends across the n region, and the diode "punches through" before avalanche breakdown is reached.

The p^+ region of the mesa-type diode is achieved by depositing and diffusing boron on the n layer. The space-charge region is 25 to 30 mils thick, and the diffused p^+n junction on the diode is similar to the abrupt-junction type.

In the course of its work, the RCA team obtained several experimental varactor diodes that were similar in design to the avalanche diodes and tried them in the test circuit used for the anomalous devices. One of the diodes gave 280 watts of peak power at 1.07 gigahertz with an efficiency of 43%. Others, from the same batch, worked from 425 megahertz to 1.4 Ghz and had efficiencies of 25% to 40% for peak powers of 150 to more than 400 watts.

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New Literature

Stepping motors. Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. 02185, has released three new product bulletins, each describing one of its series of bidirectional Cyclonome stepping motors.
Circle **446** on reader service card.

Solid state chopper. James Electronics Inc., 4050 N. Rockwell St., Chicago 60618. A four-page brochure describes the Micromodulator, a solid state chopper incorporating a pair of balanced silicon field effect transistors and magnetic drive system. **[447]**

Hysteresis synchronous motors. McLean Engineering Laboratories, Princeton Junction, N.J. 08550. Data sheet CM672 covers a line of hysteresis synchronous motors whose starting torque is approximately the same as the running torque. **[448]**

Microwave components. Sperry Microwave Electronics Division, Clearwater, Fla. 33518. The 1969 edition of the components catalog includes microwave IC's and solid state signal sources. **[449]**

Operational amplifier. Analog Devices Inc., 221 Fifth St., Cambridge, Mass. 02142. A four-page data sheet describes the model 801 monolithic IC operational amplifier. **[450]**

Microwave multiplier diodes. Micro State Electronics Operation, Raytheon Co., 152 Floral Ave., Murray Hill, N.J. 07974, has available a four-page booklet describing the MS-5000 series microwave multiplier diodes. **[451]**

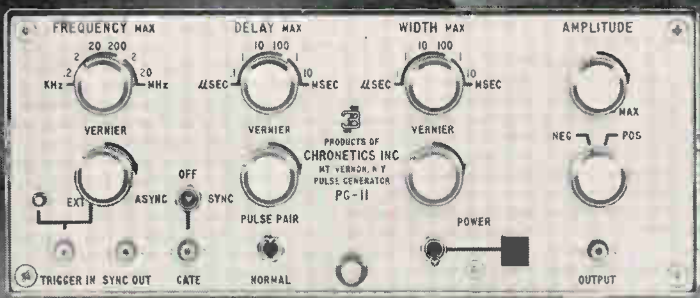
Tone signal/control systems. Trepac Corp. of America, 30 W. Hamilton Ave., Englewood, N.J. 07631, has issued a 16-page booklet on Datatone tone audio range signaling and control transmitters and receivers. **[452]**

Tubeaxial fan. Rotron Inc., Hasbrouck Lane, Woodstock, N.Y. 12498. Product bulletin E-3002 describes a 265 cfm tubeaxial fan that will provide continuous cooling for up to five years without maintenance. **[453]**

Conductive composite materials. Chomerics Inc., 85 Mystic St., Arlington, Mass. 02174, has published a four-page brochure describing a complete line of electrically conductive elastomers, epoxies, and powders. **[454]**

Pulse transformers. Sprague Electric Co., 35 Marshall St., North Adams, Mass. Engineering bulletin 40351 gives complete design information for the type 55Z DST pulse transformers. **[455]**

Quartz crystals. Tedford Crystal Labs Inc., 4914 Gray Road, Cincinnati



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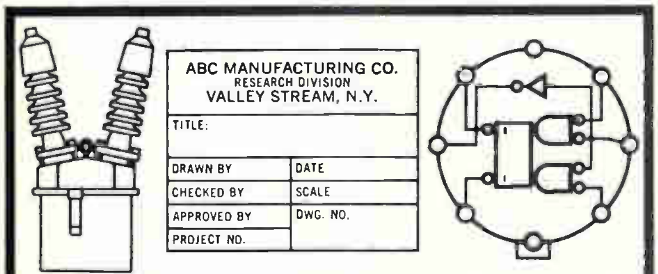

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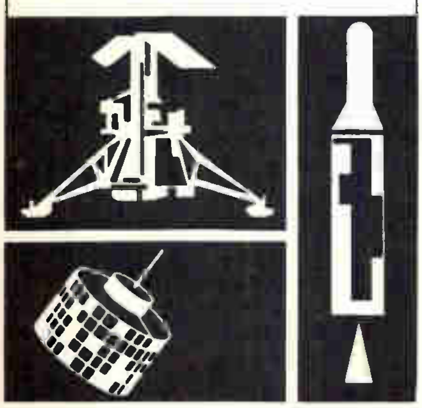

New Literature

45232. A listing of low and high frequency quartz crystals in a range from 90 khz to 210 Mhz is given in a four-page bulletin. **[456]**

Pressure transducer. Electro-Science Inc., 1502 W. 34th St., Houston 77018, offers a leaflet on the PT-400 pressure cell, a strain gage transducer designed to detect pressures from 0 to 20,000 psi. **[457]**

Solid state products. Potter & Brumfield, Division of American Machine & Foundry Co., Princeton, Ind. 47570. A 24-page catalog contains general information, pertinent data, selection tables and dimension diagrams for solid state time-delay relays, voltage sensors and dry reed time-delay relays. **[458]**

Magnetic tape cleaning. Data Devices Inc., 18666 Topham Ave., Tarzana, Calif. 91356, has issued a brochure describing an innovative approach to magnetic tape cleaning. **[459]**

Silicon nitride etchant. Transene Co., Route One, Rowley, Mass. 01969. Bulletin 122 covers Transetch-N, a selective etchant for silicon nitride films that is important in the manufacture of semiconductor devices. **[460]**

Power supply. PEK Inc., 825 E. Evelyn Ave., Sunnyvale, Calif. 94086, has released data sheet 704 covering the model 401A power supply for the operation of 75 watt xenon and 100 watt mercury short arc light sources. **[461]**

Current probes. Components/Genistron Division, Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221. Current probes for commercial, military, laboratory and related applications are described in an eight-page brochure. **[462]**

Thermistor devices. Yellow Springs Instrument Co., P.O. Box 279, Yellow Springs, Ohio 45387, has available literature describing a line of linear thermistor products. **[463]**

Waveguide tees. Microwave Development Laboratories Inc., 87 Crescent Rd., Needham Heights, Mass. 02194. Catalog TH68 describes H and E plane tees, magic tees, and miter H plane tees covering standard EIA waveguide sizes WR10 to WR2100 and many non-standard waveguide sizes. **[464]**

P-c connectors. Amphenol Industrial Division, Bunker-Ramo Corp., 1830 S. 54th Ave., Chicago 60650, offers a 24-page catalog on a comprehensive line of printed-circuit connectors. **[465]**

Component encapsulation. Capsonic Group Inc., 1000 Bluff City Blvd., Elgin, Ill. 60120. How costs can be cut dras-

New Literature

tically in standardized and custom injection molding of electrical components is detailed in a 10-page brochure. **[466]**

Data communications systems. Teletype Corp., 5555 Touhy Ave., Skokie, Ill. 60076. Two new eight-page brochures detail actual situations of how data communication solves business problems. **[467]**

Coaxial thermistor mount. Weinschel Engineering, Gaithersburg, Md. 20760. Series 1105 temperature stabilized coaxial thermistor mount is illustrated and described in a two-page data sheet. **[468]**

Dice and wafer specifications. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051, has published a guide containing electrical specifications, dice geometrics, substitution recommendations and carrier information on a line of silicon, planar, epitaxial unencapsulated transistors. **[469]**

Push-button switches. Molex Products Co., 5224 Katrine St., Downers Grove, Ill. 60515, anounces catalog M300 describing its five versatile lighted and unlighted push-button switches. **[470]**

Video monitors. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15222. Technical data sheet 95-260 covers video monitor types 191 and 191/R designed for general use in closed circuit tv systems. **[471]**

Low-light tv camera. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15230. The STV-614 television camera, designed for use at very low light levels in commercial, industrial, scientific, and medical applications, is the subject of brochure DB 95-155. **[472]**

Nickel-alloy magnetic cores. Infinetics Inc., 1601 Jessup St., Wilmington, Del. 1982. Bulletin 86-1 provides a design guide for selecting nickel-alloy magnetic cores for custom applications. **[473]**

Audio driver amplifier. P. R. Mallory & Co., 3029 E. Washington St., Indianapolis 46206. An eight-page booklet describes the operation and applications of the MIC0201 IC audio driver amplifier for entertainment products and industrial communications equipment. **[474]**

Level comparator card. Wyle Laboratories, 128 Maryland St., El Segundo, Calif. 90245, has available a performance specifications and applications bulletin on the MST-2 level comparator IC card for d-c level detection, waveform restoration, pulse shaping, and Schmitt triggers. **[475]**

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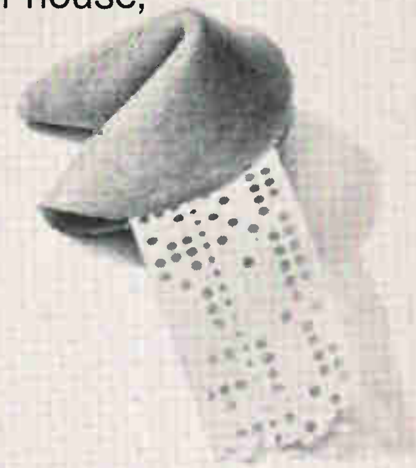

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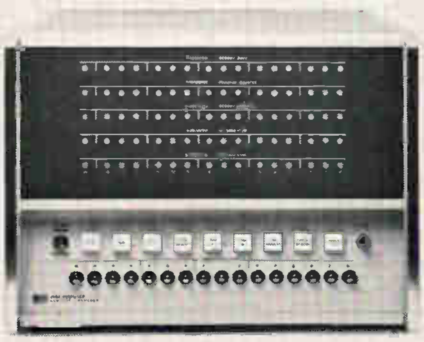

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International Newsletter

January 20, 1969

Japan's budget gives big boost to avionics

Look for a panoply of avionics gear to come out of Japan during the next few years. The budget for the upcoming fiscal year earmarks funds for Phantom jet fighters and for a supersonic trainer, both to be equipped mainly with Japanese electronics. This development, a year after funds were allocated for a military transport, marks the start of a full-fledged avionics industry in Japan.

Much of the hardware for the trainer and the Phantoms will be adapted from gear to be developed for the XC-1 transport, scheduled to make its first flight in July 1970. On the list of Japanese-designed hardware: vhf and uhf communications gear, the VOR instrument landing system, navigation and weather radar, Tacan and Loran systems, and marker receivers.

The XT-2 trainer will feature, at the very least, Japanese-designed uhf communications, Tacan, and interphone systems, as will the Phantoms the Japanese will build under license.

French color tube still 30 months off

Although work on a plant to turn out the French maskless color-tv tube should start this year, don't look for mass production before mid-1971. That's the new target date for 1,000-tube-a-day production set by Societe France-Couleur, the company formed to get the long-overdue tube on the market [*Electronics,* Jan. 22, 1968, p. 193].

France-Couleur originally hoped to be turning out the French version of the Lawrence tube sometime this year. **But the company now has decided to develop a 110° tube rather than go into production with a 90° tube.** Both have 23-inch screens. Pierre Bonvalot, the company's engineering director, says a prototype of the wide-angle tube, 6 inches shorter than its predecessor, should be ready by late 1969.

Bonn may set up technology agency

The West German government may set up an agency to speed the flow of new technology into industry. **The body, tentatively called the Organization for Technological Development (OTD), would mainly help small- and medium-size companies,** giving them both financial backing and technical advice to get new products on the market.

At the same time, the OTD would promote cooperation between German and foreign companies. And presumably it would work with the defense ministry to promote fallout from military projects.

France and USSR plan trade expansion

French electronics companies should have a good growth market in the Soviet Union over the next five years.

Under a new agreement, France and Russia will double their over-all trade by 1973. Though details of the pact still have to be hammered out, it's known that the Russians are itching for advanced equipment. That guarantees a good share of the market for electronics gear as trade between the two countries rises to some $800 million annually.

Particularly well off under the new arrangement are French makers of medical electronics equipment; a joint research program to develop medical equipment will reportedly put heavy emphasis on electronics, and the French are farther along in this area than the Russians.

←Circle 227 on reader service card

International Newsletter

The negotiators skirted a potential rift over color television. The Russians have abandoned their claim to a share in the worldwide patent rights to the Secam color-tv system developed in France and later adopted by the Soviet Union. **The Soviets, though, will be considered co-holders of the basic patents in their own bloc, and thus will get royalties if undecided Eastern European countries opt for Secam rather than for the rival West German PAL system.**

Although apparently not in a hurry to push color tv, the Russians are building about a dozen French-designed maskless 19-inch tubes a day, and are also making shadow-mask tubes in small quantities.

Japan and France set trade terms

Japanese electronics companies have another four years to wait before they get a wide-open crack at the French market.

Trade associations of the two countries **agreed this month on quotas for Japanese products through 1972. Thereafter, presumably, the Japanese will face only the same barrier that others do**—the common external tariff wall of the European Economic Community.

The January accord goes back to the principles of the "gentleman's agreement" that the Japanese abrogated in 1967 on the ground that the French showed little zeal for marketing Japanese products. **Under the old deal, "counterpart" French electronics companies peddled Japanese products. From now on, however, these companies will get only 70% of the annual quotas.** The rest will go to independent importers, who the Japanese feel will hustle their wares more vigorously.

Along with this change, the Japanese will get higher quotas. For radio sets, the figure will rise to 200,000 units in 1972 from 120,000 this year. Over the same period, the quota for components will increase to $850,000 from $475,000.

Hungary may build 'French' computer

France's state-subsidized computer firm, Compagnie Internationale pour l'Informatique (CII), is negotiating with the Hungarian government for a licensing deal covering CII's 10010 computer. Although CII claims the 10010 is a French machine, it's actually based on Scientific Data Systems' technology. CII builds SDS' Sigma series under license.

CII won't say what sort of deal it has in the works with the Hungarians. **But the word from Hungary is that the machine would be sold in large quantities to Russia and that some Hungarian production might be exported to France.**

If the negotiations are successful, Hungary will become the second Soviet-bloc country to buy a license for a computer from a French company. Bull-GE, the French subsidiary of General Electric, already has a licensing agreement with the Czech manufacturing organization, Tesla.

Addenda

The Japan Electronic Computer Co., a buy-lease firm owned by the six native Japanese processor makers, expects to buy $2 billion of computers in the fiscal year starting April 1. Fiscal 1969 purchases come to an estimated $1.6 billion . . . **In Britain, Racal Communications Ltd.—not the Plessey Co.—will take over Control & Communications Ltd.** [*Electronics*, Jan. 6, p. 249] . . . Japan will again attempt to put a satellite into orbit about Feb. 10. Three previous attempts failed.

Flat crt with large screen around the bend in Britain

Picking up a U.S. technique, a British firm has built flat crt's with diagonals as large as 4 feet and expects to do even better

Short shrift is usually given to cathode-ray tubes when designers start looking for ways to build very large displays. Even for a screen size of only 2 square feet, a crt starts to get bulky. Something big enough for an airport or a railway station —say 4 by 6 feet—so far is simply out of the question for a straight crt display.

When the big tubes are built, chances are the first to build them will be Britons. A flat, and therefore potentially large, crt was proposed by Dennis Gabor of London University in the early 1950's. Gabor didn't follow through on the idea, but William Ross Aiken of the Kaiser Electronics and Aircraft Corp. did—in a small way. He developed a 3-inch-thick tube—its faceplate measured about 8 by 6 inches—with the electron gun mounted on the lower side and with deflection electrodes on the lower and back sides of the tube.

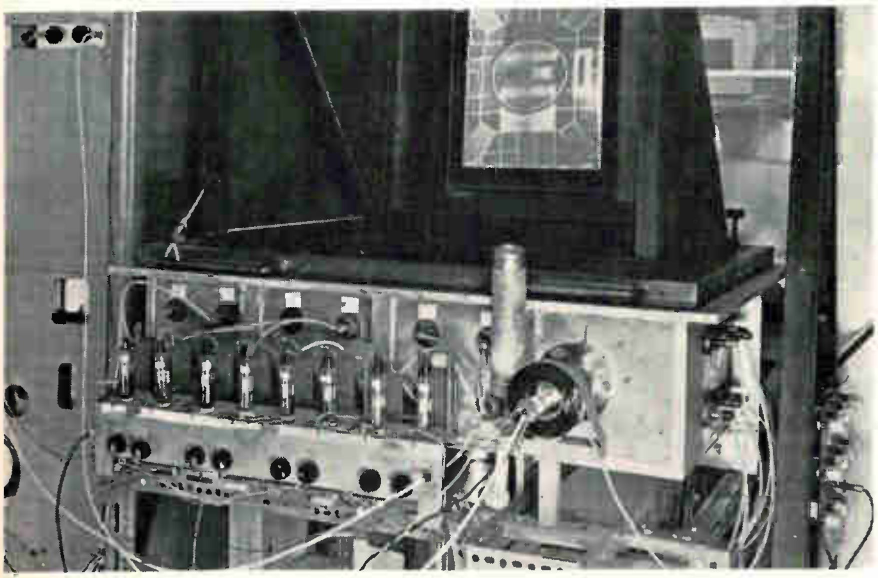
Revived. Kaiser patented the development and then let the small, flat tube languish—another good idea that didn't seem to work out just right. But six years ago Britain's National Research Development Corp. bought the rights to Kaiser's patents and licensed Twentieth Century Electronics Ltd. to develop a big tube.

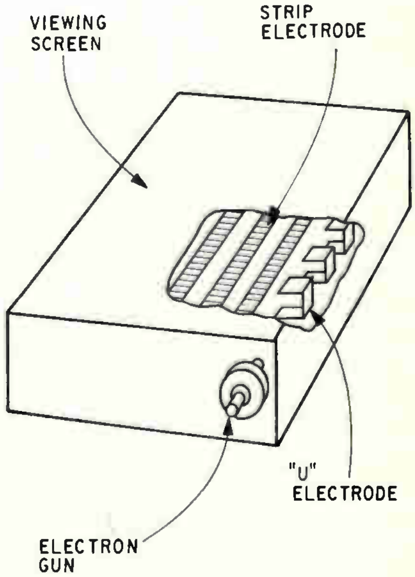
Twentieth Century since has built experimental flat tubes with diagonals of 4 feet and 2 feet. Tony Krause, chief engineer of the company's vacuum tubes division, is confident he could now build commercial tubes about 1 foot thick with screens 4 by 6 feet.

On its back. In its experimental versions, Twentieth Century uses heavy glass for the screen and the rear plate, while the walls are made of metal. The joints are sealed with neoprene O-rings. However, atmospheric pressure on the large glass surfaces forms the better part of the seal. Production versions most likely would have an integral, cake-pan-like metal structure for the walls and rear plate, with the faceplate sealed to the metal.

For convenience, Krause and his crew build their experimental tubes on a horizontal bed and view them in a mirror.

The bends. Flat on its back or hanging vertically, though, the tube will use the same scanning scheme. The beam enters the tube at the lower edge and starts down a line





Super screen. Experimental flat cathode-ray tube, placed on its back for convenience, has a 14-by-18-inch screen viewed with a mirror. The technique, particularly the double-deflection scheme (right) that makes possible a conventional tv raster scan, can be used for tubes with screens as large as 4 by 6 feet. Tubes with 4-foot diagonals have already been built.

of 11 U-shaped electrodes, normally held at a potential of 1.2 kilovolts. If the potential at an electrode is dropped to that of the gun's cathode, the beam bends through 90° when it reaches that electrode and heads toward the top side of the tube.

The bent beam's path is equidistant between the screen and the rear plate, which has seven electrode strips on it. These electrodes, at right angles to the beam's path, are normally held at 10 kv, but if the potential on one of them is dropped, the beam deflects onto the screen. By varying the potentials on groups of U electrodes and strip electrodes, it's possible to move the beam across the screen in a normal raster scan.

Sharp. With this two-bend scan, focus of the beam spot on the screen takes care of itself. The beam comes out of the gun with a circular cross-section. When it's bent the first time, it flattens out as a pipe does when it's bent at right angles. That leaves the beam ribbon-shaped, with its long axis perpendicular to the screen.

The second bend then compresses the ribbon section into a tiny spot. Because the beam always approaches the screen from the same direction and because it always travels the same distance after the second bend, it is always in focus. And since the screen is flat, there's no distortion at the edges to worry about, as there is with large conventional crt's.

East Germany

One, two, three, grow

For East Germany's state-run electronics industry, 1969 looks like another very good year.

Once again, the country's planners have tapped electronics for top priority. The output of all the sectors that come under the wing of the Ministry for Electrotechnology and Electronics is pegged to rise 13% this year, and that's twice the growth rate set for the over-all economy. Exact targets for electronics production aren't known, but it's a fairly safe bet that the 1969 rise will carry the industry past the $750 million mark.

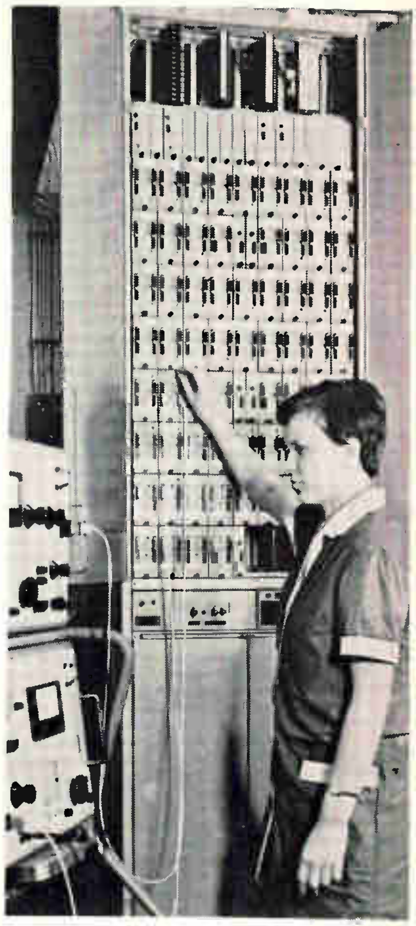
Guns and butter. Underlying the expansion in sight for electronics are continuing drives to streamline industrial plants in the country and to satisfy consumer demand. Another push will come from new long-term trade agreements with socialist countries that commit the industry to export a big share of its output. Then too, electronics should benefit heavily from big expenditures for research and development, stepped up by some 25% this year compared with 1968.

Recent political events in Eastern Europe will also affect East Germany's economy, and electronics is certain to benefit. Many Western analysts maintain that the East European crisis last summer has accelerated the shift of the center of gravity of industrial activity from Czechoslovakia to East Germany.

Watchers of the East European scene also contend that East German economic planners are counting heavily on the Soviet Union to drastically curtail the production of military gear in Czechoslovakia —equipment the country supplied to other socialist states as part of its Warsaw Pact obligations. East German planners are particularly counting on increased participation in arms-oriented R&D, say the analysts. Thus, the Czechoslovakian dilemma spells a gain for the East German economy.

Priorities. Topping the list of this year's priorities are computers and their peripherals. Economic planners are calling for accelerated development and production of electronic data processing equipment, with East German and Soviet Union research in that field closely coordinated.

As expected, production of instruments and industrial control equipment will also get top billing this year. That, together with the efforts in the computer field, goes hand-in-hand with East Germany's continuing drive to modernize and automate plants and administrative facilities—efforts spurred by a continuing shortage of labor and the need to increase productivity.



Checkout counter. Modulator for microwave link terminal gets tests at Leipzig factory. Microwave gear is big export item for East Germans.

Still another sector that's in for a boost this year is communications, with systems for digital data and for signal transmission high on the priority list. It's especially in television transmission systems and tv studio equipment that East Germany stands out among her socialist neighbors. A large number of tv stations all over Eastern Europe already use a lot of East German-made gear. Also, most of the equipment used in the "Intervision" network (the Socialist Bloc counterpart of the "Eurovision" scheme that links West European nations) is of East German origin.

Making marks. The main production plants for communications gear are VEB Funkwerk Koepenick and VEB Rafena-Werke. Koepenick concentrates on transmitters; Rafena-Werke is the prime supplier of hardware for East Germany's microwave links—now totaling more than 125,000 miles—and for most of the Intervision tv network.

An example of Rafena's output is the transmission system RVG 960, a long-distance f-m system that operates in a frequency range from 3.4 to 3.9 gigahertz. It can handle either a complete tv channel or up to 960 speech channels for telephone communications.

Another example is the RVG 962, a communications system operating between 10.7 and 11.7 Ghz. It's designed for transmitting tv signals—color or monochrome—and for two audio signal bands. It can therefore be used in such countries as Czechoslovakia and Yugoslavia where there are two official languages.

West Germany

Electronic cashier

In Germany, the introduction of coin-operated self-service fuel pumps five years ago was seen by motorists as a boon—at least by those smart enough to keep the right coins in their glove compartments. But after-hours and weekend drivers who run out of gas and change at the same time still have their problems.

Unless they live in Hamburg, that is. There, BP Benzin und Petroleum AG, a subsidiary of the British Petroleum Co., has put into experimental self-service an electronic cashier that accepts 10-mark notes as well as 5-mark, 2-mark, and 1-mark coins.

If the trial is successful, BP plans to install the equipment at 100—perhaps 200—of its 4,900 stations in Germany. That's a nice piece of potential business for AEG-Telefunken, whose Hamelin plant builds the money-handling equipment, which sells for some $2,000. Telefunken says it's the first firm in Europe to offer such equipment to oil companies.

Take five. Unlike "coins-only" equipment installed right on a fuel pump, Telefunken's cash box controls five pumps. For each pumping cycle it can process one 10-mark bill and 20 marks in coins; 30 marks (about $7.50) worth of gas will fill the tanks of most European cars.

Paper money goes into a special slot where a conveyor-like arrangement grabs the bill, pulling it into the cash box and on past a scanner. The upper side of the bill is illuminated, and a bank of photocells below it picks up the pattern of light and dark spots that the scanner recognizes as a good 10-mark bill. At the same time, other spots on the bill get a color test that compares photocell outputs to reference color-temperature voltages. A bill must pass both tests to be accepted.

Scrutinized. Coins dropped into the cash box go first through a testing unit, which checks them both electronically and mechanically for characteristics such as diameter, thickness, weight, and alloy content. Eddy currents, for example, are used in the testing for alloy content.

Once these checks have been run, the good coins go on to a storage-detector unit that holds up to six or seven coins of each denomination. An oscillator and coil pair are used to count the coins.

The bill scanner and the coin-detecting coil pairs produce voltages that are converted into pulses to control the fuel pump.

Japan

Fare game

Some of the most harried people anywhere are the men charged with supplying the clerks at Japan's National Railways with preprinted tickets.

The clerks, of course, need tickets for hundreds of destinations. And the problem of maintaining a two-month supply for each window is complicated by the railroad's insistence that the selling window's number be stamped on each ticket, plus the fact that the tickets have to be printed in traditional "kanji" (nonphonetic) characters.

However, keeping track of thousands of tickets is a job with no future at the railroad. The Tokyo Shibaura Electric Co. (Toshiba) has brought electrostatic printout techniques to ticket printing and has linked the equipment to a special computer. The system spews out a ticket 1 second after the window clerk punches a button. What's more, the computer lights up a display showing the fare and then records the transaction for bookkeeping purposes.

The railroad has been testing a prototype since May and will put it into full-fledged service at Tokyo's Ueno station next month. This initial installation has just one ticket-printing terminal—with 600 station buttons—although the computer can handle up to eight printing units.

Language barrier. Many a computer could be set up to handle this job—if the printout didn't have to be in kanji characters. Even Japanese computer makers have sidestepped the problem; with few exceptions, they use the so-called katakana syllabary—a set of 48 phonetic symbols—for printouts.

Toshiba's printer puts kanji characters on special ticket stock by laying down patterns of charges to get electrostatic images that can be fixed and developed. The character patterns are made up of closely spaced dots produced by switching voltages selectively onto a grill of 252 wires spaced six per millimeter. The grill handles the scan across the width of the ticket; the stock itself is moved past the grill for the scan along the length of the ticket.

It takes 143 milliseconds for the ticket—80 mm long—to pass by the wires. During this time, 13 rows of characters can be "printed." The remaining 857 msec in the cycle are used for developing and fixing the electrostatic image. The technique is one that Toshiba is trying to perfect for higher-speed computer printouts—20,000 characters per second [*Electronics*, Dec. 13, 1965, p. 238].

The central processor that's teamed with the ticket-printing terminals is "about as complex as a medium computer," according to Toshiba engineers. The special machine has modified diode transistor logic circuits and differs from general-purpose machines mainly in its memory; nearly all of it is read-only and made up simply of wires threaded through cores to form transformers.

Dots and bits. About 1,100 kanji characters can be produced by the equipment, and the dot pattern for each is on a 24-by-28 matrix. The read-only memory therefore needs about 800,000 bits for the patterns. And about the same number of fixed-memory bits must be added to handle the microprogram, fare table, station index, route table, and discount table.. The working memory for logic operations is a flip-flop register much like those in desktop calculators.

Toshiba expects to find other customers, particularly privately owned railways and airlines, for its ticket-printing equipment. One improvement it has in mind is a magnetic backing for the ticket so it can be coded to operate an automatic turnstile. A system with this feature is tentatively slated for the rapid-transit system that will be built at Sapporo for the 1972 Winter Olympics.

The right ticket. Toshiba's computer-controlled system takes just one second to issue a railroad ticket for any one of 30,000 destinations.

Great Britain

Have X rays, will travel

If a blower keeps acting up in a remote transmitter, a quick look inside is generally sufficient to pinpoint the trouble. An X-ray examination? Hardly likely. So-called "portable" X-ray units generally require heavy and bulky high-voltage generators.

To be sure, truly portable X-ray gear exists. The Field Emission Corp. of McMinnville, Ore., has had a 65-pound, battery-operated pulsed unit on the market since the early 1960's. But one of the company's sales executives terms the equipment—because of its low output—"almost useless" except for very special applications, such as examining the innards of liquid-fueled rockets. In his opinion, you can get a power line from a generator set almost anywhere you can lug a 65-pound black box.

Second effort. Unaware of Field Emission's experience—or undaunted by it—a small British company call Hivotronic Ltd. has come up with a 25-pound X-ray generator unit about half again the size of a shoe box. Like its U. S. predecessor, the Hivotronic unit generates a pulse about 50 nanoseconds long at a voltage higher than 150 kilovolts. The peak current tops 1,000 amps, developing enough X-ray power to penetrate 2 inches of aluminum. Both the British and U.S. portable X-ray units use field-emission tubes rather than the usual thermionic type.

Vernon Howell, managing director of Hivotronic, attributes the new equipment's lightness and smallness to the pulse generator invented by himself and a colleague when both were at Britain's Atomic Energy Authority.

Basically, the storage capacitor is a two-plate parallel transmission line wound into a spiral of 15 turns; the conductors are aluminum, the insulation epoxy. At the midpoint of the spiral, there's a switch that can short the pair of conductors. When it does, the result is a discharge at a theoretical voltage of twice the number of turns multiplied by the charge voltage. Hivotronic uses a 10-kv charge, so the discharged pulse theoretically should rise to 300 kv; in practice, the pulse gets above 150 kv.

A 28-volt nickel-cadmium battery powers the unit. The battery supply is boosted to 1,000 volts in a transistorized inverter, and then to 10,000 volts by a 10-stage Cockcroft-Walton multiplier.

Pound wise

A tire for a big truck costs $100 or more, so it's little wonder that all sorts of schemes have been put forward to warn drivers when tire pressure drops, particularly on dual wheels. Rolling on a near-flat makes for very expensive mileage.

Trouble is, most warning devices have one of two drawbacks—either they're costly and complicated or they're simple but can't signal the driver when he's driving.

A system that skirts both problems, however, may hit the road soon. It beeps through a truck's radio when tire pressure drops below a preset limit. Cambridge Consultants Ltd., the firm that devised the radio warning system, sees something like $50 or more as a potential price tag if anyone decides to put the system into production. Cambridge is solely a research and development outfit and will license others to produce its brainchild.

Snap action. In the Cambridge system, a sensor capsule about 1½ inches long and a half-inch in diameter is screwed onto the valve of each tire. The capsule depresses the valve pin slightly so that pressure is applied to a diaphragm in the capsule.

Should the air pressure drop below a safe level, the diaphragm snaps back to its original position and switches a battery supply onto an emitter-coupled multivibrator. This puts out a 100-megahertz signal that can be heard on an ordinary truck radio. The actuated capsule also elongates itself so that the driver can easily spot the bad tire.

Cambridge built its prototype with discrete components but expects any production version to have an integrated-circuit oscillator. The battery is a 2-milliwatt mercury cell, but there's no drain except when the capsule transmits.

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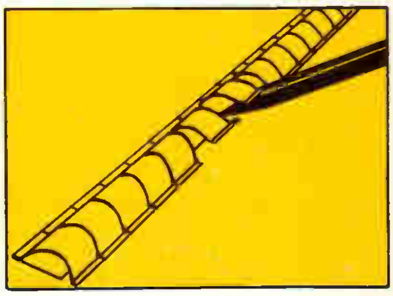

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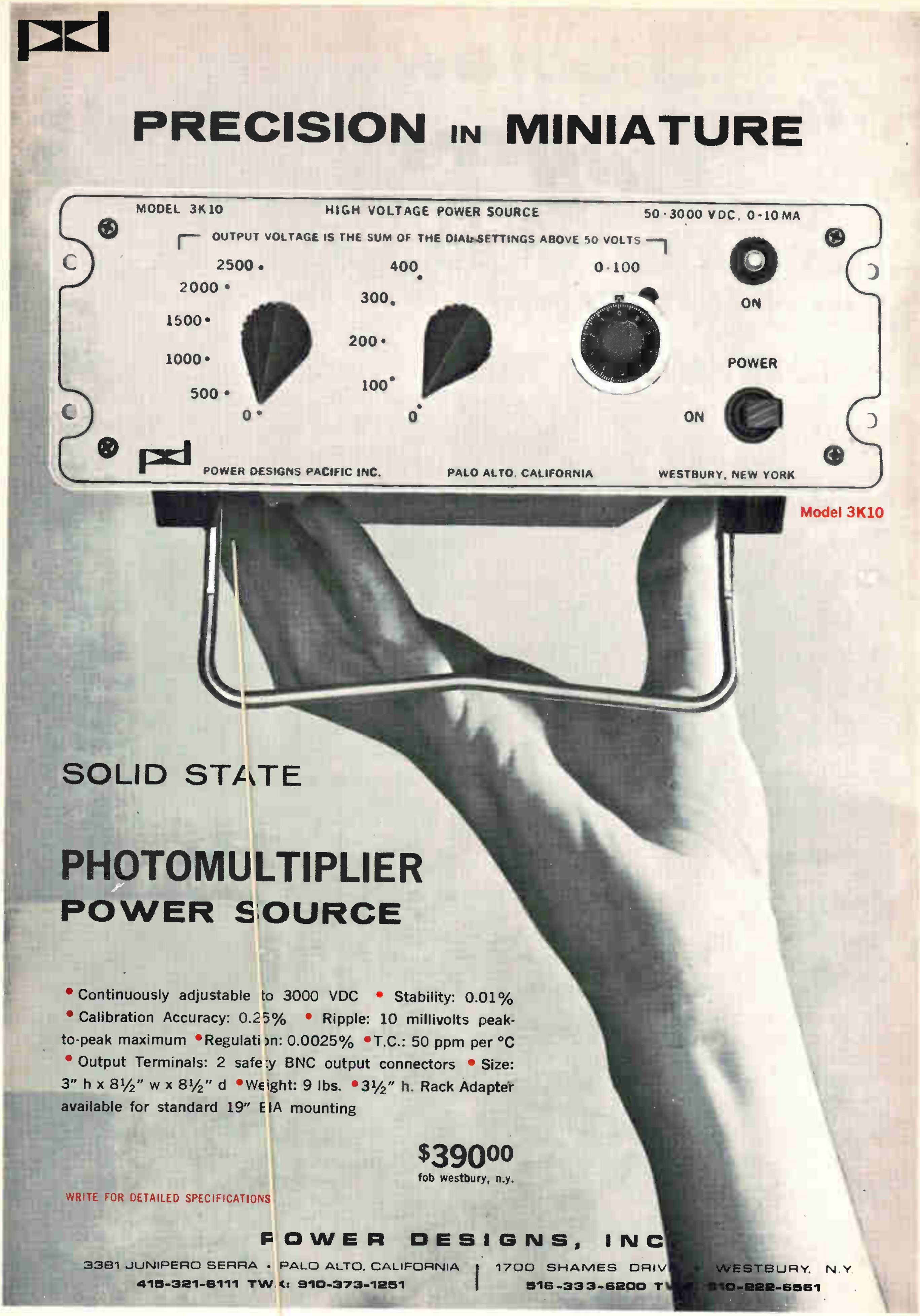
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10	29	48	67	86	105	124	143	162	181	200	219	238	257	276	295	314	333	352	371	390	409	428	447	466	485	504	952	971
11	30	49	68	87	106	125	144	163	182	201	220	239	258	277	296	315	334	353	372	391	410	429	448	467	486	505	953	972
12	31	50	69	88	107	126	145	164	183	202	221	240	259	278	297	316	335	354	373	392	411	430	449	468	487	506	954	973
13	32	51	70	89	108	127	146	165	184	203	222	241	260	279	298	317	336	355	374	393	412	431	450	469	488	507	955	974
14	33	52	71	90	109	128	147	166	185	204	223	242	261	280	299	318	337	356	375	394	413	432	451	470	489	508	956	975
15	34	53	72	91	110	129	148	167	186	205	224	243	262	281	300	319	338	357	376	395	414	433	452	471	490	509	957	976
16	35	54	73	92	111	130	149	168	187	206	225	244	263	282	301	320	339	358	377	396	415	434	453	472	491	510	958	977
17	36	55	74	93	112	131	150	169	188	207	226	245	264	283	302	321	340	359	378	397	416	435	454	473	492	511	959	978
18	37	56	75	94	113	132	151	170	189	208	227	246	265	284	303	322	341	360	379	398	417	436	455	474	493	512	960	979
19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380	399	418	437	456	475	494	513	961	980

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