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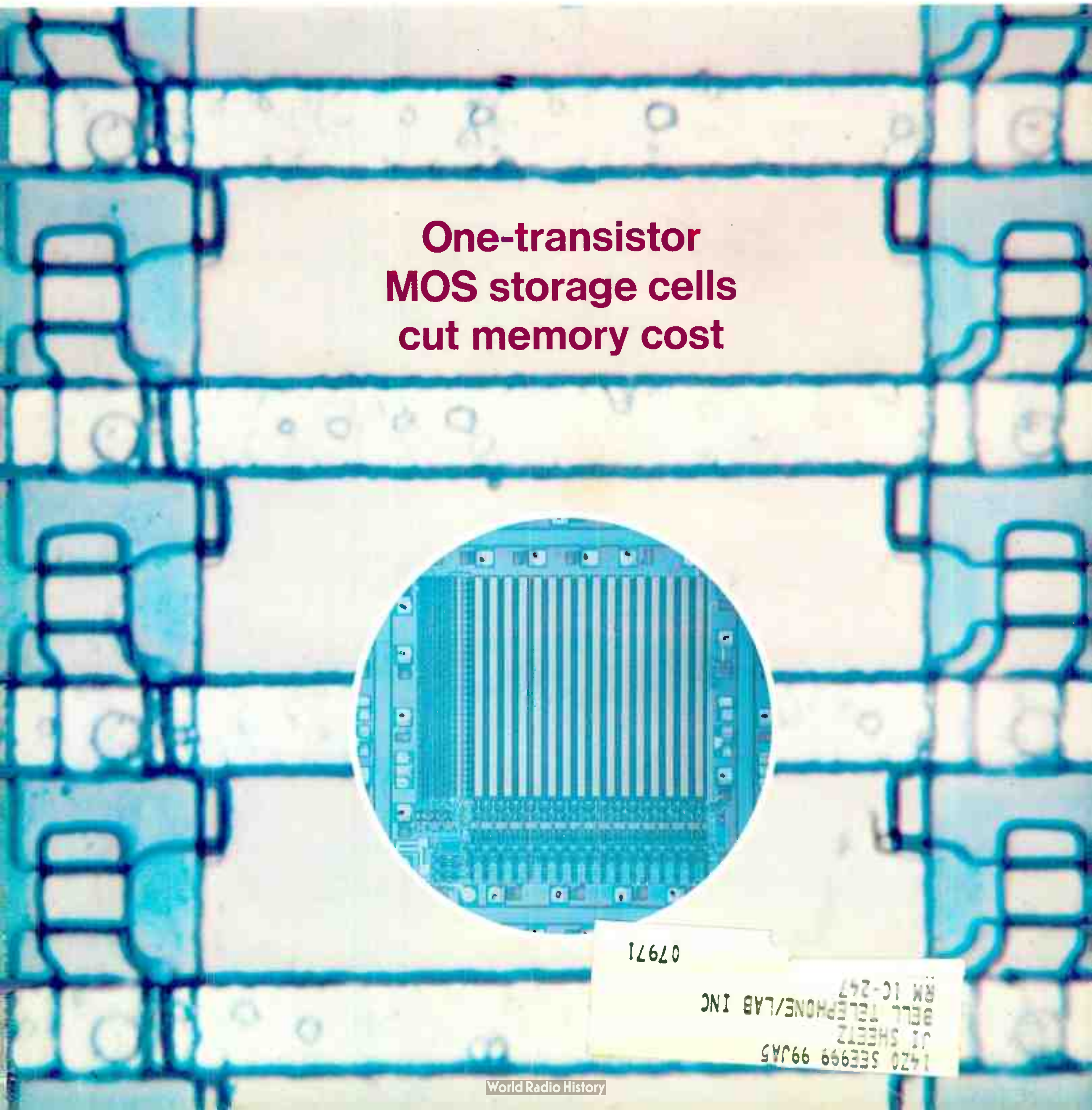
Electronics®



One-transistor MOS storage cells cut memory cost

When you don't need a custom circuit...

AMI, the leader of custom MOS, has a completion record of a new circuit every three days. Filling the needs of over 650 specific applications. But, we don't stop there. Knowing the need for standard products in design, we have engineered, tested and put into production reliable lines of devices for you to choose from . . . If standard products fill your needs, we have them. If your needs are better filled by a custom circuit . . . we'll design it. For the full story call or write today to . . . American Micro-systems Inc., 3800 Homestead Road, Santa Clara, California 95051 (408) 246-0330

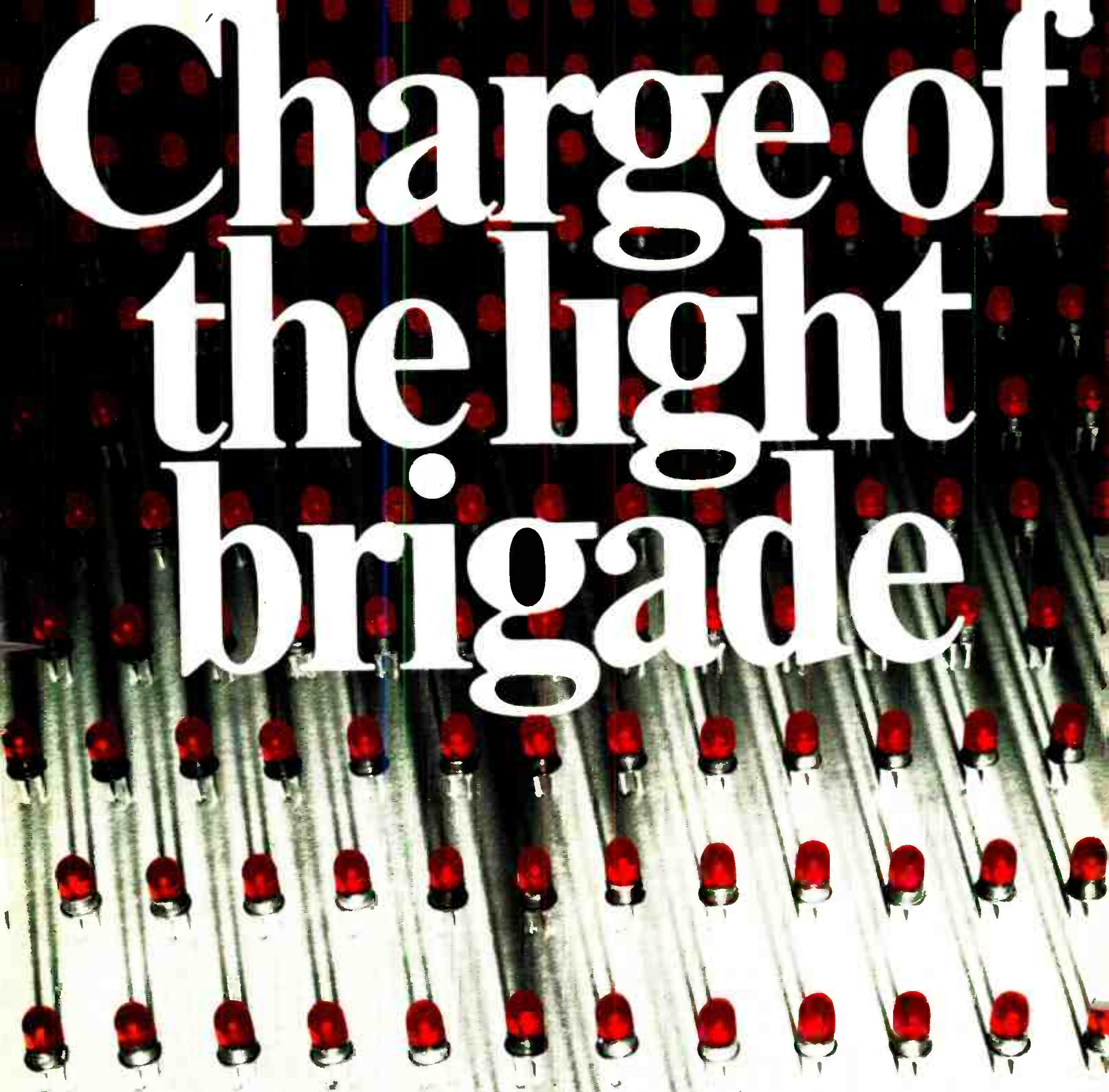
AMI American Micro-systems, Inc.

	PART NUMBER	DESCRIPTION	LEADS/PKG.	FREQUENCY RANGE	NUMBER OF BITS	TYPICAL POWER DISSIPATION	CLOCK LEVELS	GATE THRESHOLD
DYNAMIC SHIFT REGISTER	RD55G	Dual 50	10 TO5	10KHz - 1MHz	100	240mw	-27V	HVT
	S1708	Quad 40	12 TO8	10KHz - 1MHz	160	200mw	+5, -12V	LVT
	RD63G	Triple 66	10 TO5	10KHz - 1MHz	198	125mw	-27V	HVT
	S1724	Variable 256	14 DIP	10KHz - 1MHz	2-257	200mw	+5, -12V	LVT
	S1606	Quad 84	16 DIP	10KHz - 2MHz	336	200mw	+5, -12V	LVT
	RD65G	Single 426	10 TO5	1KHz - 5MHz	426	280mw	+5, -12V	LVT
	S1723	Dual 256	10 TO5	10KHz - 2MHz	512	150mw	+5, -12V	LVT
	S1705	Dual 256	10 TO5	10KHz - 1MHz	512	300mw	+5, 0V	LVT
	S1685	Dual 480	12 TO8	10KHz - 2MHz	960	200mw	+5, -12V	LVT
	S1687	1000/1024	12 TO8	10KHz - 2MHz	1000/1024	150mw	+5, -12V	LVT
	S1701	Dual 512	14 DIP	10KHz - 2MHz	1024	250mw	+5, -12V	LVT
	S1709	FIFO 8 x 13	24 DIP	10KHz - 100KHz	104	500mw	+5, -12V	LVT
STATIC SHIFT REGISTERS	SP51L	12 bit Serial/Parallel	24 DIP	DC - 2MHz	1-12	250mw	-27V	HVT
	RS53G	Dual 40	10 TO5	DC - 1MHz	80	150mw	-27V	HVT
	S1463	Dual 64	12 TO5	DC - 3MHz	128	180mw	+5, -12V	LVT
	S1670	Dual 100	14 DIP	DC - 3MHz	200	250mw	+5, -12V	LVT
RANDOM ACCESS MEMORIES	S1509	128 x 1, 64 x 2, 32 x 4	28 DIP	1.5 MHz	128	300mw	+5, -12V	LVT
	S4006	1024 x 1, Static	16 DIP	1.5 MHz	1024	600mw	None	I2
	S2103	1024 x 1, Dynamic	18 DIP	1.5 MHz	1024	320mw	-15V	SIGATE
READ ONLY MEMORIES	S8452	256 x 4	28 DIP	DC - 200KHz	1024	500mw	None	HVT
	S8457	128 x 12 Hollerith to ASC II	24 DIP	DC - 300KHz	1536	500mw	None	I2
	S8539	128 x 12 ASC II to Hollerith	24 DIP	DC - 300KHz	1536	500mw	None	I2
	S8538	2048 x 1	24 DIP	20KHz - 1MHz	2048	400mw	+5, -12V	LVT
	S8453	512 x 4	28 DIP	DC - 200KHz	2048	500mw	None	HVT
	S8502	256 x 8	28 DIP	DC - 1MHz	2048	650mw	+5, 0V	LVT
	ME51L	2240 - 5 output	28 DIP	DC - 1MHz	2240	300mw	None	LVT
	S8327	2240 - 5 output	24 DIP	DC - 2MHz	2240	400mw	+5, -12V	LVT
	S8499	2240 - 7 output	28 DIP	DC - 300KHz	2240	300mw	None	HVT
	S8501	256 x 10	40 DIP	DC - 1MHz	2560	650mw	+5, 0V	LVT
MULTIPLEXERS	MX52D	6 Channel	14 FP			NA	NA	HVT
	MX53C	10 Channel	22 FP			NA	NA	HVT
	MX54C	4 Channel, 50Ω	22 FP			NA	NA	HVT
	MX55C	4 Channel, 50Ω	22 FP			NA	NA	LVT
STANDARD LOGIC ARRAYS	UL51L	Dual FF, Dual Excl OR	24 DIP	1 - 100KHz		60mw	-27V	HVT
	UL52L	Quad 2 NAND Expandable	24 DIP			40mw	-27V	HVT
	UL53L	Quad 2 NOR Expandable	24 DIP			120mw	-27V	HVT
	MX53L	10 Input Expander	24 DIP					HVT
	SP51L	12 bit Serial/ Parallel	24 DIP	DC - 2MHz	12	250mw	-27V	HVT
	S1694	8 bit Counter/ Shift Register	40 DIP	DC - 1MHz	8	15mw		LVT

	PART NUMBER	DESCRIPTION	LEADS/PKG.	RON @ - 15V	PROTECTION	TYPICAL V_{GST}
DISCRETES	DM01B	Dual Matched 50mw	6 TO5	1250	No	-4V
	DM02B	Dual Matched 100mw	6 TO5	1250	No	-4V
	DM03B	Dual Matched 150mw	6 TO5	1250	No	-4V
	DM05A	Dual	8 TO77	250	Yes	-4V
	DM06A	Dual	8 TO77	250	No	-4V
	DD07K	Single	4 TO72	125	Yes	-4V
	DD08K	Single	4 TO72	125	No	-4V
	DD09K	Single	4 TO72	250	Yes	-4V
	DD10K	Single	4 TO72	125	Yes	-2V
	DD11K	Single	4 TO72	700	Yes	-4V
	DD12J	Single	3 TO5	32	Yes	-4V
	DD13K	Single	4 TO33	32	Yes	-4V
	DD15K	Single	4 TO33	18	Yes	-2V
	T1368	Quad	14 FP	125	Yes	-2V
	T1337	Quad	14 DIP	125	Yes	-2V

Circle 900 on reader service card

Charge of the light brigade



Here are the LEDs you can order by the brigade full. HP's indicator lights—unbeatable for brightness and wideangle visibility. Use them on circuit boards—their tough leads will keep them firmly in place. Or mount them on a front panel; they just clip on. In fact, you can put them anywhere you want a small, tough bulb that needs only 2 volts DC to light the way.

Price? 65¢ in 10 K quantities. And they're available in any quantity you want. Call your local HP office for the exact figures and specs on the 5082-4440. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SOLID STATE DEVICES

Circle 1 on reader service card

01105

Now, there's a digital voltmeter that offers a combination of capabilities never before available. The new Hewlett-Packard 3403A.

Outstanding features of the 3403A are its eight-decade bandwidth, its six-decade ac voltage range (10 mV to 1000 V full-scale), its ability to measure both simple and complex signals with great accuracy (±0.2% reading ±0.2% range), and its advanced, solid-state 3-digit display.

With the 3403A, you can measure ac, dc, or ac + dc, with **true-RMS accuracy**—and get your readout in either volts or dB. Its wide voltage range, and **extraordinarily wide frequency range** give it unprecedented versatility. Its **direct readout in dB** makes it a "natural" for all kinds of communications work. And its ability to measure complex signals with crest factors as high as 10:1 makes it especially useful for noise measurement.

The 3403A is available with a wide variety of options and accessories, including dB display, autoranging, isolated or nonisolated digital output, isolated remote control, printer cables, active probes, and a rack adapter frame... making it ideal for systems applications, as well as lab and production work.

The 3403A's price ranges from $1400 to $2100, depending on options. An ac-only version, the 3403B, is also available, starting at $1150. For further information on the versatile new 3403A, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

091/19

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

HP's new 3403A voltmeter puts it all together... at an amazingly low price

- ☐ True-RMS accuracy
- ☐ AC from 2 Hz to 100 MHz, plus DC
- ☐ Digital readout, in volts or dB

Electronics

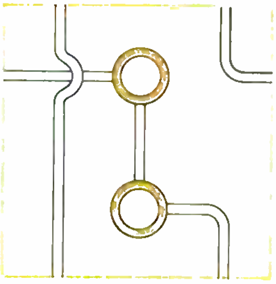
The International Magazine of Electronics Technology

August 2, 1971

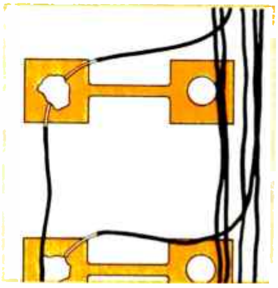
Volume No. 44, Number 16

Electronics

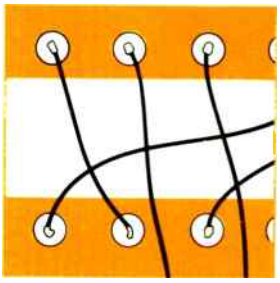
Publisher's letter



Multiwire



Reflow soldering



Automatic welding

We had mislabeled illustrations last issue, as the interface between man and machine—our new computer typesetting operation—widened a bit because of that old-fashioned national pastime, the summer vacation. We apologize and want to sort out the mix-up on page 85 in our cover article on automated production.

The three illustrations above should have gone with the material indicated by the caption. We hasten to say that the computer is doing its thing fine, but we are still debugging our new computer-oriented operating procedures.

Here's another chapter in the fascinating chronicle of how things get invented. Determination, lucky timing and hard work all helped develop the random access memory described in our cover story (page 69), but it was a flight of fancy at 38,000 feet that finally made it work.

It seems that Moses "Monty" Shapiro, president of General Instruments, was determined to come up with new products. His corporate director of technology, Lee Seeley, looked around. Among the people he talked with at Hicksville, N.Y. plant was Leo Cohen, manager of MOS memory products. Cohen had just worked out a RAM design in his spare time and whipped out the designs. A new product was born—on paper at least.

When an improved version of the RAM finally got off the drawing board and onto the bread board, the all-important sense amplifier was not stable enough to consistently detect the low logic swings—the bane of all single-transistor-cell memories. One way to fix that was to tap the company's R&D operation in Salt Lake City.

So Cohen and Seeley, bringing along his high-level technical support, set off for Utah. But they might as well have stayed at the airport. Their big jet climbed skyward, headed west. Their flight was smooth and so were the cocktails. With no phones to ring or memos to write, they got down to some detailed talking on the amplifier and had the guts of the fix sketched out by touchdown.

Cohen says that Seeley's design help was so to the point that he put Seeley's name in as a candidate for GI's Engineer of the Month. Seeley won.

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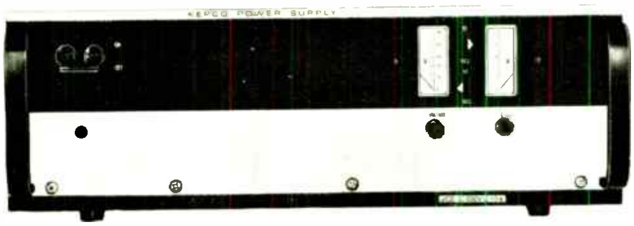
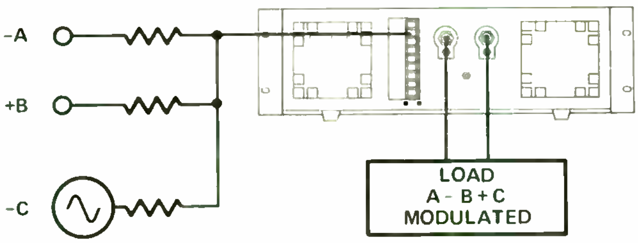
when is a power supply not just a power supply?

This is Kepco's JQE 100–10MHS Power Supply. It looks and is built much like the many hundreds of similar power supplies made by power supply companies. It will produce an adjustable voltage 0–100V, with a 10-turn front panel control—will drive loads up to 10 amperes and is backed by a 5-year warranty.

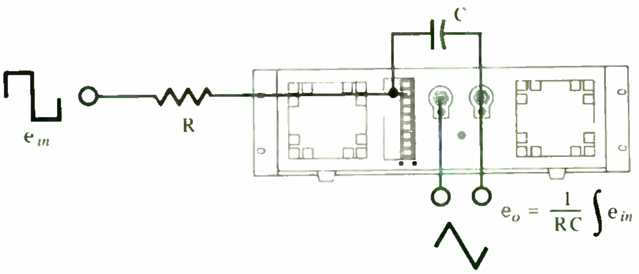


That's where the resemblance to the product of other power supply companies stops. The JQE 100–10MHS is made by Kepco, the power *CONTROL* company.

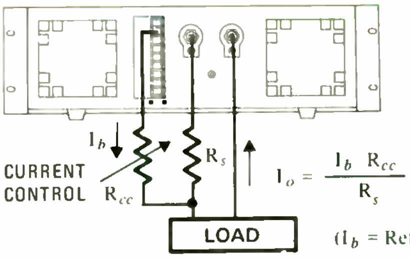
This means that you can manipulate its output to suit your purposes. You can use it as a 1 kW, d-c power amplifier and use as much of its 500,000 volts per volt d-c gain as you please. With that suffix "HS," the JQE will allow you to modulate its output with signals of your choice up to about 300 Hz for full 100V peak-to-peak swing. For 10V p-p modulation, you've got a 3 kHz bandwidth.



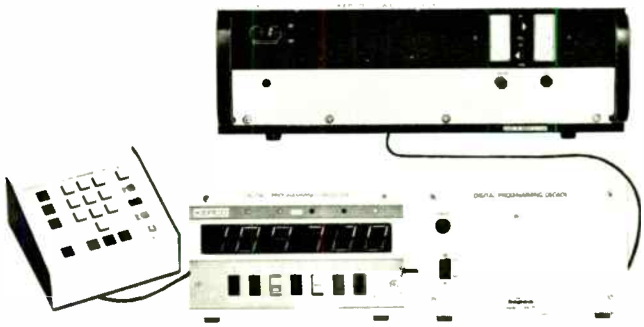
Would you like to sum several signals? Connect the JQE as a summing amplifier and use it to perform arithmetic operations.



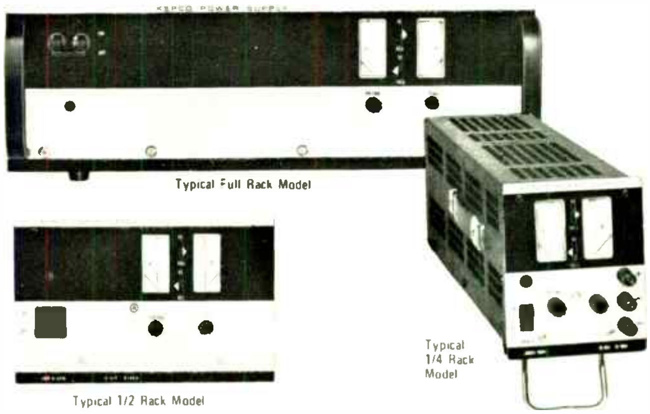
With a capacitor connected to its convenient feedback terminals, your JQE makes a dandy integrator.



Bring feedback from a current sensor and it will regulate current.



Vary its feedback and input resistors digitally and you'll have a computer-controlled voltage source. We make an excellent digital programmer to work with our controllable power supplies (the Kepco DPD, DPR, DPK Digital Programming System).



There are thirty-one (31) different JQE models in all sizes and output voltages from 0–6 to 0–150 volts up to 1125 watts . . . modules, too.

Our new Catalog B–703 is just off the press with details on the JQE and other fine Kepco power controllers. We would like to send you a copy.

Write Dept. DL– 14

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Circle 5 on reader service card

Readers comment

Misquoted

To the Editor: The article on solid state multipliers for TVs [July 5, p. 81] misquoted me. I said: "Only in the last few years have we had the technology to economically manufacture reliable devices to perform at 10 kilovolts. This device consists of multiple chips bonded together in a small, single package. Devices such as these are used in our multipliers."

Seymour Winuk
Electronic Devices Inc.
Yonkers, N.Y.

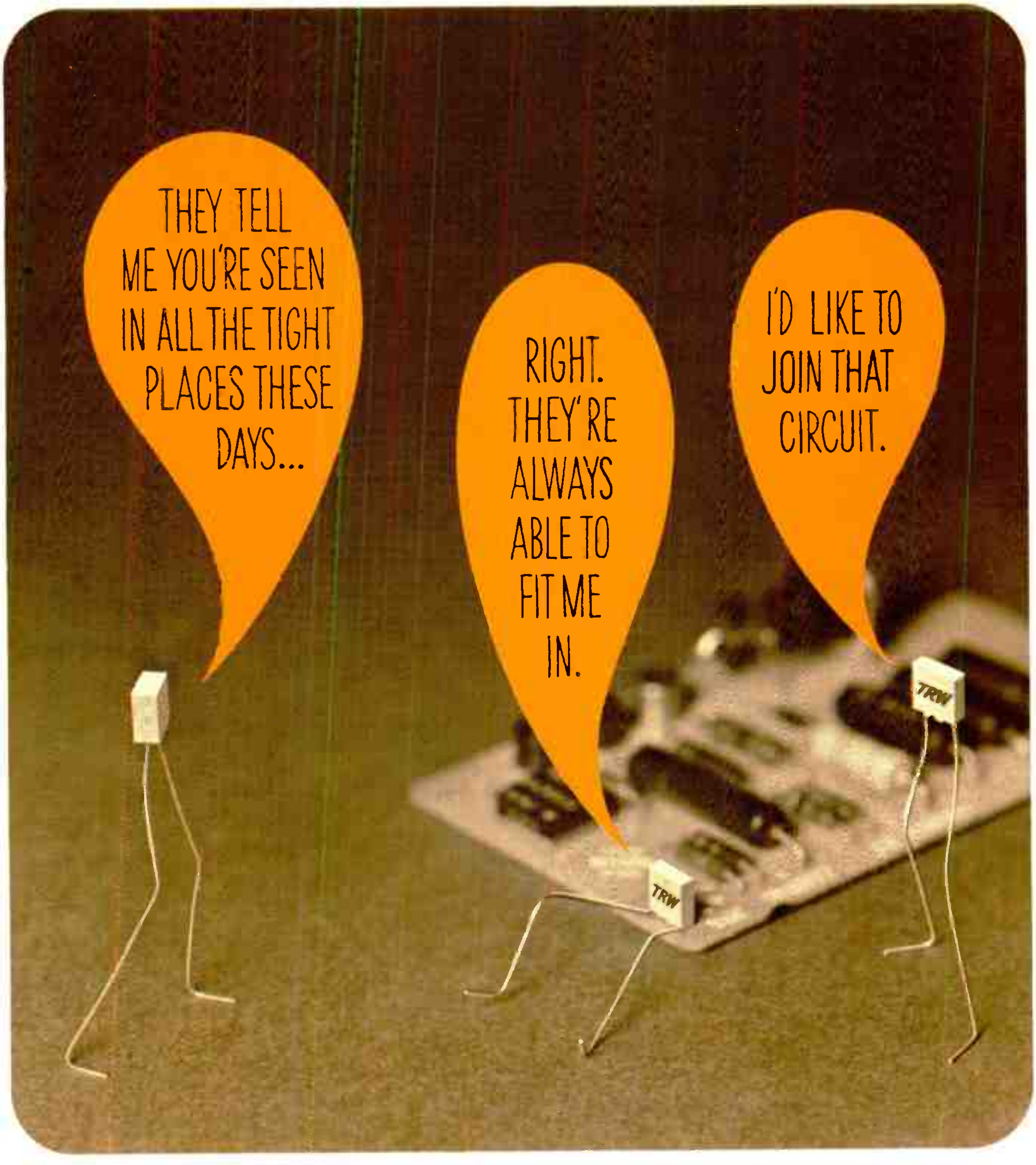
Display economics

To the Editor: The special report on displays [May 24, p.65] brings to mind the basic economics of too many firms with similar products going after the same markets. The result is an oversupply/overcapacity situation that reduces the product to a commodity selling at cost. I'm afraid that if light-emitting diodes ever get down to a selling price of five cents per diode, this situation could happen in displays. If LEDs don't reach this point, there will be room for gas discharge, liquid crystal, and LED displays to share markets based on their advantages for specific applications. Even so, I think we can expect a significant shakeout of display producers over the next few years. Of course, the ability to compete under price-erosion conditions hinges on many factors, and I wonder how many of the firms in and entering the display business are looking at the future market and technologies in terms of their effectiveness to compete under such conditions.

L.L. Pond Jr.
Sperry Information Displays
Scottsdale, Ariz.

Modulation man

To the Editor: I was particularly interested in the article on "Modulation scheme permits use of low-cost-recorder" [April 12, p. 35], and call your attention to my paper published in J. Sci. Inst. (Vol. 44, 1967) in which I described this technique. I showed that information contained in the ratio of mark-to-space



When TRW X440 capacitors get together, it's all small talk.

Since we introduced the X440 precision film capacitor it's been showing up in all the tight places. The X440 features a precision epoxy case with accurately located leads, and is ideal for use on densely populated printed circuit boards.

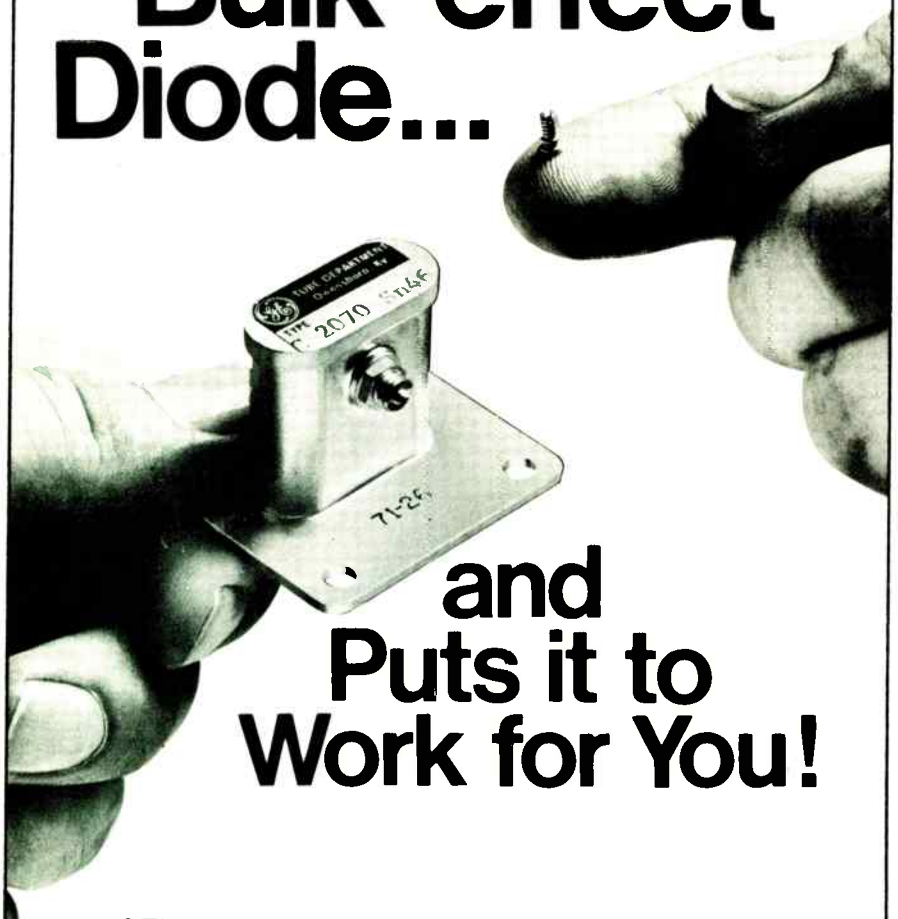
TRW pioneering in metallized polycarbonate film assures rigid stability and reliability in these tiny capacitors. Environmental and electrical performance of the X440 *will help you meet your toughest specifications.* And being the smallest film capacitors on the market, they're often the only answer to a tight packaging problem.

Voltage...50VDC; capacitance...001 to .10 mfd; tolerance to ±1%.

For samples, detailed data and applications assistance, contact TRW Capacitor Division, Box 1000, Ogallala, Nebraska 69153. Phone (308) 284-3611. TWX 910-620-0321.

TRW®

Circle 7 on reader service card



Readers comment

of a rectangular wave may be recorded without loss of linearity or resolution by simple recorders. Also, data in this form may be transmitted over relatively low-quality channels without significant loss since the original quality is restored at the receiver.

F.J. Mahler
Commonwealth Scientific and Industrial Research Organization
Mordialloc, Australia

Tuner tracking

To the Editor: The article on Scott's new tuner [June 21, P. 32] states that the unit actually "nails down a carrier and tracks it," but it's not supported in the block diagram. Rf amplifier tuning is accomplished by the loop-control voltage, but it by no means tracks a commercially transmitted carrier. Instead, it can be thought of as locked to the crystal reference oscillator, since the rf local oscillator is, in fact, phase-locked to this reference via the frequency prescaler and programable divider. The rf amplifier is tuned as the rf local oscillator is forced by the loop to track the reference. The rf amplifiers are still 10.7 megahertz below the local oscillator as in any fm tuner. AFC, using a discriminator reference, is merely replaced by phase-locking to a crystal reference, while the programable divider lends itself to the digital tuning technique.

David M. Thomas
St. Joseph, Mich.

▪ *The local oscillator in this tuner tracks to and is locked to the center frequency of an fm channel, plus 10.7 MHz. While tuned to a station, the unit continually corrects for drift in the local oscillator using the crystal reference shown in the block diagram.*

Since the overall drift specification is tighter than the FCC specification for stations themselves, further tracking would be redundant. The diagram was simplified both to protect patentable designs and for editorial considerations. There is one error: the prescaler programable divider and the binary-to-decimal decoder blocks should be interconnected.

40 years ago

From the pages of Electronics, August 1931

Any engineer who has been confronted with the problem of allocating radio channels to all the manifold demands for radio service, must quickly become impressed with the fact that a "ceiling" has always overhung the usefulness of space radio. Nature has provided us with only one ether spectrum, and all classes of radio service must accommodate themselves to its sharp limitations. Multiplication of the spectrum, it was apparent, could come only through subdivision—or else through expansion into the higher frequencies.

Recent work with television in the very short waves and with quasi-optical waves, now seems to open up a vast new realm for radio service.

Kilocycles have always been the crying need in radio, and as we go down into the short waves, we turn up kilocycles in profusion. For, every time we halve the wavelength made useful for radio, we add to the former spectrum as many kilocycles as we had, altogether, before!

At last then, we have "kilocycles enough," and down in the short waves we can use the same frequency over and over again.

Thus the lid is lifted. From this point on, the limits on the multiplied use of space radio become only equipment and demand.

Already the pioneers are trekking out into this new promised land. As this is written, tests have been witnessed of telephoning between two panels, each hardly larger than this page of *Electronics*, mounted on 30-ft. poles, 25 miles apart, using 68-cm. waves. The English Channel has been bridged with 10 cm. waves. The week's newspapers have reported the leasing of the 1,250-ft. Empire State Building for television broadcasting within visible range, over New York City, probably on 2½ meters.

Private-line telephones, mechanical control, and a host of other uses may follow, until the cities and countryside of the future are everywhere cross-threaded with "wireless" local circuits.

At last, the lid is being lifted off space radio!

The 256-bit bi polar RAM.

(If we give you six advantages and no trade-offs, you can forget about us.)

Are you thinking about your random access memories more than you want to? Do you think you can't get tri-state output and full decoding on the same chip?

Are you trying to choose between low power and speed? Relax.

Ours.

	Typical Speed Chip Select	Typical Speed Read Access	Decoded	States	3 Chip Select Inputs
Am2700	12 ns	60 ns	Fully	Three	Yes

All our random access memories undergo 100% pre-seal visual and post-seal environmental stress testing to MIL STD 883. No exceptions.

Theirs.

	Typical Speed Chip Select	Typical Speed Read Access	Decoded	States	3 Chip Select Inputs
CMI's	40 ns	90 ns	Fully	Two	Yes
Intel's	75 ns	75 ns	Partially	Two	No
Intersil's	75 ns	75 ns	Fully	Two	No
Fairchild's	75 ns	75 ns	Partially	Two	No

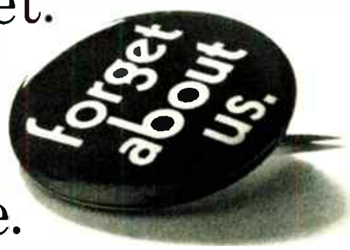
Circle Bingo Card #307

Advanced Micro Devices has a TTL 256-bit RAM that gives you all of the above plus three chip select inputs.

How many other companies have a product like it? None.

The Am2700 is in stock now at our place and at Hamilton/Avnet.

So, if you're thinking about RAMs more than you want to, think about us. Just once.



Advanced Micro Devices, Inc.

Telephone 800-538-7904 toll free, and ask for Shel Schumaker. In California, call 408-732-2400. In Los Angeles, call Steve Zelencik at 213-360-2102 In Chicago, call Chuck Keough at 312-297-4115. In the eastern United States, call Steve Marks at 212-343-2220. 901 Thompson Place, Sunnyvale, California 94086/TWX 910-339-9280/TLX 346306

Meetings

Western Electronic Show and Convention (WESCON), Western Electronics Manufacturers Association, IEEE; Brooks Hall/Civic Auditorium, San Francisco, Aug. 24-27.

Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, Aug. 25-27.

London International Symposium on Network Theory, IEE; City University, London, England, Sept. 6-10.

Conference on Computers for Analysis and Control in Medical and Biological Research, IEE; University of Sheffield, England, Sept. 7-9.

Conference on Displays, IEE; University of Loughborough, England, Sept. 7-10.

International Conference on Engineering in the Ocean Environment, IEEE; Town & Country Hotel, San Diego, Calif., Sept. 14-16.

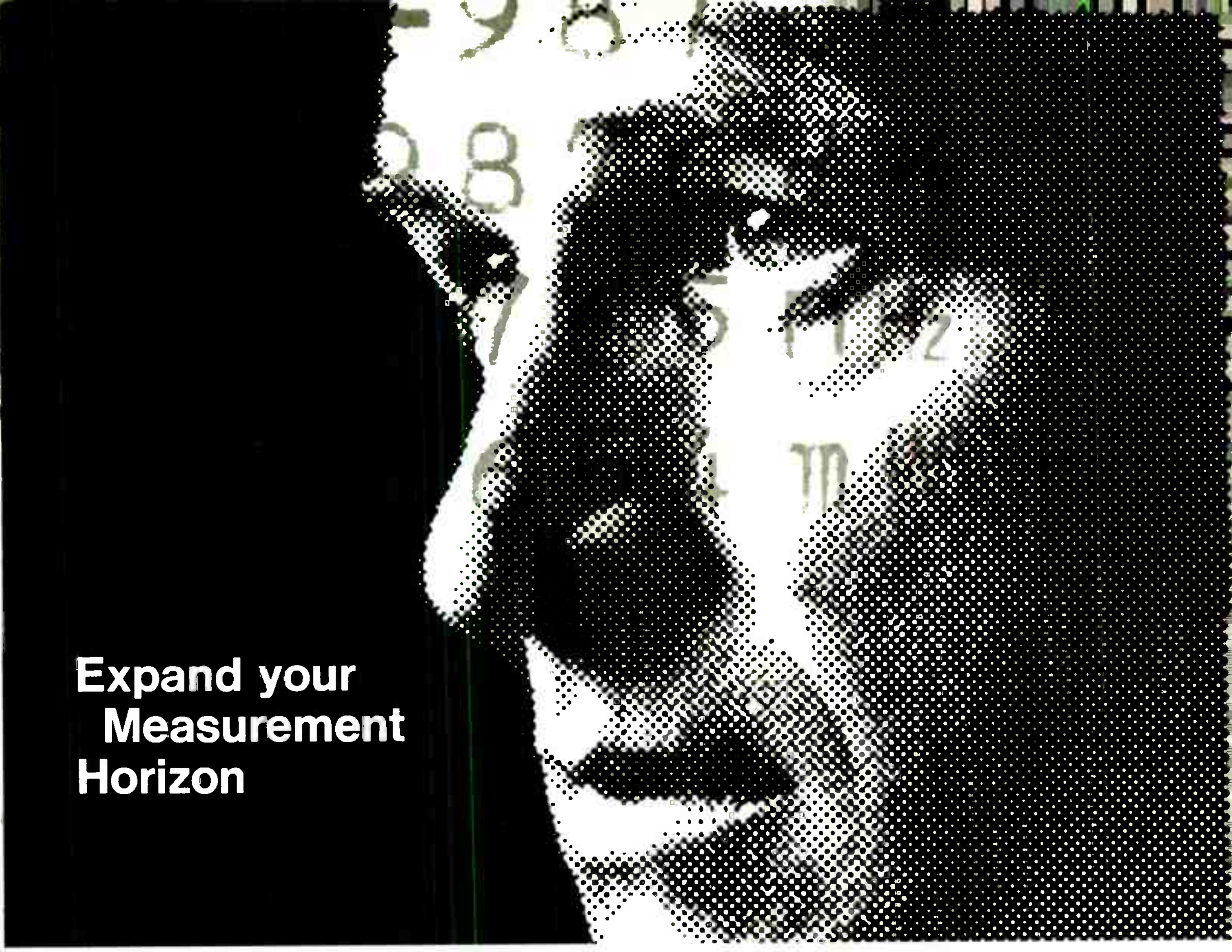
Joint Power Generation Technical Conference, IEEE; Chase Park Plaza Hotel, St. Louis, Mo., Sept. 19-23

International G-AP symposium & USNC/URSI meeting, IEEE; University of California, Los Angeles, Sept. 20-23.

CALL FOR PAPERS

Annual Meeting and Technical Conference, Numerical Control Society; Palmer House, Chicago, April 17-19, 1972. Oct. 1 is deadline for submission of abstracts to Chairman of Technical Program, George Putnam, IIT Research Institute, 10 West Thirty-fifth St., Chicago, Ill., 60616.

Integrated Optics-Guided Waves, Materials, and Devices, Lasers Technical Group, Optical Society of America, International Commission for Optics; Sands Hotel, Las Vegas, Feb. 7-9, 1972. Oct. 29 is deadline for submission of abstracts to Optical Society of America, Integrated Optics Meeting, 2100 Pennsylvania Ave., N.W., Washington, D.C. 20037.



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People

The industry that helped put man on the moon is still having trouble automatically monitoring buses in Chicago. This comes through in a conversation with Martin Lukes, the engineer who manages the Windy City program for automatic bus location called Monitor-CTA.

"This was the first installation of integrated circuitry aboard a bus—a major technical step that proved to be a major technical problem," says the young project manager. "It turns out that a bus is a most hostile environment for electronics. For example, the electronic memory is wiped out every time a bus door is opened" because of interference from the door-opening mechanism.

Lukes: Making first integrated circuitry aboard a bus work—even when doors open.

Motorola's Communications division, which won the Monitor-CTA contract in 1968, solved the conflict between door opener and electronic memory with extra shielding, but Lukes says that reports of wrong locations and unintentional alarms still hamper the system.

As a prototype of the EE who will be writing specifications and then pushing for their delivery in automatic vehicle monitoring systems of the future (see p. 99), Lukes presents an interesting study. He joined the Chicago Transit Authority's electrical department in early 1963 just before receiving a degree from Illinois Institute of Technology, moving up to assistant project manager of Monitor-CTA when Motorola got the job.

"Vehicle monitoring is nothing new to us," says Lukes, and he can point to a dozen or so vintage strip chart recorders whose dancing pens watch the progress of about 150 trains on seven elevated and subway routes. "But bus monitoring is a different ballgame."

Monitor-CTA isn't operational yet. The original four-year program—two-year implementation and two-year demonstration—is running a year and a half behind schedule. As designed, it must keep track of 500 buses on 64 "owl" service routes, midnight to 4 a.m., and would have to be expanded to 3,000 buses on 139 routes, 24 hours a day, to cover all Chicago.

The system, now slated for demonstration in the autumn, is of the proximity type, with 120 signpost transmitters spread about a mile apart along the fixed bus routes [*Electronics*, March 2, 1970, p. 150]. CTA would like eventually to expand the system to include monitoring of passenger and fare count plus engine status, and hopes to create an automated control loop by starting buses from the terminal with audio and video signals, Lukes says.

"Our $2 million runs out any day now," he adds. "We're in the process of determining future budget requirements and we'll request new funds." So far, the Urban Mass Transportation Administration has contributed 78%, and the prognosis

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Gardner-Denver Company, Quincy, Illinois 62301 for further funding is good: assistant UMTA administrator Robert A. Hemmes says he anticipates continued support for fixed-route systems like Monitor-CTA.

The first thing Harry W. Painter did when he became technical director of the Army's Picatinny Arsenal was set up a technical board. Formation of this group of civilians from each of Picatinny's four missions—conventional and nuclear fuzing, R&D, and quality engineering—best illustrates the 42-year-old Painter's management philosophy, one that's a bit unusual for a military installation: the corporate approach.

Painter has spent 21 years at the arsenal, which is nestled in rolling hills near Dover, N.J., and, though the pipe-smoking 42-year-old is a mechanical engineering graduate of Newark College of Engineering, has become something of an EE by virtue of on-the-job training. "Fuzes of all types are becoming more and more electronic," says Painter, "and in the next decade we look for still more of the same. For instance, I expect ICs to find their way more and more into high-acceleration (30-G) systems because of their ruggedness."

Before Painter set up his board, all major technical decisions were made by the arsenal's commanding officers. "This was impractical," says Painter, "because COs didn't stay long enough—three to five years—to really soak up all the necessary background." Under the new system, the CO still makes most final decisions, but he has a formal body of expert advice to rely on.

Painter says existence of the board also permits more research with developments that are out in front of the technology. He points to a coded communication system for nuclear weapons as an example; it utilizes MDS/LSI fresh out of RCA's labs.

Also, 95% of the Army's work in amorphous semiconductors is being done in Picatinny's labs, Painter points out. The military's interest in the devices is based on their radiation-hardness, he says.

Electronics Newsletter

August 2, 1971

Study sees crystals overtaking LEDs . . .

The light emitting diode display, causing such a stir today as it finds its way into more and more applications, will find its growth flattening out by 1975 in the face of competition from liquid crystals. At least that's what analysts at Arthur D. Little Inc. say. In conjunction with another study, Little's experts found that the largest markets for miniature displays—calculators—and miniature lamps—autos—would effectively be closed to LEDs because of their cost and power dissipation.

The Little study points out that liquid crystal, which dissipates less power, holds promise of much lower cost than LEDs.

. . . as liquid crystals show up in watches

Virtually every watch company is evaluating liquid crystal displays for solid state watches. By now, they're being combined with complementary MOS logic, and half a dozen major semiconductor houses and a number of lesser lights are vying for development contracts.

For example, the Hamilton Watch Co. is on the verge of signing up a C/MOS-liquid crystal supplier but doesn't expect that timepieces will be on the market for at least a year and maybe two. Reason: lifetime of the liquid crystals is still too uncertain. Says John Bergey, director of watch development for Hamilton, "We're looking for three to five years' life when suppliers can only talk of 10,000 hours."

But while the watch companies are joining the liquid crystal movement, it's also possible that an electronics company able to make the circuit and the display may be the first on the scene with its own electronic watches, despite the risks in learning a new consumer market.

Meanwhile, North American Rockwell Microelectronics Co. will show a multimeter at Wescon that it believes to be the first U.S.-made instrument sporting a liquid crystal display.

Radiation rumor may be probed

A national investigation of the biological effects of low-frequency radiation is getting under way. It was sparked by the concern of engineers over persistent rumors that brain tumors were caused by exposure to non-ionizing radiation at 20 kilohertz to 10 gigahertz.

One incident that fueled the spread of rumors is alleged to have occurred several months ago at Philco-Ford in Philadelphia where work was being done on a secret Government project. A company spokesman has branded as an "out-and-out hoax" any stories connecting the experiments and one death from astrocytoma and another case of brain damage.

Edward Baier, director of the Pennsylvania Environmental Resources Department's Division of Occupational Health, had cleared Philco-Ford of any negligence, but has requested that the case be reopened and that a national study determine whether other cases have occurred elsewhere.

And as Federal and Pennsylvania officials met, the U.S. Bureau of Radiological Health said that the meeting was triggered by three companies' informal request for an official bureau statement.

DEC 'monitor' to eye machine tools

The Digital Equipment Corp. has introduced a machine monitor version of its PDP-14 computer. Called the MAP-14 (for machine analyzer package), it's expected to reduce computer-controlled machine downtime drastically. According to Donald Chase, DEC's industrial control products manager, 85% of machine failures are electromechanical and only 15% are in control electronics, and it's the 85% the MAP-14 would deal with. Its capabilities include automatic fault isolation, failure diagnosis, and warning of potential failures.

Operation is simple. The MAP-14 holds in memory the operations schedule of each electromechanical part of the machine (or of a group of machines), and reviews the positions of switches, solenoids, and other parts on a cycle-by-cycle basis. Acting as a comparator, it spots particular devices at the time they begin to deviate from the machines' operation plan and prints out this information on a Teletype console operating through the existing control minicomputer. Deliveries of the MAP-14 should begin in October; prices start below $2,000.

TI opens pc service to outside customers

TI in Dallas is expanding its computer-operated printed-circuit board layout service to a complete automated electronic designing service, including logic simulation, partitioning, documentation, data checking, and functional test generating. The system was developed for TI's advanced scientific computer, but up to now had not been available to outside customers.

Karl W. Hunter, marketing manager for the service, says it is the first of its magnitude offered outside by any company; earlier systems incorporated only a part of the capability. Customers can use remote terminals at TI facilities for entry or can have a terminal installed.

Troubled Transitron ousts Georgoulis

The semiconductor operation at Transitron Electronic Corp., after going into the black in June 1970, has skidded back into the red. The result has been another management reshuffle in which Straton Georgoulis, manager of the operation, has been replaced by James Malloy, who was in charge of the firm's Transitron Mexicana assembly facility.

Georgoulis came to Transitron when it was losing about $600,000 a month. Through layoffs, sale of inventory, closure of one of the firm's three Boston plants, and other overhead-cutting moves, he forced the semi-conductor operation into the black in five months. But the trend reversed itself over the past year, and as it did, president David Bakalar gradually absorbed Georgoulis' powers.

FCC wideband OK a boon to Multitran

A small Los Angeles company has already moved to take advantage of the FCC decision to permit intermixing of different speed data bit streams on wideband channels. The company, Computer Transmission Corp., says its Multitran is the only multiplexing equipment that can do the job.

Raymond W. Sanders, president, says Multitran is more than a multiplexer. Essentially, it's a synchronous system, with the common carrier facility embedded in it. "It can multiplex any number of asynchronous and synchronous terminals with any combination of any data rates up to 2 million bits per second," he says.

Announced two years ago, Multitran's market is just opening up because of the FCC decision. The advantages of the system, says the company, include greatly reduced transmission line costs, substitution of small terminals for large computer mainframes, and the increase in reliability (three orders of magnitude) that is recognized as inherent in wideband systems.

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III-V compounds add efficiency to vacuum tubes

Tubes with highly sensitive GaInAs cathode surfaces are beginning to become commercially available

Solid state is quietly invading the heart of vacuum tube technology. At laboratories of several major electron tube manufacturers, various combinations of III-V materials, such as gallium phosphide and gallium arsenide, have been used as cathode surfaces in highly sensitive photomultiplier detectors, and experimentally as a cathode source of electrons in vacuum tubes generally.

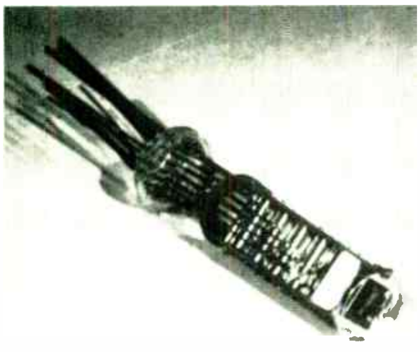
RCA's Lancaster Tube division has now extended the range of such tubes into the infrared region, to wavelengths beyond 1.06 microns. By using various percentages of indium, RCA engineers have developed GaInAs photomultipliers with quantum efficiencies more than four times as great as those of the S-1 photocathode, which is the only conventional surface with any useful response at the 1.06 micron wavelength. And the future could bring 20 to 40 times the efficiencies of conventional S-1 and S-20 surfaces.

Commercially available III-V tubes have already been built that can detect light many times more efficiently than old photoconductive S-1 and S-20 surfaces over most of the optical spectrum. Moreover, since the III-V compounds can be made extremely sensitive to a wide spectral range by having other elements added to them, single solid state cathode tubes can efficiently span a greater portion of the optical spectrum—from ultraviolet to the long wavelengths of red.

Already, RCA engineers have operated GaInAs photomultipliers in the laboratory at 2.5% quantum efficiency, compared to the S-1's 0.05%. And packaged tubes sent for evaluation to the Army Electronics Command at Fort Monmouth, N.J., which is funding the work, operated typically at better than 0.01% efficiency, double that of the S-1. What's more, the RCA researchers feel that they'll be building photomultipliers with efficiencies in the 10% to 20% range and could go as high as 40%, the limit being set only by the quality of the material.

More important, dark current (noise) with the GaInAs cathodes is a thousandth that of the S-1 surface tubes. Because of this, sensitivity is greatly expanded: at 1.06 microns, a typical GaInAs photomultiplier has the sensitivity of 10,000 amperes per watt of light input and a bandwidth of 100 megahertz. Said another way, 1 nanowatt of light incident on a typical five-stage GaInAs tube yields an easily detectable 10-microamp signal. The detection limit appears to be about 10^{-13} watts, and this together with an extremely fast rise time (better than 600 picoseconds) makes these tubes ideally suited to high-speed, low-level infrared applications.

The RCA tubes are now being evaluated for optical communications systems and laser rangers running at 1.06-micron wavelength. For instance, photocathodes with lower indium content would be



Infrared. RCA's commercial photomultiplier uses GaInAs cathode surfaces.

Packaged power

In an independent effort, RCA's Lancaster tube engineers are integrating power supplies into the photomultiplier tube package, a development that rids the tubes of the last vestige of the old vacuum tube technology—the oversized, bulky external supply required to operate them. Because 100 to 5,000 volts are typically needed, the power supply requirements limit the tubes to systems that can tolerate bulk. Designers often must use photodiodes, which can't offer the sensitivity and noise performance of photomultipliers.

Early integrated laboratory tubes use a standard silicon diode voltage multiplier on a standard pc board. They require only 5 to 15 V/input and occupy only several cubic inches of tube space. New models under development will employ the latest flip-chip techniques, and will occupy about 0.5 square inch.

ideal with GaAs lasers, while those with higher indium content are ideal with YAG lasers. Astronomers are also using these tubes, primarily to look at red stars with weak emission spectra.

At the same time, Varian is using indium arsenide phosphide. Ron L. Bell, of the firm's Palo Alto, Calif., R&D labs, says: "InAsP is slightly better than gallium indium arsenide. We get more than 2,000 microamps per lumen and a 2% quantum efficiency." Varian/EMI has changed its name to Varian/LSE (for light sensing and emitting), and will soon start producing III-V tubes.

Advanced technology

Ferroceramics may mean inexpensive surface waves

The use of surface acoustic-wave devices in signal-processing subsystems has been held back because devices were expensive to make. Despite its ability to deliver components far smaller than those now being used, the technology has been limited to bandpass filters, delay lines, and pulse-compression filters, which usually have been built on lithium niobate substrates.

That's where another obstacle arose. Since it was difficult to obtain lithium niobate in single-crystal form more than 12 inches long, the delay achievable was limited. Although lab work continued [*Electronics*, Nov. 23, 1970, p. 93], no devices emerged at a marketable price.

However, recent experiments involving nonlinear interaction of two acoustic waves in ferroelectric materials—specifically, PZT—have proved true signal multiplication both possible and practical. And this multiplication process, coupled with surface acoustic-wave delay lines and bandpass filtering characteristics, has led to development of integrated devices that can do many signal-processing jobs—convolution, correlation, waveform compression, Fourier transformation, and variable waveform delay.

The PZT work (for lead-zirconate-titanate) was done at North American Rockwell's Science Center at Thousands Oaks, Calif. Edgar A. Kraut, group leader in solid state physics, and coworkers T.C. Lim and B.R. Tittmann, have extended the principles of convolution, time inversion, and electronically variable time delay using relatively inexpensive ferroceramic materials with excellent results. Using PZT instead of $LiNiO_3$, they have produced marketable convolution/correlation filters.

The real-time nonlinear acoustic surface-wave convolution/correlation filter can perform many signal processing functions. And, in addition, a single device can perform multiple functions.

These devices have myriad uses in today's complex systems. In avionics computers, for example, they are used for real-time fast Fourier processor sensor correlation, target signature recognition and tracking, multisource data compression and enhancement, and in analog test function generators. In radar and navigation systems, they serve as pulse compression or correlation devices, code signal identification delay-line interrogators, time average product arrays, and high-frequency quadratic mixers.

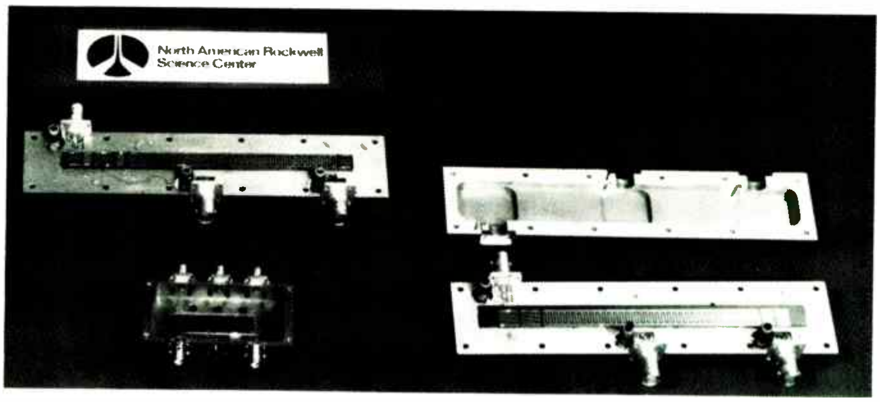
Until recently, matched filters for complicated (coded) waveforms required the use of complex, lumped-constant analog or digital delay lines. A drawback was that the processor could be matched to only one signal—if the input waveform were changed, the matched filter had to be changed. The signal correlator, however, can be changed by changing the reference signal.

Either cross correlation, auto correlation, or Fourier transform functions can be achieved very simply. The signal output of the correlator will be the cross correlation of the input and reference signals, and will be at a maximum whenever the two

Lithium niobate properties vs PZT

Property	PZT G1408	$LiNiO_3$
Surface wave speed (Y cut, Z propagating)	2,150 meters/sec	3,470 meters/sec
Electrical insertion loss for matched filter application	42 dB at 44 MHz	64 dB at 210 MHz
Typical operating input power	25 mW at 22 MHz	100 mW at 105 MHz
Typical cost	$1.82 per cm	$62.46 per cm
Maximum practical operating frequency for surface wave use	about 50 MHz	about 1.5 GHz
Maximum length obtainable	Theoretically unlimited	Single crystal considerations limit to about 12 inches

Sources: E. A. Kraut et al, M. Luukkala et al



Boxed in. The small ferroceramic device is a 22-megahertz convolver. The two larger ones shown along with their covers, are both 1-megahertz correlators. Material is PZT.

waveforms are completely correlated. However, if the signal is directed to the correlator signal input and reference input, the signal auto correlation function is formed. This function is particularly valuable for real-time analysis and classification of unknown signal waveforms. And, if the reference input is a swept frequency signal, the output becomes the input's Fourier transform.

Honeywell ready for PLZT rush

When Sandia Corp. in the spring of 1970 announced its PLZT ferroelectric crystals for image storage and display, scientists predicted a fine future for them in applications as diverse as computer memories and avionics displays. At that time, however, even the developers of the fine-grained lanthanum-doped lead-zirconate-titanate crystals, which can be electrically switched to states that either transmit or retard polarized light, said the technology was in its early stages and needed far more work.

Today, however, more than 50 companies are experimenting with samples of the substance, and applications may be close at hand. The reason for their sudden interest is that Honeywell's Golden Valley, Minn., Ceramic Center claims to have mastered the production of PLZT crystals.

"We have more than 50 specially-made hot-press furnaces for making the crystals," says John Huff, the cneter's manager. "That gives us quite a lot of production capacity. We just hope that some of the firms that have been ordering samples start turning in some orders." He says that hundreds of samples, which sell for $8 each, have been ordered by 54 companies, including International Business Machines Corp., Sylvania Corp., and General Time Corp. Sixty to 70 more have requested printed information.

Potential advantages of the material are many, Honeywell sources say. In display applications, for example, the ferroelectric crystals could be used to make flat screen displays, with display cells that required a minimum of electronics and microwatt power. Because of the potential of the crystals, General Time has ordered samples to determine if they can be used in digital readout devices for electronic watches. Meanwhile, within Honeywell, the firm's Aerospace division is determining if the crystals might be substituted for airborne CRT displays.

"We think the material will probably first be used in displays," says Huff. However, high voltage is required to switch it between 15 and 50 volts per square mil. One way of reducing it would be to deposit closely spaced grids of a transparent conductor on the surface of the material.

Further down the road, Huff says, PLZT could find use in computer memories, since it has a capacity of 2 million bits per square inch and nonvolatile storage characteristics. Honeywell engineers add that the material can be switched in as little as 100 nanoseconds. Existing thin film and semiconductor technologies and tight budgets, however, are expected to put a damper on optical memory development in the near term.

Employment

Retraining the jobless: who will do the work?

The Administration and the Congress appear to be engaged in a lively competition over just how to retrain unemployed engineers and scientists and who's going to do it. However, while Administration officials have testified that they can't support the measure introduced by Sen. Edward Kennedy, (D., Mass.), and Reps. John W. Davis (D., Ga.) and Robert N. Giaimo (D., Conn.), the legislation is far from dead.

Although Kennedy has been slow in scheduling hearings before his subcommittee—they're now expected about September—Giaimo and Davis have garnered 111 co-

Listeners. Reps. Giaimo, above, and Davis plan further hearings in California and possibly Georgia this summer on their retraining bill for jobless engineers.

sponsors in the House for the so-called Conversion Research and Education Act that would establish a new national science policy. "Generally and conceptually, Congress supports a conversion measure," says a House committee staffer.

Many committee members questioned the bill's focus on National Science Foundation management. The revised bill, now expected to surface about October, will probably lodge the responsibility for coordinating Federal retraining and job search efforts in an independent commission. "Most of the NSF's relationships are with academia and not with industry," the staffer explains, and adds that there was some subcommittee concern that the NSF might not be able to administer such a project.

"The policy statement received

strong support from Congressmen and witnesses," he continues, and probably will not be changed as the bill is refined. The new science policy would raise total Federal investment in civilian science and technology to the level of Federal defense obligations, and then increase it at the same rate as Gross National Product. It would also place the responsibility for employing engineers and scientists in "socially useful" positions squarely with the Federal Government.

The Senate and House versions vary slightly. The Kennedy measure would authorize $500 million over the next five years for conversion research and retraining activities; Giaimo and Davis favor $450 million over three years. Most of the $450 million package would be slated for conversion fellowships, but funds probably will be reallocated within the bill to cut retraining money and add provisions to provide jobs at the end of the reeducation efforts.

Meanwhile, the Administration is working on its own plan. Director William D. McElroy of the National Science Foundation, in criticizing the Kennedy-Giaimo-Davis-Giaimo bill, says: "The solution lies in two areas: first, modifications in our educational system to foster greater individual flexibility, and second, the development of more comprehensive and accurate long-range prediction capabilities with respect to future manpower requirements and the impact of technology on society." For the short term, McElroy continued, "the critical point for unemployed engineers is simply job opportunities."

Commercial electronics

Calculator sales multiply, but so does competition

Despite extravagant sales gains, electronic calculator prices have fallen through the floor amidst all the symptoms of overproduction and crowded competition. At the same time, these declines have shoved low-end models into direct consumer sales, causing a shakeup in traditional marketing approaches to this big personal-purchase market.

Calculators for consumer, business, and scientific users, which sold for $395 to $4,000 a year ago, are now going for just under $200 to $3,000. In closeouts, minicalculators have gone on sale for as little as $139 as well. Most of the action has been in the nonprogramables in the under-$1,500 category.

Still reeling from the nosedive, industry observers last week were predicting more price declines and greater penetration of mass consumer sales this year triggered by the arrival soon of a simple four-function adding machine selling for less than $100.

New entries. Nevertheless, despite the heavy influx of Japanese models and the shaky health of a couple of U.S. producers this summer that have turned the calculator field into a wild, unpredictable horse race, the lure of consumer sales continues to attract newcomers.

For example, Miida Electronics division of Marubini-Iida America Inc., New York, jumped directly in with what it claimed to be the lowest-priced, non-closeout unit going. Suggested retail price is officially $229.95, but it's actually selling for $199.95. Model MC800, the company's only calculator, has an eight-digit readout, weighs 3.3 pounds, and features complete logic on three U.S.-made LSI chips. It's being distributed through appliance, department, and photographic supply stores only. In addition, a U.S. camera company is also getting set to develop consumer-only calculators before the end of the year.

In the meantime, the oldest U.S. calculator manufacturer, SCM Corp., New York, last month announced a new line of machines to go along with a new marketing strategy aimed at independent dealers. The line of American-made machines, starting at $525, is aimed at the almost-consumer market of engineers, accountants and students who want personal machines. But to reach this new group the company has organized a separate sales structure outside the traditional business supply houses.

Part of the reason for this move, explains Robert Galland, national sales manager in the calculator group for SCM's Business Equipment division, is to counter Japanese competition. He predicts that American companies will make a comeback in the electronic calculator field now dominated by Sharp, Sanyo, Canon, and Seiko because of U.S. leadership in LSI technology coupled with new marketing penetration.

As though to prove the point, Monroe International division of Litton Industries, Orange, N.J., has begun selling the Canon minicalculator under the Monroe name. This machine was adapted to Monroe specifications and different testing requirements.

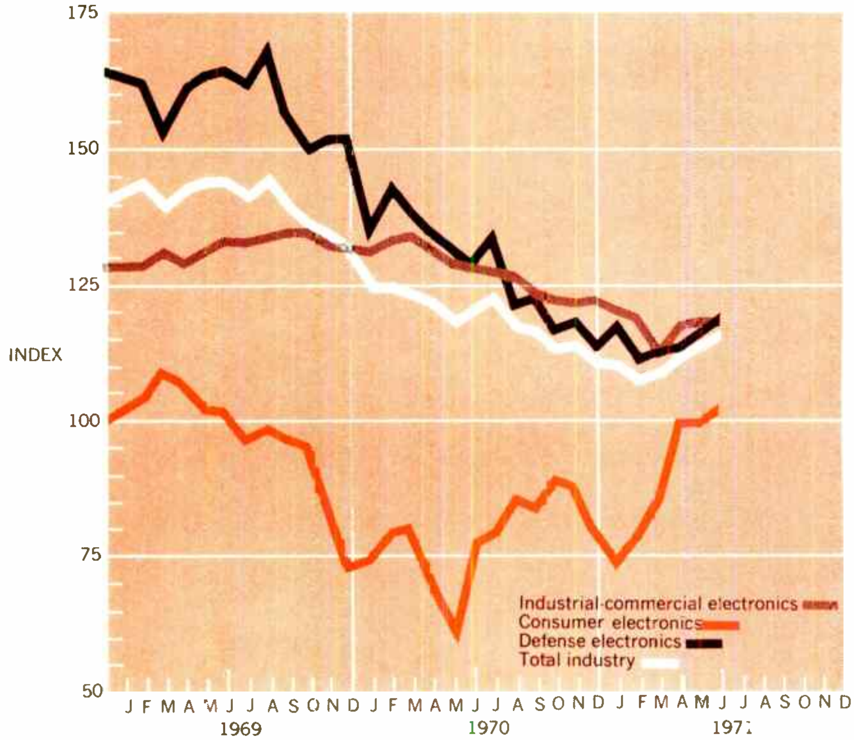
Commenting on the price decline in the nonprogramables, a Monroe official points out that it's not so much a case of over-production or over-competition, but over-modeling. There are too many different models available but they will eventually be shaken down to fewer, basic types, he adds.

The Japanese will not be sitting still, though there have been some casualties in their ranks, too. Still, overproduction is not a problem, a spokesman for Sharp Electronic Corp., Carlstadt, N.J., says. "There is tremendous demand, particularly in the personal market once the price is right. While prices have been seeking this level, there have also been product improvements over the earlier and higher-priced calculators. But even if the sales volume is high, it's too wild right now to predict what the dollar volume will be."

Communications

Leased CATV advocate shows scrambler system

While cable television broadcasters are debating the dollars and sense of two-way cable systems [*Electron-*



Segment of Industry	June '71	May '71*	June '70
Consumer electronics	103.1	100.5	77.6
Defense electronics	119.6	116.8	129.1
Industrial-commercial electronics	118.4	118.5	129.0
Total industry	116.3	114.3	120.0

Electronics Index of Activity

Aug. 2, 1971

A modest comeback was chalked up by the June index. It rose 1.7%, to 116.3, from May's upward revised 114.3. The increase was made possible by significant month-to-month increases in consumer and defense electronics. Consumer was up 2.6%; defense 2.4%—only its second such rise since last November. Consumer was up 32.9% over last June's level, but defense was off 7.4%.

June's only loser was industrial-commercial, dipping 0.1% to 118.4 from May's upward revised 118.5, leaving it 8.2% behind last year's figure.

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

ics, July 19, p. 27], Optical Systems Corp. of Los Angeles has started talking up channel leasing as another, more immediate source of income. Claiming that it's now possible to cablecast over as many as 52 channels, the company is promoting the lease of unused channels for special purposes.

To back up the idea, Optical Systems has built equipment to scramble and reconvert television signals (video and audio) especially for such use. The company has available two scramblers, a medium type for general use and a full security version.

For the receiving end there's a terminal unit that in the deluxe form combines an all-channel converter (like the set-top device by Oak Manufacturing Co., Crystal Lake, Ill.), a decoder, and a bypass circuit to permit remote control tuning. This unit will cost about $50 to $60, but an everyday version selling for $20 to $25 will also be available. The cost of modulators for transmitter encoding begins at $2,000.

By making spare channels available to police, fire, medical, school, and special entertainment leasers, cablecasters will be able to make an immediate income well before the Wired City dream becomes reality, says Geoffrey M. Nathanson, president of Optical Systems.

World body parcels out space frequencies

Nearly 700 delegates from 100 nations are seeking their government's approval of a draft treaty on space communications frequency allocations following a grueling six-week meeting of the World Administrative Radio Conference on space telecommunications in Geneva. The treaty will become effective Jan. 1, 1973, if approved, as expected, by WARC member governments.

FCC Commissioner Robert E. Lee, a member of the U.S. delegation, says that the allocation of the 2,500-to-2690-MHz band for instructional services is probably the most important action taken at the conference. It will permit the distribution of signals that may be received with low-cost equipment within the U.S.

Though there were surprises for all parties at the session, the chief of the U.S. delegation, Robert C. Tyson, said: "We are quite satisfied with the results." He should be, for with minor exceptions, the treaty reflects the positions taken by the U.S. in its inch-thick pile of proposals.

Largely because developing nations feared "cultural imperialism," Tyson says, the delegates could not agree on how satellites should be used for direct TV broadcasting to the home. So they decided to hold a world planning conference in the mid-1970s to determine how orbital positions and frequencies should be shared. Even so, and despite the fact that direct TV distribution to the home will not be used widely until 1985, delegates allocated the 11.7-to-12.2-gigahertz and 470-to-790-megahertz bands for broadcasting uses. The 11.7-to-12.2-GHz band will be shared by two-way satellites and mobile users.

In the area of general-purpose communication satellites, the conference allocated the 10.95-to-11.2-GHz band and the 11.45-to-11.7-GHz bands for worldwide down links and 12.5-to-12.75-GHz band for up and down links in regional fixed systems. WARC also set aside the unused 14.4- and 14.5-GHz band for uplinks in international systems while the 14-to-14.4-GHz bands were earmarked for fixed satellite uplinks and radio navigation.

As expected, the draft treaty allocates 1,535-to-1,600 MHz for mobile services. But instead of setting aside 2.5 MHz in each direction for maritime, 15 MHz for aeronautical, and 80 MHz for aeronautical radio navigation, WARC allocated 7.5 MHz each way for maritime, 15 MHz for aeronautical, and 78 MHz for radio navigation. The conference also set aside 157.3-to-162 MHz for maritime services and 406-to-406.1 MHz for emergency-position-indicating radio beacon service.

For research. In the area of space research, the conference allotted the 1,750-to-1,850-MHz and 2,025-to-2,110-MHz bands for earth-to-space bands and paired them with the 2,200-to-2,300 MHz space-to-earth bands. The 7,145-to-7,235-MHz upband was also paired with the 8,400-to-8,500-MHz band for similar uses. These two frequencies will be used in scientific satellites, manned space, and deep space research. Ten bands of frequency above 40 GHz were allocated for the purposes of space research.

In another policy area, the WARC delegates also decided not to ration out orbital slots to member nations. Instead a complex formula will be used which would set strict limits on how much interference will be permitted on the ground and in the air. In cases of interference, a procedure will be developed that would require the operators of satellites causing interference to move their spacecraft.

Air traffic control

Cockpit CRT duplicates ground controller's picture

Airline pilots feel a certain coolness toward the FAA's overworked ground controllers and, especially in heavy traffic areas near terminals, are unwilling to depend entirely on their instructions and judgment. That's why a one-year MIT exploration of advanced air traffic control techniques, that may eventually lead to cockpit CRT displays showing almost exactly what's seen by ground controllers, has been hailed by the head of their union.

However, like most new developments, the system raises questions—most important, that of final authority for control of aircraft. Most experts agree that this power of decision can't be divided—either the pilot or the controller must be in command. The final word would probably continue to rest with the ground-based controller because of his knowledge of the commands given other aircraft, though cooperative decision-making might result.

On the other hand, John J. O'Donnell, president of the Airline Pilots Association and an Eastern Airlines captain, tried out the simulation and called it, "The greatest thing I've seen in years; it would take a lot of tension out of the cockpit by giving the pilot all the information."

His point is that the ability to look at the video data on which a controller bases decisions would reassure and relax pilots and let them pay more attention to the business of flying—especially during terminal approach and landing, the most nerve-racking time in any flight.

The Boeing 707 cockpit simulator was built by MIT's Electronic Systems, Flight Transportation, and Man-Vehicle Labs. Engineers used computer-generated displays to simulate a complete set of flight instruments (altimeter, artificial horizon, rate-of-climb indicator, and many others), a moving map for area navigation, and air traffic control information plucked by simulated telemetry from FAA radar. Thomas Imrich, a graduate student in MIT's Aeronautics and Astronautics department, used his father as the program's chief unpaid consultant. A DC-9 pilot for Allegheny Airlines, the senior Imrich helped the team with the cockpit simulator.

Mark E. Connolly, project manager, hopes that giving the pilot virtually all the information available to controllers would lead to more efficient use of airspace, and help reduce the danger of midair collisions, which occur more frequently near airports than anywhere else.

The air traffic control display used in the mockup mapped the approaches to Boston's Logan International Airport, indicated the surrounding air route structure, showed an instrument landing system approach path to runway 4R, and gave expanded views of Logan's runway layout. (The CRT scaled its maps to cover areas 4, 8, 16 and 32 miles square.) An Adage AGT-30 computer called up to six other "planes" from holding areas and flew them through displayed maneuvers, with the pilot in the simulator evading them or just using the display for reassurance.

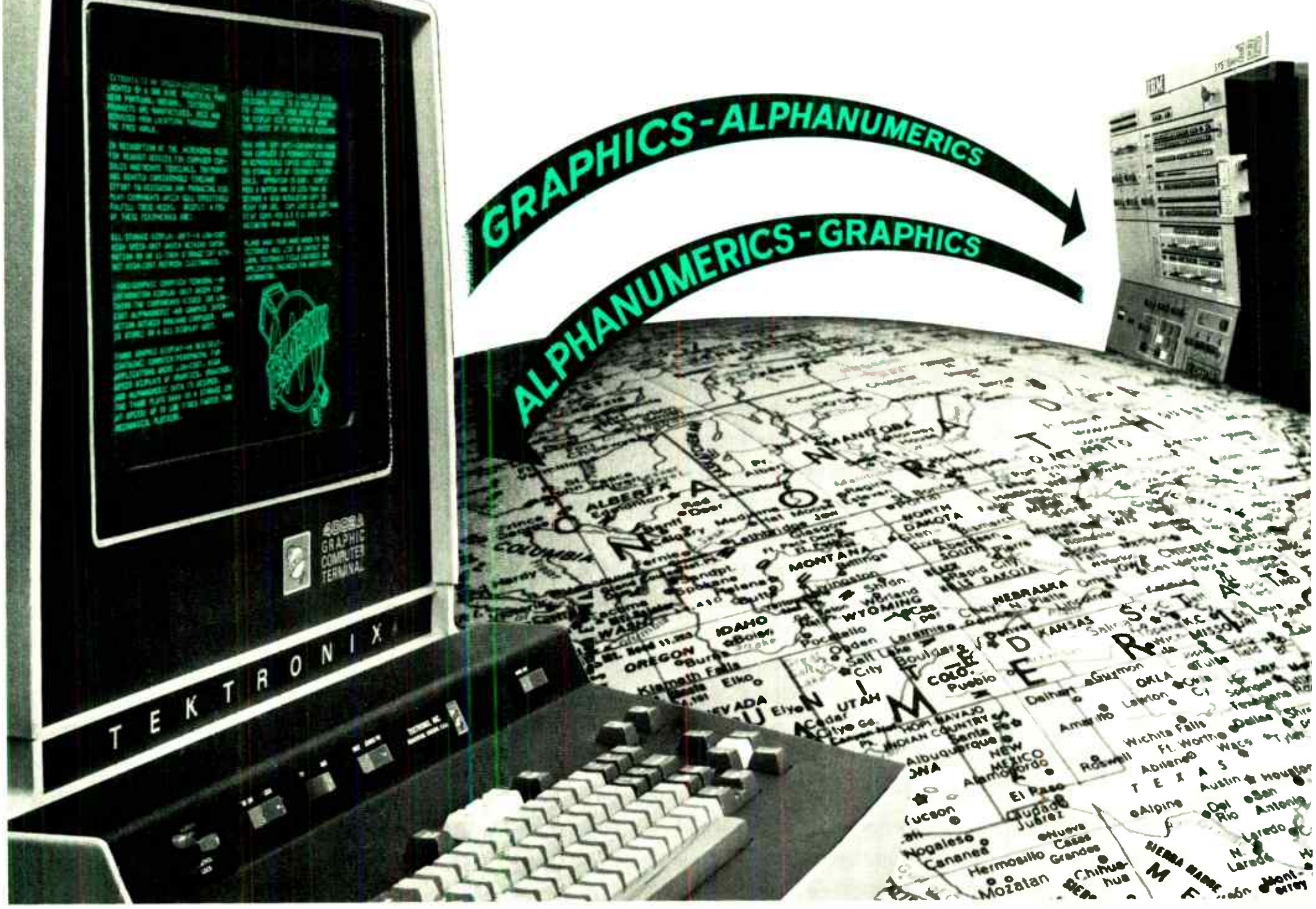
Such a system, if implemented—and there's no money in sight—would be updated every four seconds or so using data accessible through the National Air Space Automated Radar Terminal System computers.

Displays

Turning TV into time, calibration source

An ordinary television set becomes a highly precise clock and signal source in a system being worked on by engineers at the National Bureau of Standards in Boulder, Colo. If

NEW Interactive Computer Terminal



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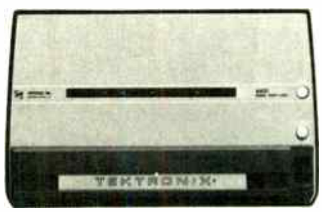

4601 Hard Copy Unit

Circle 27 on reader service card

their system is adopted by TV networks and gets approval from the Federal Communications Commission, TV sets will be able to continuously set all the clocks in a house or any other building, display the correct time, generate a precise signal for calibration work, and act as a high-accuracy ranging instrument.

Top line. Called the TV Time and Frequency System, the NBS concept is keyed to transmitting timing signals on line 1 of every frame. Like the other top 20 horizontal lines in each broadcast picture, line 1 contains no video information. In fact, it contains no information at all.

NBS would have a cesium beam or other frequency standard and some decoding equipment installed at TV broadcast stations. On the first half of line 1 a station would put a 1-megahertz signal, which would be as stable as the frequency standard itself. This signal, points out NBS engineer George Kamas, would be invaluable for calibrating crystal oscillators and other local frequency standards.

Three different signals could take up the second half of the line. What NBS labels the hour-minutes-second output would contain the correct time. Decoded by a special circuit in a TV set, and made available at an output jack, this signal could continually reset clocks, keeping them accurate to within 1 microsecond. Furthermore, a second circuit in the set would allow the time to be displayed on the TV screen on demand.

A second signal that could be broadcast is the so-called precise time code. Having a higher resolution than the hour-minute-second signal, this transmission would be useful for comparing the network frequency standard with a local standard of similar stability. NBS has developed encoding circuits that match the precise time code with the local standard, and then display on the screen the difference in microseconds.

The third possible signal is teletypewriter transmissions, but this would be useful only to TV stations as an added message channel.

NBS is in the midst of a local test of its system—a CBS affiliate in Denver is broadcasting the timing signals, which are being picked up by TV sets modified by NBS. Kamas says results have been "superb." A nationwide test involving one of the major networks is slated for this fall. At that time, NBS plans to loan or lease several of its modified sets for demonstration purposes.

If the idea gains general acceptance, then the FCC will have to be persuaded to allocate line 1, and stations to broadcast the information. On both counts, NBS is optimistic, says Kamas.

It's estimated that a station could begin broadcasting the timing information (but not messages) for less than $50,000, including the price of an atomic clock. For local stations that wished only to relay the signals, the hardware bill would be around $300.

Decoding circuits for TV sets are costing in the neighborhood of $400 to build. But Kamas points out that it wouldn't be difficult to make an hour-minute-second decoder as an LSI circuit, which set manufacturers could build into their products. On this basis, Kamas sees the price falling to around $10 per set.

Industrial electronics

Microwave system measures carpet backing

Measuring the amount of latex applied to the back of carpeting in the factory is something of a black art. Many variables are involved in the application of latex by the latex oven, and each style of carpet requires a different setting. If the latex is too thick, the carpet is stiff and difficult to lay; if too little is applied, the carpet is too thin and wears easily.

Until now, the only sure way to check the thickness has been to cut off a piece of completed carpet and weigh it. However, a microwave monitoring system developed by the Microwave Sensor Systems division of Spectran Inc., Hollywood, Calif., promises to take the guesswork out of the process and save individual

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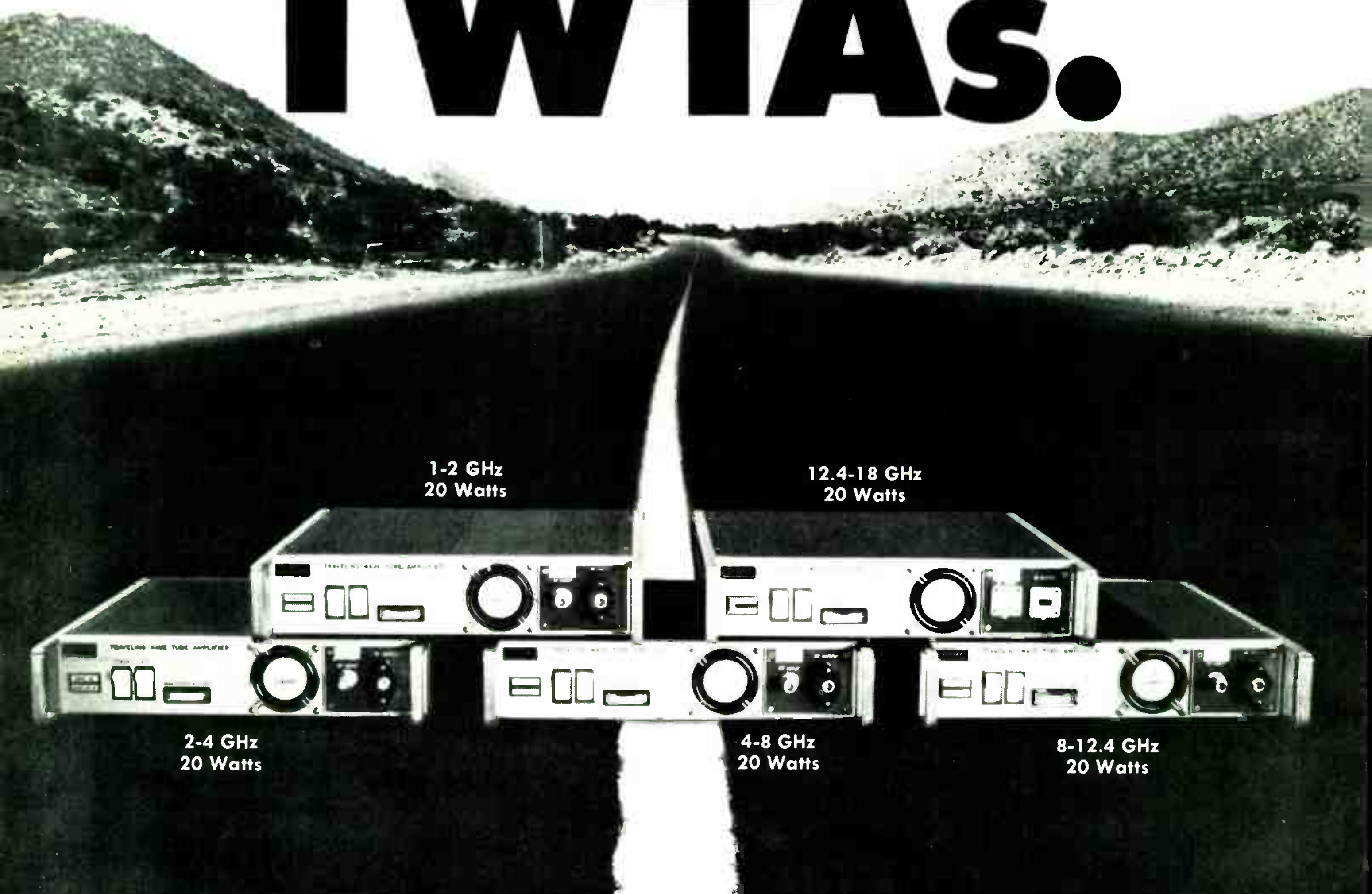

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Circle 30 on reader service card

carpet manufacturers hundreds of thousands of dollars annually.

Called the latex coating monitor, Spectran's first system is in operation at California Weavers Inc. Developed to meet the mill's needs, the system consists of a microwave source and detector, two aluminum tubes that are set above and below the carpet immediately behind the latex application, a sampling oscilloscope that provides an instantaneous picture of the application, and a strip chart recorder for a permanent printed record.

The two aluminum tubes are 5 inches in diameter, approximately 5 in. apart, and 18 ft 6 in. long (the width of the frame). A cable feeds microwave pulses to each tube. The stepped pulses, which go from dc to about 4 gigahertz, are transmitted along the tubes, which are simply passive conductors, like parallel wire transmission lines.

Spectran's equipment is actually a time domain reflectometer system, measuring the dielectric constant between the two tubes. Since the dielectric constant of the water in the latex is much higher than in the rest of the carpet, the moisture is the only element really visible to the detector. As the stepped pulses are fed along the tubes, there is a constant reflected feedback from the carpet to the microwave detector. If there is no variation in thickness, the feedback is simply displayed as a straight line. Any variation shows as a slope.

Each pulse takes 18 nanoseconds to cross a tube, and there are about 3,000 sampling points. For the strip chart recorder, logic in the system compares data with a reference (a section of fixed transmission line with no carpet) integrated across the section of carpet to obtain a dc voltage that is proportional to the average weight of latex applied across the section. This average is then drawn on the strip chart recorder.

An alarm circuit causes high-intensity dots to be displayed if the latex application goes above or below predetermined limits. If the dots become very intense or if the situation persists, an audible alarm may be triggered to warn the operator that the machine needs adjusting.

The system measures the amount of latex applied to within 1 oz per sq yd. Andre LaRocca, quality control manager for California Weavers, estimates the system will save the company about $200,000 on latex and carpets it might otherwise have had to sell as seconds. A basic microwave system, with one pair of tubes, costs $16,000. One system can control several sensor stations (pairs of tubes) via cable, for installation of each additional pair of tubes costing $2,900.

Spectran is now studying ways to use the feedback from the monitoring systems to achieve closed-loop control of the latex oven. William Conway, vice president and director of engineering for the division, says that this is still some way off, however, because of the complexity of the operation.

Another carpet manufacturer, Coronet Industries Inc., of Dalton, Ga., which has ordered a Spectran system, is developing its own closed-loop system in cooperation with IBM and several other equipment manufacturers. Coronet declines to give details of its plans.

Computer helps weigh sloshing liquids

It hardly seems as though a computer would be necessary to weigh something, but that's what Sands Measurement Co. in Dallas uses to solve the sticky problem of how to weigh heavy, moving railroad cars full of sloshing liquids. It uses the same type of equipment for making exceedingly accurate measurements on items as small as postage stamps. But it's taken Sands 10 years of research into sensors and electronic circuitry, plus sophisticated mathematical analysis, to come up with this solution.

Strain gages have long been used to measure weight, but they still give rise to many practical problems. They're rugged and reliable if not overstrained, but they're nonlinear and subject to damage with overloads. When Sands started de-

Electronics review

veloping its system for measuring railroad cars, the company had to go back to basics: much experience with strain gages led it to develop a very simple load cell that gives linear output by using nonlinearities in steel supports to counteract nonlinearities in the strain gages.

The load cells also are almost unaffected by temperature changes, and detect force in only one direction, as is desired in weighing. They can also stand a 700% overload with no damage, since the gages are subject to only about one-seventh the load.

However, this also means that the output from the cell is very low, 5 millivolts typical, though it is stable, linear and accurate to 0.5 microvolts. If the total system accuracy was to achieve the requisite 1 part in 10,000, this low signal output had to be separable from the considerable noise and purious signals that accompany it.

The usual way to separate small signals from noise are filtering and averaging. However, filtering causes delays and limits speed. Sands filters as much as possible without losing the signal, but this still results in a ±10% error. And averaging at that point can't do better than 1%.

S.H. Raskin, president of Sands, says that's where the computer and analysis came in. The vibration of the carton—or railroad car—follows a definite pattern, so in the first few milliseconds of weighing, the computer analyzes the oscillation, and determines from that pattern what error correction should be applied. From this, Sands is able to get an accuracy of equal to the weight of one penny on a 20-lb scale, or to four significant digits, even in railroad cars moving by at 15 mph.

The computer used for the train measurements is a hybrid one in a 19-inch relay rack about 2 ft high. More recently, Sands has developed a unit that adds only about an inch to the back of a standard digital panel meter. Sands subcontracts everything possible, and does no manufacturing itself.

Raskin says that Sands equipment can offer two things: In dynamic measurements, static accuracy for objects moving at high speed; and for static measurements, the same or better accuracy than conventional balances, but at much higher rates and with much less chance of gross errors.

And he says that, even with the complex equipment and development, Sands is competitive in cost to other ways of weighing, if the others are even remotely comparable. For instance, on a railroad scale, the instrumentation is considerably more, but the only installation required is a flat concrete slab instead of the 60-ft concrete-lined pit of conventional scales, and this brings the prices in line—roughly $50,000 to $75,000 for an in-motion scale. A portable scale on a hand truck that can weigh 5,000 lb is $5,000 to $10,000.

For the record

Proper attitude. Work on the most accurate attitude control system ever to be developed for a NASA synchronous satellite is under way at Honeywell's Aerospace division. Designed to point the 30-foot dish of the space agency's Applications Technology Satellites F and G, the system will be built around parallel Honeywell HDC-401 computers.

This is a rerecording. Ampex Corp., Redwood City, Calif., has reeled out a new, medium-speed tape duplicator that will handle cartridge, cassette, and reel-to-reel in both mono and stereo with one to three slave units running from a master. The AD-15, selling for $5,000 to $16,000, is intended for applications where small numbers of audio tape duplications in a variety of formats are required.

Microwave landing. The division of labor between ITT Gilfillan Inc. and Honeywell Inc. in their joint development of a microwave landing system for the FAA [Electronics, July 5, p. 21] is as follows: Gilfillan will handle the ground radar system; Honeywell, through its Government and Aeronautical Products division, will develop the airborne and distance measuring equipment.

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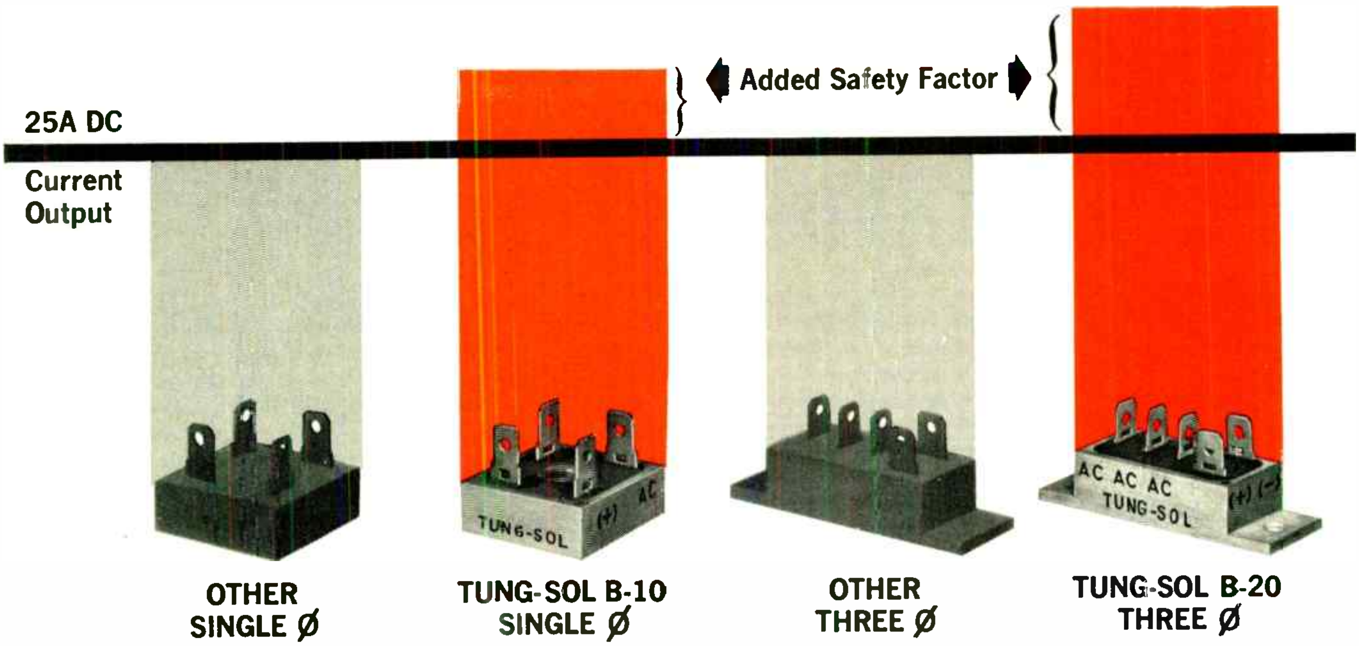

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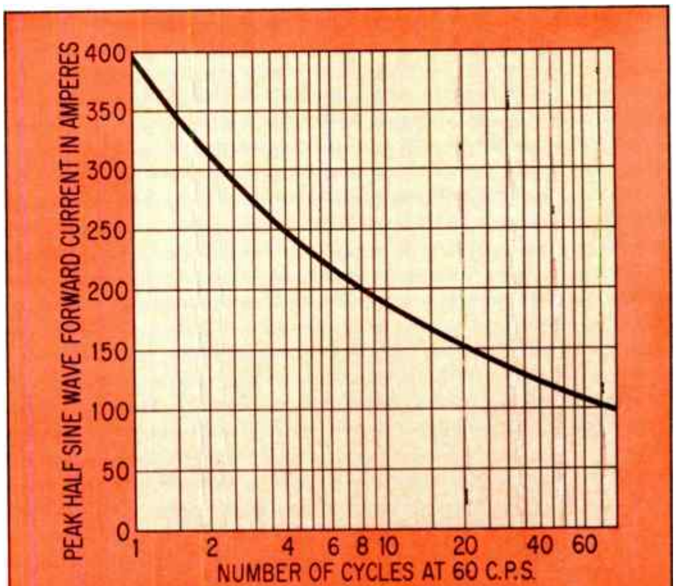

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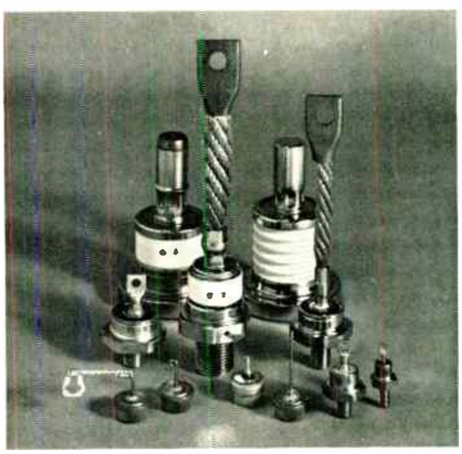

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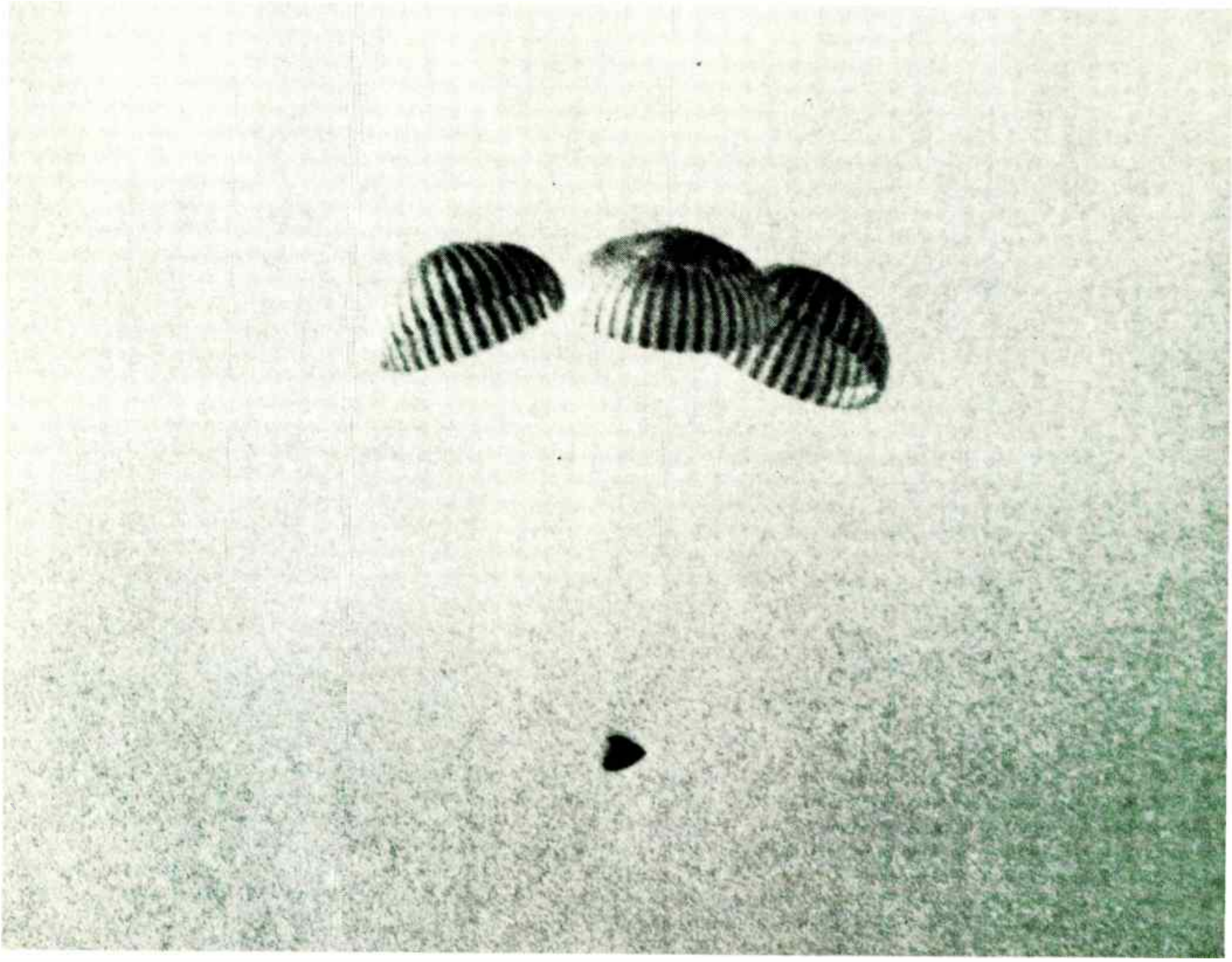

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Washington Newsletter

August 2, 1971

Packard gets strong boost from White House . . .

Strong White House support for Deputy Defense Secretary David Packard is implicit in the statement by the President's press secretary that Packard is not resigning from DOD. Packard got the requested White House putdown of the resignation reports [*Electronics,* June 21, p. 40], which surfaced in the public press at the end of July, apparently in return for abandoning his opposition to a $250 million Federal loan to Lockheed Aircraft. But the California capitalist, who built his $300 million personal fortune from scratch with Hewlett-Packard Co., is still adamantly opposed to a broader $2 billion bill that would make loans available to other troubled corporations.

First soundings on the White House-Packard pact in the capital indicate the Pentagon's top manager will have an even stronger hand in his efforts to control military program costs and improve contractor performance. **New speculation now replacing the old resignation rumors: a second Nixon administration would see Packard taking over as Defense Secretary from Melvin Laird,** who has said he would like to opt out in another year.

. . . and himself boosts new plan for prototyping

Packard's new position of strength is regarded by military R&D sources as increasing his leverage in getting the services and industry to buy a recent proposal of his. **He wants to break out small corporate design teams from appropriate industries and fund them annually, at about $25 million each, to develop and build competing hardware prototypes for new systems.** The teams, which could run to four or five to an industry, would be small versions of such engineering think tank groups as Mitre Corp., Bedford, Mass. **The program goal: to work out with hardware the costly unknowns that regularly cropped up in paper studies of systems in the** Robert McNamara era at DOD and so eliminate costly overruns that came after commitment to a production contract. If the Packard concept wins, it will be applied to aircraft first, then electronics subsystems.

The idea reportedly is similar to a European approach that impressed Packard when he first became interested in successful performance and cost controls there—an interest that led him to tell the Army to buy and evaluate models of the French Crotale field air defense missile [*Electronics*, Dec. 21, 1970, p. 39] as well as the British Aircraft Corp.'s Rapier and the West German Roland [*Electronics,* March 29, p. 31].

International airlines attack aerosat plans

Fearful that air carriers may some day have to soak up the cost of the proposed pre-operational Pacific and Atlantic aeronautical satellites, international carriers are launching a counterattack against Federal Aviation Administration plans to put the spacecraft aloft by the mid-1970s. Still miffed by the Nixon Administration's decision to go with L-band frequencies rather than the vhf approach they have long pushed, airline officials are telling the FAA they are unwilling to invest the $50 million required for L-band avionics. Such an investment would not be required with a vhf satellite since airliners already use vhf radios and some newer planes are even equipped with vhf satellite antennas. **Instead of spending $120 million for the pre-operational systems, the airlines recommend the use of Applications Technology Satellite F's 1.6 GHz transponder to technically justify an L-band aerosat.**

FAA program director David Israel, however, predicts that the counterattack will fail. He notes that satellite service will not cost the airlines anything until 1980 when operational aerosats go into service. The airlines, however, say that while the U.S. may not charge for the service, its European partners probably will. Moreover, they predict the costs of pre-operational service will probably be added to the investment base that will determine rates for the operational service.

NASA okays pair of ATS-G lasers

Approval has been given to two laser communications experiments for Applications Technology Satellite G, provided they can be integrated into the spacecraft. NASA sources say **Goddard Space Flight Research Center and Hughes Aircraft Co. have received "semi-approval" to put a 10.6-micron, carbon-dioxide, two-way communications experiment aboard the spacecraft**, which has been scheduled for launch in 1975.

Also in line for ATS-G is an experiment sponsored by the Office of Advanced Research and Technology that would use a neodymium-doped YAG laser to send pseudo-random code to the spacecraft. The code would be beamed back to earth by a helium-neon link. NASA planners say that putting the YAG laser on the ground will give them more control over a promising but risky technology.

EIA opposition to Commerce plans is criticized

The Electronic Industries Association is getting bad political marks and a Washington reputation for being "the most backward of the so-called forward-looking" industries, says one ranking National Bureau of Standards official. **For the association is reported to be giving "less than strong" support to the Commerce Department's plan for converting the U.S. to the world standard metric system.** Commerce Secretary Maurice Stans is readying the Administration proposal for Congress, following a $1 million study that took two and a half years.

The criticism of EIA comes on the heels of its opposition to another Administration proposal to give the Commerce Department strong powers in standards setting and authority to represent the U.S. in international agreements, an authority which—contrary to practice in most countries—no single U.S. agency has ever had. EIA, just about the only association of any major industry to oppose the bill, wants a study commission to examine the standards issue, claiming it would increase its members' manufacturing costs and make them less competitive. Despite its opposition, the standards bill will probably pass.

Addenda

Stimulated by Motorola's petition concerning the manufacture of its CBS-developed Electronic Video Recorder, **the Federal Communications Commission has proposed rules which would limit the power output and permissible radiation from Class 1, restricted-radiation TV devices**, including video recorders and cameras, character generators, and TV modulators. Unless TV receivers are modified to include input jacks for video and sound signals, these devices have "a considerable potential for causing interference in neighboring TV receivers," the FCC says. . . . William D. McElroy may leave his post as director of the National Science Foundation—but not before February—to fill the vacant chancellorship of the University of California at San Diego if he gets a formal offer. . . . The White House Office of Telecommunications Policy has named Bruce M. Owen as senior economist to assist in studies of the broadcasting and common carrier industries.

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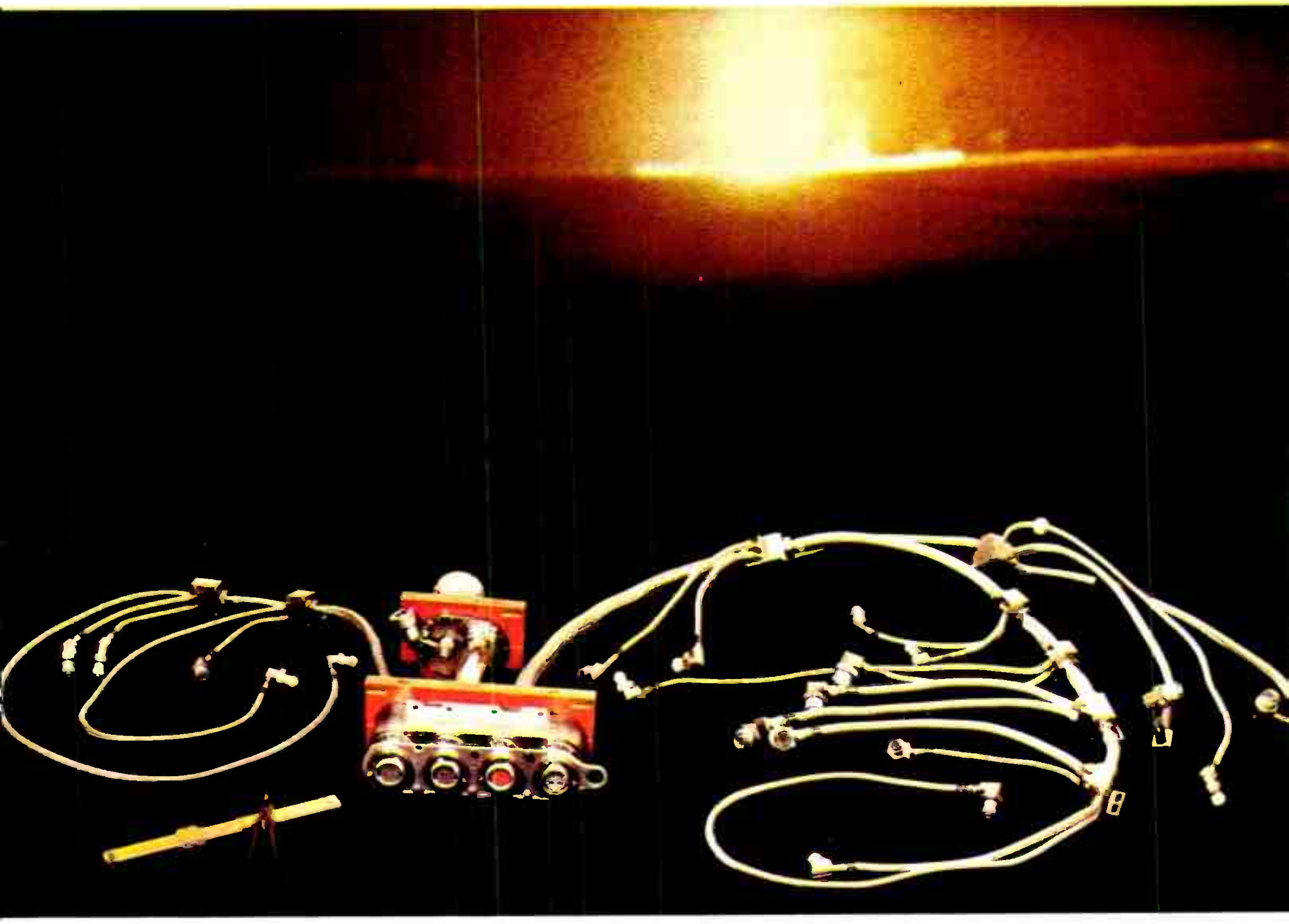

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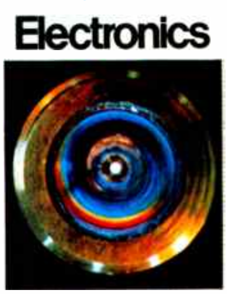

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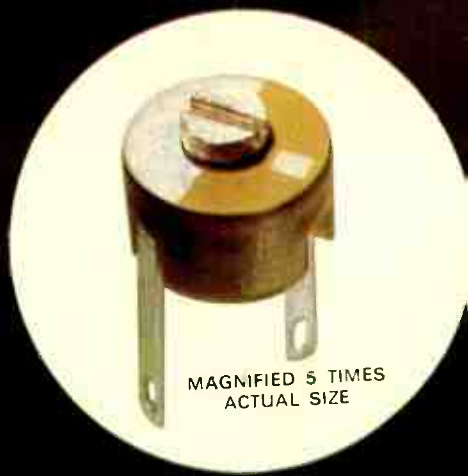

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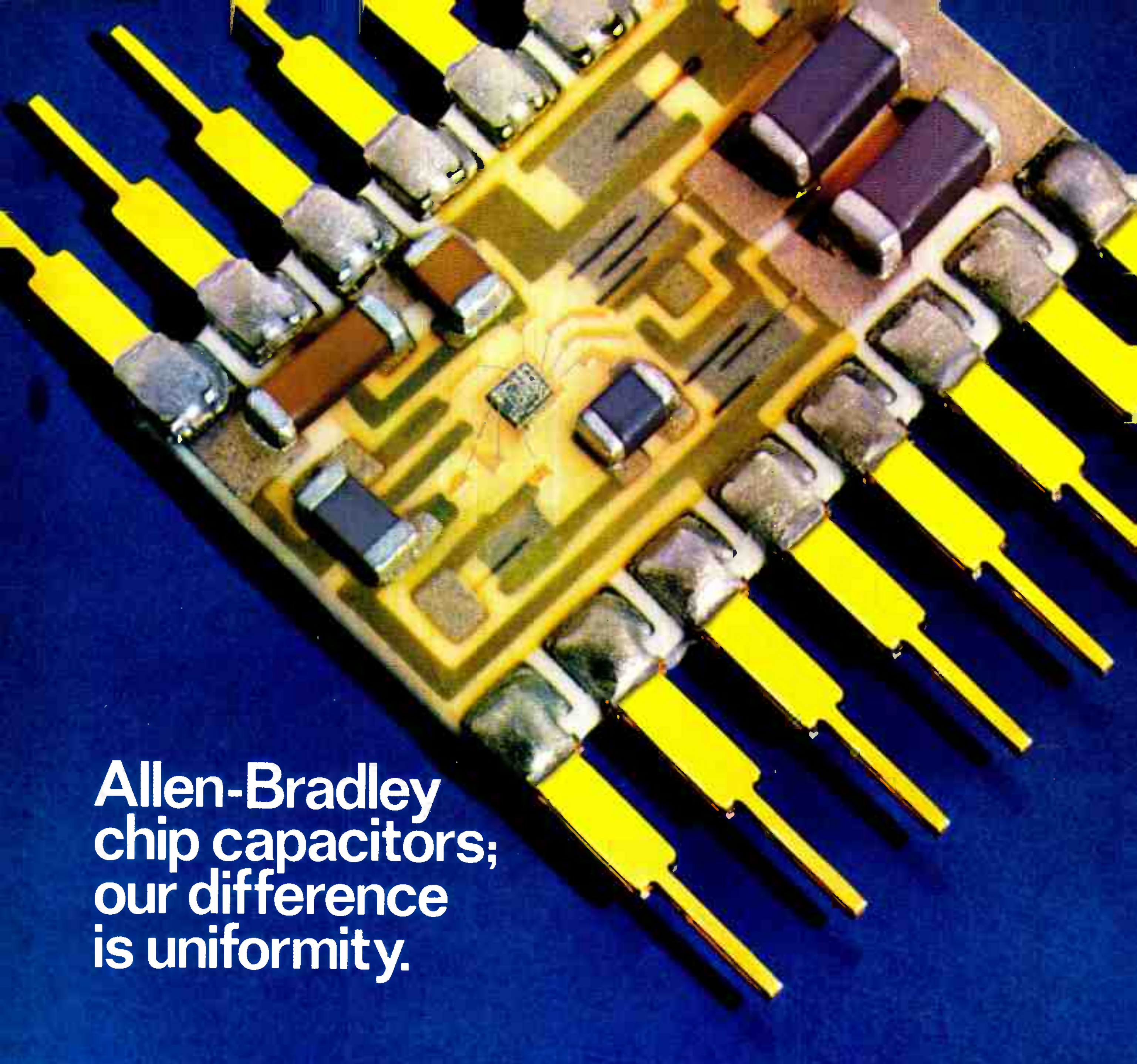

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NEW DIMENSION ELECTRONICS

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Technical articles

Hall-effect ICs open new applications horizons: p. 46

In discrete configurations, Hall-effect devices have been useful, but rather limited in use. But as integrated circuits—with amplifiers, regulators, and other peripherals on the same chip as the generator—they will find many new jobs, says author Michael Oppenheimer. Among them: brushless motors, recording heads, and measuring gear.

A union for EEs? What's your opinion? p. 50

Hard times have raised a storm of controversy over whether engineers should try to secure a better position for themselves by organizing nationally. To help clear the air, *Electronics* asks you to use the enclosed ballot to tell us how you feel about an EE union or association and whether you think it could help.

Test engineers, Getel speaks your language: p. 53

Only trained operators could master the mysteries of automated testing programs—that is, until Getel came along. This English-based language and translator, says author Gene Kierce, can be applied to a wide range of testing equipment, permitting engineers and technicians to talk to them all.

Amplifier design made easy with computer-calculated curves: p. 62

Designers building broadband communications amplifiers need no longer undertake the hours of drudgery associated with breadboarding and testing, says author Frank Egenstafer. A few computer-calculated design curves are the answer: they cover gain response, impedance, and resistance selection, bypassing the usual skull-numbing dogwork.

With one-transistor cell, there's more room for memory: p. 69

Density is an important economic factor in an MOS memory, and one of the best ways to achieve it, say the authors from General Instrument Corp., is to cut down the number of transistors in a cell from three to one. The cell, as well as the smaller overhead circuits, leaves more room for memory on a chip, leading to a 2,048-bit silicon-gate RAM that's about the same size as most 1,024 bit units.

The cover: Shown against a backdrop of its single-transistor storage element is the first RAM that can process 2,048 bits on one silicon chip. That level of complexity points to lower costs in the next generation of memory parts.

And in the next issue . . .

Special report on the Wescon show . . . silicon gate C/MOS for micropower circuits . . . new concepts in semiconductor memories . . . capacitive transducer for position-sensing . . . computer-aided design attacks problems of nonlinear circuits.

In IC form, Hall-effect devices can take on many new applications

Brushless motors, recording heads, measuring gear are just a few jobs opening up for Hall circuits now that amplifiers, regulators, and other peripherals can be integrated onto the same chip as the generator

by Michael Oppenheimer, *Sprague Electric Co., Worcester, Mass.*

□ In discrete form, Hall generators already are doing an important job measuring magnetic fields and power dissipation; acting as magnetically controlled switches in keyboards and as sensors in tape drives; and aiding in semiconductor materials research. But since it's now possible to make complete Hall-effect devices monolithically, their use should expand markedly, opening up such significant applications as:

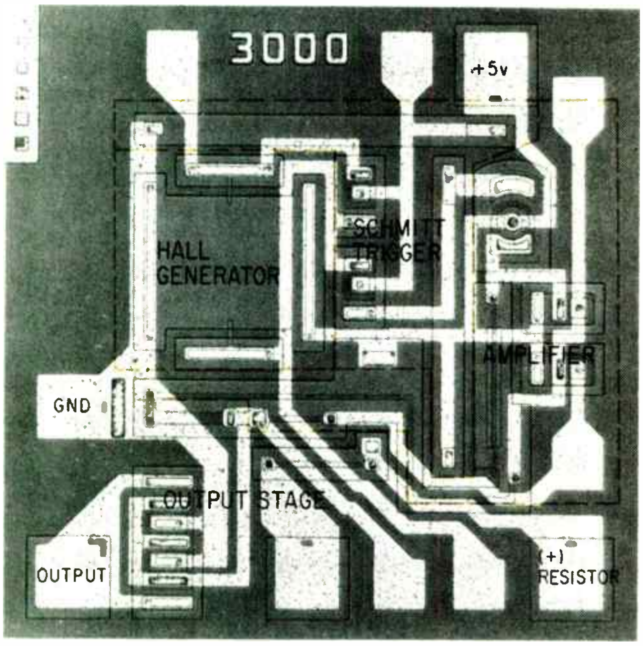
- Magnetic recording heads.
- Brushless motors for precise videotape drives, laser beam scanners, lunar vehicle drives, and spacecraft attitude-control systems.
- Printer paper-feed positioning controls.
- Gyroscope pickoffs for inertial navigation systems.
- Aircraft two-axis compass elements for autopilot heading control.
- Gaussmeters and other types of magnetic-field measuring instruments.

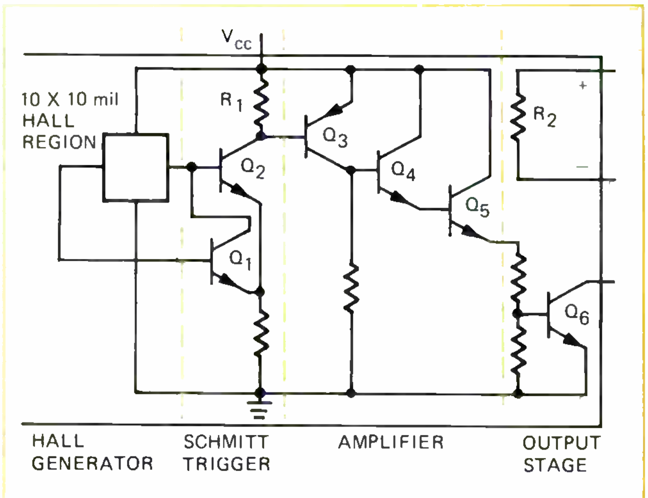
Devices based on Hall generators have received limited acceptance in the past because they've been expensive, complex, unstable under varying temperatures, and unreliable. Incorporating the Hall generator as part of a monolithic IC overcomes all these deficiencies. In fact, all the peripheral circuitry Hall generators need, such as amplifiers and regulators, can go into the same chip as the generator itself, making the devices much simpler for designers to work with.

The use of standard IC production techniques greatly improves reliability. Temperature stability also is improved as a consequence of using a silicon substrate—conventional Hall generators, made with III-V compounds like gallium arsenide or indium arsenide, are many times more sensitive to temperature changes.

The monolithic approach further reduces instabilities by permitting regulators and other compensating circuitry to be built into the chip with the generator. Commercial Hall-effect circuits with onboard regulators soon will be available with temperature stability expected to be approximately 100 times better than that of discrete Hall-effect components.

Silicon hasn't been used before simply because output is very small. A typical silicon Hall generator has a sensitivity of only 33 millivolts per kilogauss with an output current in the low-microampere to nanoampere range. In contrast, the output available from a GaAs Hall generator is 100 times that of a silicon generator driven with the same current and exposed to the same magnetic field. But with an amplifier integrated on the





1. Hall on a chip. Sprague's ULN3000M—a monolithic Hall-effect circuit—is shown along with its schematic diagram. Resistor R_2 helps to tailor output. When it connects Q_6's collector to a 5-V supply, IC directly drives TTL and DTL. With 15-V supply, circuit operates MOS devices. Hall generator is simply square section of silicon.

same chip as the silicon generator, the output rises to a much more useful level. Furthermore, since amplifier and generator are on the same substrate, the problems of noise and long leads that would exist with a discrete amplifier are greatly reduced. Another serendipitous effect of the IC fabrication process is that the long and narrow resistor patterns that result are virtually immune to the magnetic fields used to trigger the generator.

Designers will find the Hall-effect ICs much simpler to integrate into a system than discrete units. Input and output circuitry that's directly compatible with logic elements or any other type of desired circuitry can be included along with the Hall generator on the chip. For example, recently introduced Hall-effect switches are directly compatible with both diode-transistor and transistor-transistor logic. They operate from the same nominal 5-volt power supply used for standard logic functions, and performance is guaranteed over the 4.75-v–5.25-v range. And they operate over the commercial temperature range—0°C to +70°C—with each device's output specified to drive a standard TTL fanout of 10 of the 54/74-type logic inputs.

Monolithic technology also sharply reduces manufacturing costs. Hall-effect ICs sell at competitive prices—the switch, for example, costs less than $5—and with increasing volume, and the availability of equipment to test magnetic ICs in quantity, the price is sure to go even lower. No special, and therefore costly, processing is required to make the Hall device; it's just an epitaxial layer of n-type silicon.

The monolithic switch is shown in Fig. 1. When a suitable magnet, having a flux density within the sensitivity range of the device, is brought closer than 0.06 inch, the IC changes its output from a 1 to a 0. When the magnet is pulled back more than 0.12 in. from the circuit, its output switches back to the 1 level.

The chip is divided into four sections. The first is the Hall generator itself. The second, a modified Schmitt trigger, accounts for the hysteresis in the output characteristic. This assures that the circuit's output is fully on before it can again turn off, resulting in a clean, unambiguous output instead of the multiple signals caused by contact bounce in a mechanical switch or a relay. The monolithic switch can feed signals directly to logic circuits without the usual antibounce gate.

The third sector, the amplifier, not only boosts the output of the generator, but improves the circuit's efficiency as well. When the trigger is off (when Q_1 is on and Q_2 is off), no current is pulled through resistor R_1; thus transistor Q_3 also is off. Therefore, the amplifier re-

Hall and his effect

The Hall effect bears the name of E.F. Hall, an Ohio State University researcher. Back in 1879, while investigating the nature of forces acting on a conductor carrying a current in a magnetic field, he observed that a magnetic field induces a voltage perpendicular to the direction of current flow.

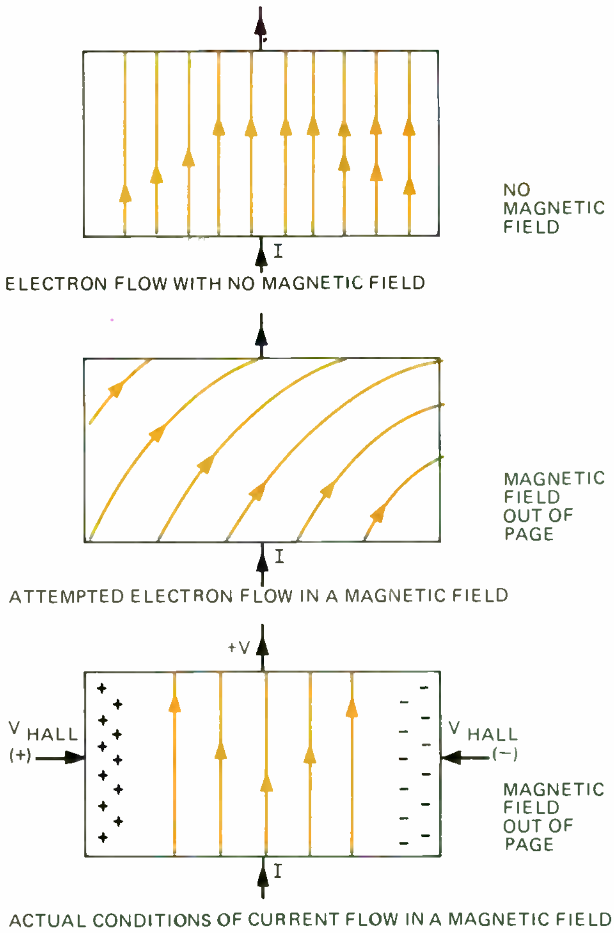
For either a conductor or semiconductor, a magnetic field generates a voltage, called the Hall voltage, which is proportional to the magnitude of the cross-product of the field and current: **H × I**. This means, first, that a device that exhibits the Hall effect is a multiplier, hence the use of Hall generators in wattmeters. With a constant current, Hall voltage is directly proportional to the magnetic field, making the devices popular for measuring magnetic fields.

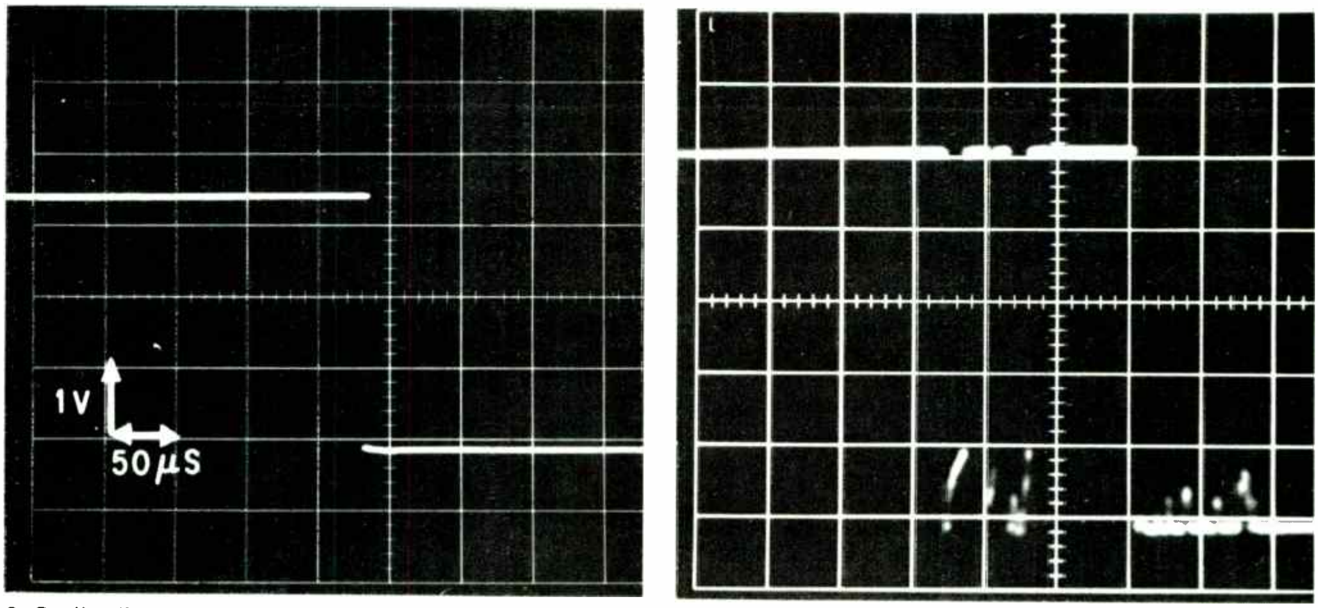
The Hall effect is demonstrated in the figure. Consider a block of conductor or semiconductor material carrying a current. In the absence of other internal forces, electrons flow undistorted, as illustrated at the top. The current flow is of uniform density, assuming only that the material is homogeneous.

When a magnetic field is applied, Lorentz forces cause electrons to try to follow a curved path (middle). This curving of the current path causes a buildup of negative charges on the right side of the material.

However, balance is restored when electrons pile up on one side of the material, and holes, or positive charges, gather on the other. This charge buildup continues until the voltage across the material exactly balances the force exerted by the magnetic field. Then the electron flow is exactly as it was in the undistrubed material, except that a Hall voltage is present at right angles to the initial current.

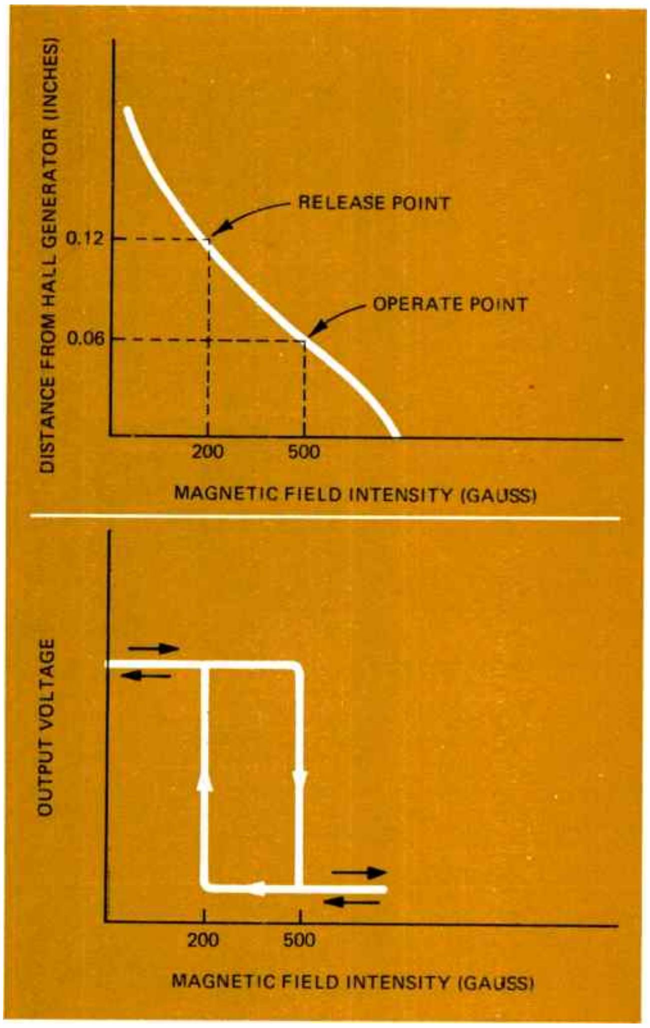
Hall generators are made almost exclusively with semiconductor materials. Their high resistance results in Hall voltages that are on the order of millivolts, or even volts. Conductors, while they do exhibit the Hall effect, put out voltages that are no higher than a few nanovolts.





2. Beating the bounce. Trace (left) from Hall-effect IC provides clean switched pulse; reed relay's (right) has unstable transition due to contact bounce. Furthermore, since it's a mechanical switch, reed relay has shorter lifetime than all-electronic Hall-effect unit.

3. Stable switch. Schmitt trigger provides hysteresis for Hall-effect switch in Fig. 1. Although output switches from 1 to 0 when field through Hall generator reaches 500 G, it won't switch back until field drops to 200 G. Other ICs can be made with different trigger points.



mains off when the trigger is off, conserving power. Transistors Q_4 and Q_5 provide further gain when the amplifier is activated.

The final section makes the circuit's output compatible with most standard logics families. Output transistor Q_6 sinks 20 milliamperes with a drop of less than 0.4 V. Resistor R_9 can be connected between a voltage supply and Q_6's collector, so that the output level can drive logic circuits directly. To drive DTL or TTL circuits, the resistor is connected to a 5-V supply; for MOS circuits, a 15-V supply is used.

The value of the hysteresis action provided by the Schmitt trigger can be seen from Fig. 2. On the left is an oscilloscope trace of the IC's response. Note the smooth transition when compared with the same voltage being switched by a reed relay (right).

The clean switching waveform assured by the hysteresis characteristic is essential in applications such as keyboards. Because the circuit won't switch until the magnetic field intensity reaches a certain value (see "Hall and his effect," p. 47), a key must be fully depressed bringing the magnet close enough to the IC to turn on the switch. Then the key must be fully released to turn the circuit off.

The process by which a small permanent magnet activates the Hall-effect switch is illustrated in Fig. 3. The distances on the top graph are for a bar magnet, ¼-in. in diameter and 1 in. long.

A typical Alnico magnet of this size produces a magnetic field intensity of 1,000 gauss, far more than is required to operate the device. As the magnet approaches the IC, magnetic flux through the chip increases until it reaches 500 G. At that point, the circuit turns on (the output drops to the 0 level) and remains on until the magnet is withdrawn far enough to reduce flux density in the IC to 200 G. At this value the output stage returns to its off level. To actuate the circuit again, the magnet must be moved close enough so that flux density once again exceeds 500 G.

The magnetic-field intensity values of 500 and 200 G

Other Hall makers

Sprague researchers aren't alone in building Hall generators. At both Ohio State and Southern Methodist Universities, for example, scientists are combining the Hall effect with MOS field effect transistors. When a pair of leads is fabricated on either side of a MOSFET's channel, it becomes a Hall generator: a magnetic field and a current in the channel combine to produce a Hall voltage across the leads.

Ohio State's efforts are directed exclusively toward building and evaluating Hall-effect MOSFETs, says A.E. Middleton, director of the school's electronics materials laboratory. Although the first transistors will be made of silicon, Middleton's goal is a gallium arsenide unit. The higher mobility of GaAs, he points out, will make for a very sensitive Hall generator.

SMU researchers already have fabricated single transistors, which they call Magfets [*Electronics*, June 21, p. 33]. The next step, says William Carr, professor of electrical engineering, is monolithic arrays.

Carr already has picked out the first application for Magfets: he wants to design them into the tiny biomedical transducers that are placed inside the body to transmit physiological data, such as the pH of stomach juices or body temperature. Magfets would allow these transducers to be turned on, adjusted, or otherwise controlled from outside the body with a magnetic field.

Taking yet another tack is Semitronics Inc. of Columbus, Ohio. Active in materials research, the company does a lot of custom designing of Hall generators, particularly for high-temperature work. Semitronics routinely makes units that work at over 100 C; according to president Warren Bulman, the firm is investigating materials that would push that figure to 300 C.

But success in the Hall generator business doesn't necessarily require new materials or fabrication techniques. Business is booming at Scientific Columbus, says director of sales Wayne Traetow, because designers added an operational amplifier to the output of a Hall-effect probe for measuring power. The result is a probe whose output current is almost completely independent of load conditions. This is important, says Traetow, to power companies that are increasingly turning to computer control [*Electronics*, July 5, p. 79]. The constant-current probe drives any control system without the need for interface circuitry.

The largest producer of Hall generators is F.W. Bell Inc., also in Columbus. Although it's not doing any work in the monolithic area, Bell plans to announce a small Hall-effect circuit of its own. A beam-lead hybrid unit, the new circuit is contained on a 400-by-500-mil substrate. It has a thin film Hall generator connected through a resistive network to a monolithic amplifier. Bell will offer the circuit as either a switch or an analog device. On a design basis, the only difference between the two is an extra feedback loop in the analog version. **—Owen Doyle**

were chosen because 500 G can be provided easily by small permanent magnets, and because 200 G is much larger than stray magnetic fields usually generated by electrical circuits. Most inductors produce less than 30 G, and even transformers are unlikely to produce field intensities of more than 100 G. By adjusting trigger and amplifier design, ICs can be made with almost any desired magnetic sensitivity. The lowest sensitivity so far is 0.5 G; theoretically, there's no upper limit.

Hall-effect ICs, all very similar to the basic switch, are available now. One device supplies two outputs, each from a separate emitter follower. Another provides magnetic latching by sensing a change in magnetic field from north pole to south pole, rather than a change in magnetic field intensity; this one also can be supplied with two emitter-follower outputs. Another switch puts out a single 40-microsecond pulse, instead of a dc signal pulse, when activated.

Some of the most interesting applications for Hall-effect ICs are in tape recorders and disk memories. Hall generators in general have not enjoyed much success in these areas because inductance in the leads going from the Hall device in the playback head to the amplifier or trigger limits overall bandwidth. However, this won't be a problem with monolithic circuits—with short leads inductance will be much lower.

When playing back digital information, Hall generators theoretically can read a tape or disk that isn't moving. This is because the Hall voltage depends on the magnitude of a magnetic field, and not on the change in magnitude. Thus, tape speed would be far less critical with a Hall-effect head.

Hall ICs also can be built to have linear outputs for analog tapes. This could be done just by replacing the Schmitt trigger with a differential amplifier.

Hall-effect pickups have a higher inherent bandwidth than conventional playback heads. Theoretically, they can operate from dc to somewhere in the gigahertz region. The limiting factor is building monolithic amplifiers with matching bandwidth. Nevertheless, Hall-effect pickups capable of covering the audio range probably will be available within a year; they'll be able to give full-range record and playback capabilities instantly without the degradation that occurs while the tape drive reaches operating speed. The goal after that is pickups for video recorders.

Other potential uses for Hall-effect ICs are as angular position and velocity sensors, such as shaft-angle encoders and tachometers. One specific application for Hall-effect ICs is as wheel-speed sensors in antiskid braking systems. Wheel speed could be determined by placing a fixed magnet around the circumference of a notched wheel and then counting the interruptions in the flux path to a Hall-effect IC in a given time.

Since Hall generators are multipliers, linear Hall-effect ICs should find use in portable wattmeters.

The possibilities for new types of circuits are encouraging. For example, adding a flip-flop could permit latching of the output. This type of IC would be particularly useful in sensing overload conditions, and shutting down a system and keeping it that way until reset. A coil put in series with a load to be monitored would produce a magnetic field, activating a trigger that would shut down the system in the event of an overload. Moreover, adding a timing circuit would allow an overload condition to exist for a predetermined time. □

EE union: which side are you on?

Here's your chance to review the issues and vote on whether or not engineers should form a national organization

☐ Never before have electronic engineers taken such intense interest in unions and associations. But then never before have layoffs, inflation, and the apparent start of an era of lean engineering staffs, made job security such a burning issue among EEs.

Will a national union or association provide job security, portable pensions, seniority, retraining, and placement? The answer to this question has suddenly become controversial, more so than any technical debate of recent times.

Even the word "union" tends to make management-level engineers wince. Yet EEs, whether at the bench or pounding the streets for a job, are saying, "Why not?" Panacea or Pandora's box, the issue has created clearcut divisions. There is even dissension among unionists as to how engineers should organize—should it be along tradeworker lines or as an association? The trade group says that an association won't organize its members on a uniform, national scale and so will be ineffectual. Association spokesmen retort that a blue-collar type organization will never be able to attract significant numbers of engineers.

Because this issue has become a hot one, the pros and cons for a national organization are presented here in the way two debaters would present their cases. Neither side allows much middle ground on this subject.

Here are the arguments and a questionnaire that will enable you to choose between them and also comment on the impact a national organization would have on the EE's career.

Simply check your selections on the ballot, clip out, and mail, no later than Aug. 16, 1971, to

Editor, Code U,
Electronics
330 W. 42nd Street
New York, N. Y. 10036

Please feel free to amplify on your position with additional comments.

Results of this questionnaire will be reported in *Electronics* soon after the August 16 deadline. So, in the words of an old union organization song,

"Which side are you on?"

THE PRO-UNION ARGUMENT

The recent spate of layoffs throughout the electronics industry has taught everyone a lesson—it's time to organize in order to prevent rampant disregard of the engineer's livelihood and to insure that those out of work will not be cast adrift indefinitely.

To reach this goal, engineers need a strong national union geared to protecting their interests. An organization of this nature would offer tangible benefits financially and professionally to all engineers, whether the business barometer reads fair or foul.

Specifically, the engineer who joins the proposed national union gains:

- Guaranteed job security negotiated by his bargaining representatives and backed up by the combined weight of all members.
- A portable pension plan, recognized by every employer, which provides an income beyond Social Security after retirement.
- Career planning made easier by the national union's placement program.
- Immunity from arbitrary or precipitous layoffs when a company loses a big contract or the Government cuts back funding. Severance pay or notice of separation would be guaranteed.
- Continuous education organized for the EE's benefit and sponsored by union dues. A national union would have a stake in keeping its members employed, since an out-of-work engineer is not a very active union participant.
- Lobbying activity in Washington to get job security legislation for engineers and Government funds for retraining educationally obsolete EEs. Engineers are one of the few large groups of Americans who do not have an active voice in Washington promoting their interests. With a union, it can be done.
- Potential for a truly effective dual design-or-management promotion ladder, so that an engineer does not have to cross over from solving technical problems to managing personnel simply to increase his salary.

The days of the rugged individualist engineer are over, as many EEs now out of work have found. Throughout the sixties, each engineer who got fed up with a job in a sense organized his own one-man strike—he went to a headhunter and asked for another position at 10% better pay. It was simple, but he left behind the job condition that caused him to move, and didn't attempt to change it. Another EE filled that position and repeated the same cycle. Now all of this job hopping has come home to roost on the older engineers—no security, no pension, no job, no prospects.

The answer is clearly to organize a national union to put muscle behind the engineer's brain.

THE ANTI-UNION ARGUMENT

Engineers are first and always professionals. That BEE or equivalent degree sets him apart from nonprofessional employees in outlook, career interests, and educational demands. The degree also sets the EE apart in the employment problems he needs to solve. Whatever else they are, engineers are not Molly Maguires.

Not only are they uncomfortable in any union organization, but there are good, practical reasons not to put together a national group made up of small locals each dealing with a different company.

Specifically, engineers should avoid a national union because it would:

- Discourage individualism. Unions are all for all, not all for one, because it's the only way to make these organizations work. The individual member has to modify his personal interests for the good of the whole.
- Limit career flexibility. Instead of mapping his own future as any professional would do, the engineer turns over important job negotiation to others. This typecasts the individual who might be able to spot more opportunities if he dealt directly with his employers.

Cut off the management ladder. It will be a rare company indeed that's going to promote a union member into the management structure if it is possible to avoid doing so by hiring somebody else. There is also a subtle gulf between the union EE trying to work with a nonunion engineering department manager.

- Force counterproductive action. A union's main weapon against recalcitrant management is the strike. Engineers are not ready to go on strike nationally. And what about honoring the picket lines of blue-collar unions which may be on strike for other issues? And will the other unions be ready to do the same for the professional engineers? While mulling over these superfluous questions, the EE's real interest— solving a problem, designing a product—is going down the drain at a crippled company.
- Work no better than before. The national engineering union proposal is not new. The most telling argument against such an organization is that previous attempts were unsuccessful. In addition, how good were the local, one-company engineering unions in keeping the rank and file happy during the current layoffs? No one's going to hop on a dead horse at this stage of the game.

The only reason that union organization is an issue now is that engineers are being hurt economically. But to conclude that lack of a union caused the problem is a delusion. The real source of all the trouble was that engineers were not professional enough.

Where do you stand?

Use this ballot to record how you feel about the controversial issues surrounding organization of a national engineers' union or association. After you have completed your entry, mail it to the address above. If you need more space for comments, attach an additional sheet. You may sign the ballot or not, as you please, since all quotes will be kept strictly anonymous.

The deadline for this ballot is August 16, 1971.

☐ 1. I *favor* organization of a national trade union of engineers.

Reasons ____________________

____

____

____

Go to question 4

☐ 2. I *favor* organization of a new, professional association for engineers similar to the American Medical Association

Reasons ____________________

____

____

____

Go to question 5

☐ 3. I am *against* formation of a trade union or association.

Reasons ____________________

____

____

____

Complete information on your job below.

4. If organized, a trade union should: (number items 1 to 6 in order of importance)

☐ (a) Negotiate wages and employee benefits.

☐ (b) Set minimum and maximum salary brackets based on job categories and seniority.

☐ (c) Insure seniority and job tenure.

☐ (d) Promote a portable pension plan.

☐ (e) Establish continuous education programs sponsored by union dues.

☐ (f) Set up formal grievance procedures for EEs dissatisfied with a management decision.

5. Instead of belonging to a union, engineers should organize a new professional association like the AMA to: (number items 1-8 in order of importance)

☐ (a) Permit negotiation of individual contracts with employers on a project basis or annually.

☐ (b) Require national licensing of practicing engineers.

☐ (c) Require that all design drawings be signed by the licensed engineer responsible for their creation.

☐ (d) Establish apprenticeship or internship periods for beginning engineers before they are licensed.

☐ (e) Set up quotas on the number of engineers that can be licensed in a given year.

☐ (f) Work with universities to establish education standards and quotas for engineers.

☐ (g) Sponsor a national advertising campaign to inform the public of the challenges of engineering and its contributions to society.

☐ (h) Lobby in Washington for engineering job benefits.

6. The IEEE should take the lead in organizing an engineers' association. Yes ____ No ____

Comments ____________________

____

____

____

Title and function ____________________

Highest degree ____________ Age ________

Total years of engineering ____________________

Your company's (or division's) main products ____________

____

City ____________ State ________

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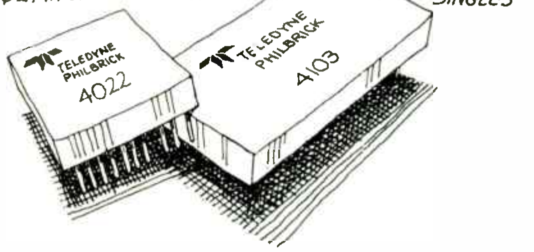

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Programs in Getel speak test engineer's language

English-based language and translator can be applied to automatic test equipment, making it easy for engineers and technicians to write in new routines and check out program parameters

by Gene Kierce, *General Electric Co., Schenectady, N.Y.*

☐ Because each computer-controlled test system must be addressed in its own language, only the operators have had the opportunity to become fluent in those languages. As a result, many engineers with product quality responsibilities have not been able to easily check what parameters actually were being measured. Such difficulties have even spread to the equipment troubleshooters, who had to figure out what the test equipment was testing before they could even begin the task of finding out what was wrong with the equipment under test.

To solve such problems, test equipment engineers from 15 different departments at General Electric Co. joined forces to develop a single language and a translator that applies it to any piece of automatic test gear. An added bonus is that the language, Getel (for general test engineer language, pronounced jee-tell), is based on English, so that an operator needs little formal training and almost anyone else can understand what's actually being tested.

Experience with the language has shown that technicians and engineers can learn to read and understand a Getel program in anywhere from a few minutes to a couple of hours and can be programing proficiently in less than a week. The use of English also allows even a typist to correct many spelling and programing errors, and troubleshooters can use the source listing as a checkout routine.

Getel is now in wide use in many General Electric plants, furnishing inputs to a wide range of systems such as the GE-MAC tester controlled by a GE-PAC 30 controller, the Hewlett-Packard rf tester, the tape-driven Systomation Fixit tester for checking wiring, and the tape-driven Texas Instruments TI553 integrated-circuit tester.

Mini-translator. Although English is the most convenient language for an operator, it is difficult to translate into a useful format for controlling machines. Originally, the plan was to develop a large central software translator to process Getel. The translator was to produce an intermediate language that could be processed by a smaller machine, which in turn would control a specific instrument. However, the language and the translator became larger and larger as the development went on, so that only the largest computers could be used to process the translation program. Although this software translator has actually been designed (and named Mark III), it is not actually in use. Rather, a smaller translator, the Mark I, is in regular use, since it can fit into a minicomputer with an 8,192-word memory.

The Mark I can translate from Getel into any language that the user desires. In the case of the GE-PAC 30-GE-MAC test system, the Getel compiler translates test statements directly into GE-PAC 30 assembly code.

A medium-size translator, the Mark II, has also been developed. It can fit into a 16,384-word machine, and is mounted in a computer, but has not yet been used at GE because the Mark I has been able to serve all the users' needs to this time.

Filling the blanks. The Mark I's translation from Getel into a tester's language is performed with a template-type approach. The Getel statement is considered to have a fixed portion that corresponds directly with a statement in the translated language, and a variable portion, which contains the specific numbers relating to the test at hand. For example in the statement

```
100 SET 'L1' TO 50 OHMS
```

the value for the load, 50, is a variable. The remainder of the statement is fixed and thus, if the variable part is deleted, the statement appears with a hole in this place (denoted by an asterisk) and thus can be considered to be a template.

```
100 SET 'L1' TO * OHMS
```

Such templates are part of the automatic test equipment (ATE) conversion table, which is composed by a test engineer for each particular automatic test system. The ATE table thus relates Getel to a particular test system, requiring only the specific numbers to fill the holes and thus complete an instruction to the automatic test system in its own language. For example, the corresponding statement in GE-PAC 30 assembly code for the above term, as might be required for the GE-MAC test systems would be

```
        LHI RE,2
        BAL RF, MONITR
        B* +8
        DC A(Z99999)
        *
        *     *
Z99999 DC 50
```

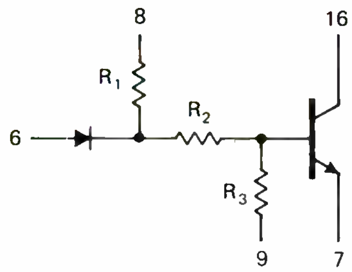
The statement in Getel is called a source statement and the translated form is called the object statement. Once the templates have been created for the ATE conversion table, any engineer can write programs in Getel without concerning himself with the details of the particular automatic test equipment that will perform the tests. However, note that not all Getel statements will have holes—many will be control-type statements that have direct counterparts in the object language that controls the tester.

Getel is based on a logical assignment of tasks to man and the computer, taking advantage of the capabilities of each. The early steps of carrying out a test program either are creative or require decision-making ability that is best performed by a man, while the later steps are best assigned to the computer, since it can store and retrieve data without error. To demonstrate the assignment of tasks, here are the typical steps in the process of performing a test.

After getting together all the necessary prints, schematics, and specifications the test operator must establish parametric requirements for the unit to be tested. This is best done by a man at present, since he can evaluate the circuit performance and thus set limits on the various parameters to be tested. However, some design automation programs are closing the gap since they can be designed with a capability to analyze the circuit and relate certain internal parameters to input-output requirements.

Next, the operator must determine the best test sequence, taking into account the likelihood of failure for each test and the relative importance of each test in meeting the specifications. The next step is to determine what actions must be taken based on the results of the test.

1. Easy reading. Test routine for simple inverter circuit is written as instructions for manual test (left column), and also in programing languages for four different testers. Getel program for same test is at right. Note close correspondence between Getel terminology and instructions for manual test that would be performed by a technician at the test bench.



CIRCUIT INPUT REQUIREMENTS:

+12 volts dc on pin 8
−12 volts dc on pin 9
Ground on pin 7
Logical 1: +6.1 volts dc } pin 6
Logical 0: +0.0 volts dc } pin 6

CIRCUIT OUTPUT REQUIREMENTS:

Unloaded output, pin 16
Logical 0, or 'down level'
High limit: +0.5 volts dc } 12 ma.
Low limit: +0.0 volts dc } 12 ma.
Logical 1, or 'up level'
High limit: +12.0 volts dc } 0 ma.
Low limit: +11.3 volts dc } 0 ma.

MANUAL TEST INSTRUCTION

1.0 Test 1

Apply 12 volts dc to pin 8 reference to pin 7.

Apply −12 volts dc to pin 9 reference to pin 7.

Apply 12 ma dc to pin 16 reference to pin 7.

Apply 6.1 volts dc to pin 6 reference to pin 7.

Measure output dc voltage on pin 16 reference to pin 7.

Compare output dc voltage against high limit −0.5 volts dc —and low limit—0 volts dc.

Record the value if it fails.

A

01 @TEST NO. 01@
02 FB +12.00, TB08
03 FC −12.00, TB09
04 TG07
05 FE +012.0, TE16
06 FD +06.10, TD06
07 MV16/H +0.5v/L +0.0v
08 PFC

B

TID001
BV11200
BC1PL2
W1001
BV21200
BC2NL2
W1102
W0911
BIX03M1200
BVX03M1200
BV30610
BC3PL2
W0703
W201403
MTRSVPOR
MAXP0050P0
MINP0000P0
RIU4

C

980000040001
010120850800
021120850800
034120807800
040610704800
100000047120
110000030000
221600000000
214000070000
202050000000

D

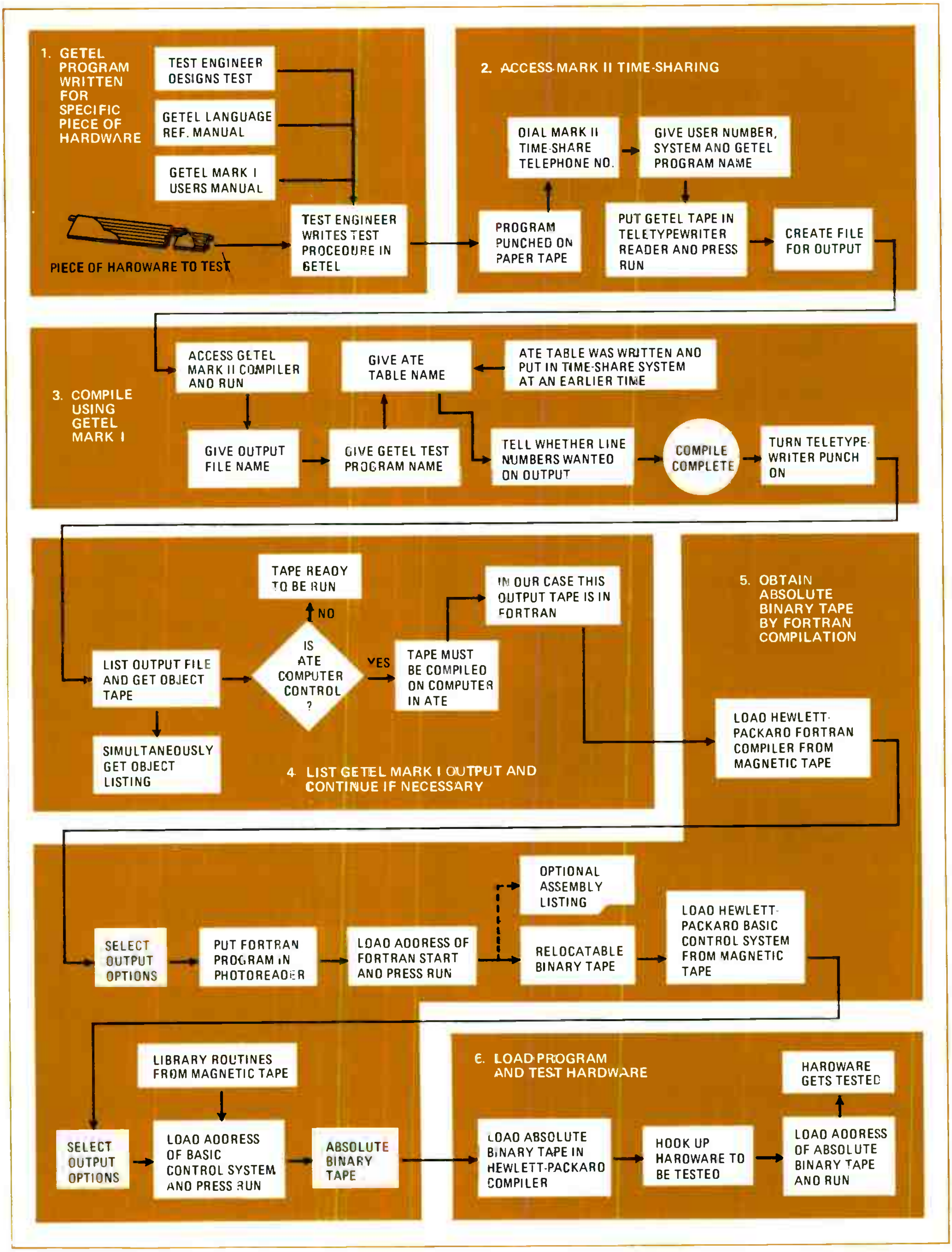
04
10
20
31
08
20
88
39
20
89
39
20
87
39
24
81
34
21
96
31
24
85
33
20
96
33

GETEL

100 Test 1
110 Apply 12.0 VDC to 'pin 8'
120 Apply −12.0 VDC to 'pin 9'
130 Apply 12.0 MADC to 'pin 16'
140 Measure 'DC voltage', 10±.1%
150 VDC at 'pin 16'
160 Record 'result'
170 Compare 'result' to '0.5, '0.0' goto 'HIGHM', 'LOWM'
180 Perform Test 2
190 HIGH; MESSAGE TEST1 FAILED HI
200 LOWM; MESSAGE TEST1 FAILED LO

A: AAI Model 1000 IC tester; B: TI 553 IC tester; C: Fairchild Model 5000; D: GE-PAC 200 controller

2. Test run. At GE, test engineers use the Mark II time-sharing system to prepare Getel programs. After accessing the system, Getel is compiled with the Mark I translator program (Getel MI). In this example, Getel is translated to Fortran for use on the Hewlett-Packard rf tester. The output of the system is a tape to be inserted in the tester to control the actual test.



Likewise, the operator is best able to decide how much data is enough and how best to control the operator displays. He also can explore other possible ways of performing the test, if he decides that the test station cannot do it.

However, after this, the computer can take over. The computer can be instructed about what equipment is available and what its capabilities are. From this instrument pool, the computer can choose the instruments, since it can even keep track of which instruments are in use on other tests and which instruments are available for this test.

The computer can then translate the instructions into machine code to operate the instruments, using look-up tables. This is one step that a man performs poorly—it is an unthinking task and errors often creep in. Also, the translation of these machine codes back into English to see if any errors have been introduced is unnecessary with the computer. The machine can also optimize test time by checking the machine code for duplications. Thus, with Getel, the user can describe the parameter to be tested and the computer will select the instrument for the job.

Test instrumentation falls into three categories: sources (power supplies, signal generators); sensors (digital voltmeters, electronic counters); and loads (resistors, capacitors, inductors). To control such instruments, the operator uses as statements simple imperative sentences containing verbs that are commonly used by test engineers. Prefixes, suffixes, and units abbreviations for Getel are taken from IEEE standards and Government documents.

The user also can define synonyms and insert standard routines into the body of the program to compose new complex test functions based on groups of simple test functions.

As an example of how Getel differs from languages used in the automatic testers, consider a typical inverter circuit that is common enough to be tested practically on any of several types of automatic testers. The test will be programed in each of several languages and also in Getel. (The actual meaning of each command in the languages is not really important for this discussion—the example is presented only to illustrate complexities.)

Testing. To test the inverter, appropriate supply voltages must be applied along with a certain signal level to the input. Then the output must be measured and compared with the design value, and the output must be recorded if the inverter fails the test.

The circuit is shown in Fig. 1, along with a set of test instructions written for interpretation by a technician actually doing manual testing. The instructions in the column for tester A—AAI Corp.'s model 1000, a popular integrated circuit tester—are almost self-evident. This tester uses a pseudo-variable-field technical programing language, in which the alphabetic terms are used: FB means fix bias supply B, and TB means tie (connect) bias supply B, but still an engineer might find it difficult to interpret the instructions with certainty unless he actually knew the language.

Tester B, TI's 553, also uses some alphabetic characters, but Tester C, Fairchild's model 5000, uses numeric code only, as does Tester D, the GE-PAC 200 controller. In many cases, single instructions for the manual test must be expanded into several subinstructions for the automatic tester.

In Getel, there is little difference between the instructions for manual test and the instructions for automatic testing. Only line numbers have been added and all labels have been apostrophized.

Most users at General Electric access Getel through GE's Mark II time-sharing system (the Mark II in this case bears no relationship to the presently unused Mark II translator for Getel; the redundancy occurred because of the assignment of the name Mark III to the large translator, and this term propagated through later versions of Getel translators).

Step by step. Before the test engineer signs onto the Mark II system, he familiarizes himself with the unit to be tested and designs the test. He then converts the test instructions to a Getel program. The Getel program then is punched on paper tape in ASCII (American Standard Code for Information Interchange), and then the engineer dials the GE Mark II system on a telephone hooked up to a teletypewriter, as shown in the diagram in Fig. 2.

Upon request from the time-sharing system, he gives his user number to identify himself as a qualified user, and the system then queries him on which of the two available languages—Basic or Fortran—he wants to use. Since the Mark I translator is written in Fortran, he responds with that selection. He then gives a name to his Getel program and enters the paper tape into the teletypewriter reader for insertion in the time-sharing memory. He then creates a file in the time-sharing system in which the translated program (the object program) will be stored.

After telling the system that he wishes to use the Getel Mark I program, he goes through some bookkeeping steps with the teletypewriter, loads in the proper ATE conversion table, and the system then delivers a punched tape of the object program for use on the automatic test system that he intends to use. This tape can then either be processed further on the test system's computer or the test can be run directly from the tape, depending on the tester in use. □

Anyone can use Getel

Getel is available to users outside General Electric. It has been put on GE's Network Service, a time-sharing service centered in Cleveland. Remote concentrators in Los Angeles, Kansas City, Atlanta, Teaneck, N.J., Schenectady, N.Y., and Washington, D.C., link the central computer complex—which comprises a GE-635 central processor, a GE-4020 communications processor, and a disk file complex—to remote buffer units in major metropolitan cities. Customers can gain access to the system with a local phone call. Overseas, the network can be used in such cities as Amersfoort, Brussels, London, Manchester, Birmingham, and Paris. In the western hemisphere, outside the continental United States, the network can be dialed from remote units in such cities as Mexico City, San Juan, Montreal, Toronto, Vancouver, and Anchorage.

GETEL VOCABULARY

OPERATIONS

APPLY
CALCULATE
CLEAR
COMPARE
COMPLETED
CONNECT
CONTINUE
DEFINE
DELAY
DISCONNECT
END
EXECUTE
EXTERNAL
GOTO
IF GOTO
IF PERFORM
INSERT
LET
MEASURE
NOTE
PAUSE
PERFORM
PROCEDURE
READ
RECORD
RESERVE
RESET
ROUTINE
ROUTINE END
SELECT
SENSE
SHARE
TEST
TITLE
TURNOFF
TURNON
USE

LOGIC SIGNAL

ZERO MAG
ONE MAG
RT
FT
NOISE
FREQ
SKEW TIME

SQUARE WAVE

BW
IMP
PHASE-JITTER
RT
FT
TIME ASYM
OVERSHOOT
UNDERSHOOT
PRESHOOT
DROOP
RINGING
ROUNDING
DC-OFFSET

MULTIPLIERS

P	(10^{-12})
N	(10^{-9})
U	(10^{-6})
M	(10^{-3})
K	(10^{3})
MEG	(10^{6})
G	(10^{9})

TIME INTERVAL

TIME
SEC
MIN
HR
START
STOP
TRIG
FIRST POS SLOPE
FIRST NEG SLOPE
CHANNEL A

TRIANGULAR WAVE

FREQ
BW
IMP
PHASE-JITTER
NONLIN
TIME ASYM
PEAK-DEGEN
DC-OFFSET

UNITS

AAC
AMP AC
AMPS AC
ADC
AMP DC
AMPS DC
VAC
VOLT AC
VOLTS AC
VDC
VOLT DC
VOLTS DC
WATT
WATTS
A/SEC
AMP/SEC
AMPS/SEC
DB
DEG
DEG-C
DEG-F
DEG-K
DEG-R
FD
HY
HZ
HERTZ
HR
OHM
PCT
PPS
RAD
REV
SEC
S-PARAMETERS
V/HZ

AM SIGNAL

MODUL-AMPTD
CARR-AMPTD
CARR-FREQ
HARMONICS
NONHARMONICS
NOISE
PHASE-JITTER

DC SIGNAL

POWER
CUR-LIM
VOLT-LIM
IMP
RIPPLE
RIPPLE-FREQ
NOISE
DISTORTION
CUR MONITOR
VOLT MONITOR

FM SIGNAL

FM-INDEX
CARR-FREQ
MODUL-FREQ
HARMONIC DIST
NONHARMONIC DIST
AMPTD-MODUL
MODUL-DIST
NOISE

SUFFIXES

-TRMS (true rms)
-AU (average)
-PP (peak-to-peak)
-P (peak)

Designer's casebook

Light-emitting diode pair forms null indicator

by Michael H. Loughnane
Temple University, School of Medicine, Philadelphia, Pa.

Visual indication of a null voltage to ±0.2 millivolt can easily be accomplished by using light-emitting diodes in the feedback loop of an operational amplifier. When both LEDs are dark, the input voltage is approximately 0, indicating a null.

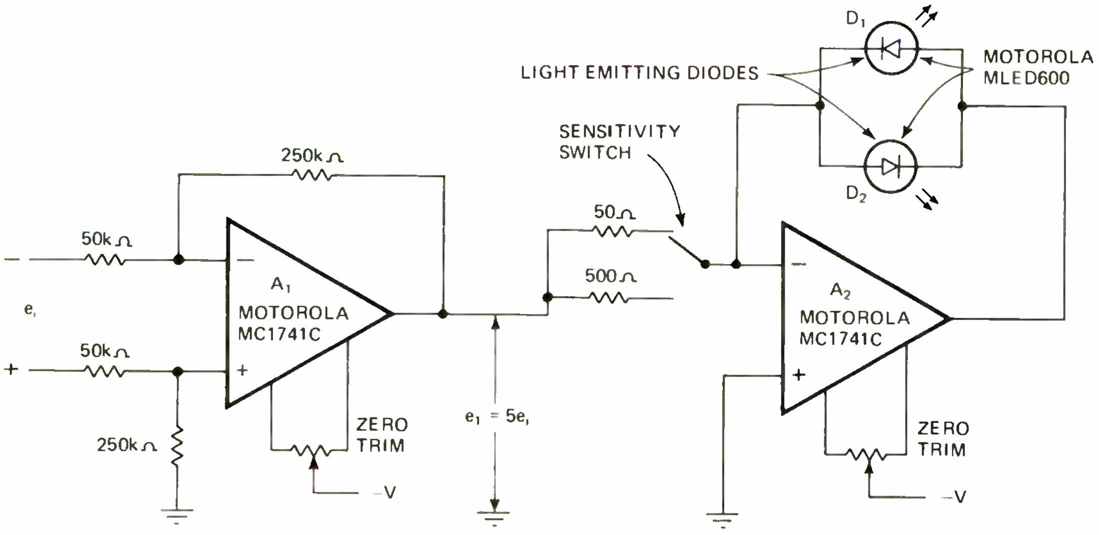
Differential amplifier A_1 provides a single-ended, low-impedance output for driving A_2, which functions as a zero-crossing detector. When A_2's output is between ±1.4 V (the forward-voltage drop of the LEDs), the amplifier operates with essentially open-loop gain.

With a negative input voltage (e_1 less than 0 V) applied to A_2, only diode D_1 conducts (lights); with a positive input (e_1 greater than 0 V), only D_2 will light. As e_1 approaches 0 V (null), the current through the conducting diode decreases and both LEDs appear dark, even though one is really in a clamped state.

Both brightness and width of the null band are controlled by the sensitivity switch. When 500 ohms is selected, the input voltage can be nulled with a repeatability of about ±2 mV in ambient light. Switching to 50 ohms improves repeatability to ±0.2 mV. Even better sensitivity can be achieved if the LEDs are shielded from ambient light.

Total parts cost is approximately $10. The trimmers allow amplifier offset voltage to be zeroed out.

LED null indicator. Two-amplifier circuit uses light-emitting diodes to pinpoint null voltages within ±0.2 mV under normal lighting conditions. Amplifier A_1 supplies proper driving signal for zero-crossing detector A_2. For negative inputs to A_2, D_1 lights; for positive inputs, D_2 lights. When a null is reached both LEDs are dark. Measurement sensitivity depends on position of switch at input of A_2.



VISUAL INDICATION

	e_1 0V	e_1 0V	e_1 0V
D_1	●	●	●
D_2	●	●	●

NULL SENSITIVITY

SWITCH RESISTANCE	NULL ACCURACY
50 OHMS	± 0.2 mV
500 OHMS	± 2 mV

Widerange multivibrator costs just 25¢ to build

by Michael Faiman
University of Illinois, Urbana, Ill.

A simple astable multivibrator can be made from one-half an inexpensive integrated circuit, a load resistor, and a single timing capacitor—bringing total parts cost to about 25 cents. The circuit (a) never fails to start and can generate frequencies from under 1 hertz to over several megahertz. Its on-to-off-time ratio is almost unity and is unaffected by the value of the capacitor.

The multivibrator employs a TTL hex inverter with open-collector outputs (a type 7405, for example). To understand circuit operation, look inside the integrated circuit: (b) shows Q_1 as the output transistor of inverter I_1 and Q_2 as the input transistor of inverter I_2.

Suppose that node b is low so that node c is high. Q_1 is in saturation, and node a is clamped at V_{SAT} (about 0.2 volt). The voltage at node b rises exponentially towards $V_{cc} - V_{BE}$ with the time constant R_1C. When node b reaches the threshold voltage (V_T, about 1.4 v) required to switch Q_2, node c goes low, turning off Q_1.

Current through R_2, which was flowing into Q_1 via the emitter of Q_3, can now pass only into the base of Q_4 and the left side of capacitor C. Transistors Q_4 and Q_5 turn on, causing the voltage at node a to jump to V_T. This voltage step is transmitted through the capacitor to node b, which rises to the potential $2V_T - V_{SAT}$.

Transistors Q_3, Q_4, and Q_5 now behave like an operational amplifier. Although Q_4 and Q_5 are on, they are not saturated. Aside from a small base current into Q_4, most of the current through R_2 flows into C and Q_5 via the emitter of Q_3.

If this current increases, the voltage at node a drops, reducing the base drive at Q_4, which tends to turn off both Q_4 and Q_5. Since less current can pass from C into Q_5, the voltage at node a goes up. A similar process occurs if the voltage at node a rises, since it is clamped at V_T by negative feedback through capacitor C.

The capacitor receives a constant current from R_2, which causes the voltage at node b to fall linearly. When it reaches V_T, Q_2 switches back to its former state, node c goes high, and Q_1 saturates. Also, the voltage at nodes a and b snaps back down to V_{SAT}, and the cycle is complete. The node waveforms are shown in (c).

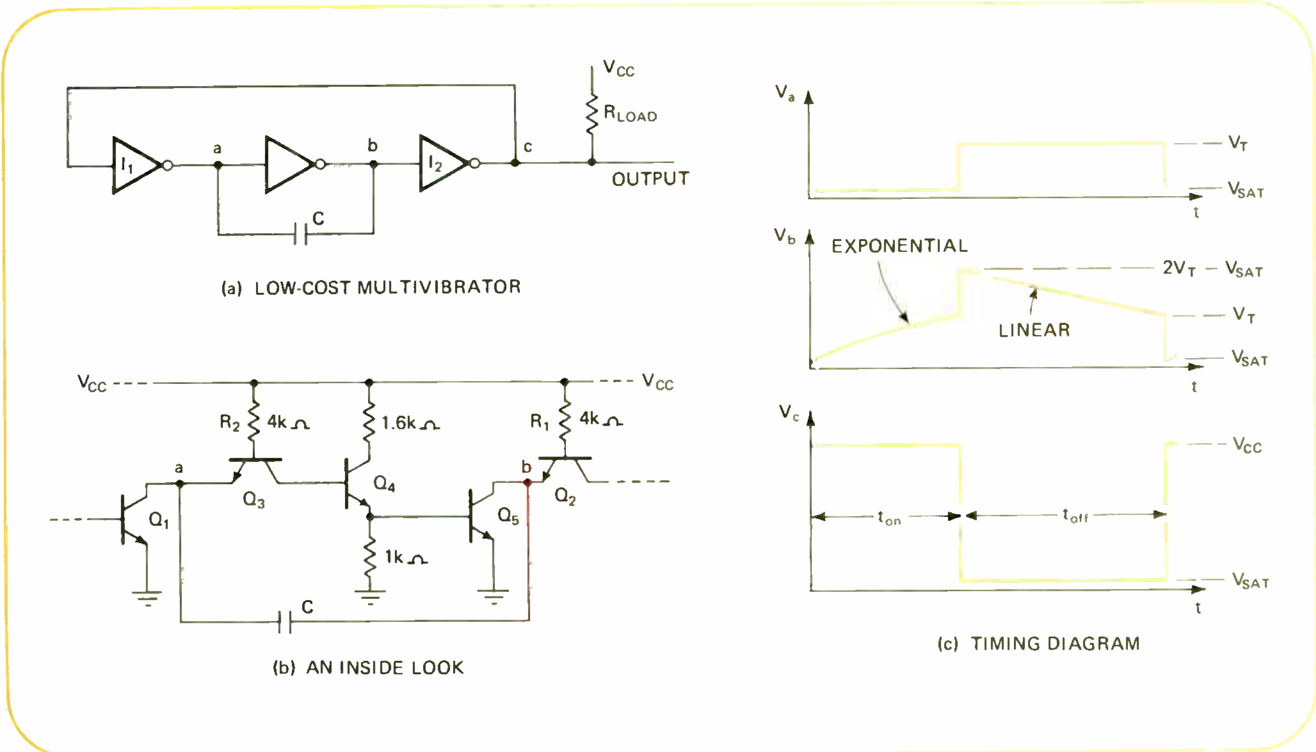
Circuit on time (t_{on}) and off time (t_{off}) are easily obtained by neglecting the switching times of the individual transistors and Q_4's base current when it is on:

$$t_{on} = R_1C \ln [(V_{cc}-V_{BE}-V_{SAT})/(V_{cc}-V_{BE}-V_T)]$$
$$t_{off} = R_2C(V_T-V_{SAT})/(V_{cc}-V_{BE}-V_T)$$

Nominal circuit values of $R_1 = R_2$, $V_{cc} = 5$ v, $V_{BE} = 0.8$ v, $V_{SAT} = 0.2$ v, and $V_T = 1.4$ v yield an on-to-off-time ratio of t_{on} st_{off} approximately equals 0.83 or 5/6.

If equal on and off times are needed, t_{off} may be reduced, without affecting t_{on}, by connecting a suitable resistor (about 26 kilohms when $R_1 = R_2 = 4$ kilohms) between node a and V_{cc}. Capacitor values range from 300 microfarads to 300 picofarads for output frequencies from 1 Hz to 1 MHz.

Inexpensive multi. Three inverters, a resistor, and a capacitor make up this 25-cent multivibrator. With Q_1 saturated, node b is low and node c is high. Voltage at b then increases exponentially until Q_2 switches, so that node c goes low and Q_1 turns off. R_2 then delivers constant current to capacitor C, making voltage at b decrease linearly until Q_2 switches again. Node c is now high and Q_1 saturated.



IC frequency doubler runs at logic speed

by C.H. Doeller III and Aaron Mall
Bendix Corp., Baltimore, Md.

Two integrated circuits can serve as a digital frequency doubler that can perform at the operating frequency of the logic used. The frequency range of conventional doublers usually is limited to about one decade because they use discrete resistors and capacitors. But the circuit shown successfully operates at frequencies as high as 10 megahertz over a temperature range of −55°C to +125°C.

When the input signal is at ground potential, the outputs of NAND gates G_1 and G_2 are positive, and the output of NOR gate G_3 is grounded. If the input signal transition is positive, the output of G_1 goes low and forces G_3's output to become high a gate delay later.

With two positive inputs to G_2, its output goes to ground. The output of G_1 becomes positive, resulting in a sharp negative-going pulse that is applied to output NOR gate G_4. Circuit output is a positive-going spike.

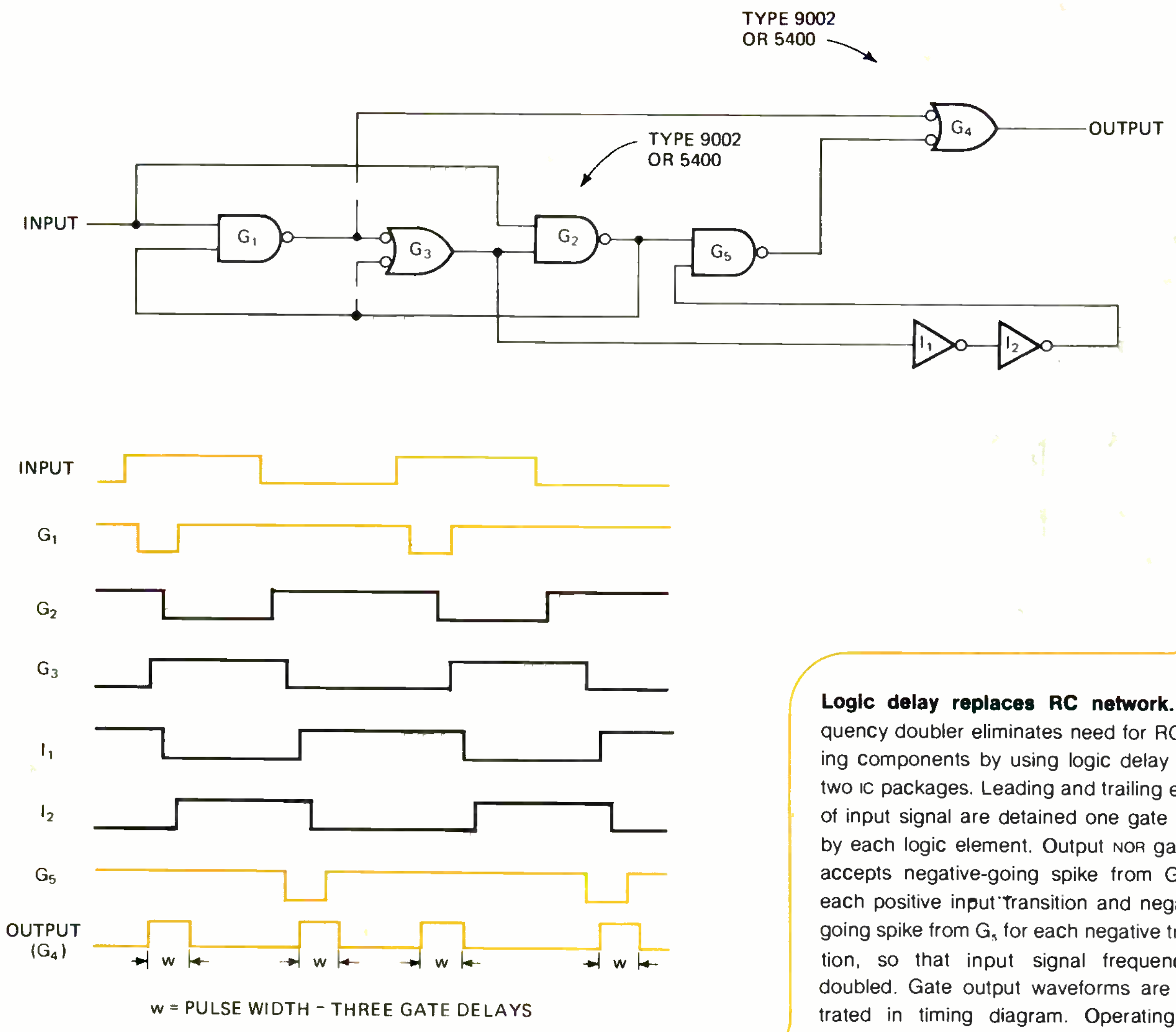
Gate G_3 follows the input signal and drives inverters I_1 and I_2. These delay the input-pulse trailing edges by the same gate delay as the leading (positive) edges.

The output of G_2 is an inverted, delayed version of the input signal that is applied to NAND gate G_5 along with the output of I_2. This causes G_5 to produce a negative-going pulse at every negative transition of the input signal.

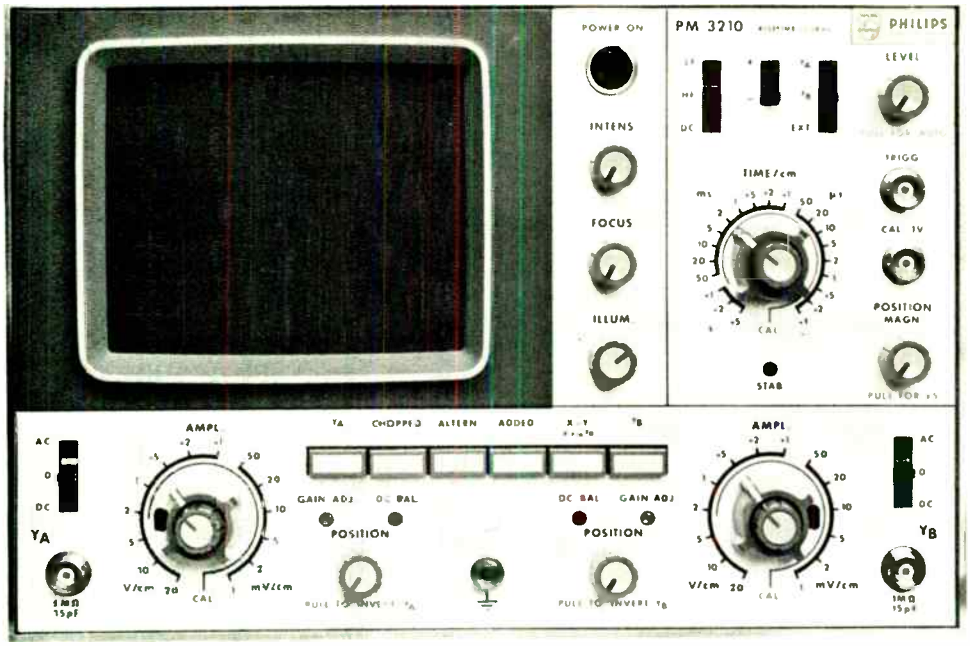
Because the output of G_5 is applied to output NOR gate G_4, there is a positive-going output pulse at every negative transition of the input pulse train. Input signal frequency is doubled since G_1 contributes a sharp pulse for every leading edge of the input, while G_5 gives an identical pulse for every trailing edge.

Symmetry of the doubled signal is affected only by the symmetry of the input waveform. The timing diagram shows the output waveform for each gate.

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Logic delay replaces RC network. Frequency doubler eliminates need for RC timing components by using logic delay of its two IC packages. Leading and trailing edges of input signal are detained one gate delay by each logic element. Output NOR gate G_4 accepts negative-going spike from G_1 for each positive input transition and negative-going spike from G_5 for each negative transition, so that input signal frequency is doubled. Gate output waveforms are illustrated in timing diagram. Operating frequency of doubler is limited only by speed of logic used.



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Design curves simplify amplifier analysis

Computer-calculated graphs bypass breadboarding normally needed in first-approximation designs of wideband, communications amplifiers; they cover gain response, impedance matching, and resistance selection

by Frank L. Egenstafer, *Paladin Electronics, King of Prussia, Pa.*

☐ A few computer-calculated design curves take much of the the tedium out of building a high-performance, broad-band, communications amplifier. They yield an accurate, first-approximation design, and obviate all the breadboarding, testing, and trimming that have often been needed before specifications could be met.

The amplifier that results uses two feedback paths for optimum current and voltage gain stability. Moreover, its gain response is flat over a wide frequency range, and its input and output impedances are matched. And although the plots are intended for a single-stage amplifier, they can be applied to a cascaded configuration.

First, a look at two basic feedback circuits will be helpful. Voltage-shunt feedback, as Fig. 1(a) shows, tends to lower both input and output impedance and to stabilize current gain:

$$A_i = R_F/R_L$$

Current-series feedback, as Fig. 1(b) shows, increases input and output impedance, while stabilizing voltage gain:

$$A_v = R_L/R_E$$

Combining both types of feedback yields the amplifier of Fig. 1(c), which is stabilized in current and voltage gain. For matched conditions ($R_S = R_L$), the circuit becomes a communications amplifier with a gain of

$$A = 2[n\beta R_F - (\beta+1)R_E]/[2(\beta+1)R_E + (n\beta+1)R_L + (\beta+1)R_F R_E/R_L + R_F] \quad (1)$$

where β is transistor current gain and n is the transformer's turns ratio.

This equation can be simplified because current and voltage gain are equal under matched conditions. Letting $\beta = \infty$, n = 1, and $A_i = A_v$ yields

$$R_L^2 = R_F R_E \quad (2)$$

Substituting Eq. 2 into Eq. 1:

$$A = 2[n\beta R_F - (\beta+1) R_E \Theta\Sigma 11_{2(}\beta+1)R_E + (n\beta+1)R_L + (\beta+1)R_L + R_F] \quad (3)$$

Since a resistance of 75 ohms is a common value for R_L, R_F can be restricted to

$$R_F = R_L^2/R_E = (75)^2/R_E = 5{,}625/R_E$$

so that Eq. 3 can be plotted. The resulting curves (Fig. 2) show how amplifier gain changes with transistor beta when n = 1, β ranges from 3 to 21, and R_E is between 6 and 28 ohms.

Using transistor beta as a coordinate actually relates amplifier gain to frequency since

$$\beta = f_t/f_m$$

where f_t is transistor unity-gain cutoff frequency, and f_m is the frequency of interest. The curves terminate at β = 21, since amplifier gain varies only slightly beyond this point.

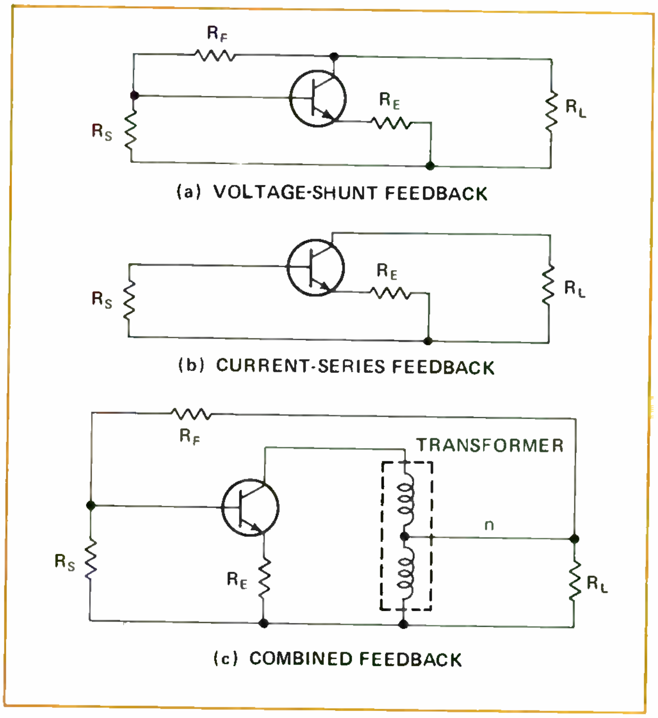
Selecting specific values for R_E and R_F is rather difficult with these gain curves because of the beta parameter dependence. However, at low frequencies, both beta variations and the distributed circuit capacitance are negligible. A good approximation for the low-frequency amplifier response can be obtained from Eq. 3 by letting $\beta = \infty$ and n = 1:

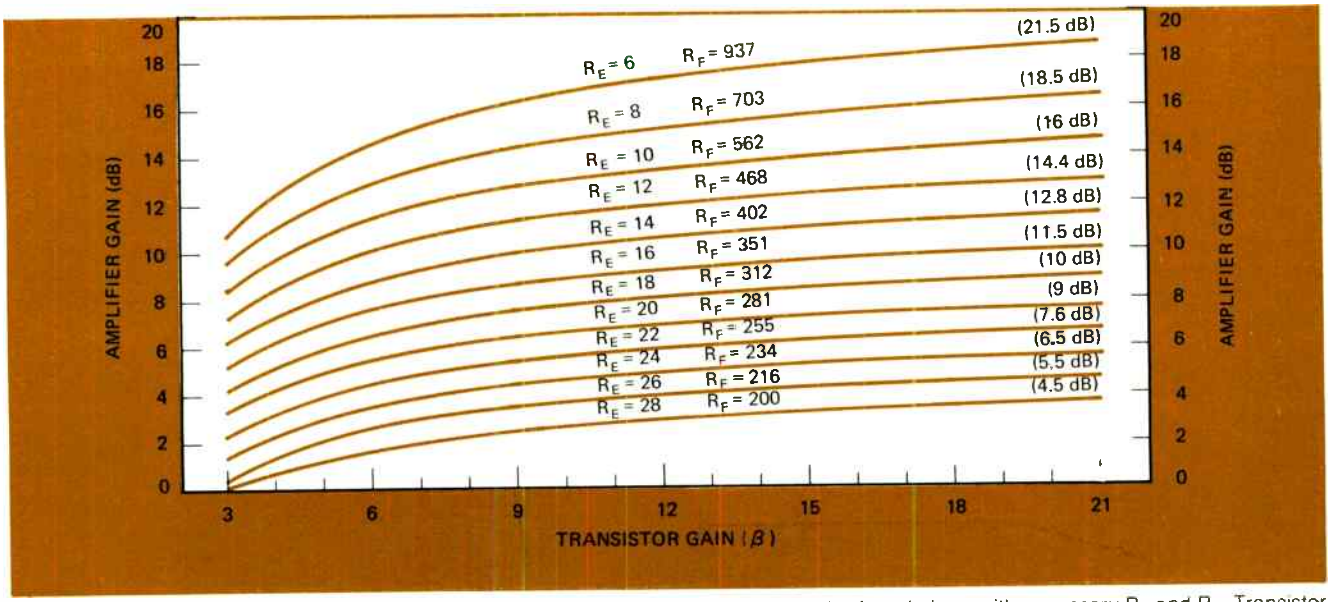
$$A = (R_F - R_E)/(R_L + R_E) \quad (4)$$

Plotting Eqs. 2 and 4 yields the curves of Fig. 3. The values of R_F and R_E that are determined with Fig. 3 should be checked against those of Fig. 2 to ensure that gain tilt will not be severe as frequency increases.

Besides amplifier gain, input and output impedence are also important design factors. The general equation

1. Amplifier feedback. Voltage-shunt feedback (a) stabilizes current gain so that $A_i = R_F/R_L$, whereas current-series feedback (b) helps voltage gain, $A_v = R_L/R_E$. Combining the two (c) gives equal gains ($A_i = A_v$) under matched conditions ($R_S = R_L$)





2. Frequency vs gain. When β is known, amplifier gain for the circuit of Fig. 1(c) can be found along with necessary R_E and R_F. Transistor beta is related to frequency since it equals f_t/f_m, where f_t is transistor unity-gain cutoff and f_m is the frequency of interest. Curves reflect amplifier response when $n = 1$, $R_S = R_L$, $R_F = R_L^2/R_E$, and $R_L = 75$ ohms. Gains for $\beta = \infty$ are noted at the right of each curve.

for input impedance is

$$Z_i = [(\beta+1)R_E(R_F+R_L)]/[(\beta+1)R_E + (n\beta+1)R_L + R_F] \quad (5)$$

while for output impedance it is

$$Z_o = [(\beta+1)R_E(R_F+R_S) + R_FR_S]/[(\beta+1)R_E + (n\beta+1)R_S] \quad (6)$$

Input impedance Z_i equals output impedance Z_o when $\beta = \infty$, $n = 1$, $Z_i = R_S$, $Z_o = R_L$, and $R_L^2 = R_FR_E$.

Impedance match and amplifier gain are direct tradeoffs; for Z_i increases (from less than 75 ohms) as β, R_F, and R_E increase, while Z_o decreases (from more than 75 ohms) as β increases and as R_F and R_E decrease.

Input impedance can be implicitly related to gain since amplifier gain varies inversely with R_E. Letting $R_F = R_L^2/R_E$ and solving Eq. 5 for R_E yields:

$$R_E^2[(Z_i-R_L)(\beta+1)] + R_E[Z_iR_L(n\beta+1) - R_L^2(\beta+1)] + Z_iR_L^2 = 0$$

This equation can be plotted (Fig. 4) for different values of Z_i with β and R_E as coordinates, and with the constraints $n = 1$ and $R_L = 75$ ohms. The necessary R_E to yield a desired Z_i at a specific frequency (β) can now be determined.

Similarly, the output impedance can also be expressed in terms of R_E by using Eq. 6 and letting $R_F = R_L^2/R_E$:

$$R_E^2[(R_S-Z_o)(\beta+1)] + R_E[R_L^2(\beta+1) - Z_oR_S(n\beta+1)] + R_L^2R_S = 0$$

Curves can now be plotted for Z_o (Fig. 5) with the same restrictions as used for Z_i: $n = 1$ and $R_L = 75$ ohms.

Impedance match, also called return loss, is commonly measured with bridge-type instrumentation in conjunction with an attenuator readout that is calibrated in decibels. As usual, a simple logarithmic relationship allows conversion of ohms to decibels. If Z_x is the unknown (variable) impedance and Z_r the reference impedance (75 ohms in this case), then the return loss in decibels is

$$20 \log [(Z_x + Z_r)/(Z_x - Z_r)]$$

Each value of Z_i in Fig. 4 is referred to a resistance of 75 ohms, as is each value of Z_o in Fig. 5. It can be seen from Fig. 6(a) that Z_i and Z_o are distributed symmetrically about an impedance of 75 ohms. And if expressed in decibels, the input impedance and the output impedance are equal at all points when $R_L^2 = R_FR_E$ and $n = 1$.

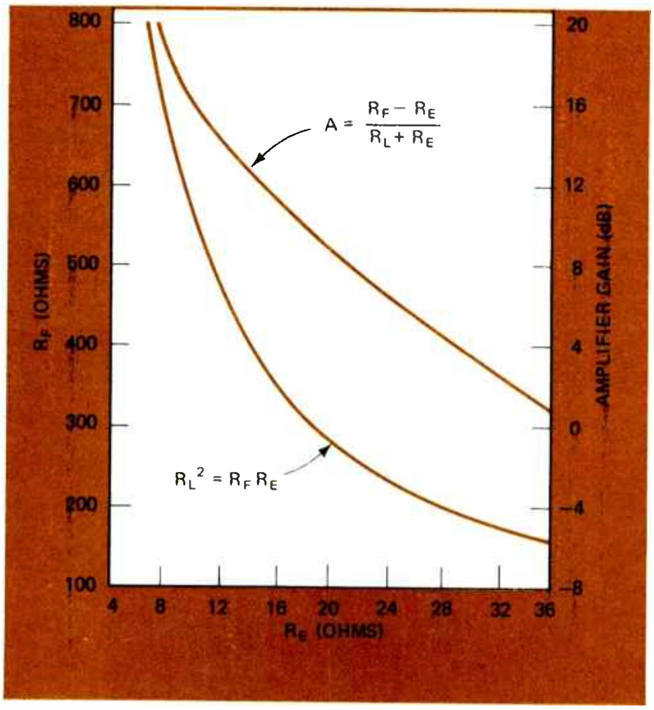
All input impedances are less than 75 ohms, while all output impedances are greater. By using the table of Fig. 6(b) to transform ohms into decibels (and vice versa), the graph for Z_i (Fig. 4) may be used to determine Z_o, and the graph for Z_o (Fig. 5) may be used to find Z_i.

Figure 6(a) clearly illustrates the tradeoff between match and gain in the design of an amplifier stage. The plot also indicates what happens when two similar stages are cascaded. At $\beta = 10$ and $R_E = 24$ ohms, for instance, the output impedance is about 19 dB while the input impedance is about −19 dB. Although they are equivalent in decibels, however, the impedances are not suitable for coupling because 94 ohms (Z_o) is not close enough to 60 ohms (Z_i).

Such matching problems can be helped by using a transformer that will facilitate the transition from a high output impedance to a low input impedance. Since both Z_i and Z_o vary with β, the transformer turns ratio will have to be a compromise for the best match between high-frequency and low-frequency impedances.

Theoretically, with R_E constant, R_F should act like a flat-response gain control so that changes in amplifier gain are the same for low and high values of β. In practice, however, when R_F is varied, the gain tends to pivot downward at some high frequency. In order to control the pivot point, R_F is made variable and a small inductor is inserted in the transistor's collector loop.

This forms a tunable tank circuit for obtaining the proper resonant frequency (pivot point). For example, a 3-picofarad distributed capacitance, a 3-pF transistor



3. Resistance selection. R_E and R_F can be determined from low-frequency amplifier gain. From point of desired gain on gain curve, move down to find R_E needed. Intersection of this R_E value and load curve fixes value of R_F on left-hand axis.

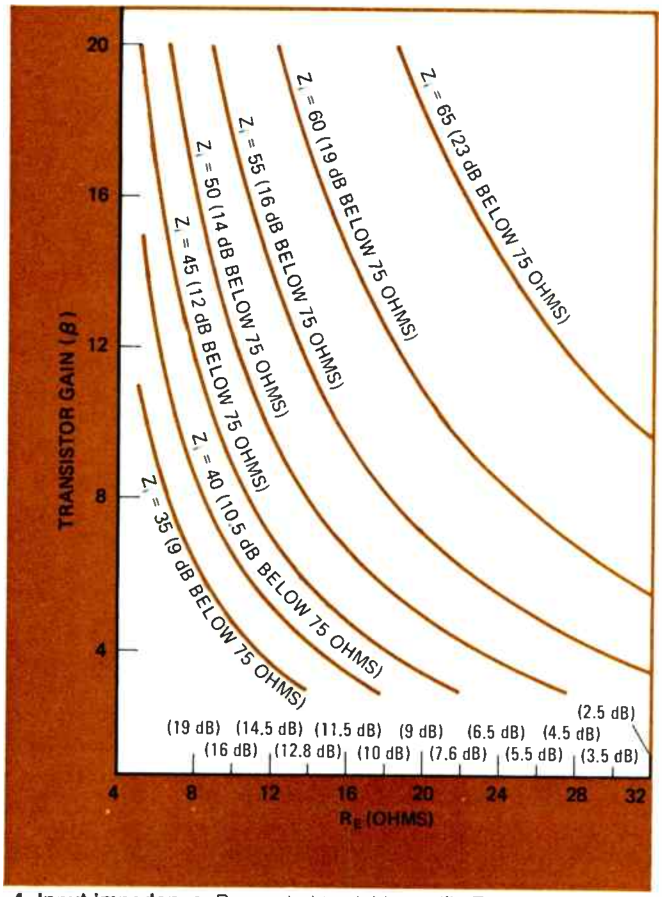
junction capacitance, a 50-nanohenry leakage inductance from the transformer coil, and a 10-nH inductance from R_F result in a tank circuit of 6 pF and 60 nH, with a resonant frequency of approximately 300 megahertz and with a Q that is related to the value of R_F.

None of the graphical results developed so far have accounted for the effect of the transfomer turns ratio, n, since it was equated to 1. But variations in amplifier gain, input impedance and output impedance occurring when n is greater than 1 can be predicted from the original circuit equations.

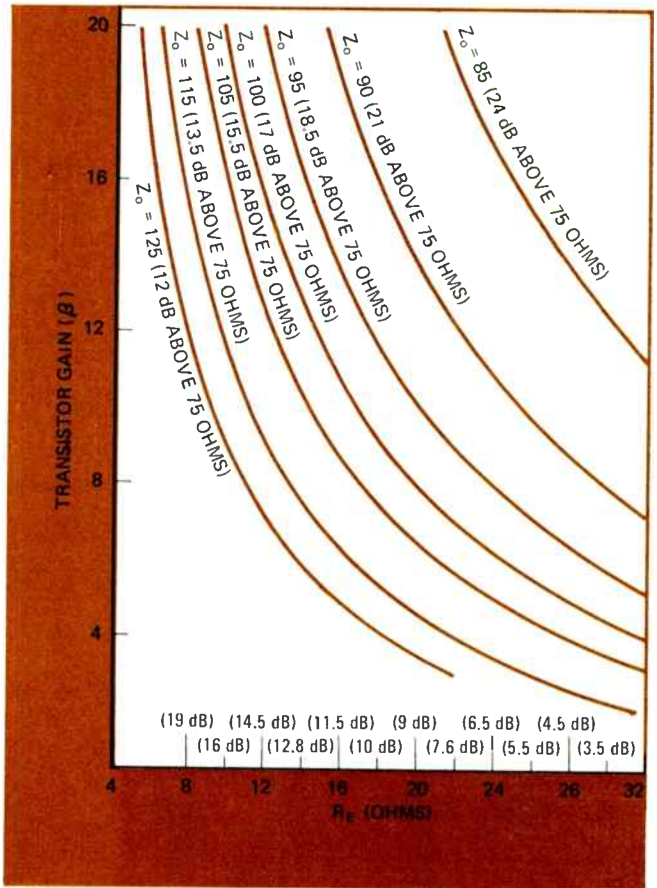
The influence of n in the complex gain equation (Eq. 1), because it appears in both the numerator and denominator, is not immediately apparent. But since R_F is always larger than R_L, the net result of increasing n will be an increase in amplifier gain.

In Eqs. 5 and 6 for Z_i and Z_o, respectively, n appears only in the denominator. Therefore, larger values of n reduce the value of Z_i or Z_o. Since Z_i is always less than 75 ohms for practical values of β and R_E, making n greater than 1 pulls Z_i away from 75 ohms. The opposite is true for Z_o: here, the impedance for practical β and R_E is always more than 75 ohms, and making n greater than 1 moves Z_o toward 75 ohms.

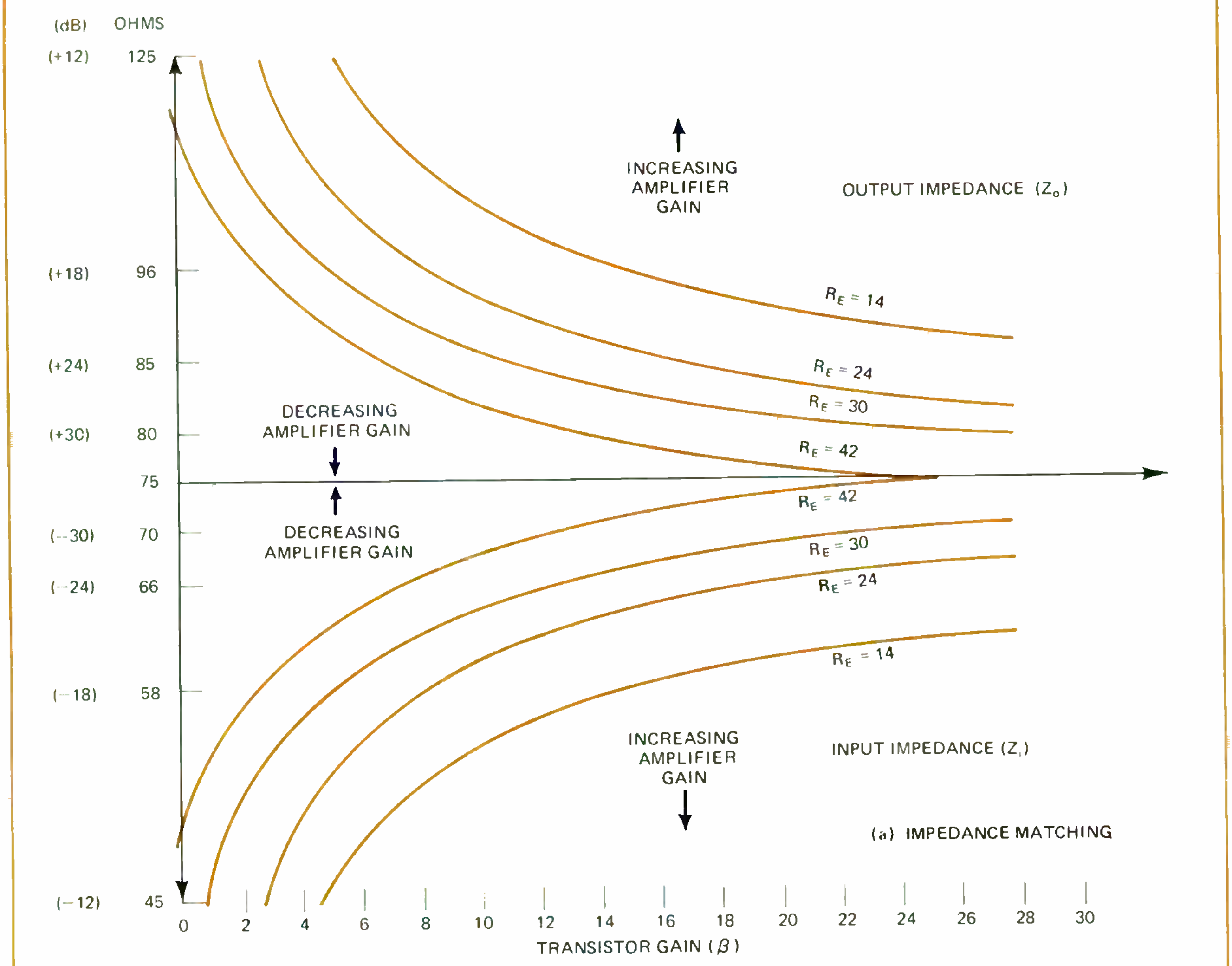
The effect of an n greater than 1 on the plot of Fig. 6(a) is to move all the curves down from their present positions. This lowers the "impedance asymptote" to some value below 75 ohms. Therefore, if 75 ohms is



4. Input impedance. R_E needed to yield specific Z_i can be found for known β ($\beta = f_t/f_m$) by selecting the Z_i desired and then finding R_E on horizontal axis. Feedback resistance is constrained by $R_F = 5{,}625/R_E$. Amplifier gain at $\beta = \infty$ is indicated for each R_E value.



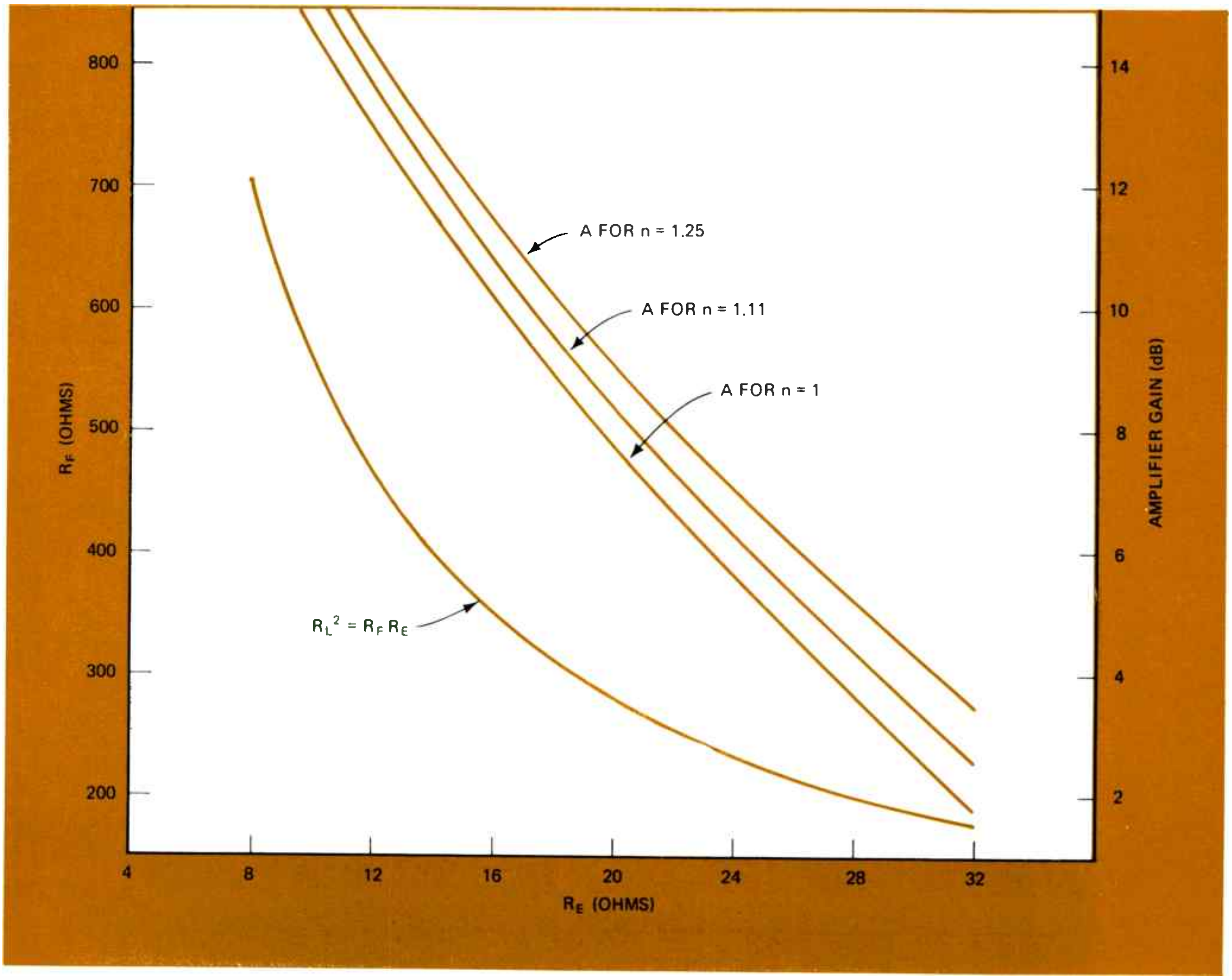
5. Output impedance. Like Z_i, Z_o can be related to β and R_E, and its curves read in the same way. Again, circuit restrictions are n = 1, R_L = 75 ohms, and $R_F = 5{,}625/R_E$. Amplifier gain decreases with increasing Z_i but increases with increasing Z_o.



(b) OHMS TO DECIBEL CONVERSION

RETURN LOSS (dB)		IMPEDANCE ABOVE 75 OHMS		IMPEDANCE BELOW 75 OHMS	
1	21	1304.322	89 677	4.313	62 725
2	22	654.317	87 943	8.597	63.962
3	23	438.603	86 428	12.825	65.083
4	24	331.457	85 102	16.971	66 097
5	25	267.733	83 938	21.010	67 014
6	26	225.714	82.914	24.921	67 841
7	27	196.093	82 014	28.685	68 586
8	28	174.214	81 219	32.288	69 257
9	29	157.491	80 518	35.716	69 860
10	30	144.371	79.898	38.962	70 402
11	31	133.867	79.350	42.019	70.888
12	32	125.317	78.865	44.886	71 324
13	33	118.267	78.435	47.562	71 715
14	34	112.389	78.054	50.049	72 066
15	35	107.444	77.716	52.353	72 379
16	36	103.251	77 416	54.479	72 660
17	37	99.673	77 149	56.434	72 911
18	38	96.604	76 912	58.228	73 135
19	39	93.957	76 702	59.868	73 336
20	40	91.667	76.515	61 364	73 515

6. Matching. When expressed in decibels, Z_i and Z_o are symmetrical about an impedance of 75 ohms. Curves (a) show variation of match with frequency, β. Conversion table (b) tabulates decibel equivalent of impedance referenced to 75 ohms. Match in decibel values of Z_i and Z_o does not indicate actual Z_i/Z_o match because ohms values are unequal.



7. Varying n. This graph of high-frequency amplifier gain for three values of n allows R_E and R_F values to be compared with those of low-frequency plot (Fig. 3). The two graphs are read in the same way. Beta is restricted to 21 for high-frequency plot.

taken as a reference, any transformer with n greater than 1 will improve Z_o but worsen Z_i.

For a few values of n greater than 1, an accurate approximation of the high-frequency amplifier gain response can be obtained by using some low fixed value for β. Figure 7 illustrates the results of computing amplifier gain with Eq. 1 for $\beta = 21$, and n = 1, 1.11, and 1.25. The values of R_E and R_F obtained from these high-frequency curves can be checked against those from the low-frequency plot (Fig. 3).

A transistor beta of 21 is a good choice for the graph of Fig. 7 since it occurs below 75 MHz for most transistors, eliminating the need to consider transformer leakage inductance. For an actual amplifier, transformer leakage inductance increases circuit gain to a higher value than the turns ratio alone indicates at frequencies above 75 MHz.

The graphs can be used in various ways, depending on the amplifier specifications that must be met. Designing an actual amplifier will illustrate one approach and point out some practical considerations, too.

Let the desired specifications for a broadband rf amplifier be: a frequency range of 40 to 300 MHz, a gain of approximately 8 dB, and an input and output impedance match that is within 16 dB of 75 ohms. The transistor will be assumed to have a typical f_t of 1,200 MHz. Transformer turns ratio, n, is 1.

The first step is to find beta for the amplifier's high-frequency response:

$\beta = f_t/f_m = 1{,}200/300 = 4$

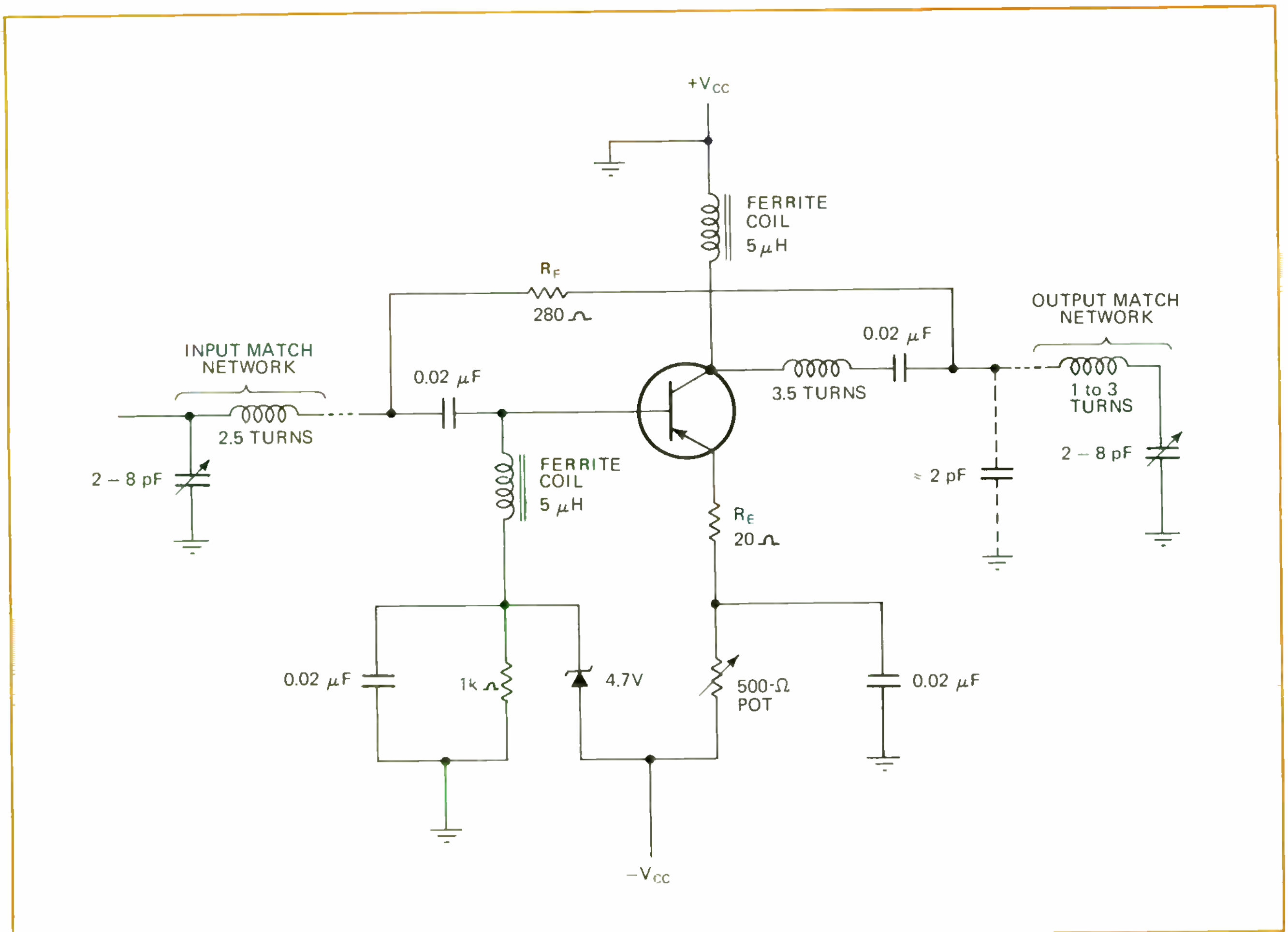
Once beta is known, Fig. 2 can be used to determine the degree of gain tilt encountered for various values of R_E when amplifier gain is 8 dB.

The curves show that the lower R_E is, the higher the gain, and the greater the amount of tilt when going from high to low frequencies. Making R_E too small, in the interest of high gain, results in a tilt that becomes extreme when beta approaches 4 and that will be very difficult to flatten out in the final design.

For practical amplifiers, R_E values of 16 to 24 ohms are the best choice when transistor f_t ranges from 1,000 to 1,500 MHz. A resistance of 20 ohms is a reasonable selection for R_E since amplifier gain degrades only about 4 dB from $\beta = \infty$ to $\beta = 4$.

Now Fig. 4 should be used to determine the range of available input impedances. The intersection of R_E = 20 ohms and $\beta = 4$ puts the input match at about 12 dB (Z_i is approximately 47 ohms). This is a workable value because there are several techniques for improving the high-end match without appreciably degrading the low-

8. Broadband rf amplifier. Real amplifier whose preliminary design was based on gain and impedance plots, delivers 8-dB gain from 40 to 300 MHz with 16-dB impedance match. Any of several transistor types can be used because pot in emitter loop adjusts collector current to desired value. Auxiliary networks shown would improve impedance match.



end match. The graph shows why—going up the plot to higher values of beta (lower frequencies) brings Z_i closer to 75 ohms.

If the amplifier is to be an input stage, the high-end input match can be improved by placing an LC network, like the one shown in Fig. 8, in series with the amplifier's input. A small resistance, of about 5 to 20 ohms, can be used instead of the LC network if the amplifier is to be a middle stage.

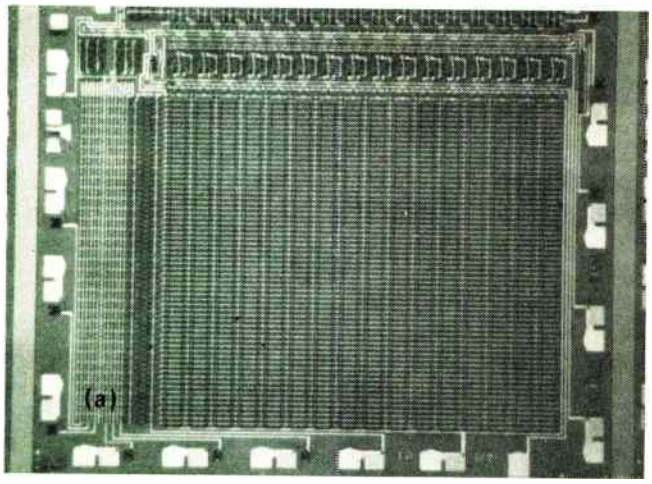
The next design consideration is output impedance match. Figure 5 indicates an approximate match of 13.5 dB (Z_o is about 120 ohms) for $\beta = 4$ and $R_E = 20$ ohms. This match value is not really as low as it seems. Since Z_o is always above 75 ohms, anything that is connected to the amplifier's output shunts Z_o and lowers it towards the desired 75 ohms.

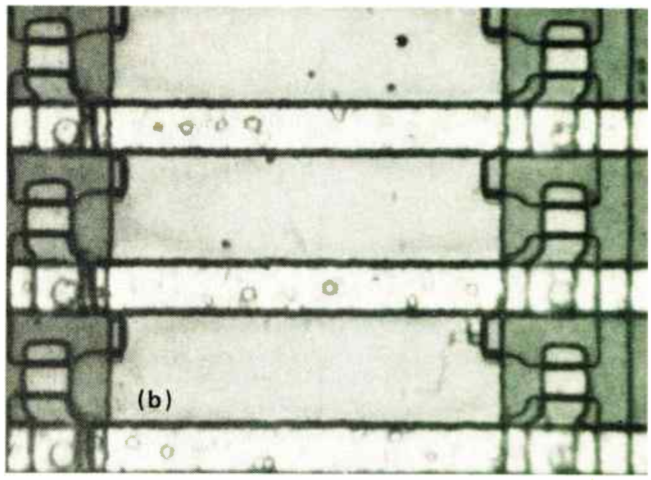
As with input match, output match can be improved with a correction circuit. The output terminal of the amplifier is assumed to have some small capacitance to ground so that adding an inductor and capacitor, like those shown in Fig. 8, forms a pi network. This scheme is useful when the amplifier is an output stage. A small resistance (5 to 20 ohms) is best for improving the output match of a middle stage.

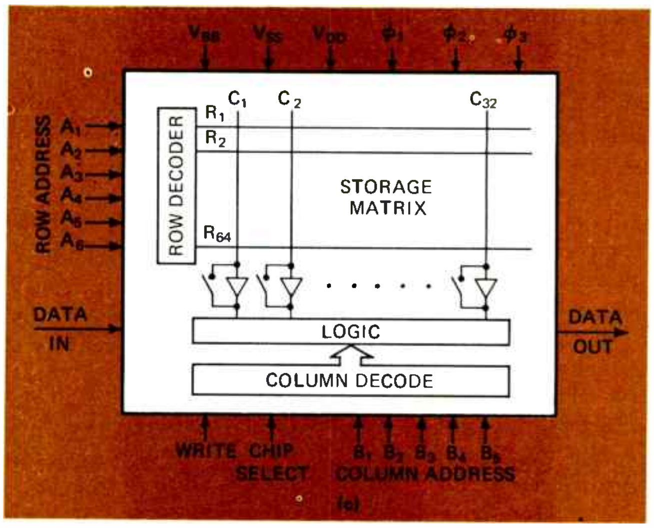
The last step in the graphical analysis is a final check with the graph of Fig. 7. From an amplifier gain of 8 dB on the right-hand axis, traverse the plot to the gain curve for n = 1. Descending from this point to the horizontal axis shows that R_E should be slightly less than 20 ohms. For simplicity's sake, however, let $R_E = 20$ ohms. Next, move up to the "load" line. Going to the left-hand axis from this intersection yields $R_F = 280$ ohms, which is very close to the R_F value of 281 ohms from Fig. 2.

Only a few practical considerations now remain to be dealt with. Figure 2 indicates that amplifier response will roll off before 300 MHz. This can be corrected by adding a small nanohenry coil to the transistor's collector loop and adjusting R_F from its "computed" value of 280 ohms. Usually, R_F is made smaller to lower the gain at low frequencies, while the collector coil increases the gain at high frequencies

A recommended circuit for the desired amplifier is shown in Fig. 8. Since there is no transformer, the turns ratio, n, is effectively 1. The two 5-μH coils control the amplifier's low-frequency cutoff, while the 3.5-turn coil controls its high-frequency response. A number of transistor types can be used because the pot in the emitter loop allows collector current to be adjusted. The zener diode simply keeps the base-emitter voltage constant. □







2. Big RAM. Getting the most memory on the chip with a minimum of overhead circuitry (decoders, drivers, refresh amps) required silicon gate processing as well as single-transistor cell construction. The area of the 2,048-bit RAM (a) is more than two-thirds memory. Six memory cells are shown in (b); cell area is less than 3.6 mil². The layout schematic (c) shows organizational flexibility.

ues required for the long refresh storage times of dynamic memories. It's conceivable that C_1 could be formed simply by the capacitance resulting from the drain diffusion itself—thus saving a process step—but this method would result in relatively leaky, low-value capacitors on the order of 0.05 pF/mil².

Memory cells storing logic 0 levels are uncharged capacitors, and need not be refreshed. But the charged capacitors storing logic 1 levels tend to slowly discharge with time. During this time the discharge current heats up the junctions, further accelerating charge leakage. But with low leakage, thin-oxide capacitors coupled to a sensitive refresh amplifier, the storage cell can decay beyond normal digital logic levels and still permit logic-level discrimination.

Using this cell structure and standard thin-oxide (MTOS p-channel processing, a 512-bit evaluation array organized on a 97-by-127-mil chip, in 16 rows by 32 columns, was built to show the practicality of the single-transistor cell approach. It's shown in Fig. 1(b).

All cells in the evaluation array operated satisfactorily, but because the cell structure was so small and because standard processing was used throughout, more than two-thirds of the chip area was devoted to decoders and refresh amplifiers. In an economical memory chip, the ratio of the area of nonstorage devices to that of storage units must be low.

The answer was p-channel silicon gate technology. With this process overhead circuits can be made smaller, yielding more space for memory. The result is the 2,048-bit memory shown in Fig. 2(a), in which memory cells occupy almost the entire chip area.

A photomicrograph of six memory cells is shown in Fig. 2(b) (see cover for another view). The storage area is less than 3.6 square mils per bit or 60% of the size of the 1,024-bit RAM. Chip size at 138 x 143 mils, is only 15% larger than the 1,024-bit RAM. As shown in the layout schematic of Fig. 2(c), it forms the basic storage element in a memory system.

Functional. A schematic of the 2,048-bit memory appears in Fig. 3. The chip contains 2,048 dynamic storage elements plus address decoding for reading, writing, and refreshing of data. A capacitor in each storage cell is connected to the drain of a single MOS transistor. The cells are organized in a 64-row-by-32-column matrix.

Each of the word locations is uniquely defined by a row-column intersection. Decoders, in 6–64-bit and 5–32-bit configurations, convert 11-bit address information into discrete row-column commands. Data output lines may be wire-ORed and serviced by a single sense amplifier.

The output capacitance shown in Fig. 3 is the parasitic capacitance resulting from the wire-ORing of several chips on a memory card. High current drive permits this capacitance to be quite large (50–100 pF) at little cost in access time or signal-to-noise ratio.

As shown in Fig. 3, the chip uses three external clocks and a drain power supply. Both operate at 18 volts, as do the 11 address lines, chip select, write, and data inputs. The output device is essentially a single-pole, single-throw switch: it's an open circuit on all unselected chips and on a chip selected for reading a 0. It's closed for reading a 1; in that mode its drive capability exceeds 10 milliamperes.

This high current level can drive directly into a TTL gate or the base of an inexpensive switching transistor. By contrast, many memories require more expensive

Taking off

Although static MOS random access memories have been available since 1965, the emergence of the refresh-type dynamic array in 1967 really got the technology off the ground. The dynamic MOS RAMs gave computer and peripheral memory manufacturers the combination they wanted: high circuit function density, high operating speed, and lower power dissipation.

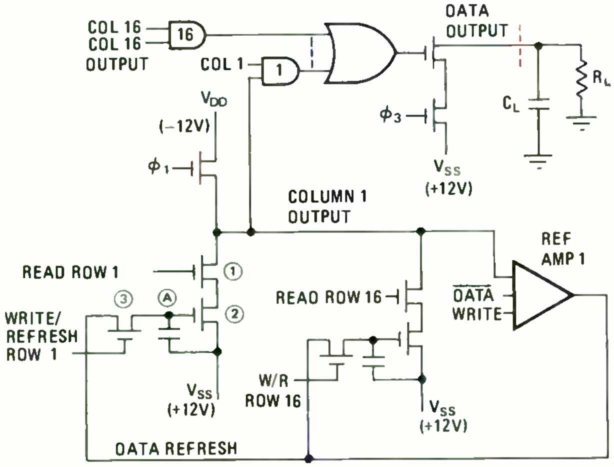
The first dynamic RAM had three transistors per storage cell (Fig. a); cell area, at 12.4 square mils, represented an almost 3–1 improvement over static RAMs. Used in 256-bit arrays (Fig. b), these fully decoded devices achieved cycle times of 500 nanoseconds and access times of 300 ns. Power dissipation was less than 400 microwatts per bit (100 milliwatts total), against 2 mW per bit for equivalent fully decoded static RAMs, at greater than 1-microsecond access time, a 6–1 improvement at comparable access speeds. But higher-density circuits still were needed to allow semiconductor RAMs to compete with the cheaper price per bit offered by core arrays.

Enter silicon gate. With its third-interconnect capability and smaller cell size, the process can give very-high density circuits with increased yields and lower cost per bit. Still using three-transistor cells (Fig. c), the silicon gate structure led to cell sizes smaller than 6 square mils, a 2–1 improvement over the old devices. Thus, it was possible to pack 1,000 bits on single 114-by-148-mil chips, only 50% larger than those used in the 256-bit devices (96 by 112 mils)—and at no sacrifice in performance.

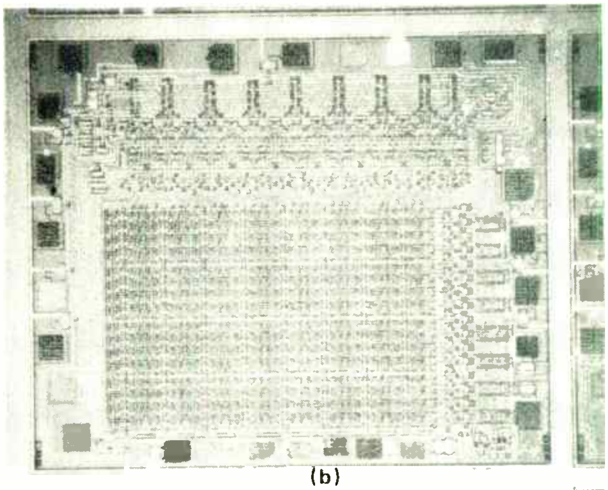
Silicon gate circuits were rapidly placed in production by several semiconductor manufacturers and soon, their shift registers and RAMs became the foundation of the MOS memory market. Intel was a leader in marketing this type of device: its 1,024-bit RAM (Fig. d), the 1103, has been announced by almost all semiconductor manufacturers, including GI. It represents the state of the art in production memories of this complexity: access time is 300 ns and cycle time 580 ns; 220-ns access and 400-ns cycle times can be obtained in even faster versions.

But many analysts feel this three-transistor, 1-kilobit memory, popular as it is, doesn't represent the optimum memory configuration; indeed, there's growing feeling among semiconductor memory builders that the 1103, even in a cheap plastic package, is only marginally competitive with core memories, whose prices still are falling.

Clearly, with more functions per chip, the MOS device would have the edge. That's providing the impetus for the single-transistor memory cell; built into a 2,048-bit array, its smaller size and high yield should lower costs per bit to the point where MOS RAMs can become a key component in the computer and peripheral hierarchy.



(a)



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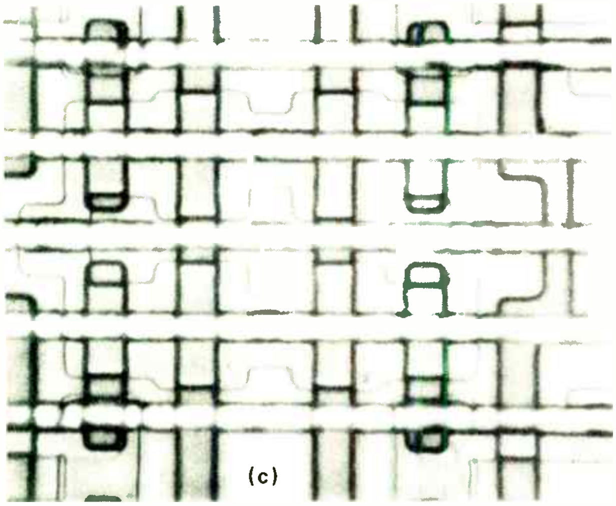
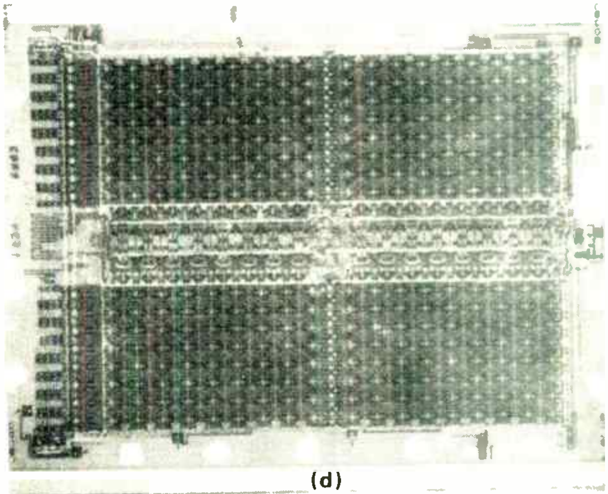


(c)



(d)

How it works

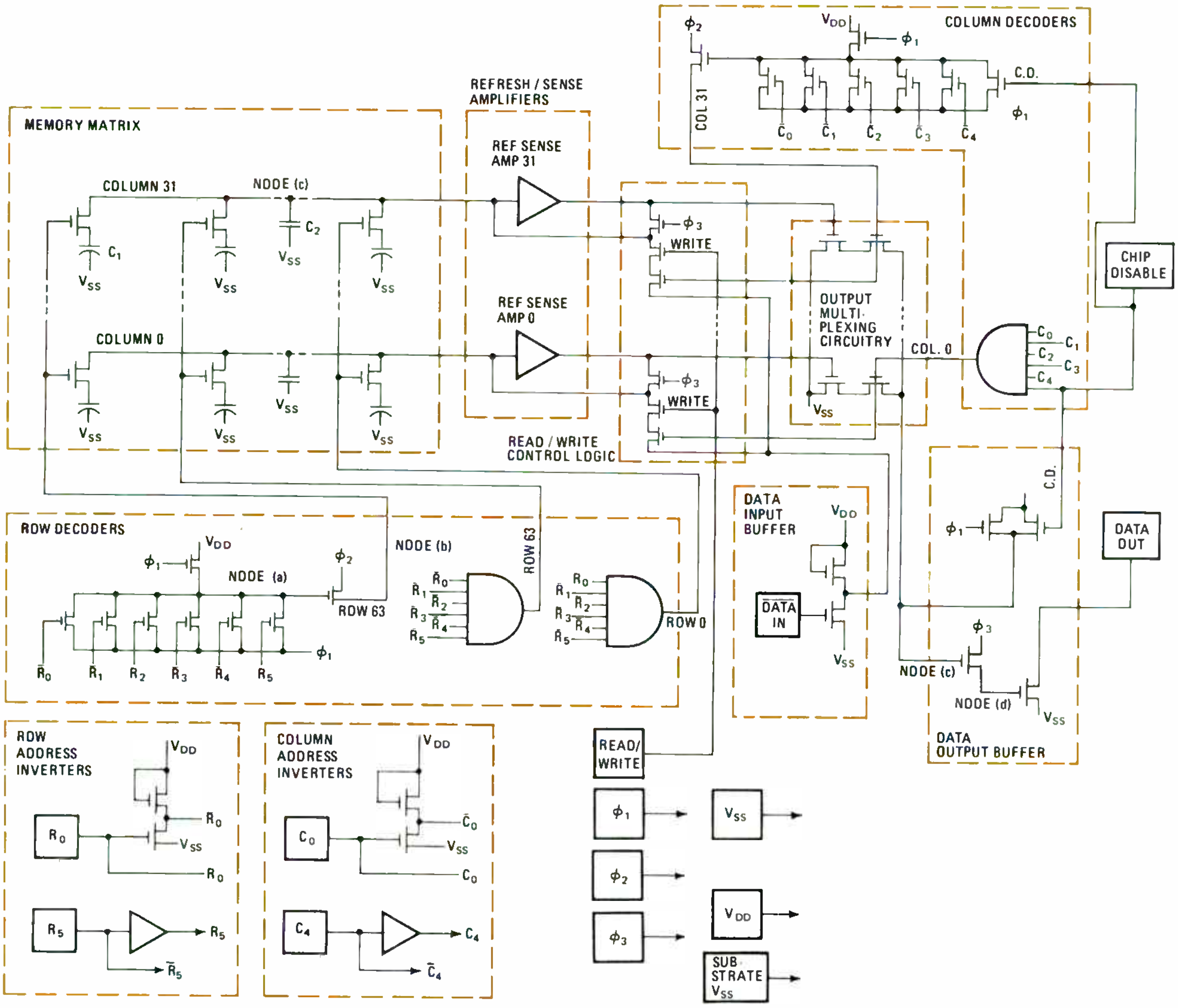
The RAM circuit consists of sections for a memory storage matrix, row-and-column decoders, row-and-column inverters, and refresh amplifiers. Also included are read and write control logic, output multiplexing circuits, and data input and output buffers. All of these circuits are contained on a single chip.

The memory matrix provides the 2,048 bits of storage, the decoders the address information, and the inverters the complement of the address information. The refresh amplifiers do the sensing and regeneration of the low-level memory information. The control logic's job is either to refresh the old information or write in the new data. The output multiplexing circuits combine the outputs of each of the columns and then select the desired bit for output. The output buffer provides high current to the overall system, while the input buffer performs a considerable noise isolation service between the data input bus and the memory array.

During clock phase in this three-phase system, all row and column addresses and the chip disable signal are updated and stabilized before the trailing edge of clock phase ϕ_1, is received. These inputs must be held stable for the entire cycle—until 20 nanoseconds after the trailing edge of the last clock phase, ϕ_3. Then, during ϕ_1 time, all row and column decoder nodes are preconditioned, all address inputs are internally complemented, and the refresh amplifiers are present for low-level sensing.

During all of ϕ_1, time node (a) on all 64 row decoders unconditionally precharges negatively, forcing node (b) of the row decoder outputs to a low impedance (V_{SS}) level. This action assures that all isolation gating transistors in the memory matrix are off during setup time. In addition, all true and complemented row decoder inputs are stable prior to the end of the ϕ_1 precharge and during the gap time (t_g) between the end of ϕ_1 and the start of ϕ_2.

By the end of t_g, node (a) on all the unselected rows will discharge to V_{SS}; the undesired row addresses outputs (node b) will stay at V_{SS} for the remainder of the cycle, thereby isolating all unaddressed cells. Node (a) on the selected row has no discharge path and remains negatively charged for the entire cycle. During ϕ_2 time the selected node (b) address output goes negative, enabling an entire



row of memory on all system chips.

When any row address for any operation—read, write, or refresh—is applied, the information in all 32 cells witn that address on all chips is assigned to each column's refresh amplifier. Node (c), the input to a refresh amplifier, combines 64 memory cells on a column bus. These combined cells, in effect, can be represented as a parasitic capacitance, C_2, somewhat greater in value than the storage capacitor, C_1.

During ϕ_1, the refresh amplifiers again are preconditioned to accept low-level inputs. An internal reference voltage is generated that is a function of the threshold V_T; it's independent of external power supplies and automatically tracks changes in V_T as a function of temperature and process variations. By the end of ϕ_1 and until the start of ϕ_2 node (c) is unconditionally set to this reference potential. At the start of ϕ_2 the selected row decoder is enabled and the charge stored on C_1 is redistributed with C_2. This redistribution of charge occurs for each of the 32 cells per chip.

If a logic 0 is stored in C_1, node (c) incurs a positive voltage transition. This signal ripples through the noninverting refresh amplifier during the first half of ϕ_2. At ϕ_2 time, the feedback loop closes and a low-impedance logic 0 level, $V_{..}$, is fed back onto node (c), and simultaneously back into storage cell C_1. However, if a logic 1 level is stored on C_1 then node (c) makes a negative transition during redistribution.

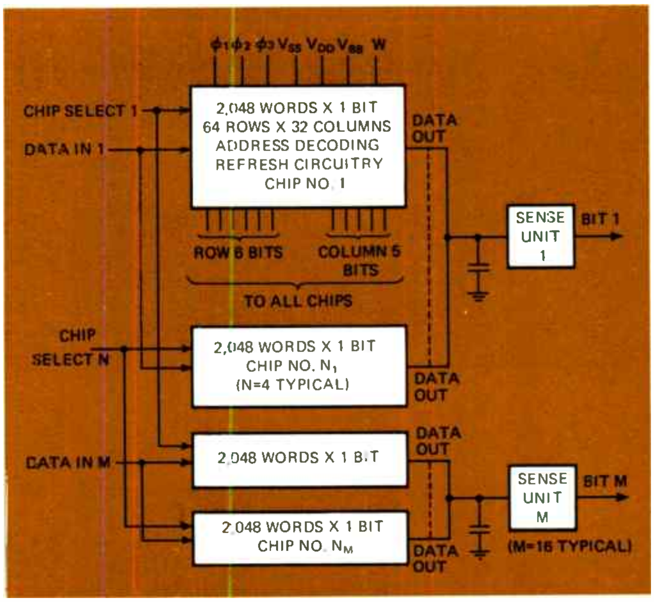
This relatively low-level excursion is amplified and fed back as a low-impedance, high-amplitude negative level V_1 during ϕ_2. At the end ϕ_2 the row decoder turns off, thereby trapping the regenerated voltage V_0 or V_1 in storage for each of the cells associated with that particular row address.

The output multiplexing circuitry gates each of the 32 column decoders against its corresponding refresh amplifier output. The selected column passes data from the refresh amplifier output to the data output buffer. The data input buffer improves the signal-to-noise ratio on the input bus by clipping low-level noise pulses. It also maintains a low input capacitance (6 picofarads) to the data input line.

For a reading operation, the read/write line is held positive, disabling the data input. During a writing cycle the read/write line is held negative, starting 50 nanoseconds (T_{DH}) prior to the start of ϕ_2, until the leading edge of ϕ_3. In order to ensure the proper acceptance of write data, the data input line is held stable for an additional 30 ns following the end of the write command.

Of the 32 cells, 31 cells are refreshed as for a read cycle. The one cell with the row-column address dumps its old data onto node (c) but is overridden by the new input data which is written into storage cell C_1. The new data then is regenerated around the refresh amplifier, goes to the output multiplexing circuitry, and ultimately, lands in the data-out line where it can be read. This operation provides the verification that information indeed has been properly written into memory.

The data output buffer is a high-gain, single-pole, single-throw switch. (The simplest output interface circuit would be an external pulldown resistor to a negative supply.) The output transistor is unconditionally held off for the entire cycle when the chip disable is in the negative state, thus allowing for a hard-wire-ORing configuration to be used for the outputs.



3. Up the organization. The storage cells are organized in a matrix of 64 rows by 32 columns. Using three external clocks, the circuit's output is a single-pole, single-throw switch.

low-level sense amplifiers; because only fractions of milliamperes are available, these systems encounter severe signal-to-noise problems.

High drive current also results in high speeds. Read access time is less than 250 nanoseconds and cycle time is less than 400 ns. Power dissipation at the highest frequency of operation is only 300 mw (150 microwatts per bit). And because it fits into a 22-lead dual in-line package with 0.4-inch row spacings, very dense board layouts are possible.

In operation, when the corresponding chip select and address lines are activated, an entire word may be updated with a write command, or read out nondestructively in the absence of the write strobe. Row addresses refresh the rows on all chips within one clock cycle. This is accomplished by accessing each of the 64 rows (regardless of column address) at least once within the required refresh storage time. A +5-v bias supply is used to achieve a refresh storage time of better than 4 milliseconds at 70° C.

In the refresh circuit design there was a possible tradeoff—a 32-row-by-64-column organization also could have been used. But each column requires a refresh amplifier with this organization, and the additional 32 amplifiers would have produced sufficient power dissipation to raise junction temperatures by nearly 10°C. This rise would increase junction leakage, shortening refresh time and increasing the time the memory is not available to the central processor. The 64-×-32 organization not only reduces the number of amplifiers but results in a smaller, higher-yield chip.

Note that the V_{BB} supply shown in Fig. 3 biases the n-type substrate by +5V with respect to the most-positive diffused p regions. This bias prevents the forward biasing of undesired p-n-p regions resembling bipolar transistors. Without the bias supply, these transistors, even with their low current gain, would produce nodes that store charge and discharge prematurely. The V_{BB} also results in a magnitude less increase in refresh time.

Processing and performance

Since fully half-a-dozen processes are available to semiconductor manufacturers on several levels of complexity, the one a fabricator chooses for his memory fabrication processing is critical. The right choice is particularly important in a sector as cost-sensitive as semiconductor memories where small mistakes turn quickly into large losses.

Because RAMs are expected to be one of the largest segments of the MOS business they're receiving the greatest concentration of development attention. Other things being equal, two requirements—access time and cost per bit—will be the key factors.

Figure a shows access times that will be expected of future RAMs: the upper curve gives access time usable in 20% of MOS applications, the middle line for 80% of the jobs, and the bottom line for 100% of the tasks. The 2,048-bit RAM design is based on the 80% line, which will require a 250-nanosecond access time by 1973.

The major manufacturing processes, along with the principal companies that use them, are listed in Table 1. The three process candidates most capable of meeting this access time requirement are complementary MOS, n channel, and silicon gate. Table 2 summarizes the results of a comparative study. C/MOS readily provides the access time, single low-level clock, and output drive current needed. However, the decode section of a C/MOS RAM occupies so great a chip area per bit at the expense of memory that cost per bit is high. And there is little indication now that the more complicated C/MOS process can be manufactured cheaply in production quantities with the high performance required of RAM circuits.

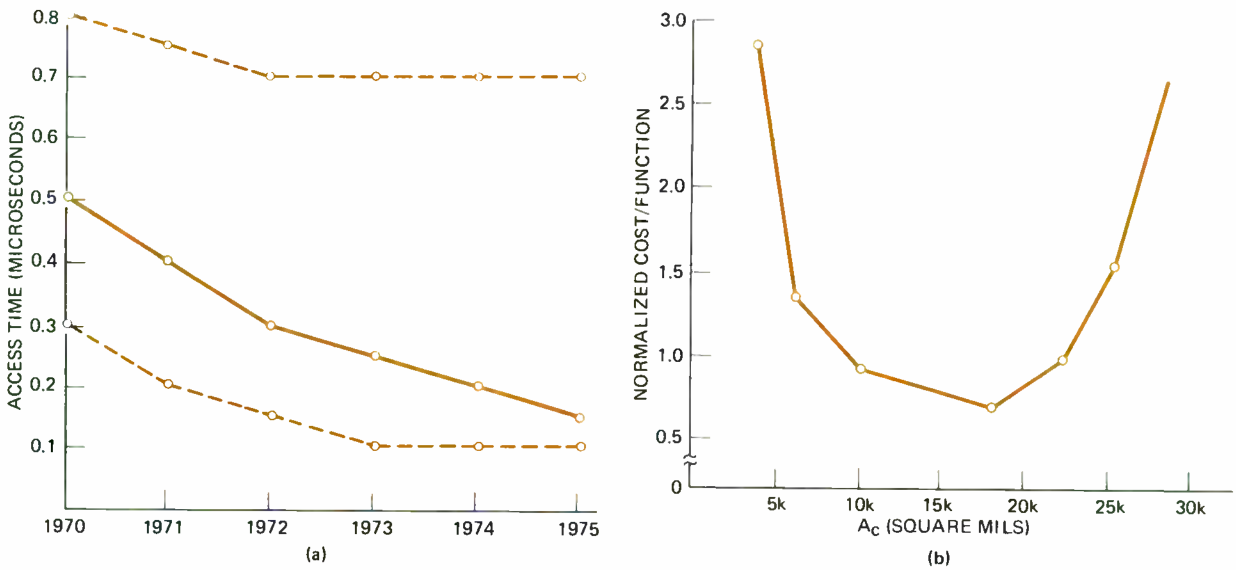
N-channel devices show excellent promise for meeting the access time and price requirements. But the process has essentially no product manufacturing history and equally serious, no short-term promise of viable alternate sourcing.

The silicon gate process appears to be the best for RAMs. The access time, 250 ns, of silicon gate RAMs is at least as good as other processes, except for C/MOS. More compact layouts can be achieved with self-aligning polysilicon gates; added to the extra interconnect level available with polysilicon conductors, the result is a 30% reduction in chip size compared to conventional p-channel, low-voltage processes. In addition, high-speed performance is achieved more easily with silicon gate because it reduces the Miller capacitance that exists between the source-to-gate and gate-to-drain overlap diffusions.

Still another silicon gate benefit is that with a silicon-nitride/silicon-oxide sandwich for the gate dielectric, low-cost plastic packages can be used.

Taking the overall view, three elements determine a product's cost: chip yield, package price, and labor cost. Fig C, which displays data that has been accumulated in the last year, relates yield as a function of area; this data, combined with package cost, is used to calculate manufacturing cost as a function of chip area, (shown in Fig. b). From that curve it's apparent that 135-by-135-mil chips provide the minimum cost per unit area (or equivalently, cost per bit of storage).

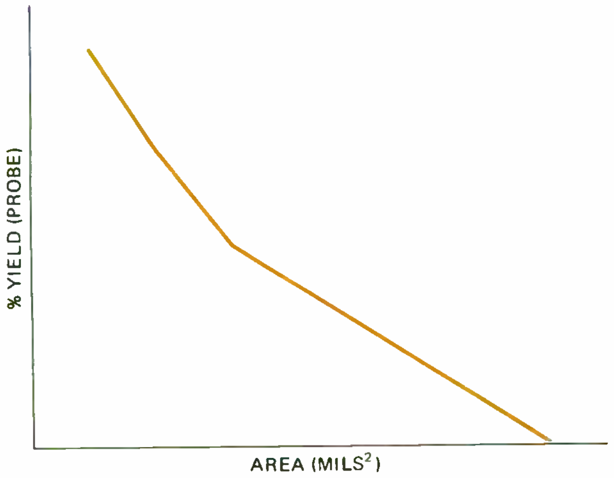
This optimum size will increase in the future as manufacturers learn to process larger and larger chips. By the end of 1971, it's expected that the optimum size will exceed 150 mils on a side. Right now, the 2,048-bit single-transistor-cell RAM's size is very nearly optimal since it provides maximum memory on chips that can be manufactured with high yields.



(a) (b)

From a black-box point of view, the data input-to-output path is noninverting. The output stage can source 10 mA of current from the V_{SS} supply, making for a much simpler output interface-sensing circuit. A TTL or DTL gate can be driven directly, eliminating the need for an intermediate balanced-voltage comparator. This feature saves money and access time.

From a systems viewpoint, silicon gate processing allows greater flexibility in overall design. Memory planes in the older, three-device structure generally have been limited to 4 kilowords by 18 bits. The new RAM, however, lends itself to many organizations, such as the 8-kiloword-by-18-bit plane shown in Fig. 3. Most important, this plane, with associated circuitry, can readily be



(c)

Table 1: MOS process characteristics and principal manufacturers

High voltage, p channel	
Shallow junction, high resistivity	General Instrument Corp.
Deep junction, low resistivity	American Micro-systems Inc., GI
Ion implantation	Hughes Semiconductor division
Low voltage, p channel	
MTOS	GI
(100)	AMI, National Semiconductor Corp.
Ion implantation	Mostek Corp.
Silicon gate	Intel Corp., GI
N channel	
Single devices, depletion	GI
Single devices, enhancement	GI
ICS	in development (Intersil Inc., Cogar Corp.)
C/MOS	
High voltage	RCA Solid State division
Low voltage	GI
C/MOS/bipolar	GI

Table 2: MOS technology tradeoffs

Technology	Access Time	Price	Low-level inputs	Output drive
Silicon gate	yes	yes	no	yes
N channel	yes	yes	no	yes
C/MOS	yes	no	yes	yes

implemented on one printed circuit board. This high board density owes much to the use of a 22-pin 0.4-in. package. Memory planes in the standard 18-pin package would require 2 × (0.5 in. by 1.115 in.) = 1.115 in.² for each 2,048 bits of memory. But with 2,048 bits in the 22-pin package, only 0.78 in.² of space is required.

Interestingly, the 22-lead package appears to be optimal for space consideration; a package with more pins housing 2,048 bits offers no improvement in board density over a 1,024-bit RAM in an 18-pin package, and both occupy 41% greater area than the 22-pin, 0.4-in. package.

With this scheme, 64 memory packages supplying 128,000 bits of memory (typical for a standard hierarchy), occupy only 49 in. of board space. Because of the space savings, level translators may be either monolithic or the larger but cheaper discrete variety. Discrete versions driven directly by open-collector TTL circuits, such as the SN75451, can be constructed quite inexpensively with one transistor, one diode, and two or three resistors; they can drive 400 pF at a slewing rate of 1.25 V/ns. Monolithic bipolar quad/totem-pole level translators, typically capable of driving 500 pF at the same slewing rate, also are readily available at less than $1.25 per translator stage.

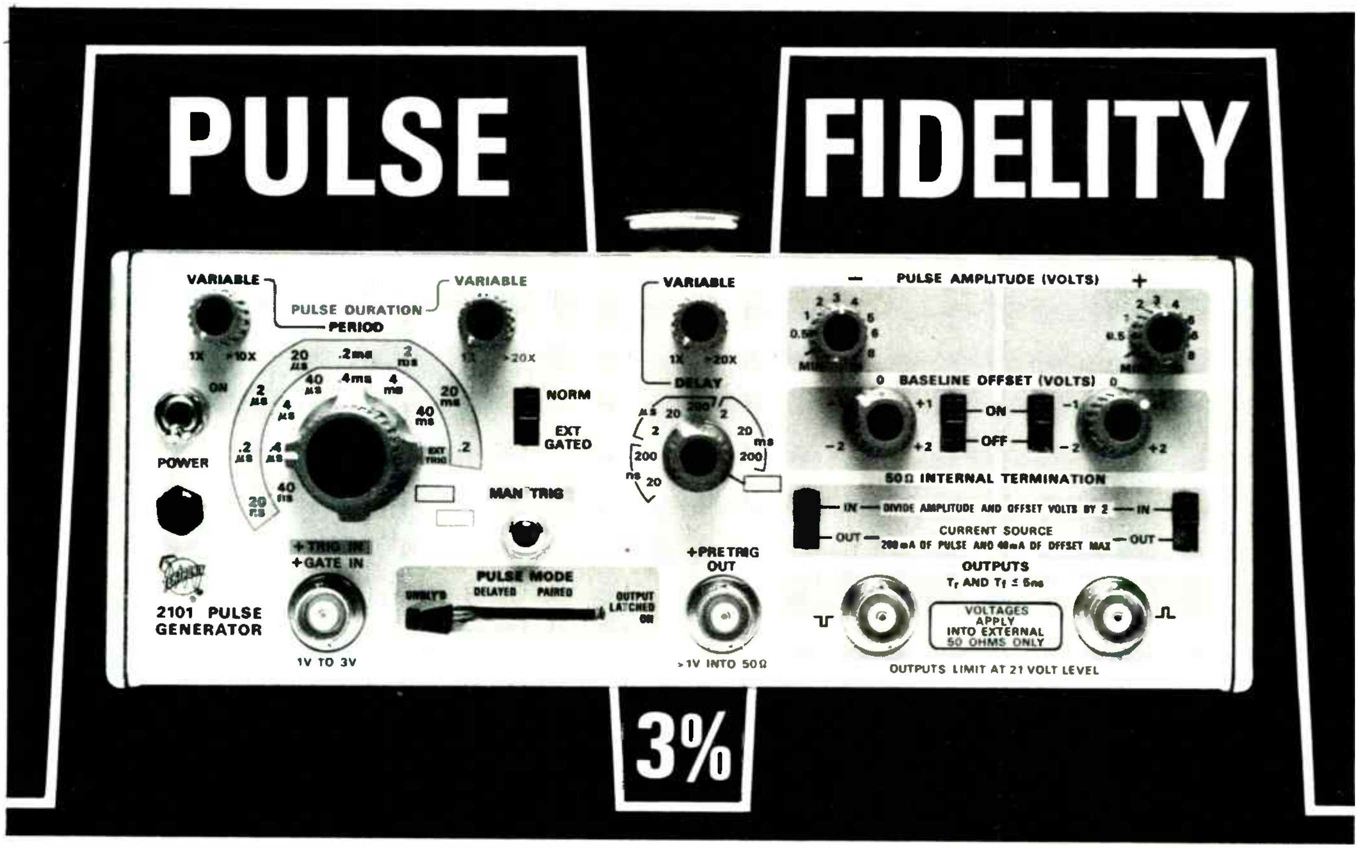
Each address line (10 pF maximum) must drive all 64 chips for a total load of 640 pF. Two monolithic translators must be used, at a total cost of $2.50 per address line, in order to exceed the desired slewing rate.

Clearly, the greater the quantity of bits available per package, the lower the cost of overhead circuitry per bit. Again, the level translator provides a good example. The capacitance loading and number of translators required for this system are summarized in the table. Judging from the capacitive loading on the data input bus, translators typically are underutilized and might be replaced by much simpler and less-expensive circuitry. In the single-transistor RAM design, the number of translators can be reduced from 56 to 40 for a total cost reduction of $20.00. Large-volume purchases reduce this even further—amortized over 128,000 bits, cost comes to approximately .029 cent per bit.

The 2,048-bit RAM also helps diminish the cost proportion of other overhead circuits. For example, the chip's 10-mA output current capability allows direct interface with TTL logic, eliminating the cost of 16 sense amplifiers. □

Capacitance data and number of translators for 2,048-bit RAM

Single function	Capacitance per chip	Signal input capacitance	Number of chips	Number of translators
11 address lines	10 pF ea.	640 pF	64	22
Data in	8 pF	32 pF	16 groups of 4	16
Write	10 pF	640 pF	64	2
Chip disable	8 pF	128 pF	4 groups of 16	4
ϕ^1	50 pF	3,200 pF	64	7
ϕ^2	18 pF	1 160 pF	64	3
ϕ^3	11 pF	705 pF	64	2
				Total: 56 (14 packages)



Simultaneous Positive and Negative Pulses

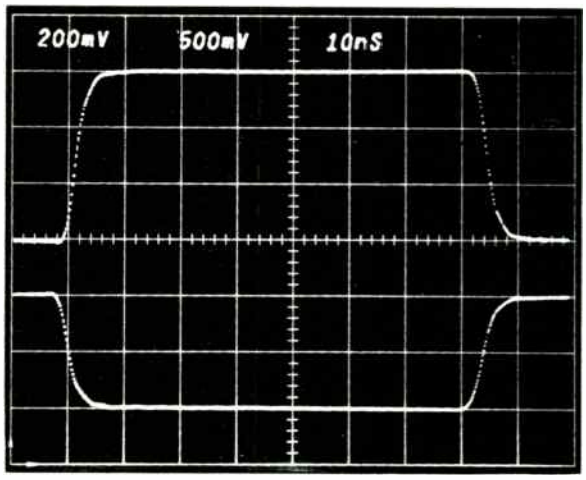
This 25-MHz, 10-volt, general-purpose generator produces exceptionally clean pulses with aberrations not exceeding 3%. Positive and negative-going pulse outputs are simultaneously available and independently variable from 0.5 V to 10 V. (See photo at right.) Each output is provided with a continuously variable baseline offset of +2 V to −2 V.

A choice of paired, delayed and undelayed pulses, as well as a DC output is provided by the four operating modes.

Pulse duration, period and delay are separately variable; pulse duration from 20 ns to 400 ms, period from 40 ns to 400 ms, and delay from 20 ns to 4 s. Mechanical coupling prevents the duration from exceeding the period for all calibrated positions.

Risetime and falltime of 5 ns (2.5 Hz to 25 MHz rep rate), simultaneous positive and negative outputs, with aberrations less than 3%, make the 2101 an ideal pulse source for logic testing or wherever the need for clean pulses exists.

A demo of the 2101 will prove its merits — call your local Tektronix Field Engineer. Tektronix signal sources are available for other applications. For complete specifications on these instruments, consult your 1971 Tektronix Catalog, or write P.O. Box 500, Beaverton, Oregon 97005.



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Roadblocks for vehicle location

Multipath, cost problems plague automatic monitoring systems, and Government drags its heels on multi-user approach; but makers are still optimistic

by Larry Armstrong, Washington bureau

The nearest police car is located and dispatched to the scene of a robbery so swiftly that the felons can't get away with their loot. The highway maintenance man does his sleeping at home, not in the cab of a truck parked up an alley. Taxis spend more time carrying fares, and less time cruising for them.

This is the promise of automatic vehicle location. But despite the cautious interest shown by private fleets and governments at every level—and the optimism of the electronics companies scrambling to manufacture the systems—the concept will remain stuck in low gear until a formidable technological barrier is removed. And economic and political problems also are slowing down implementation.

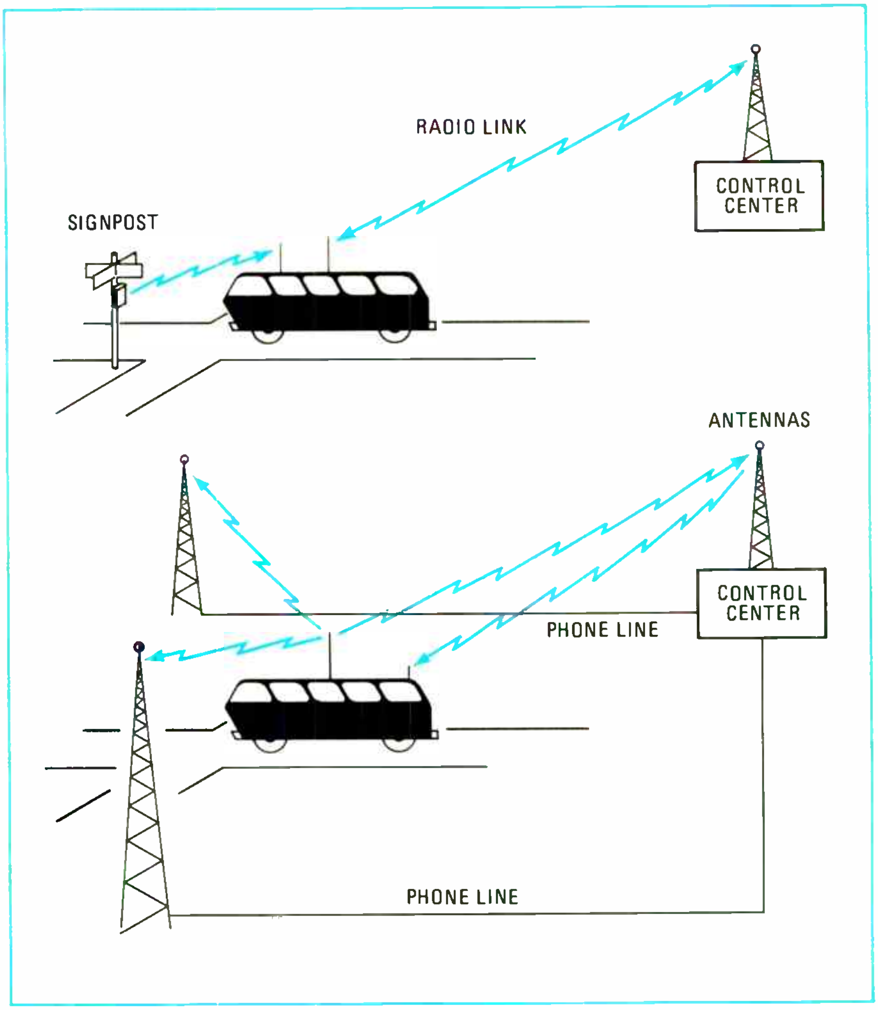
The biggest technological jam facing vehicle-locating systems is the inability of companies making rf-dependent systems to come to grips with problems arising from multipath reflections. These reflections, necessary for successful rf blanketing of dense, high-rise urban areas, cause signal degradation that can drop accuracy far below acceptable levels. Proximity systems avoid the problem by using transmitters housed in signposts, but the large number of signposts required would be prohibitively expensive for single, small-fleet customers.

Politics. Prospects for system viability also are tied up in economic and political considerations. Right now, only a beleagured big-city police department could justify the estimated $2.5 million cost of a skeleton network. But the grouping of users, which would make an expensive setup pay for itself, is getting short shrift from planners, and there's no saying if law enforcement customers could be persuaded to accept a shared network.

The Government, however, has been generating a lot of short-term research; it's the "pre-election-year" variety, concedes a Department of Transportation official, and consists of plugging state-of-the-art hardware in and out of flashy systems. And DOT has indulged in plenty of blue-sky speculation on ambitious programs for personalized vehicle services, such as dial-a-ride [*Electronics*, Jan. 4 p. 81], which would require expensive, large-scale monitoring setups.

"If vehicle location is going to

Location. Uniquely-coded signpost transmitter of proximity systems are within lines of sight; frequency dependent systems require blanketing an area with polling signal.



proliferate in single-user systems, then it is doomed to failure," argues Robert Thomas, R&D administrator in the Department of Housing and Urban Development. (That department's mass transit programs have been absorbed by DOT as UMTA, the Urban Mass Transportation Administration.) Thomas sees vehicle monitoring evolving as a public utility that would array police, fire, ambulance, bus, and taxicab services in a minimum configuration with room for other potential users—construction suppliers, for example, who want to keep track of concrete deliveries.

Time is ripe. Despite all the obstacles communications equipment makers still remain optimistic and predict that vehicle location is an idea whose time has come; their views are evidenced by the 39 responses received by the transport agency for four demonstration system awards. The manufacturers see those as the beginning of a large, profitable market of $30 million to $50 million within five years, and climbing to $500 million by 1980.

Almost half of the 39 proposals call for an rf technique that depends on solving coverage and multipath propagation problems. Awards went to Teledyne Systems Co., Northridge, Calif. ($184,488), for a system utilizing the Loran ship and aircraft navigation network; and to Cubic Corp., San Diego, Calif, ($188,299), and Sierra Research Corp., Buffalo, N.Y. ($263,000), for phase-trilateration techniques. The fourth contract was awarded to RCA's Government and Commercial Systems division, Camden, N.J. ($202,823), to demonstrate a proximity system using low-power signpost transmitters.

The RFP calls for the monitoring systems to estimate the location of 1,000 vehicles within 500 feet of true location with 95% confidence, operative over 100 square miles of urban environment. The systems must sample 20% of the vehicles every 15 seconds, the rest, every minute. And manufacturers must provide duplex voice compatibility, with no interference between digital and voice links.

The four electronics firms will be demonstrating their equipment in Philadelphia for the next several months in a short-term evaluation program that will conclude by February. "We don't want to say if a system is good or not good," says Samuel R. Rondberg of UMTA's Office of Research, Development, and Demonstration. "We just want to say what the system will do. If the contractors can acceptably meet the requirements of these tests, then we'll have a pretty high level of confidence in any system they could deploy anywhere," he continues.

The Philadelphia tests will be rigorous: the tentative route runs from the relatively flat outlying residential and suburban districts to the high-rise inner city. "Philadelphia's a good, dirty city," says Rondberg—referring to radio interference and spectrum congestion.

Contractors relying on rf techniques are understandably disturbed by the choice of test site. For instance, Cubic Corp., which did the development and testing of its phase-comparison system in its home town, low-rise San Diego, points to the formidable problem of blanketing a high-rise city like Philadelphia with rf energy. Cubic's is a typical phase-trilateration vehicle-location system: each vehicle has a simple transceiver—meeting voice, digital, and monitoring needs—that transmits a tone near the fm broadcast band when keyed by a polling signal from a master transmitter. The tone is picked up by at least three receivers and is relayed back to a control center over leased phone lines. Then it's compared for differences in time of arrival, and hence differences in range. Cubic uses a Varian 620/i to calculate the vehicle's coordinates from hyperbolic lines of position.

Limits. The multipath phenomenon is something of a paradox for rf-dependent systems. Without reflection of electromagnetic waves from buildings, water tanks, and the like, areas blocked from line of sight would receive no signal. But those same reflections also endure for as long as 20, and perhaps 30, microseconds later than the line-of-sight signal, badly deteriorating system accuracy. In fact, Raytheon Co., Sudbury, Mass., has shelved the rf gear [*Electronics*, March 2, 1970, p. 48] it used in recent tests with the Boston Police Department and now is rethinking various approaches to vehicle identification and location. "We're between systems now," says Richard W. Krupa, transportation marketing manager at Raytheon. "We're studying several other approaches, almost all of which tend toward less complexity and which may be both more accurate and more cost effective," he adds.

Extras. Multipath degradation can be cut by using redundant receiver sites and periodic rf mapping of dense, urban areas. In Sierra's "multilaterative" approach, says program manager Basil E. Potter, the company plans to use eight slave receivers instead of the usual three. Sierra further compensates for multipath effects with a proprietary set of algorithms applied to the signals in the base station computer (a Data General Corp. Nova 800).

In its proposal, Sierra substituted a continuous-wave signal, with a standard 25-kilohertz bandwidth, for the wideband pulsed approach developed by its Environmental Systems group in Denver. Time of arrival is gauged from the zero-crossing of the 425-megahertz signal, not a pulse's leading edge.

A pulsed trilateration system generally is three to four times more accurate than a phase-comparison system because the former ranges on the arrival of the first (usually line-of-sight) pulse, eliminating multipath ambiguities. But the Federal agency decided not to consider pulsed systems, says Rondberg, because equipment complexity and bandwidth utilization are costly. In addition to customary land-mobile communications equipment, pulsed systems require a wideband transponder to accommodate the high-power, 1-gigahertz pulses.

The agency has in hand field test results for a pulse-ranging system developed by Hazeltine Corp., Greenlawn, N.Y. Based on recent tests in New York, Hazeltine claims an accuracy to within 300 feet 95% of the time, and typically, within 100 feet from true vehicle location. Product manager Jerome Zauderer quotes a transponder price of $1,000 per vehicle for "production prototypes" and says the system requires one stationary receiver per every 10 or 15 miles in suburbs.

Like phased trilateration techniques, Loran-based systems are susceptible to rf interference and multipath propagation, and like pulsed approaches, require two radio receivers. Existing Loran receivers cost $20,000 to $50,000, although a spokesman for Teledyne projects that, in quantity, receiver price for the vehicle-monitoring application would approach $500.

While the proximity system proposed by RCA uses rf propagation, it is strictly a short-range, line-of-sight link with spacings of no more than a few hundred feet. Each signpost transmitter's short-range, 10.6 GHz signal identifies its own location; the vehicle receives this signal and, upon request, retransmits it to the base station, together with a vehicle identification code. One transmitter would have to be mounted on every street corner in an average city, says RCA program manager Anthony Liguori, with an extra one placed in the middle of extremely long blocks. Once the design is completed, RCA expects the transmitter to sell for less than $100 and to be about the size of a blackboard eraser. The X-band receiver in each vehicle should cost about the same, Liguori says.

Goals. But some contend that there is no technologically viable approach. "Unless someone comes up with a radically new technique, we're not going to get automatic vehicle monitoring in a hurry," says Inspector Stephen T. Walsh, commander of New York City police communications. Walsh wants to locate patrol cars to within a city block, an accuracy figure of 75 feet. And Walsh says he has seen no system this accurate, including the Raytheon and Hazeltine setups. He holds out little hope for a proximity system: "It would require 44,000 signpost transmitters," he says.

The Government, however, is far from giving up on existing technologies. "If one or more of these four systems prove adequate," says Robert A. Hemmes, assistant administrator for program demonstration within UMTA, "we'll fund them in an operational [pilot] mass-transit application." And if tests prove successful, automatic vehicle monitoring will qualify for matching capital grants from the Government. □

Space electronics

Learning the facts of life on Mars

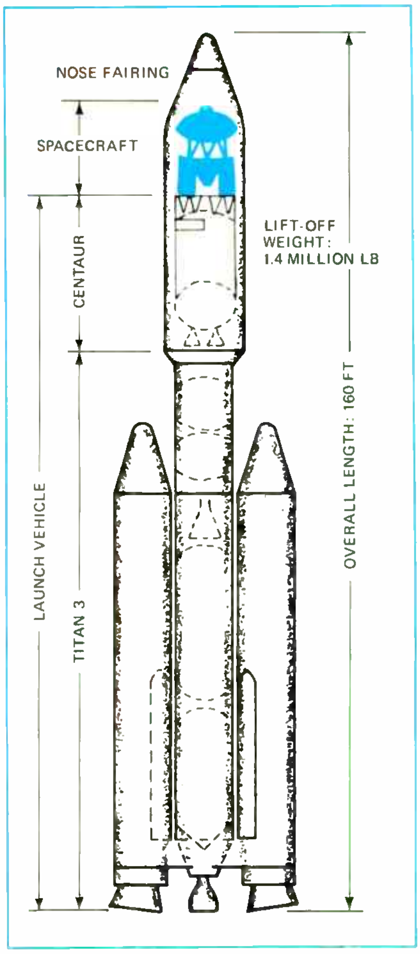
Funding problems are probably over for the two Viking spacecraft now scheduled for launch in fall of 1975

by Paul Franson, Dallas bureau manager

In 1976 the question of whether life exists on Mars may be answered as the Viking mission lands on the planet after its long passage—first through Congressional approval and development, and only then through the empty reaches of space. To be sure, program officials carefully play down Viking's search for life—past, present, or future—because they fear a sense of failure if it is not found. But this is obviously the most exciting part of the $800 million program. In fact, two Soviet spacecraft are already heading toward the planet, though it isn't known whether they intend actually to land on its surface.

In spite of its exciting prospects, Viking has had funding problems since it began in 1969 under the name Titan Mars [*Electronics*, Sept. 15, 1969, p. 145]. But now, according to Walter Jakobowski, Viking program manager at NASA headquarters in Washington, the program seems to have cleared its fiscal hurdles and most likely will be launched in August or September of 1975. Launch was originally scheduled for 1973, but in January 1970 the program was slipped because of budget problems; that move, program officials say, added $150 million to its costs. Congressional approval seems certain for the $180 million NASA is requesting this year.

The Viking mission, the longest one yet, will begin with two launches of identical spacecraft within 30 days of each other, a period when Mars and the earth are in good position that occurs only every 26 months. The redundancy has two purposes: a safeguard against losing an experiment because of mechanical failure, and a means of gaining more knowledge about Mars. The launch vehicle will be a 1.4-million-pound Titan 3-Centaur. The Titan 3 is a two-stage rocket with two solid rockets attached; Centaur, the upper portion of the launch vehicle, will both support the Viking spacecraft and provide the final-stage propulsion that will place it in the



Standing tall. Spacecraft for the Viking mission will be carried aloft atop a Centaur-Titan 3 launch vehicle.

proper trajectory for its trip to Mars, a 460-million-mile voyage scheduled to take 305 to 360 days.

The spacecraft itself consists of an orbiter and lander. During the interplanetary trip and orbital observation of Mars, the two will remain joined. The orbiter will supply electrical power from solar cells and correct the course with its propulsion system. The orbiter portion is expected to bear a final price tag of around $251 million; the lander construction and integration of the system will cost about $359 million, and the remainder of the program's expected price of $750 to $830 million will pay the bill for program management and the 63 scientists who are cooperating with Viking managers. NASA expects to spend between $250 million and $300 million in each of the next two fiscal years on the program.

During orbit, the spacecraft will search the surface of Mars with two TV cameras, and will chart thermal and water vapor with an infrared spectrometer and radiometer. This information will be transmitted to earth, and used to construct maps of the Martian surface. The orbiter also contains instruments that will investigate the atmospheric and planetary structure, propagate the results through space, and also transmit the spacecraft locations.

System responsibility for the orbiter lies with the Jet Propulsion Laboratory in Pasadena, Calif., which was also responsible for the Mariner Mars missions in 1969 and 1971. That portion of the craft is based on Mariner. In fact, according to H. W. Norris, Viking orbiter system manager at JPL, the only truly new subsystem is the relay link that will retransmit signals from the lander. The orbiter will have a minimum design life of 140 days after reaching Mars orbit, but is expected to continue to operate significantly longer.

Data from the orbiter will be used partly to re-evaluate preselected landing sites and could even lead to the selection of new sites. Once a site is selected, the lander will be powered, checked out, and start descent. Martin Marietta in Denver is the prime contractor for the lander, which will be highly automated. It will use a medium-sized digital computer, the only practical approach because commands will make a 45-minute roundtrip.

One of the first steps in separating the lander from the orbiter will be to remove the bioshield in which the lander will be sealed after sterilization to avoid contaminating Mars with earthly micro-organisms. Sterilization, at about 125°C for 480 hours, will place severe constraints on components used in the craft, and Martin is preparing a standard parts list. Says NASA's Jakobowski, "We've been thinking about this for years, and I think we've got most of the problems licked. Germanium transistors can't handle these temperatures so we keep them out of our designs. On the other hand, most silicon devices can handle it quite nicely." Nevertheless, he says, "there are thousands of parts that have been used on other missions that can't be used here."

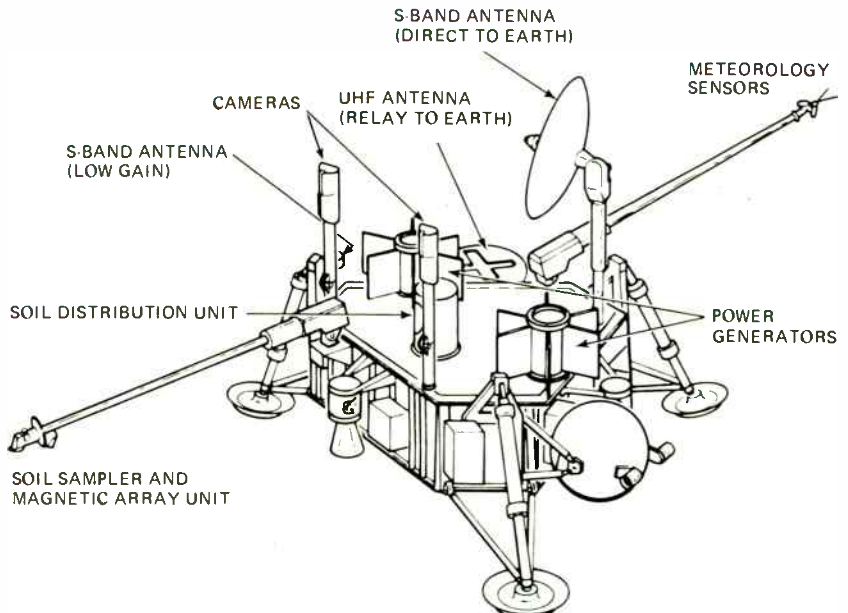
The lander's descent will begin at 800,000 feet in an aeroshell heat shield necessary because of Mars' atmosphere. At 20,000 ft, the aeroshell will be cast off and a parachute deployed to slow the fall. At 5,200 ft, terminal propulsion will begin, with a multi-beam doppler radar and a broadband radar altimeter assisting the inertial navigation system. Martian winds may complicate landing, but terminal engines will shut off about 10 ft from the surface, and the lander will fall freely—and gently—to the landing site.

During the descent, a mass spectrometer will measure the structure and composition of the atmosphere. Pressure, temperature, and density will also be measured, and all information will be transmitted to the orbiter for relaying to earth.

After landing, contact can be maintained with earth through the orbiter by a uhf link, or directly through a high-gain S-band antenna that is usable for 2 to 4 hours a day at 4,000 to 8,000 bits per second. A low-gain S-band antenna also can be used for direct commands from earth, but at only 2 to 4 bps.

Many of the most interesting aspects of the mission occur after the lander is on the planet's surface, where it's scheduled to spend 90 days. Here begin the experiments that may tell us whether life exists on Mars, or did exist once, or is evolving toward existence. As Jakobowski says, "a major objective is

Mars explorer. This is the craft that will descend to the surface of the planet; it's to cost about $359 million. The lander will spend about 90 days doing Mars experiments.



obtaining information about the evolution of life on another planet. This is something you can't do from an orbiter or fly-by mission. You also can't accurately measure the constituents of the atmosphere, or perform meteorology or seismometry experiments.

"As far as finding life, we're really trying to determine what stage Mars is at in evolution. One experiment will make a direct search for life. Another will look at organic compounds, water, etc. For example, life may just be starting to evolve and still be in a chemical form that isn't life but is headed in that direction. We might find some of the complex molecules that could lead to life under the right conditions, amino acids, and so forth. And there's also the possibility that life may have been there a long time ago—and something happened."

A vital part of the lander is the computer used to control its landing and supervise its instruments. Jakobowski says that power and weight will be the major constraints on the computer design. NASA's schedule calls for the selection of the contractor by October 2, and formal award of the contract by November 22. Five of the six bidders on the computer are proposing plated-wire memory, although IBM's Federal Systems division is proposing a miniaturized-core storage the company claims will meet NASA's stringent power and weight requirements. Other bidders include North American Rockwell's Autonetics division, Teledyne, General Electric, and Westinghouse. The memory will have 16,000 to 24,000 words of 16 to 24 bits.

Engineers at NASA's Langley Research Center, which has project management for Viking, say that contractors will have a choice in selecting the circuitry for the block redundant computer. They can either select components on the JPL's mandatory parts list, which would mean low-power TTL devices, or choose P/MOS circuits, which they must qualify for space use themselves. NASA sources note that complementary MOS and Schottky diode circuits were proposed but were rejected because "the data wasn't available to make an assessment about their reliability."

In general, however, Jakobowski says designers stick to proven technology in the spacecraft as much as possible: "We're looking for standard proven ways of doing things, but as on any other space mission, there are constraints, so sometimes you have to be a little inventive to do a good job or meet the requirements."

Experiments performed on the surface are being supervised by Martin because their complexity would make it difficult for universities or other scientific research groups to build them. Included are experiments in biology, molecular analysis, imaging, meteorology, seismometry, and magnetism and physics. The biological experiments, which are being prepared by TRW Systems in Redondo Beach, Calif., and the molecular analysis instruments from JPL are the two most difficult and expensive projects, costing about $20 million apiece.

Molecular analysis will be performed by a mass spectrometer and gas chromatograph that will analyze soil and gas samples. TRW's biological instruments will make four metabolism and growth analyses in searching for signs of life, and will require about 22 lb out of the lander's 90 to 100 lb of payload and an average of 10 watts out of 15 allotted to science experiments from the 70-W output of the lander's radio-isotropic thermal generator.

Also included in the lander's instrumentation package will be two cameras by Itek that will provide stereoscopic and color panoramic photographs of the Martian surface; pressure, temperature, and humidity sensors (TRW); a three-axis seismometer, a magnetic sensor, and an engineering soil sampler.

Other subcontractors chosen for lander electronics by Martin are RCA for the communications equipment; ESB, General Electric, and Eagle Picher for the batteries; Lockheed for a tape recorder; and Ryan for terminal descent and landing radar.

Besides the constraints of weight, power, and the sterilization of the lander, the components of the spacecraft will also have to endure considerable shock and vibration since the weight limitations preclude much shock mounting. □

Consumer electronics

Cassettes face furor over noise

The established Dolby noise-reduction system now faces competition from Philips plus Japanese group; price, compatibility are big issues

by Gerald M. Walker, Consumer Editor

The audio cassette, touted by recorder manufacturers as a new medium for high-fidelity sound reproduction, is becoming the center of a conflict over noise reduction. Three systems—made by Dolby Laboratories Inc., London, Philips of Belgium, and a Japanese group—are contending for the consumer's dollar in a fast-moving field [*Electronics*, July 19, p. 98]. Their systems are designed to minimize the hiss and other high-frequency noise inherent in all recording tape, but particularly prominent in cassettes because of their slow playing speed and narrow channel separation.

Of the three contenders, Dolby must be regarded as the established heavyweight. Its type B noise-reduction system, in production for over a year, is licensed to about 30 audio manufacturers, including Advent Corp., Cambridge, Mass; Bell & Howell Co., Chicago; Fisher Radio Corp., Long Island City, N.Y.; Harmon-Kardon Inc., Plainview, N.Y.; and 3M/Wollensak, St. Paul, Minn.

Recently, Dolby expanded its horizons by demonstrating a noise-reduction unit for fm broadcasting. The recorded material was Dolbyized at the transmission end and processed in listeners' decoders, which were built into stereo receivers. As a result, both Fisher and Harmon-Kardon announced plans to market Dolbyized receivers that can accommodate noise-reduced fm broadcasts and tape cassettes without external circuitry.

Price break. TEAC's deluxe Dolby unit sells for $290; its line starts at $50.

Competition. The Japanese group consists of three companies, Matsushita (Panasonic), Sony, and Victor Co. of Japan. Their approach is called The Automatic Noise Reduction System, and though they've revealed no technical data, they claim it's compatible with Dolby, but lower in cost. Both Dolby and the Japanese system require special tape processing and playback through a decoder.

The third contender, North American Philips Corp., New York, U.S. arm of the Belgian overseer of tape cassette standards, disapproves of both Dolby and ANRS because they are not compatible with non-processed tape. The company this summer unveiled its own noise-reduction system, called the Dynamic Noise Limiter. This design does not require specially processed tape, so it will handle any program, but achieves noise reduction in the playback mode only.

To counteract Dolby's leg up with audio manufacturers, Philips has added a sweetener: "An established manufacturer who is willing to adhere to Philip's specifications and standards may apply for a royalty-free license to incorporate the dynamic noise limiter circuit in its own cassette recorders and players," says Paul B. Nelson Jr., vice president and general manager of the Home Entertainment Products division.

Despite this generosity, hi-fi firms likely will remain largely loyal to the Dolby approach, according to an industry observer. "Dolby probably is noncompatible, but so what," he shrugs. "This industry has enough room to tolerate some noncompatibility."

Moreover, prices on Dolbyized recorders have been dropping sharply. TEAC Corp. of America, Santa Monica, Calif., put the skids under the usual $200-and-up price-tags when it brought out the AN-50 Dolby Noise Reduction unit for $49.50; it's a separate black box to be connected to cassette equipment. Accompanying the AN-50 are fancier models: the AN-80, with VU meter, priced at $129.50, and the AN-180 record-playback unit for $289.50. A separate dynamic noise limiter from Philips will sell for about $30 to $39, depending on VU meter and other features, according to Nelson. The company now has available the Model 2100 tape deck with built-in noise limiter retailing for $219.95.

Contention. The campaign for noise reduction supremacy goes beyond sales battles, however, and into a technical dispute. The dynamic noise limiter, says Edward R. Hanson, technical manager for the Philips division, is an "active noise-suppression circuit" that operates in quiet and silent stretches where hiss is most noticeable. An ordinary passive filter for noise reduction found in most tape decks, he charges, "cuts off the upper-frequency harmonics, which constitute much of the output of musical instruments. In loud passages this makes reproduction muddy."

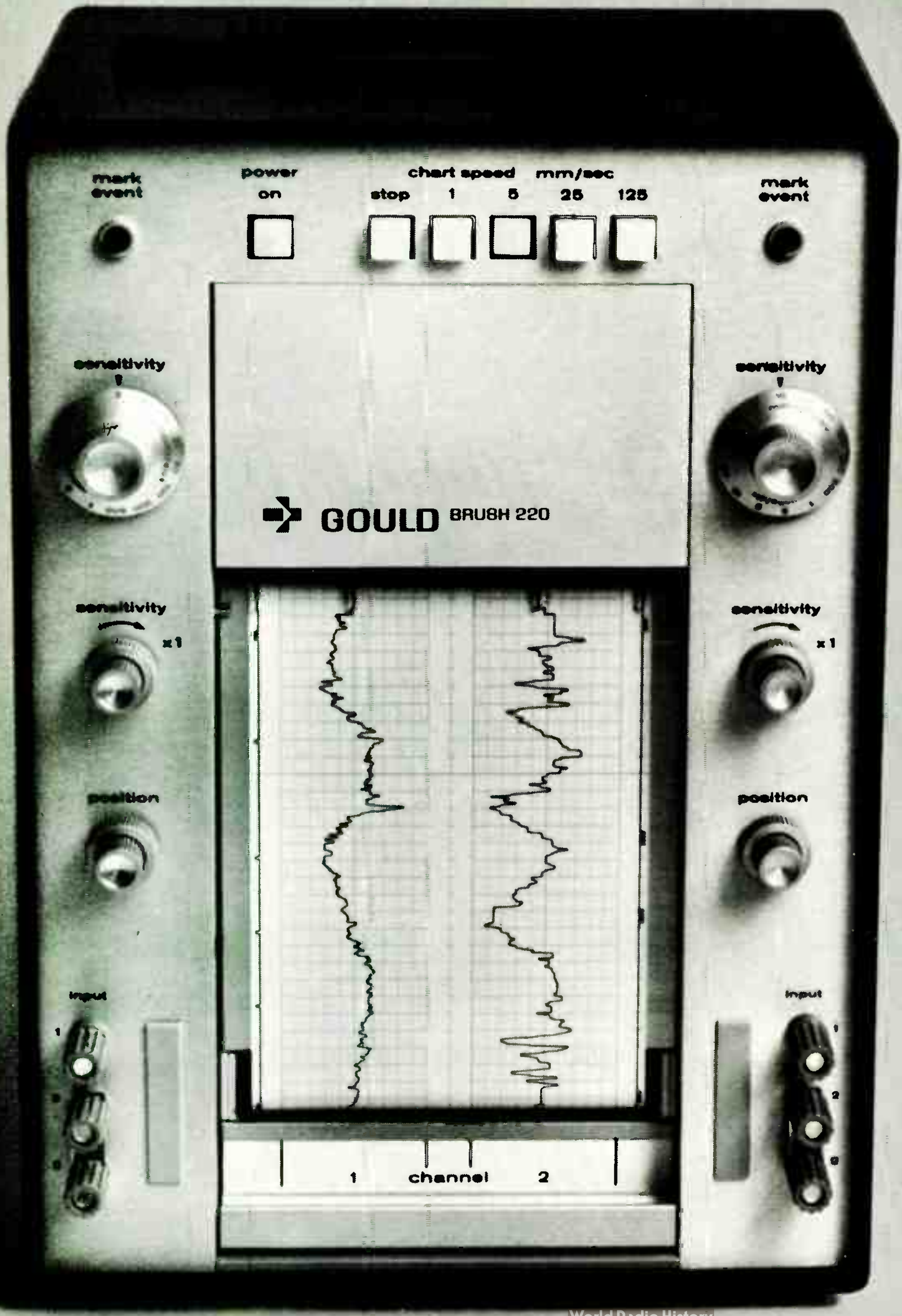
The noise limiter instead allows high-frequency signals above a certain level to bypass the filter action. It splits incoming signals into two paths; above 4 kilohertz and more than 38 decibels below reference level, the signals in the two channels are equal but in opposite phase so that they cancel each other in the adding stage. An automatic, continuously variable attenuator at this stage reacts to the signal's amplitude level and frequency to function in silent or low-level passages where most tape noise occurs. The program content is still delivered along the first path.

The noise limiter has demonstrated signal-to-noise improvements of more than 3 dB at 2 KHz, and unweighted measurements show a ratio improvement of more than 5 dB at 6 kHz and 20 dB at 10 kHz. According to Robert van Sluys, who developed the dynamic noise limiter for Philips in Belgium, it is more practical to achieve this amount of noise reduction without destroying cassette compatibility than to get the 10-dB suppression at 2 kHz in the Dolby system using noncompatible processing.

In the Dolby process, program material is treated so that low-level signals below the tape hiss threshold are boosted before recording. The tape hiss then is reduced when the boosted signal is brought back to normal by the playback circuit.

Ray Dolby, American-born founder of the British company, is unruffled by the Philips attack. He says he's more confident than ever that his systems will continue to gain acceptance among audiophiles, partly because prices are expected to decline even further when Dolby integrated circuits are introduced. By September, ICs designed and developed jointly by Signetics Corp., Sunnyvale, Calif., and Dolby will be in production and should cut the cost of components in half [*Electronics*, June 7, p. 26]. Under the agreement, Signetics has six months to market the device after production begins. Then the design, including the masks, will be made available to other semiconductor houses. And that should help ward off the Japanese competitors, too. □

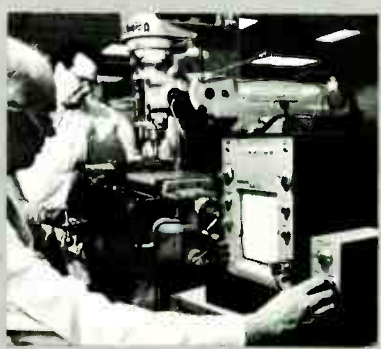
This portable will record more facts in less time, at less cost than any other 2-channel recorder on the market.



We call it the Brush 220.

And once we put it through its paces for you, you'll call it the most amazing piece of recording gear around.

To begin with, we *guarantee* 99½% linearity. Which is a good deal better than almost anything else on the market . . . regardless of size or price. The pressurized ink-writing system is the same one you'll find in our six and eight channel systems. Instead of laying the trace *on* the paper, it forces



it *in*. Run your finger over it. There's no smear, no smudge. And trace crispness and uniformity is in a class by itself.

Built-in preamplifiers give you measurement range from 1 mV per division to 500 full scale—and you never have to re-calibrate. Pushbutton controlled chart speeds. Two handy event markers. Ink supply is a disposable cartridge, good for a year.

Yes, for a 25 pound portable that's no bigger than a breadbox, the Brush 220 is quite a recorder. Ask your Brush representative for a demonstration. Or, write for complete details. Brush Division, Gould Inc., 3631 Perkins Avenue, Cleveland, Ohio 44114.

GOULD BRUSH

Circle 84 on reader service card

Frequency synthesizer is priced at $1,900; aimed at communications

by Stephen Fields, San Francisco bureau manager

Usable in most base bands in the U.S. and Europe, unit covers frequency span of 0 to 13 MHz in seven ranges

Frequency synthesizers long have been the rich man's signal source. While giving extremely pure signals and digital control, these instruments have been selling in the neighborhood of $5,000.

Now prices are falling. The latest flurry of activity comes from Hewlett-Packard Co., which is introducing two low-priced synthesizers, the 3320A selling for $1,900 and the 3320B for $2,450. Not only do they provide clean signals and allow direct digital control of output level, but they also can be programed directly from a card reader or other simple device.

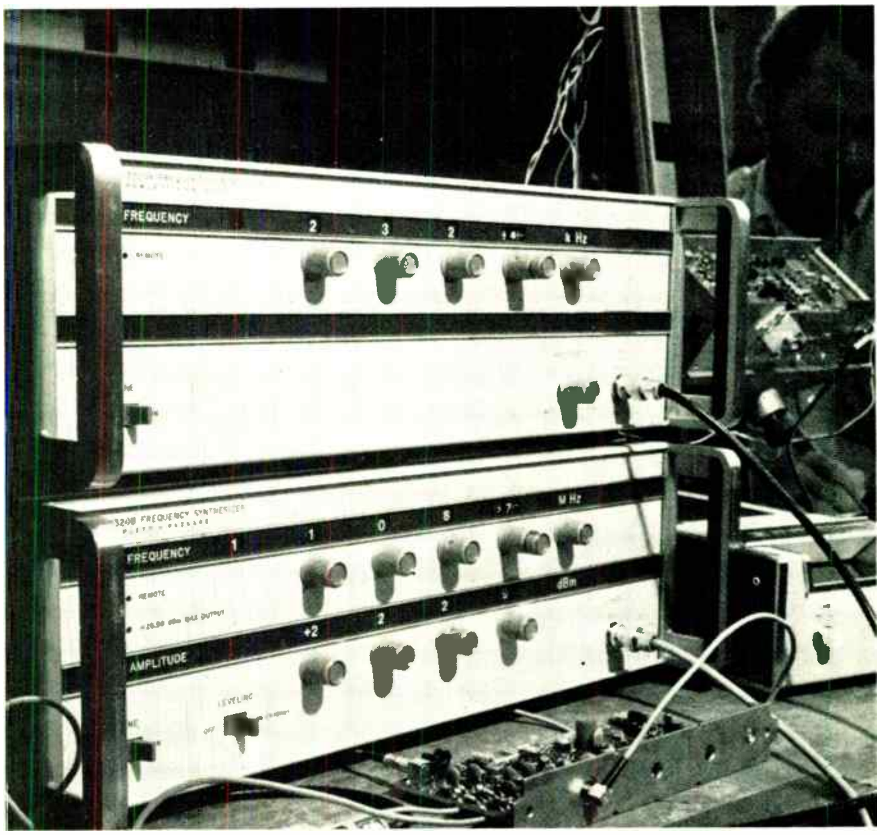
With a frequency of 0 to 13 megahertz in seven ranges, the 3320A/B is aimed at the communications industry. Last month, a frequency synthesizer introduced by Rockland Systems Corp. was priced at $2,450 and offered a frequency range of 0.0001 hertz to 2 MHz [*Electronics*, July 19, p. 107].

The 3320 models cover the range of most of the U.S. and European base bands, and so can handle long-distance phone lines, Picturephone services, and channels used by the telecommunications industry. "In those areas, accuracy is very important," emphasizes Bill Parazybok, product manager at H-P.

Three digits plus a 10-turn, two-digit continuous vernier and 30% overrange capability give the 3320 A/B a 1-part-per-million frequency resolution across its total frequency range. The instrument uses an ambient-temperature crystal reference which reduces drift to less than ± 10 ppm per year, and it can also be phase-locked to an external frequency standard or to an optional reference crystal oven.

The 3320A/B offers auxiliary outputs of 1 MHz and 20 MHz, plus a 20-MHz offset signal. And because the unit has selectable ranges, the signal-to-phase noise is reduced as the instrument is down-ranged. Spurious content is more than 60 decibels down, and harmonic distortion ranges from -60 to -40 dB depending on the frequency.

The model A provides a maximum 1 volt rms into a 50-ohm output (+13 decibel referred to 1 milliwatt) with a continuous +13 dBm to 0 dBm amplitude vernier. "This makes it applicable for situations



Instrument pacesetter. Frequency synthesizer priced in the $2,000 range can be programed directly and covers up to 13 MHz. It is particularly suited to telecommunications jobs.

where level control is not a critical parameter," adds Parazybok. In applications where high quality output amplitude is needed or it is desirable to digitally control the output amplitude, the model B is recommended.

The 3320-B features a four-digit leveling loop with a 0.01 dB level resolution of a calibrated output from +26.99 dBm to -66.99 dBm (-73.00 dBm under remote control). This is a maximum of a full half watt of output—five volts rms into 50 ohms or 10 volts rms into an open circuit. Frequency response is ±0.05 dB over the range of 10 kHz to 13 MHz, and level accuracy is ±0.05 dBm absolute at 10 kHz.

Digital remote control of level output is available only on the model B; the model A offers only output frequency control. However, the A can be ordered with an option that allows parallel BCD remote control of frequency. The first digit of the frequency vernier, the main frequency digits, and the frequency range may be controlled digitally.

The 3320-B has two remote control options. Both allow full control of all functions except the last vernier digit and the line switch. One option is a parallel BCD remote control capability. And another is a bit-parallel, word-serial ASCII programing option, which is used where several 3320Bs need to be controlled with one programing device. This ASCII option has eight input lines which allow direct interface to HP's 3260 marked-card programer, photo reader, or any other 8-bit controller. "This bus line programing," comments Parazybok, "means a saving of computer interface slots and a simplification of software. As many as ten 3320Bs can be programed in this way from the same 8-bit bus structure."

There are two leveling modes available on the model B's output level control circuitry. First, leveling-on can be used only when the unit is operating above 10 Hz, because the internal thermopile is a fast responding device and will not track sine waves below 10 Hz. All output circuits are inside the leveling loop. The leveling-off mode can be used at any frequency from dc to 13 MHz since the output level is measured at a high-frequency point. Several output circuits are outside the leveling loop and cause uncorrected variations in output amplitude because of temperature changes and other factors.

The desired level setting between -73.00 dBm and +26.99 dBm is entered either remotely or from the front panel. The setting enters the adder as a BCD number between -7,300 and +2,699. By adding a constant number (+7,300) to the input number, the figures are changed to 0000 and 9999. These numbers represent the 10,000 possible level settings.

H-P engineers used a novel design approach in the method of controlling the output level. The first digit of the four-digit number set by the operator can vary from 0 to 9 and it tells the 10-dB step attenuator, at the output, to introduce from 0 to 90 dBm attenuation.

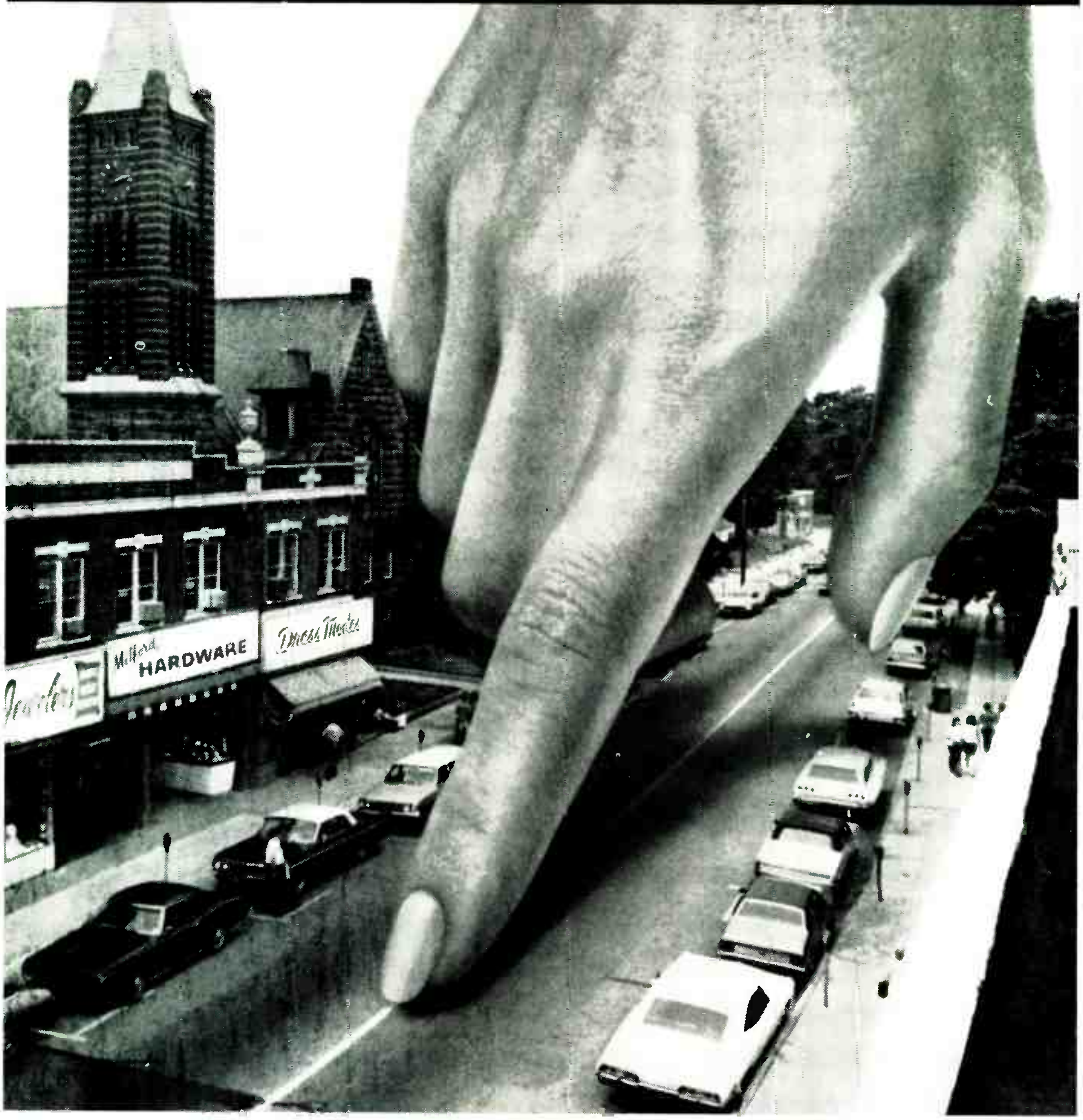
The remaining three digits vary from 000 to 999 and set a counter in an exponential digital-to-analog converter. At the same time the counter is being set, a precise 10-volt charge is applied to a capacitor. Next, the counter starts operating and the capacitor starts discharging through a resistor. As soon as the counter expires, the capacitor stops discharging and then the remaining charge is used as a dc reference level proportional to the setting of the 1 dB, 0.1 dB and 0.01 dB level digits.

This dc reference level is connected to the plus side of a summing differential amplifier and the rms value of the output voltage is connected to the minus side of the differential amplifier. The two inputs are summed and the dc output modulates a 20-MHz signal. This signal is filtered, then mixed with the synthesized 20-33 MHz. The level of the mixer output is controlled by the leveled 20-MHz input.

The mixer output is filtered twice and amplified twice, then attenuated by from 0 to 90 dB.

Delivery of the 3320A/B will begin in September.

Hewlett-Packard Co., 1601 California St., Palo Alto, Calif. 94304 [338]


HARDWARE

Subassemblies

A-d converter is fast, tiny

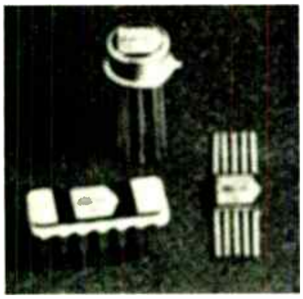
6-by-4-by-2-inch unit has 8-bit parallel binary output at 6.67-MHz word rate

"Good design and clever packaging" is a trite phrase that just happens also to be true when applied by Michael I. Neidich, product manager for ILC Data Devices Corp., Hicksville, N.Y., to a group of high-speed analog-to-digital converter modules his company developed.

Data Devices' Video a-d converter (VADC), for example, offers 8-bit resolution at a parallel word rate of 6.67 megahertz. These specifications are not unusual—except that they belong to a Lilliputian converter measuring only 6 by 4 by 2 inches and priced at only $3,000. Competitive units in this resolution and speed range, Neidich asserts, cost anywhere from three to four times as much, and occupy a standard 19-inch rack.

Along with the 8-bit converter, Data Devices offers a $595 nanosecond a-d converter (NADC) module which, when combined with a $395 video signal sample and hold (VSSH) module, provides 4-bit resolution at a 20-MHz rate. (The 8-bit converter actually includes two 4-bit and two sample-and-hold modules.) Each of the smaller modules is separately encapsulated in a rigid foam with a low dielectric constant and soldered to a printed circuit card. Two such cards, containing timing and logic circuitry in addition to four modules, are bolted together to form a complete 8-bit converter.

About specific circuit details in the three units, Neidich says only that Data Devices uses some "very clever discrete-component designs." These components are off-the-shelf high-speed transistor-transistor-



Operational amplifiers for instrumentation applications are available in five types and cover the temperature range of -55°C to +125°C. Designated series monoOP-08, they are available in TO-99, DIP or flat pack configurations. Price in TO-99 at 100 lots is $6.75 to $54.40. Precision Monolithics Inc., Space Pk. Dr., Santa Clara, Calif. [381]

Program equalizer model PEQ-4 provides control in the frequency range of about 200 Hz to 7,500 Hz in which most of the sound energy is concentrated. Unit has six selectable low frequency points for each peak and dip position, and can simultaneously boost or attenuate from 200 to 1,000 Hz. Lang Electronics Inc., 14 E. 39th St., New York, N.Y. [382]

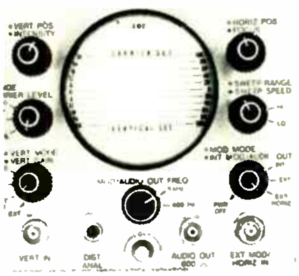
AGC linear amplifier model 5888 offers digitally programable time constant and override capability of the AGC loop. Unit is packaged in 3.125 by 2.625 by 0.625 in. module for pc board mounting, and is designed for audio, pulse and video signal systems. Price is $321-$290 depending on quantity. Optical Electronics Inc., Box 11140, Tucson, Ariz. [383]

Power supplies M-5-20 are for military, industrial applications where line voltage excursions are common. Units operate from 90 to 150 v ac, 45 to 1,000 Hz, and 90 to 240 v dc, interchangeably. No modification, derating is required. Price ranges from $170 to $250 depending on power. Aaron-Davis Co., S. Beverly Dr., Los Angeles, Calif. [384]

CMOS digital multiplexer features a buffer circuit which permits output to float. When package is inhibited, multiple outputs may be connected to build multiplexers for as many channels as desired. Unit has p and n channels on same substrate. Price is $19.90 and $29.50 depending on model. Siliconix Inc., Laurelwood Rd., Santa Clara, Calif. [385]

Synchro to digital converter measures 3.5 by 2.5 by 1.5 in. and accepts input from a 26 v or 115 v synchro. It provides a 12-bit binary or 4-decade BCD output that is ±6 arc minutes accurate. Maximum conversion rate is 400/s over temperature range 0°-70°C. Price is $350. TMI Div., Transmagnetics Inc., 210 Adams Blvd., Farmingdale, N.Y. 11735 [386]

Amplifier chain in L band consists of four cascaded stages providing maximum of 3 ms pulse width at maximum duty cycle of 0.1%. Output is 10 kw and peak power ranges from 16 watts to 10,000 watts within the four stages. Chain rise, fall time is less than 100 ns. Price is under $10,000. Acrodyne Industries Inc., Montgomeryville, Pa. [387]

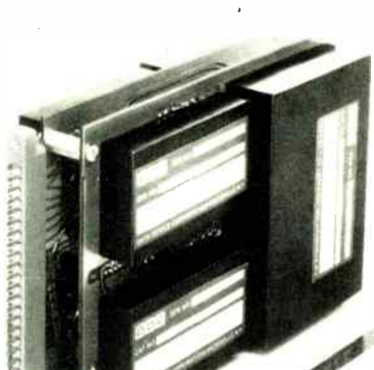


A-m module OAM-1 is for the company's FM-10 and FM-10C service monitors. Unit provides oscilloscope display of recovered audio for visual checking of transmitter problems, and measurement of percentage modulation. Plug-in supplies test tones of 400 Hz, 1 kHz. Price is $600. The Singer Co., 3211 S. LaCienega Blvd., Los Angeles, Calif., 90016 [388] logic and linear IC devices; a hybrid film and active chip approach is not used.

In particular, Neidich singles out proprietary field-effect-transistor buffer amplifiers which in the 8-bit converter produce an input impedance of 10 megohms. This compares with the 50 or so ohms usually available. The higher input impedance means that substantially less power is required from the input signal to drive the converter. And in the VSSH unit, the FET buffer amplifier produces an input impedance that is an "unheard of" 10^{11} ohms, Neidich says.

The input amplifier has an unusual combination of parameters. It is wideband—150 MHz—and maintains better than 0.1% linearity for the converter across the input voltage ranges of ± 2.5 volts or 0 to 5 V. This linearity contrasts with the 1% or 2% of other converters, says Neidich. Aperture time for the new unit is quoted at less than 300 picoseconds although Neidich believes it's probably in the 75 to 100 ps range. Accuracy is plus or minus half the least significant bit.

Speedy. A-d converter modules offer a fast word rate, are packaged to save space.



Data Devices uses a two-step parallel conversion technique in which the first 4 bits are converted in about 40 nanoseconds, the second 4 bits in an additional 120 ns. The parallel, rather than serial, conversion makes for a smaller converter, Neidich points out. It's also possible, he suggests, to interleave converters to yield 8-bit resolution at a 13.3-MHz word rate.

The units do not contain their own power supplies but must rely on power from the system they're in. Power must be at 15-V levels, plus or minus "a lenient 2%," according to Neidich. Temperature range of the units is broad, from 0 to 70°C.

The modules will be in production by the end of August, with delivery of "moderate quantities" in 4 to 8 weeks.

ILC Data Devices Corp., 100 Tec St., Hicksville, N.Y. 11801 [389]

3½-digit panel meter sells for under $100

If any one factor can delay the widely predicted replacement of analog panel meters by digital versions, it's probably price. And if $100 is the magic figure, then Datascan Inc. has made the breakthrough. The Clifton, N.J., company's new 610 is a 3½-digit, unipolar device that sells for $95 in 100-unit lots.

Moreover, there's no big price jump to the bipolar version, the 620. Since Datascan engineers use a single-slope technique for converting analog signals, the basic design can be adapted to bipolar work with just a few extra components—and for an extra $6. Datascan estimates that 70% of users want bipolar meters.

The tradeoff, relative to dual-slope integration, is accuracy. For both the 610 and 620, readings are to within 0.1% of full scale, ± 1 digit, somewhat higher than is possible with dual-slope meters.

The two units are available with ranges from 100 millivolts dc to 100 volts dc, with 100% overrange a standard feature. Stability is 0.015% per degree centigrade, and response time is 150 milliseconds. Temperature range is 0° to 60°C, and warmup time is 5 minutes.

A standard feature on both meters is a hold-and trigger circuit. This allows the units to display a single reading continuously, and then, when commanded by a trigger

Uncased. Low-priced digital panel meter is offered in unipolar and bipolar versions.

signal, to take another reading and begin displaying the new value. An optional feature is a binary coded decimal output.

A potentiometer adjustment is available on the back of the meter for zeroing the bias current. This increases accuracy of the instruments.

Designed primarily for OEM uses, the basic meters come without cases (Datascan engineers say that most customers prefer mounting the units in existing packages). However, the company is also offering an aluminum case for $5.

Samples of the 610 and 620 are available now, and production quantities are scheduled for initial delivery in October.

Datascan Inc., 1111 Paulison Ave., Clifton, N.J. 07013 [390]

10-bit digital-analog converter sells for $29

Taking aim at the very large OEM market, Analog Devices is offering more bits per dollar in its modular 10-bit digital-to-analog converter, priced at $29 when purchased in 100-unit quantities.

In addition, the type DAC-10Z converter has a very short settling time. When operated with its own output amplifier, it settles to one-half the least-significant bit (0.05%) within 5 microseconds—an improvement by a factor of four over its nearest competitor, the company says.

The unit is also available without an output amplifier. The type number then becomes MDA-10Z, settling time stretches to 300 nanoseconds, but the pricing remains the same. Both the DAC-10Z and the MDA-10Z also feature a low temperature coefficient of 30 ppm/°C.

A change in the manufacturing process accounts for the converters' precision performance at low cost. Analog has returned to printed circuit boards, and abandoned the usual practice of placing all converter circuitry on a glass substrate.

Analog found that considerable breakage occurs as switching transistors, reference circuitry, and the output amplifier are mounted, soldered, and tested before being trimmed by sandblasting to meet specifications. Since input-output pins are also anchored on the same glass substrate, there are further stresses during installation.

Besides mechanical failure, the stresses also cause a semipermanent deviation in resistance values within the precision thick film resistor network. The net result, in many instances, is a linearity error.

According to Fred Molinari, converter products marketing manager, the DCA-10Z converter remedies these problems without sacrificing the advantages and economies of the thick film fabrication. In the new module, only the resistor network is produced by a thick film deposition process. All other interconnections are placed on a standard high-quality pc board, which also carries the external pin connections.

The substrate with the resistor ladder is plugged into the main pc card after all other components have been mounted and soldered. Molinari says that damage through handling is drastically reduced.

Molinari sees the market for converter products changing and maturing. "Until recently, shipments of d-a converters were characterized by very few OEM orders, and pricing was biased to give low-volume users a distinct incentive to buy one and try one." Analog's new pricing structure, he points out, allows the 100-lot purchaser almost a 50% price advantage over the customer who buys just one.

Analog Devices Inc., Route 1 Industrial Park, Norwood, Mass. 02062 [340]

Broadband rf amplifiers can fit in coaxial line

Usually, broadband rf amplifiers are expensive instruments and they are large and bulky. But Electro-Data Inc. has developed two miniature amplifiers that fit in a coax line and require no more space than a large connector.

One is the model A-4, priced at $125 and featuring a minimum of 20 decibels gain from 5 to 400 megahertz, with a maximum noise figure of 6 dB over the range.

The second and more expensive amplifier, model 1 A-10A, is priced at $350, has a minimum gain of 15 dB from 20 to 1,200 MHz and a maximum noise figure of 5 dB.

The A-4 has BNC input and output connectors; it is three inches long and one-half inch in diameter and weighs one ounce. The A-4 requires 24 milliamperes at +20 volts, and input and output impedances are 50 ohms nominal. Several units can be cascaded for additional gain, with only minor effect on the frequency response.

"The combination of low cost and a miniature package is possible because we can get maximum performance from the transistors that are used in the amplifier," says F.E. Reisch, manager of engineering for Electro-Data.

The smaller model A-10A is two inches long including the three-millimeter coax connectors. It is also one-half inch in diameter but weighs only three-quarters of an ounce. Impedances are 50 ohms, and the power requirement is 15 v at 34 mA. The A-10A can also be cascaded for higher gain if this is needed for a specific application.

Options available for the A-10A include BNC connectors for an overall length of three inches and the same $350 price. A supply voltage that can be provided through the output connector sells for $360. A laboratory version (A100) with an integral power supply for 115 v ac is priced at $460.

Electro-Data Inc., 1621 Jupiter, Garland, Texas 75040 [350]

Microwave

Ferrite is aimed as YIG substitute

Titanium-doped magnetic material promises to cut costs of components

Microwave designers generally have no option when seeking magnetic material for their applications—it's yttrium iron garnet (YIG) or nothing. Because of its high cost, YIG is usually reserved for the most sophisticated isolator, circulator, and phase-shifter applications. But the research and development laboratory of the Ampex Corp., Redwood City, Calif., has developed a new line of ferrite materials to be used in place of YIG, promising to significantly reduce the costs of these microwave components.

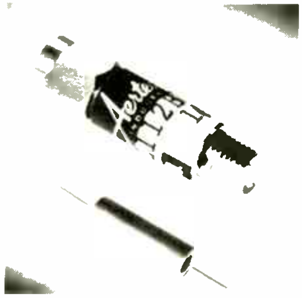
Ferrites couldn't offer the combination of low saturation magnetization levels with the relatively high Curie temperatures required for isolators and phase shifters. But Ampex's material, a polycrystaline, titanium-substituted lithium ferrite, "offers the same characteristics as polycrystaline YIG but at half the price," says Joel Zneimer, manager of the ferrite materials department at Ampex Corp.

"We developed the material in four general areas that people are working in—low power, high power, wide temperature, and low loss—to get a feel for what is needed," he adds. "Then we adjust to specific needs. After all, YIG came about in the late '50s and it took a couple of years to determine exact specs."

Ampex expects the same route to be followed with the new ferrite and intends to work with customers to come up with the right ferrite for a specific job. The material is available in rectangular toroids, slugs, pucks, and in isostatically pressured bars. What's more, their size, shape,

Type N male terminations, mismatches, TNM series, act as impedance references for swept VSWR, and reflection coefficient measurements from dc to 11 GHz. Units are suitable for laboratory or field. Four models range in price from $40 to $55 in small quantities; set of four is $195. Merrimac Research & Development Inc., Fairfield Pl., W. Caldwell, N.J. [401]

Thin film attenuators models UTF-015 and UTF-040 are designed for use with the company's series of amplifier modules and can be inserted anywhere for gain control. Units are packaged in TO-8 transistor cans and provide flat attenuation over 7-octave bandwidth. Avantek Inc., 2981 Copper Rd., Santa Clara, Calif. 95051 [402]

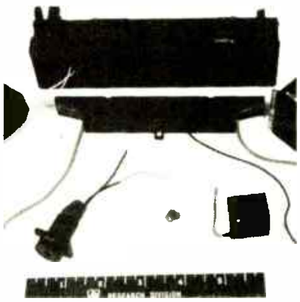


Broadband limiters cover frequency range of 1 to 12.4 GHz, have typical threshold of 15 mW in L band, and 5 mW in X band. Units are integrated into coaxial transmission line structures. Model A9L112A is modular type, A9L112B is available with 3-millimeter connectors. Aertech Industries, 825 Stewart Drive, Sunnyvale, Calif. 94086 [403]

Amplifiers series WJ-5102 cover 3.4 to 4.2 GHz and have a 7 dB noise figure. Other features include ±0.3 dB gain flatness, ±25 dBm intercept point, and 1.2:1 VSWR. The microstrip design utilizes chip components. Gains from 10 dB to 50 dB are optional. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Pk., Palo Alto, Calif. [404]

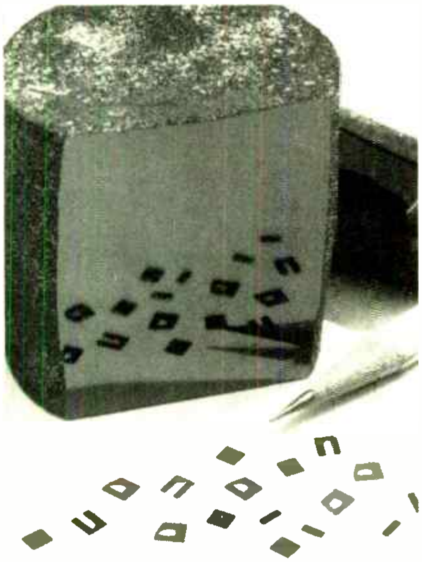
Dual two-stage nonreciprocal YIG filter XN-2201 offers two channels designed in a common package. Isolation between input and output ports is greater than 15 dB across operating frequency range of 8.0 to 12.0 GHz. Bandwidth at 3 dB is 30-50 MHz, tuning sensitivity is 17 MHz/mA. Advanced Microwave Labs, 825 Stewart Dr., Sunnyvale, Calif. [405]

Gunn oscillator model S-75A1 features voltage tuning with linearity of ±0.5% over 200 MHz range at X band. A high impedance varactor tunes without use of equalizing network, allowing tuning rate of at least 100 MHz. Power output is 10 mW minimum. Sonoma Engineering and Research Inc., 760 Montecito Center, Santa Rosa, Calif. [406]



Neodymium-glass laser weighs 16 ounces, and because of its size can be adapted for small optical ranging devices such as hand-held binoculars. Miniaturization of circuits in modular form is achieved by using epoxy resins. Output is over 1 MW with less than 20 joules input. American Optical Corp., 15 Mechanic St., Southbridge, Mass. [407]

Klystron model VKX-7753 offers 12.5 kW cw amplification with 125 MHz, 1 dB bandwidth, and frequency range of 7.9 to 8.4 GHz. Unit is designed for satellite communications ground station service, and has an automatic channel tuner. The tubes are liquid cooled and electromagnet focused. Varian, 611 Hansen Way, Palo Alto, Calif. [408]



Cut to fit. Ferrite can be custom-designed for a variety of microwave applications.

electrical characteristics, and magnetic properties can be custom engineered. Ampex is offering an individual ferrite for each of the four general areas.

Type 0 material is for use where low coercive force and high remanance magnetization are required—in low-power phase shifters, for example—and it also offers uniformly low magnetic and dielectric losses. Type 1 ferrite is for use in high-power phase shifters. Both 0 and 1 are magnetically similar to YIG and provide good square-hysteresis-loop characteristics. Types 2 and 3 are for circulators and isolators. Temperature stability is the significant factor in type 2: it does not change with temperature. Type 3 ferrite provides narrow line widths for low loss and for off-resonance devices.

Ampex is the only supplier of the new ferrites, and, says Zneimer, "We can vary the materials' characteristics by doping and mixing, and changing the power-handling capability. And, all things being equal, you can generally reduce the size of the ferrite component in a system because the ferrite has a higher dielectric constant."

Price of the titanium-doped ferrites is approximately $18 per cubic inch.

Ampex Corp., Ferrite Materials Department, 465 West Maude Ave., Sunnyvale, Calif. 94086 [409]

Data handling

Add-on memory includes buffer

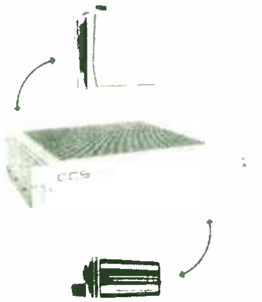
To cable drive circuits, cores look like main storage unit; can double 360/30 capacity

The technology of add-on core memories is not a new one. The challenge is to take that technology a significant step further, and Electronic Memories and Magnetics—a newcomer to the field—has done that with the Nanomemory 4850, a core memory for IBM 360 models 30, 40, 50, and 65. It can also be used to replace an original memory.

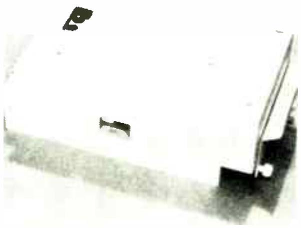
The significant step taken in the 4850 is an impedance matching buffer between the computer mainframe and the memory. This makes the memory look to the cable drive circuits like the one that IBM furnishes with the main computer. The 4850 also isolates the central processing unit from the memory, preventing possible damage to the cable drive circuits. Delay is no problem either. Says Richard Bravo, Computer Products division head, "The buffer box affects cycle time, but the memory is faster and that makes up for the delay."

In addition to add-on memory up to the capacity that IBM offers, the 4850 has the capability of exceeding IBM specifications. For example, the 360 model 30 has a memory capacity of 8,000 to 65,000 bytes, which EM&M can beef up to 131 thousand bytes. "Other suppliers offer enhanced capability, but nobody is quite in our range," Bravo states. But in order to provide this enhanced capability EM&M has to get into the computer, disable part of the invalid-address circuitry, and modify it.

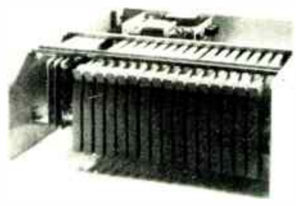
IBM has been looking the other way. It says it allows add-on core memories to its purchased and



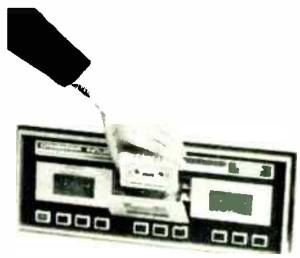
Computer interface unit model CCS-371 links Digital Equipment's PDP-11 with IBM 360 for bidirectional communication. Byte transfer rates are about 175 kHz, depending on model 360 used, and storage is two bytes per PDP word. Software package includes a diagnostic routine. Price is $9,500. Custom Computer Systems Inc., 40 S. Mall, Plainview, N.Y. [361]



Miniature tape recorder model DTU-250 for avionics and field computer diagnostic systems holds tape in a sealed cartridge. Bit-serial system has a per-track capacity of 2,400,000 bits on 250 feet of ¼-inch tape. Size of a unit for two tracks of write/read or four tracks write-or-read is 8 by 5 by 3½ in. Circuit Systems Corp., 816 E. Edna Pl., Covina, Calif. [362]



I/O modules series RTP7435 offer selection of pc cards for signal conditioning functions in company's RTP-7430 I/O system. Plug-in modules are compatible with most minicomputers. Selection includes communications interface, relay output, real-time clock. Price is $990 plus $60 per card. Computer Products, Gateway Dr., Ft. Lauderdale, Fla. [363]

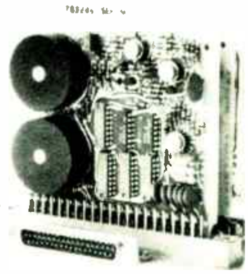


Cassette tape transport system model 2020 offers minicomputer user three independent cassette loaded tape drives, tape drive controller, interface, and software support. Simultaneous read, write is on separate decks. Price is $6,900, with OEM discounts available. Canberra Industries Inc., Computer Peripherals, 45 Gracey Ave., Meriden, Conn. [364]

Microfilm plotter called Beta Plot 100 can be connected with a computer, coupled directly to a display controller, or slaved to any graphic display. Model 110 is programable, has unbundled software, system options. Unit is offered for sale or lease, with OEM discounts available. Beta Instrument Corp., 20 Ossipee Rd., Newton Upper Falls, Mass. 02164 [365]

Digitizer called Gradicon converts any positional graphic information into usable digital form. Unit includes cursor, rear-projection graticule, servo system which allows cursor to be lifted from table without losing point of origin. Gradicon is available in three separate units or as complete system. Instronics Ltd., Stittsville, Ontario, Canada [366]

Punched card terminal C-10 Cardliner is for time sharing and batch applications, interfaces with most keyboard terminals including Teletype 33 and 35. Unit allows user to add card-reading capability, transmit information to central computer or other terminals. Price is $2,800 or $90/month rental. Tally Corp., S. 180th St., Kent, Wash. [367]



Synchro to digital converter card sets series 711 for computer interface equipment consists of three pc cards and plug-in motherboard, and uses tracking principles instead of a sampling method. Resolution is 13 bits, accuracy 0.05°, and tracking rate 1000°/s. Price is under $1,000. N. Atlantic Industries Inc., Terminal Dr., Plainview, N.Y. 11803 [368] rented equipment, but in case of breakdown IBM will maintain only its own equipment and at an increased service charge. As for rented machines, the company insists on the removal of any non-IBM equipment that causes damage to the computer or makes maintenance impossible. IBM does not explain what "damage" means, and although other companies have also been disabling the invalid-address circuitry, there has apparently been nothing done about it. If damage is irreparable, IBM says, it will "have to deal with each individual situation as it occurs."

Applications for the 4850 include real-time processing, electronic telephone and switching systems, automation and industrial control systems, medical and nuclear research instrumentation, commercial aircraft, video display, and radar data processing. The 4850 is field-expandable and uses a 3-wire, 3-d drive technique. Stacks and electronics are mounted on plug-in circuit boards and modules.

Full cycle time of the unit is 850 nanoseconds, and access time is 350 ns. System wiring lead lengths are kept short to minimize propagation delays. Storage capacity is 4,096 to 16,384 words of 40 bits, which can be organized if desired as 32,768 by 20. Two of these modules will fit in one rack, for a total of 65,536 by 20 bytes.

Operating temperature range of the 4850 is from 0 to 55°C ambient, in humidity of up to 95% RH excluding condensation. Input power is 110-115-120/220-230-240 volts ac, at ±10% accuracy over the frequency range of 47 to 63 hertz. The standard unit uses a twisted pair voltage mode interface that provides immunity from ground transients plus compatibility with most types of integrated circuits. The interface can be modified if required.

Options for the Nanomemory 4850 include a self-test facility, indicator lights for address and data, parity generation, and check.

Electronic Memories, a division of Electronic Memories and Magnetics Corp., 12621 Chadron Avenue, Hawthorne, Calif., 90250 [369]

Semiconductors

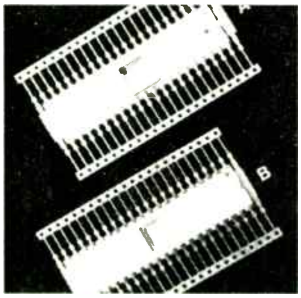
1,024-bit RAM is flexible

MOS memory in DIP seeks wide systems acceptance with three-level output

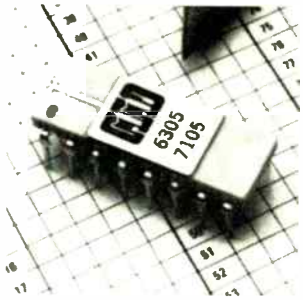
When it decided to enter the MOS memory market with a 1,024-bit random access store, National Semiconductor Corp. had its work cut out for it. Not only would it have to produce something equivalent to Intel's 1103—because the 1103 has been designed into systems and National is interested in follow-on orders—but National also would have to look ahead of the 1103. "So," says marketing manager Gene Carter, "We conducted a market survey to determine what kind of memory our customers wanted, and came up with the MM5260 with Tri-State output."

With Tri-State, the memory can be used with systems having common I/O busing, so that in addition to on, and logic 0 and 1 outputs, the 5260 has an off-bus mode. This eliminates the need for pull-up resistors and, in turn, saves space on the chip. Tri-State output also provides a wired OR capability.

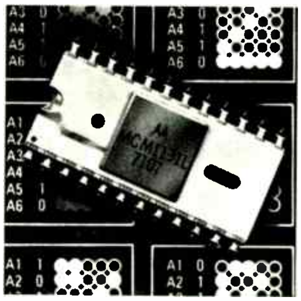
Users want a memory that's completely compatible with existing systems, Carter says. So the chip has 200-nanosecond access (350-ns maximum), operates on conventional power supplies, and has low power dissipation. But while the 1103 is packaged in an 18-pin dual in-line configuration, the 5260 comes in a smaller 16-pin DIP. Carter says the smaller package allows more bits to be packed in a given area of board space. "For example," he continues, "with the 5260 we can get 4,096 bits in one square inch, and because the sense amps are on the chip, the memory board is still further reduced in size." A 4,000-word-by-16-



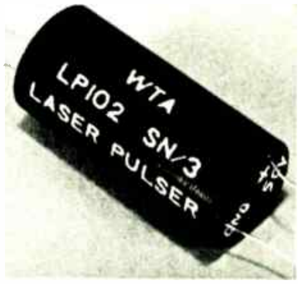
DIP packages with 24, 28, and 40 leads on 600-mil bending centers are available with new options and configurations including: wraparound lead frame, Kovar seal ring, and lead-to-dice attach pad connection which can be specified to a particular lead. Metalized Ceramics Corp., West River Industrial Park, Providence, R.I. 02904 [411]



Field programable 2,048-bit bipolar ROM uses fusible link technology requiring 90 mA for programing, no special equipment. Organization is 512 words by 4 bits. Price for MM6305 (temperature range 0–70 C) is $100-$195. For MM5305 (−55–+125°C), $140-$260. Monolithic Memories Inc., 1165 E. Arques Ave., Sunnyvale, Calif. [412]

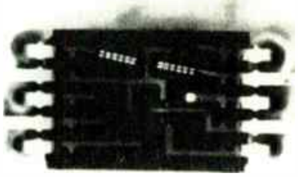


MOS integrated circuit character generator model MC1131L produces voltage patterns needed to form numbers, letters, symbols on LED arrays, cathode ray tubes. Unit is driven by address codes originating in computer or data source. Price is $14.60–$24.50 depending on quantity, type. Motorola Inc., Semiconductor Div., Box 20924, Phoenix, Ariz. [413]



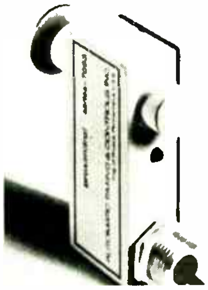
Laser pulser model LP-102 provides 100-ns-wide, 15-A peak current with 40 ns rise and fall times generated by internal clock. Other pulsers in hybrid IC forms drive laser diodes with 60-95% efficiencies at 36–150 v dc, 12–800 A. Small-quantity price is $270. Washington Technological Associates Inc., 979 Rollins Ave., Rockville Md. [414]

Infrared emitting diodes types 40843R and 40844R offer performances up to 3 mw at 50 mA, are packaged in OP-10 configuration for closely spaced pc board mounting. Units can be used with all types of silicon photodetectors. Price for 40843R is $1.95 and for 40844R, $2.50 in 1,000 lots. RCA Solid State Div., Rt. 202, Somerville, N.J. [415]



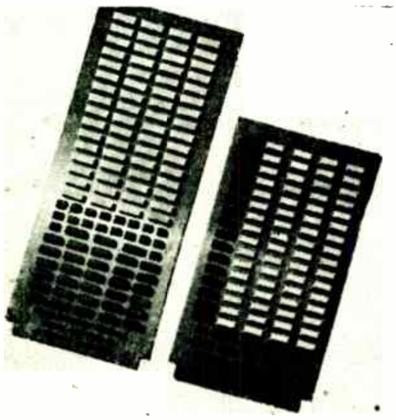
Polarity and overflow multipurpose display called Data-Lit 81 is a companion to Data-Lit 8 seven-segment display. It provides decimal point, left or right; colon, left or right; plus and minus sign; and percent sign. Unit mounts on 0.3 in. centers. Price is $7 to $9.90 depending on quantity. Litronix Inc., 19000 Homestead Rd., Cupertino, Calif. 95014 [416]

Integrated circuit op amps are housed in ⅛-by-¼-by-0.065 in. flat packs. Model MS 747 has offset null terminals, independent V⁻ terminals for additional power supply. Model MS N5558 features 10 lead package, input stages in close proximity. Price is $11.50 for 1–24. Mini-Systems Inc., David Rd., P.O. Box 429, N. Attleboro, Mass. 02761 [417]



Light emitting diode incorporated into proximity sensing unit acts as pilot light showing when an object is in sensing range of the device. Life of the LED is as long as the life of the sensing unit. It is suited for noisy environments. Price of the sensor with diode is $63. Automatic Timing and Controls Inc., King of Prussia, Pa. 19406 [418] bit board is three inches smaller using the 5260 than with the 1103, he says.

The MM5260, a fully decoded, dynamic 1,024-word-by-one-bit read/write RAM, uses low-threshold silicon gate technology to achieve bipolar (transistor-transistor logic) com-



Compact. Memory in 16-pin DIP, right, is designed to compete with 18-pin 1103 type.

patibility on all I/O lines, except on the precharge and read/write lines. "It's a systems-oriented device," says Carter, "in that the sense amps are on the chip and the address lines and chip-enable are TTL compatible." Cycle time is 450 ns minimum for read and 600 ns minimum for write. Refresh cycle time is 2 milliseconds, and memory expansion is provided by the chip-enable line.

Also, from a systems standpoint, Carter says that many new digital systems are using National's Tri-State logic devices, and the 5260 can be used with their common I/O lines.

The MM5260 is priced at $38.40 in lots of 100.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [419]

4-terminal solid state relay switches with 2-mA input

Solid state relays cost considerably more than their electromechanical equivalents. But, as Samuel R. Pearson, manager of advanced designs for Texas Instruments' Control Products division in Dallas, pointed out in introducing his TIH501 model, they are extremely reliable.

With no contacts to spark and weld, semiconductor relays have much longer lives, and are safe in such possible explosive atmospheres as may occur in hospital operating rooms. Relays of this type are directly compatible with IC logic, eliminating the interfaces required for zero-point switching, almost eliminating electromagnetic interference and reducing transients in motor-control applications.

For these reasons, says Pearson, solid state relays are becoming popular in computer peripherals and industrial control applications, and wherever else logic is used to drive motors, displays, solenoids or high-power relays.

TI's new solid state relay, according to Pearson, offers a unique combination of properties: the basic relay uses a triac output rated at 8 amperes at 140 volts, 60 hertz, while optical coupling between input and output gives 1,500-V isolation (100 gigohms). The four-terminal package, which Pearson says is vital in many applications where the solid state relay is to replace a mechanical one, includes zero-point switching as standard. Voltage across the triac rises to less than 5 V when the unit is turned on. Only 2 milliamperes input is required to switch the output, making the relay compatible with low-level logic. Off current, a problem in many solid state relays, is below 2 mA, and the unit operates at currents as low as 15 mA and supplies voltages as low as 15 volts.

The input to the unit includes diode reverse-polarity protection, and a current-limiting field effect transistor permits input overloads to ±150 V without damage. A diode and 1.6-kilohm resistor can be substituted at a lower price for applications where the protection is not needed.

The TIH501 is packaged in a molded case measuring 2.3 by 1.6 by 0.75 inches with four quick-connect/solder terminals. It costs $7 in 10,000 quantities.

Texas Instruments, Inc., Inquiry Answering Service, P.O. Box 5012, MS/308, Dallas, Texas 75222 [420]

New products/Materials

Polyimide prepreg system called Gemon L offers thermal resistance at temperatures up to 500°F, and can be laminated at temperatures as low as 350°F and pressures from 15 to 1,000 lb./in.^{2} Material withstands soldering and drilling fabrication temperatures, cures without emitting volatiles, and is reinforced with woven glass, hi-silica, quartz, carbon and graphite or boron. Application is for high performance circuit boards. General Electric Co., Insulating Materials Dept., 1 Campbell Rd., Schenectady, N.Y. 12306 [481]

High temperature ceramics in 94% or 96% alumina and steatite can be shaped into standard pressed and machine parts, are suitable as substrates for thick- and thin-film, and for standard hybrid circuits. Primary applications include substrates for photocell and optoelectronics devices, and as stand-off insulators. Mansol Ceramics Co., 141 Little St., Belleville, N.J. [482]

Epoxy system with thixotropic additives called Tra-Bond 2111 joins components to chassis parts or pc boards. System contains no solvents, cures at room temperature, and can also be used as an adhesive for rough or uneven surfaces unable to be brought into intimate contact. Tra-Con Inc., Resin Systems Div., 55 North St., Medford, Mass. 10255 [483]

Chemical stripper for polyurethane-based pc board coatings type 1063 dissolves film in less than an hour of exposure. Material is non-acidic and does not affect plastic or metals. HumiSeal Div., Columbia Technical Corp., P.O. Box 86, Woodside, N.Y. 11377 [484]

Crosslinkable polyethylene compounds for wire and cable insulation are flame retardant, generate low density smoke when caused to burn by high temperature or voltage arcs. Called Petrothene XL, material uses no halogenated polymers, is suitable for computer lead wire applications. U.S. Industrial Chemicals Co., 99 Park Ave., New York, N.Y. 10016 [486]

New literature

Solid state. Centralab Semiconductor, 4501 N. Arden Dr., El Monte, Calif. 91734, has published a 20-page catalog of its line of solid state products which include chips, hybrids, discretes, and optoelectronic devices. Circle [421] on reader service card.

Function generator. Electronic Instruments Div., Beckman Instruments Inc., 3900 River Rd., Schiller Pk., Ill. 60176. Model 9030 waveform generator covering frequency range from 0.0005 Hz to 1 MHz is described in company bulletin 2455. [422]

Ferramic material. Indiana General, Electronic Products, Keasbey, N.J. 08832. A 16-page catalog provides specifications on Ferramic material and components for design engineers. The design guide includes part numbers, materials properties, and inductance factors. [423]

Optical instruments. Opto-metric Tools Inc., Rockleigh Industrial Pk., Rockleigh, N.J. 07647. Optical instruments for inspection and measurement of microminiature parts are described in a comprehensive catalog. [424]

Terminal boards. General Electric Co., General Purpose Control Dept., Box 913, Bloomington, Ill. 61701, has available a 20-page catalog detailing its line of terminal boards and terminal board components. Specifications, applications, dimensional drawings, accessories, and ordering information are included. [425]

Film trimmers. Vishay Resistors Products, 63 Lincoln Highway, Malvern, Pa. 19355. A technical bulletin describes bulk metal film trimmer potentiometers and gives test results compiled by the company and dimensional layouts. [426]

Swept frequency measurements. Clarke-Hess Communication Research Corp., 43 W. 16th St., New York, N.Y. 10011, has published an applications bulletin illustrating techniques for utilizing function generators in swept frequency measurement. [427]

Batch terminal. M&M Computer Industries Inc., 770 North Main St., Orange, Calif. 92668. Key features, applications, and specifications on a family of intelligent, remote batch terminals are detailed in a 12-page catalog. Instruction list, installation, training and maintenance are discussed. [428]

Transducers. Sensotec Inc., 1400 Holly Ave., Columbus, Ohio 43212. Characteristics of a variety of semiconductor and foil strain-gage-type subminiature pressure transducers are discussed in a six-page bulletin giving selection and design information. [429]

Computer testing. Computer Sciences Corp., 9841 Airport Blvd., Los Angeles, Calif. 90045, offers a technical bulletin on small, automated testing facilities. Information on performance in various environments is included. [430]

Semiconductors. Semiconductor Div., Westinghouse Electric Corp., Youngwood, Pa. 15697, has published a 16-page brochure describing the company's line of semiconductor products. The format is designed to interface with current individual product selector guides. [431]

Engineering guide. Non-Linear Systems Inc., PO. Box N, Del Mar, Calif. 92014. A hardbound 395-page text details technical information on Non-Linear systems and subject information about theory, maintenance, application and calibration of digital voltmeters, data acquisition, computer and pressure systems, and MOS/LSI device testing. [432]

Minicomputer. Microdata Corp., 644 E. Young St., Santa Ana, Calif., 92705. General information, computer references, interface information, and preliminary programing details on the Micro 400 minicomputer are available in a 75-page manual. [433]

International Newsletter

August 2, 1971

SGS to merge into all-Italian combine

Semiconductor industry seers who predicted that Motorola and SGS would team up tightly after their second-sourcing deal last spring [*Electronics,* International Newsletter, Apr. 12] are now in the market for new crystal balls. Instead of a tie-up with Motorola, SGS will get a new Italian owner, an as-yet-unnamed company controlled by STET, the government's electronics-telecommunications holding company.

Into the unnamed company with SGS will go Ates Componenti Elettronici, owned jointly by STET and one of its subsidiaries. It's still not known whether SGS and Ates will keep their identities; at the very least the two will coordinate their production. STET's partners in the new company, each with a 20% share, are Ing. C. Olivetti & Cie and Fiat. Until IRI stepped in, Olivetti owned SGS. The company, like all semiconductor makers in Europe, has been beset by a lackluster market over the past 18 months. On top of that, SGS has had its own particular problems—labor troubles and a considerable bank debt.

British to test digital fly-by-wire autopilot

Elliott Flight Automation Ltd. is developing an all-digital autopilot to work with the Royal Aircraft Establishment's fly-by-wire electronic-electrical control-surface linkage system [*Electronics,* July 22, 1968, p. 164]. The combination is primarily for military strike aircraft and will fly in a test Hawker Hunter fighter within a year. The autopilot uses a single digital computer to process not only mode-selection data (climb, hold height, etc.), already processed semi-digitally in some other autopilots, but also all sensor input data. The computer is Elliott's standard 12-by-12 word design, using 256 words of read-only data store and 2,048 words of program instructions. All of the memory is semiconductor. The computer is surrounded by an interface taking digital or analog inputs and giving analog outputs.

Elliott men say all-digital construction allows quicker development—through software simulation—and easy self-test, as well as the usual pluses of simplicity and reliability. Further, in the fly-by-wire context the digital approach facilitates compensation for the maneuver-demand characteristics—variation of amount of control surface movement according to speed, to provide consistent dynamic response.

Japan eases rules on foreign ICs . . .

This month's planned liberalization of foreign investment in Japan for production of ICs, will be followed—probably late this year or early in 1972—by an easing of computer peripheral gear import restriction. Japan's minister of international trade and industry, Kakuei Tanaka, was in office less than three weeks when he disclosed that in three years Japan will allow the manufacture, sale, and leasing of electronic computers—including accessories and parts—by foreign interests.

By holding off liberalization of the key computer manufacturing industry for three years, the ministry hopes to allow the six existing domestic makers time enough to strengthen their competitive posture, with government assistance, and withstand the competition generated by foreign companies. In tackling the touchy computer liberalization issue and opening the door at least part way to foreign investment in the electronics industry, the government hopes to stem rising criticism in the U.S. about Japan's protectionist policies.

International Newsletter

... and will open up in computers

Once final cabinet approval is given to the MITI plan, foreign interests will be able to invest up to 50% in ventures that can manufacture ICs for color television sets, appliances, and for other electronic devices, excluding computers. In three years, they will be allowed to form 50% partnerships with Japanese companies to manufacture computer hardware, automatic control devices, integrated circuits for computers, and other computer parts. **The data processing industry, including computer software, will remain closed to foreign participation.**

AEG-Telefunken, Siemens drop large computer ...

Now that West Germany's two largest computer makers, AEG-Telefunken and Siemens have ended plans to jointly develop a "national" jumbo computer, AEG-Telefunken is burning the midnight oil on a new concept to present to Bonn's science ministry for government financial backing. **And it is rumored the country's small, but highly successful Nixdorf Computer AG may fit into the plans.**

AEG-Telefunken and Siemens, which have tried for a year and a half to get the project off the ground, announced last month that they were throwing in the towel, **because they couldn't see eye to eye on the terms for setting up the joint venture.** The science ministry, which had pushed the venture and was bitterly disappointed to get the news, is willing to talk over a new AEG-Telefunken proposal. **A Siemens official, meanwhile, says it will scrap all plans to develop a large national computer.**

... but Nixdorf may push project

The AEG-Telefunken decision to go ahead triggered speculation of a possible tie in with Nixdorf, which has already expressed interest in joining such a project. **That company's chief, Heinz Nixdorf, is a board-member of AEG-Telefunken's office machine subsidiary, Olympia Werke.** Although he opposed the AEG-Siemens link, believing it would stifle domestic competition, the picture has changed. Nixdorf could supply software and peripheral know-how, just as Siemens would have done, and benefit from AEG-Telefunken's development of the jumbo hardware.

A big difference, however, would be the lack of the powerful financial backing of Siemens. **Hence, an AEG-Telefunken/Nixdorf deal would likely demand a greater assist from Bonn. But it is far from certain how far the government will and can go.**

IBM pulls back on its Hanover IC expansion

After spending more than $14 million to establish a second semiconductor manufacturing facility in West Germany, IBM has decided that "recent technological improvements" in growing silicon crystals have eliminated the need for the new complex. IBM, which operates its current semiconductor plant in Sindelfingen, near Stuttgart, **decided to scrap plans for its new facility in Hanover, even as site preparation work was already underway.**

Now IBM wants to sell back the $5.7 million piece of land it purchased in February 1970 from the city of Hanover, the capital of economically-depressed Lower Saxony, which bent over backwards to lure IBM to the area. **It even relocated the city's race track to give IBM the only piece of land it felt was suitable.** Local officials estimate more than $10 million in city funds were spent to the anticipated IBM move. However, 172,000 square feet of temporary production space, established on an interim basis in rented buildings near the planned building site, will continue in production for another 12–18 months.

Master and working masks come from one automatic machine

Japanese combine computer, optical pattern generator to make both original and step-and-repeat masks

A lash-up of a numerical control computer and an optical pattern generator has automated fabrication of IC photomasks at the Electrical Communication Laboratory of the Nippon Telegram and Telephone Public Corp. Equipped with a 10-× reduction lens, the system can make both intermediate master masks and step-and-repeat working masks.

The automatic photomask exposure unit is an optical pattern generator consisting of a xenon lamp, a slit which can be varied in length, width and angular position, the 10-× reduction lens, and a precisely controlled table for positioning in the X and Y directions. Normally the pattern is generated as a series of rectangles. A pattern with 500 rectangles can be generated in about 30 minutes. Circles or slanted lines can be generated by rotating the slit.

Tape drive. Overall control is by a Fujitsu Fanuc 250 numerical control computer, which controls five axes simultaneously—width and length of slit, angle of slit, and X and Y positions of table. This computer has 16,000 words of memory, permitting operation directly from computer-aided design tapes.

The automatic exposure unit, produced by Dainippon Screen Manufacturing Co., includes sufficient electronics for the table to operate closed loop, with a diffraction grating providing high-precision feedback signals. Positioning accuracy is ±1 micron. The minimum dimension of the slit is 100 microns, variable upward in 50 micron steps. The 10-× reduction lens, though, gives a minimum dimension of 10 microns variable upward in 5 micron steps.

Steps. Usually this automatic photomask exposure unit is used to generate individual IC patterns 10 times the size of the device to be made, with a maximum size of 3 inches square rather than the tablecloth size originals generated at the start of the conventional process. These patterns can be inserted in the exposure unit in place of the slit, and then the lens and precision table enable the unit to be used as a step-and-repeat camera.

The unit can also generate actual size patterns for IC interconnection and discretionary wiring. For this type of application the 10-micron minimum width and 1-micron position accuracy should be sufficient.

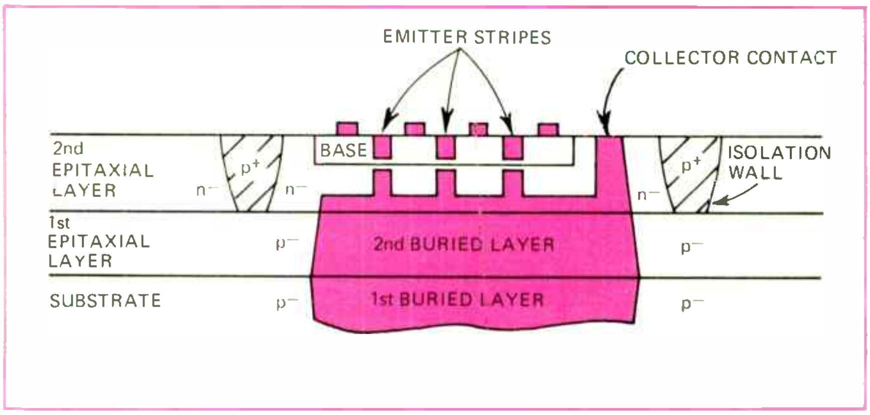
Great Britain

Control of logic IC doping ups speed/power ratio

In making bipolar logic integrated circuits, the doping level of the collector region has to be a compromise. A high level is needed to give a low resistance path immediately below the emitter. However, a low level is needed to give specific capacitance over the base-collector junction. Practicable compromises are usually around 10^{16} impurity atoms per cubic centimeter.

Researchers at Mullard's Research Laboratories are developing a construction technique that will let the collector have it both ways: high doping almost up to the base immediately under the emitter, and low everywhere else. In experimental transistors made so far, they have maintained a level of 10^{16} atoms per cm^2 just below the emitter and re-

Cross-section. Mullard's researchers call their devices profiled collector transistors.



duced the bulk collector doping to 10^{15} atoms per cm^2. The effect has been to reduce collector-base capacitance to about half what it would be in a normally constructed transistor with the same base-emitter geometry, and also to reduce capacitance where the collector meets the isolation wall.

ECL. Charles Fuller, team leader at the Mullard Labs, says this reduction can be used to get a better speed/power ratio in logic ICs and will be particularly useful in emitter-coupled logic, where collector-base capacitance usually forms an important part of propagation delay (the voltage change at the junction is effectively twice the logic swing voltage change). However, Fuller will not build any logic ICs using his new technique until he has simplified it so that it's compatible with normal IC manufacturing methods.

Basically, the technique, called profiling, is to extend upwards towards the emitter a selected portion of the n+ buried layer that constitutes the low resistance collector path to the surface contact. This is done by ordinary outwards diffusion methods. Fuller says the critical factors are to make sure the out-diffused finger has the right impurity concentration when it arrives at the base region, and that it gets to the base directly under the emitter. Furthermore, the gap between the bottom of the base region and the bulk of the buried layer on either side of the fingers must not become too narrow during the out-diffusion to accomodate the particular depletion layer width for the bias conditions of the transistor.

Test. Fuller's experimental devices use the same emitter-base geometry as the Philips BFY-90, 1.5-gigahertz transistor, to simplify measuring the effects of profiling the collectors. This transistor has three emitter stripes. The substrate is p-type with impurities at 5×10^{14} atoms per cm^2, into which arsenic is diffused to produce an n+ buried layer with a surface concentration of 5×10^{18} atoms per cm^2. This is covered with a 5-micron thick, low doped p-type epitaxial layer. Arsenic is deposited onto the top of this layer to the same surface concentration as before in localized regions in line with where the emitter stripes and the collector contact will eventually be.

A second 5-micron epitaxial layer cm^2) n-type to provide the low specific capacitance in the base-collector junction away from the emitter regions. This complete structure is then heat treated, so that the first n+ buried layer diffuses up through the first epitaxial layer to meet the localized surface deposition, which simultaneously diffuses up through the second epitaxial layer towards where the emitters and the collector contract will be, arriving at base depth with a concentration reduced to 10^{16} atoms per cm^2.

Goal. To simplify processing, Fuller plans to cut out one of the epitaxial layers. He says he can deposit onto the substrate surface two impurities, arsenic and phosphorus, the second of which diffuses much faster than the first. On top of these two impurity layers he puts down a single low-doped, n-type epitaxial layer. The arsenic deposition is laid out to diffuse through as the bulk buried layer, and the phosphorus to form just the extended fingers to the emitters. If everything is just right the phosphorus and arsenic will both get to the right places in the right concentrations at the right time, in a single heat treatment. Fuller can control the arsenic and is working on the phosphorus.

West Germany

Now a computerized fishing trawler

The West German science ministry is financing a 15-month study to determine the feasability of computerizing the nation's commercial fishing fleet operating in the North and Baltic Seas. Two Bremen electronics firms—ERNO-Raumfahrttechnik and Krupp-Atlas Elektronik—plus a ship-building company called Seebeckwerft in nearby Bremerhaven—are working on the $175,000 study.

"What we want to develop is a computerized system that will locate a school of fish relative to the position of the boat, then spit out data for the course and speed required to attain proper positioning for the fish catch, plus data on when and where to deploy the net and how long to leave it out," explained Hartmut Schulte, the contract manager at the science ministry. "We also want to have the winches and other mechanical equipment tied into the system, so they can be activated and run automatically."

Human. "Right now the catch is dependent on the quality of the captain," says Volker Graefe, project manager on the study for Krupp-Atlas. "The captain is essentially a data processor—he finds the fish and determines from his sea-sense when to fish and when to haul in the nets. What we want to do is make him more efficient."

"The capital investment for a modern fishing boat runs about $5.7 million," says Graefe. "If we increase the catch by 10%, then I think an additional cost of $570,000 per boat can be justified."

Echo sounders with sets of transducers will be placed at the top of the net opening. While hardware is currently available that provides accurate depth readings, Graefe says advances must be made to provide a "looking-forward capability" on the net electronics, so that the position of the net in relation to the ship can be tracked.

"The nets are always behind the ships, but often currents will cause them to shift to the right or left, so a boat can go right over the top of school but miss it with the net," he says.

"We are also studying the possibility of backward-looking sonar mounted on the ship, but there are problems with this approach, since the equipment would have to look back through the turbulance of the boat wake."

Once the catch begins, the timing involved in bringing in the net can be critical. Krupp-Atlas is studying sound-transducer systems which would provide accurate data on the amount of fish entering the net per unit of time. This would not only be available in a digital readout for the captain's use, but could also be fed directly into the computer, which would determine when to active the winches to bring the nets out of the water.

The Netherlands

Yet another improvement on nitride isolation

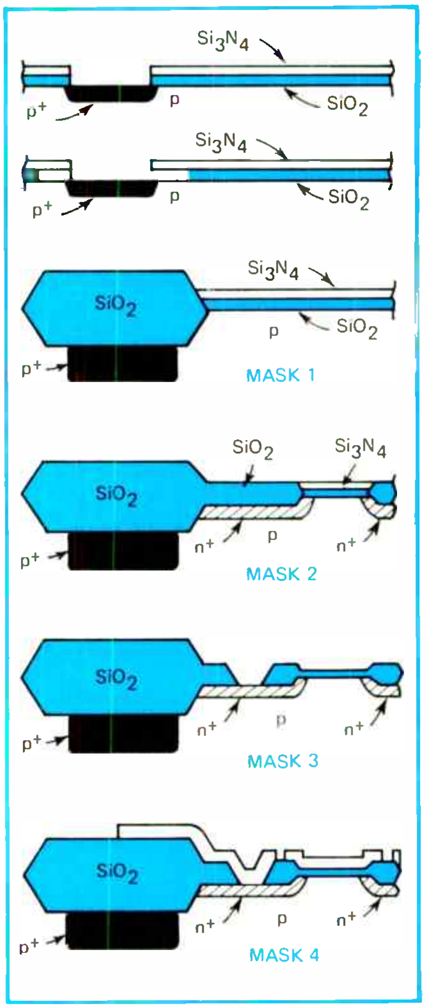
For the past two years or so, semiconductor makers around the world have been playing a highly specialized game of leapfrog. Every time one bounces to the front of the line with a new technology for faster and denser integrated circuit arrays, another has soon come from behind to hurdle still further ahead.

In IC isolation, Philips Gloeilampenfabrieken was one of the first to leap ahead with something substantially better than the conventional pn isolation, a month before the Italian company Societa Generale Semiconduttori (SGS) unveiled its Planox MOS structure at a semiconductor devices meeting in the U.S. In the fall of 1969, Philips researchers bared their very similar Locos technique for isolating with oxide at a conference in England.

Since then, Fairchild Semiconductor has come up with a way to extend the technique to bipolar ICs with its Isoplanar process [*Electronics*, Mar. 1, p. 52] and now Philips has wrought some significant improvements on its version of the technique, putting it, apparently, at the head of the line again.

Nitride first. All these techniques have much in common. They all depend, for example, on the fact that silicon nitride stubbornly resists oxidation. Mask off what will be the active areas of an IC chip with a thin layer of nitride, then, and it's possible to grow thick, precise local deposits of silicon dioxide on a substrate. (Locos, in fact, is an acronym for local oxidation of silicon.)

What's more, the oxide is at least partly countersunk into the silicon, something that's difficult to do with conventional planar technology.



Foursome. Philips' nitride process gives countersunk oxide with only four masking steps. Called Locos II, the method saves on chip real estate.

The countersunk oxide brings double advantages: there's only a small step at the edges of active-area windows to set up weak spots in the metalization. But more important, the countersunk oxide as isolation saves a lot of real estate. "You can gain as much as 10 microns on each side of a 40-micron active element," explains Else Kooi, who now heads the Locos development effort at Philips' research facility in Eindhoven.

Effective as the countersunk oxide alone is for isolation in bipolar circuits and for field oxide in MOS circuits. Philips has found a way to make it even better for tightly packed MOS circuits like memories and diode arrays. "It's quite simple if you know how to do it," says Kooi. The key: buried channel stoppers beneath the countersunk oxide isolation, a technique Philips calls Locos-II.

Philips has found a way to produce channel-stopped Locos-II devices with just four masking steps. The process starts with growing or depositing an oxide layer a few hundred angstroms thick on the substrate and then putting a nitride layer about 1,500 A thick atop the oxide. After that comes the first masking step: opening windows for the channel stoppers.

Next. Then comes a boron diffusion to obtain the p+ stopper regions, followed by an etch with hydrofluoric acid, which attacks only the oxide and thus leaves an underetched rim of nitride around each window. Oxide is then grown in the windows, this forces the p+ areas down into the substrate, where they become buried channel stoppers.

Masking step number two opens the windows for the source and drain diffusions. The remaining two steps provide windows for making contacts and finally for metalization.

In this way n-channel MOS structures, hard to fabricate conventionally, can be made as easily as p-channel devices. The n-channel devices are inherently fast, of course, because electrons in an n-channel move faster than do holes in a p-channel. Experimental four-by-four memory arrays that Philips has made are an example of how much faster. P-channel units fabricated conventionally have cutoff frequencies of 2 GHz. Locos gives a cutoff frequency of 4 GHz.

Uses. MNOS memories fabricated by Locos-II combine high speeds during the read cycle with the possibility of high-voltage write pulses, the latter because of the channel stoppers.

Another important application for oxide isolation is in charge coupled devices. Philips is working on MOS bucket brigade analog memory units and expects they'll reach speeds of 10 megahertz.

Channel-stopped vidicon silicon-diode arrays also perform admirably. Experimental devices show no blooming at 20 volts, where some conventionally made arrays show a splotch of overbright white.

Japan

Microwave oscillator sires other products

Although a microwave burglar alarm is the first product using its germanium microwave oscillator, Matsushita Electronics Corp. is seeking a number of consumer applications for it—including mini-radars.

Matsushita, which is a joint venture of Matsushita Electric Industrial Co. of Japan and Philips Gloeilampenfabrieken of the Netherlands, is also developing a number of other applications for the germanium oscillator, including an automobile air bag actuator.

Intruder. The first item ready for market is a microwave burglar alarm, which the company expects to start selling in November. Initially price will be $1,380, which will drop in the future when increased production allows. Matsushita is now producing the alarm itself but will probably transfer production to the parent Japanese company when demand becomes large.

The alarm operates at 10.4 gigahertz and utilizes the straight-line propagation characteristics of microwaves. Energy striking a moving person in the room is reflected back with a Doppler shift. The shift signal is received with a minimum of complication, because in addition to serving as microwave source, the germanium microwave oscillator acts as a receiving mixer. A discriminator circuit connected to the mixer/oscillator provides audio output whenever a Doppler-shift signal is received. An audio amplifier further amplifies the signal and drives the alarm circuits.

Hiroyuki Mizuno, who developed the microwave germanium oscillator, says that excellent signal-to-noise ratio of the device enables it to provide these two functions while operating at a very low power level. Radiated output is less than 1 milliwatt, yet the alarm can be used in an area as large as 80 feet high by 83 feet long by 70 feet wide. When adjusted to maximum sensitivity, the alarm is actuated by the slight motion from breathing of a man who is standing still. However, sensitivity can be reduced so that alarm will not be actuated by cats or dogs even though it will be activated by a human prowler.

France

Electronic controls knit complex fabric patterns

A group of French electronics engineers took up knitting about five years ago—looking for profit rather than a pastime. The result is the computer-controlled UTRAS knitting machine, which leaves makers of mechanical controls wondering how they can pick up their stitches.

Designers of knitted goods can use the new programing and machine control system to expand the complexity of their patterns well beyond the limits of classic knitting machine. UTRAS can operate with 36 or 48 spindles of yarn mounted on a circular machine, feeding 2,000 needles and producing an endless cylinder of cloth 180 centimeters in circumference. The developer's objective was to come up with a system of electronic programing and machine control that could produce complex, four-color patterns over 5 square meters.

Teamwork. To design the machine, engineers at the Société d'Electronique Industrielle et Nucléaire (SEIN), collaborated with knitting machine builders of the French firm Etablissements Georges Lebocey. SEIN will furnish the electronic equipment and Lebocey will assemble and market the machines.

It is SEIN's first sortie into the knitting business, and technical director Jean Goupil says it was a profitable one. The machine already is operational at a Lebocey plant in Troyes, 75 miles southeast of Paris. SEIN still is developing new accessories for the system to give textile makers a choice of methods to get their designs into and out of the computer.

Lebocey machine-makers had decided that the conventional method of controlling needles with an elaborate rotating spiked drum—similar to the principle of music-box mechanisms—was too costly to "program." The design could be altered only by manually snapping off the spikes that mechanically operated the needles.

SEIN engineers, after first learning how to knit, have developed a color photoelectric scanner that reads the artist's design point-by-point, feeding the data stitch-by-stitch into an IBM 3 magnetic-disk memory with a 10-million-bit memory capacity. The memory then relays the design to a Digital Equipment Corp. PDP-11 computer, which transfers the data onto a reel of 35-mm film in the form of transparent or opaque microdots. The dots then serve as an optical memory of the design—each dot representing a stitch.

The SEIN-Lebocey system opens the possibility of knitting a pattern large enough for an entire dress, or for a large piece of upholstery. On conventional machines large knitted patterns contain the same small design repeated several times. The electronic system also cuts programing time by eliminating the old rotating needle-control drum. SEIN claims a reliability factor of one error in 500 million stitches.

Goupil says a special problem that arose during development was how to keep the knitting machine in production without a second's interruption when the film comes to its end. His engineers solved it by putting two sets of microdots on the film—one set to be read as the reel turns clockwise, the alternate set to be read counterclockwise. To avoid a momentary pause as the film reels reverse, a buffer memory is used.

Another system for "canning" the design is being developed at SEIN's laboratories—a magnetic tape cassette that serves the same purpose as the film. SEIN also is working on a light pen/CRT input for textile artists.

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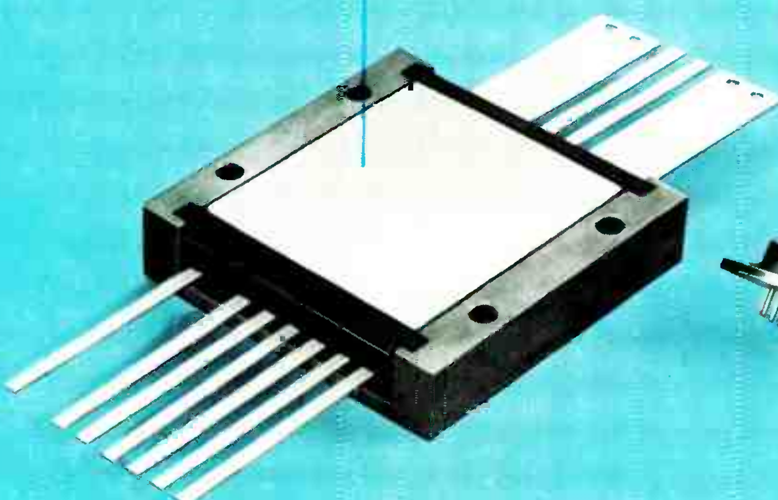

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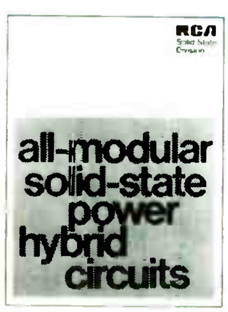

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