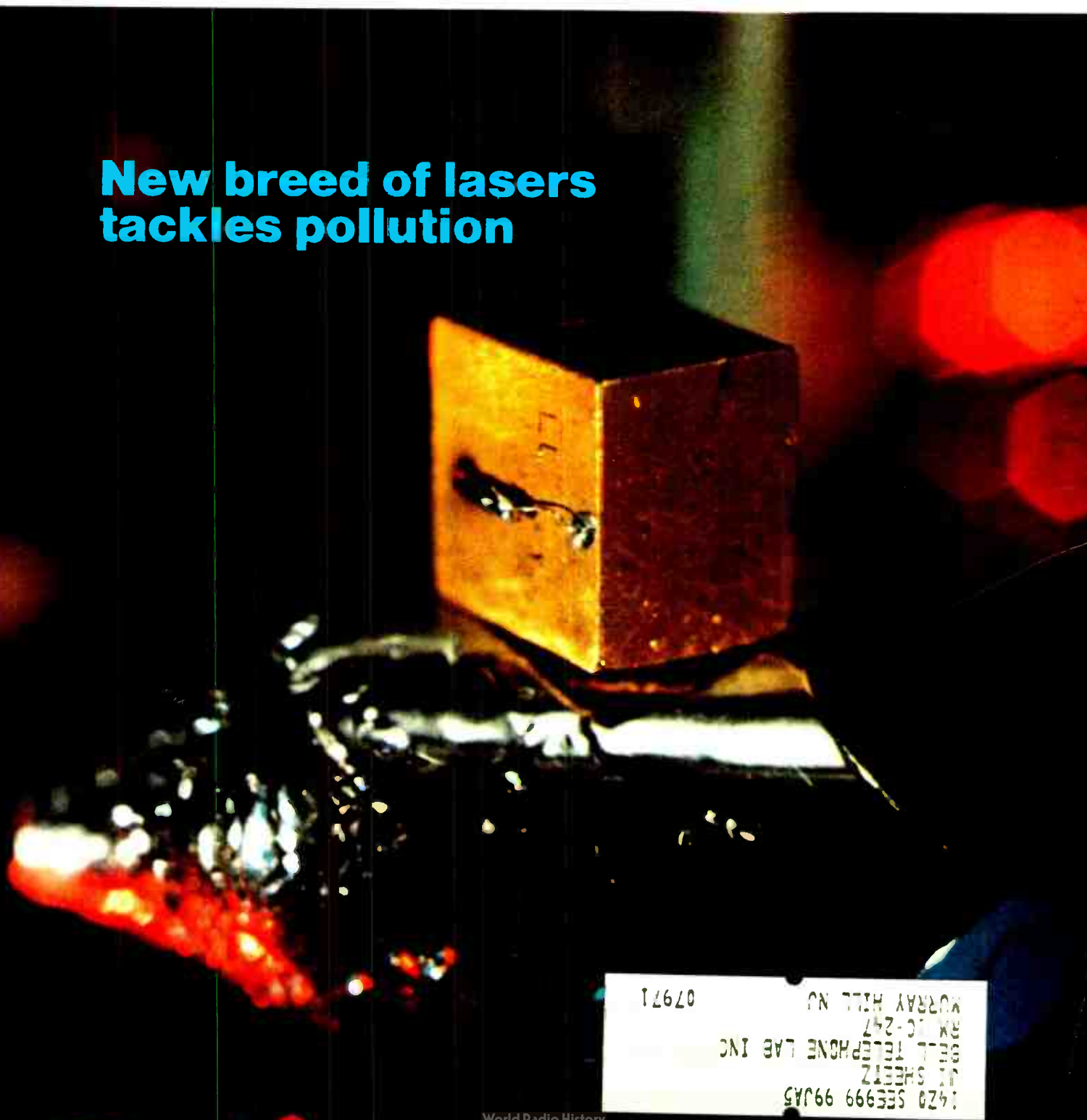


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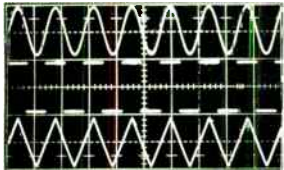
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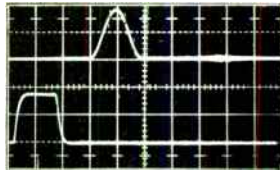
outperforms any signal source from 0.0001 Hz to 11 MHz



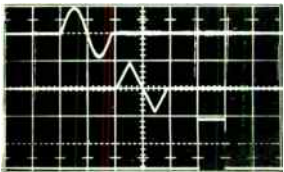
new function generator works harder, operates easier



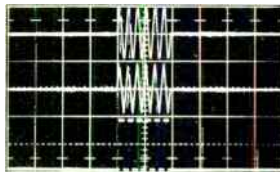
Sine, square and triangle waveforms.



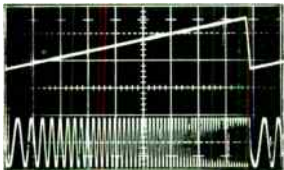
Sine² pulse (top waveform) and 100 ns pulse (bottom waveform).



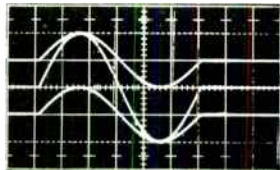
Single shot waveforms.



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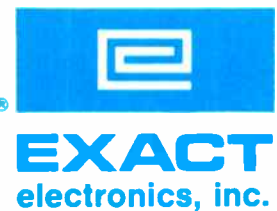
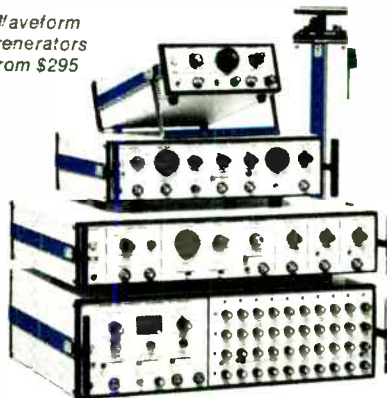
As a pulse generator, the Model 7060 produces pulses with widths variable from 100 ns to 1000 seconds, and repetition rates from 0.0001 Hz to a full 11 MHz. Ramp waveforms with ramp times from 100 ns to 1000 seconds are another first in this instrument.

The Model 7060 sets the pace in D.C. offset, too, with the ability to select either fixed positive or negative or variable ± 10 V offset. Offset also can be externally programmed with an analog voltage.

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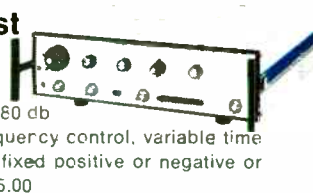


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Publisher's letter



Roundtable. Our articles on the EE's career spawned a radio panel talk. Casper Citron (left) hosted *Electronics'* Gerald Walker, EE Harvey Bloom, and Harvard's Paul Thompson.

Every so often the pages of *Electronics* present articles that have fallout beyond the electronics industries. This was certainly the case the first week in December, when our consumer editor, Gerald Walker, appeared on a national radio talk show hosted by Casper Citron. With him were a worried Harvard Business School professor and a concerned engineer.

Walker had headed the team of editors that produced our 24-page special report on the EE and his career [June 7, p. 55], which was the subject of the program. Also on the panel was Paul Thompson, assistant professor at the Harvard Business School, who was the subject of another *Electronics* article on the EE's career, "How managers misuse engineers" [Oct. 25, p. 109].

The third member was Harvey Bloom, an engineer whose participation was triggered by yet another *Electronics* article. This was the report on whether engineers should unionize [Sept. 27, p. 72]. Bloom sent in a ballot on the union issue, but also included a comment that he

would like to participate in any public forum that would help bring to light the plight of the engineer.

The questions covered during the half-hour program did just that. Thompson pointed out that engineers, particularly in the aerospace industry, reach educational obsolescence earlier and earlier, and that continuing education programs do not seem to reverse the trend. He said that new approaches, such as sabbatical leaves, may be needed to keep engineers current.

Bloom brought these points into personal perspective. He astonished Citron by suggesting that a lack of job security and early obsolescence are the normal way of life for EEs, despite the stature of technology.

"Citron's reactions," says Walker, "were much like those of the general public—disbelief. In fact, if his understanding of the issues is typical, then I feel our participation was worthwhile."

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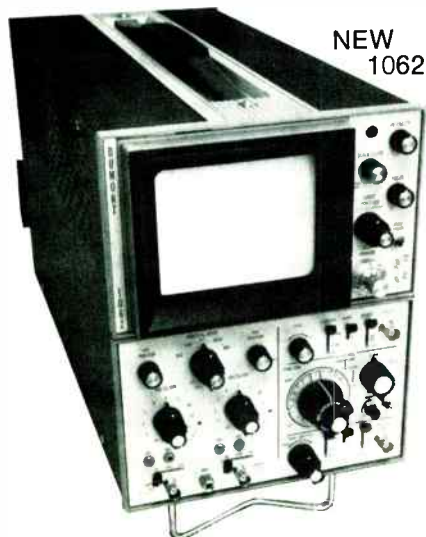
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Readers comment

Who's in charge?

To the Editor: Let a 30-year pilot assure you that airline pilots' "coolness" toward the FAA's "overworked" ground controllers gets to be a lot more like "frigid" when it comes to being "unwilling to depend entirely on their instructions and judgment" [Aug. 2, p. 26]. The article brings up the important question of who is ultimately in control, and says that final authority for control of aircraft "would probably continue to rest with the ground-based controller." The regulations clearly state (FAR 91.3a): "The pilot in command of an aircraft . . . is the final authority as to the operation of that aircraft." In 1960 and again in 1965, FAA proposed rule changes that would have given controllers pseudo-authority, but was unwilling to shift concomitant responsibility to the controllers and thus had to drop the proposal. So the pilot continues to be the final authority. This has been borne out in dozens of appeals court cases that consistently held in accord with the explicit regulation that the pilot—not the controller—is directly responsible and has final operational authority. The only way the authority can be shifted to controllers is by shifting the operational responsibility. It's a sticky problem, but, for now, the pilot is stuck with it.

Allen W. Hayes
President
Chartair Inc.
Ithaca, N.Y.

■ *Reader Hayes is correct about the letter of the law. However, much in the way a ship's captain takes the advice of a harbor pilot to maneuver his vessel into port, an airline pilot relies on the ground controllers at an airport when he approaches a terminal.*

Mask-making

To the Editor: The article on automatic machinery for mask-making [Electronics International, Aug. 2] was of considerable interest to me because I conceived the identical idea on May 25, 1965. A manually operated version of the machine was built in our shop and has been in regular operation since November 1968; a numerically controlled ver-

sion is being built by us and will have dimensional accuracy and picture-element size increments almost identical to those mentioned in the article.

The manual unit has positional accuracy of ± 50 microinches and continuous adjustment of picture elements. With monochromatic light and a small optical field, an Airy resolution of 500 line-pairs/mm is achieved for any single element with a relatively inexpensive lens. Since mask-making is direct at 10 times final size, resolution is more than adequate compared to the limiting 2,000 line-pair/mm specified for the high-resolution plates used in the step-and-repeat process. With appropriate program organization each picture element can be completed in about 20 seconds, much shorter than the time needed for cutting an equivalent area in opaque-overlay material. Program time for the manual machine with complex arrays can be substantial, but for simple projects, such as isolation diffusions or microwave ICs, the masks can be made in less time than that required to place opaque-overlay material on the coordinatograph.

Alexander B. Bereskin
University of Cincinnati
Cincinnati, Ohio.

To the Editor: The article on "Solid state invades Detroit" [May 10, p. 105] neglected to emphasize the real value of solid state electronics in the vehicular market. Since both consumers and Government are demanding more reliability and greater performance in terms of cost/function, the needs will be satisfied if redundant components and assemblies can be eliminated through more reliable primary functioning units, via solid state, and more sophisticated electromechanical assemblies.

Norman Rautiola
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To the Editor: The International Newsletter of Sept. 13 contains a

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The speedy new MH0026 has also been designed to be driven from standard DTL/TTL circuits.

All in all, the MH0026 is a welcome addition to a line of clock drivers which already includes the industry's only TTL compatible clock

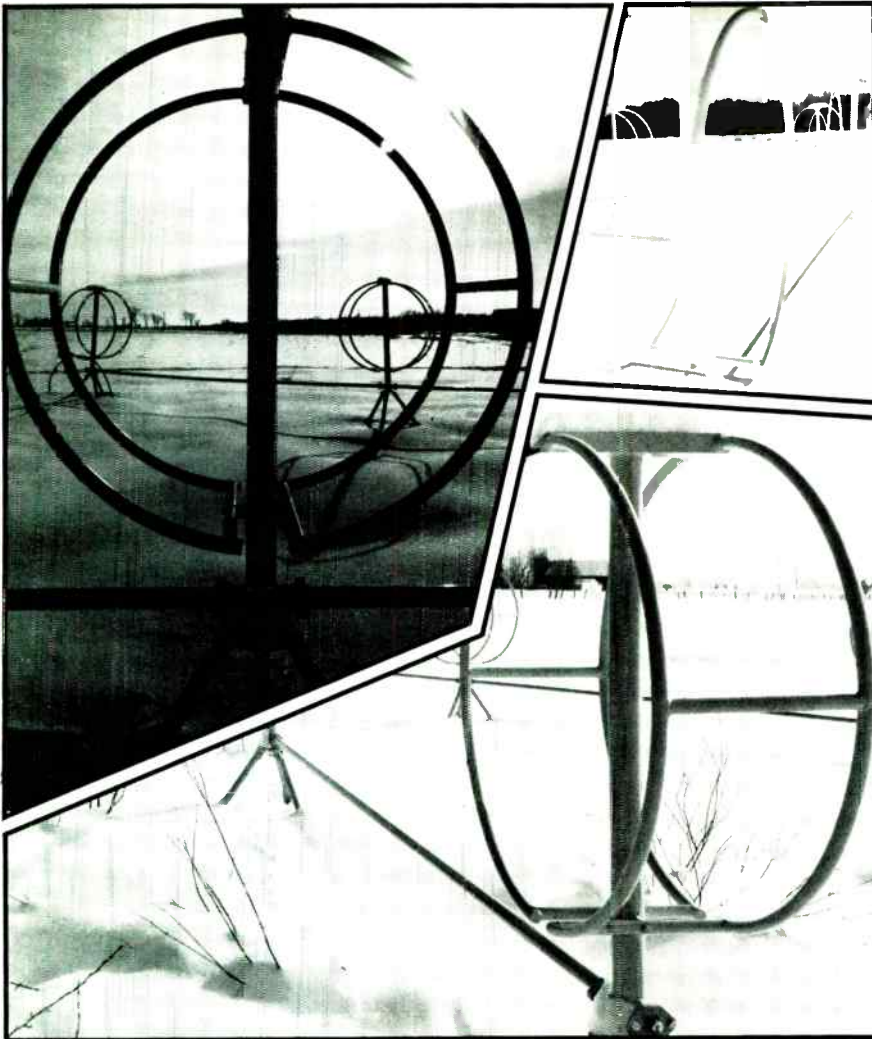
driver (MH0007), one capable of dc operation (MH0009), a 10MHz clock driver (MH0012), a dual ac coupled driver (MH0013), the world's first monolithic (the low cost MH0025) and a TTL-to-MOS memory interface driver (MH0027).

Incidentally, our drivers are available in TO-5, TO-8 and one watt mini dip packages.

For clock drivers, it would behoove you to write, phone, TWX or cable us today. (Although orders more than a week old will also receive prompt attention.)

National Semiconductor Corporation,
2900 Semiconductor Drive, Santa Clara,
California 95051. Phone (408) 732-5000.
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National



Communications Men Think Big Small

The Canadian Broadcasting Corporation uses aperiodic loop antenna above ... and that's big and small.

Big ... at Britannia Heights, near the nation's Capital at Ottawa, Canadians listen to the world.

Small ... CBC listens on the aperiodic loop antenna which is only 50 meters in diameter in Rosette array.

Big ... Its omni-directional, point-to-point, broad band, long and short range receive capability is big enough to replace vast rhombic or log-periodic antenna farms.

That's why, whenever communications men think big and small, Hermes Electronics Ltd. supplies the aperiodic loop antenna to government agencies and military forces around the world.

Roof mountable, fast set up, small spaces, big jobs, or just below ground level it snows a lot at Canada's Britannia Heights.

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Hermes Electronics Limited

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2020 F Street N.W.
WASHINGTON
D.C., 20006
Telephone 202 296-2978
TWX 710-822-1106

Readers comment

reference to the development of a multiplex carrier-frequency system with a capacity of 10,800 voice channels to be put into operation in Sweden. The impression is given that Siemens AG of West Germany was the only manufacturer involved in this project. This is incorrect: LM Ericsson Telephone Co. of Sweden designed the terminal equipment that makes the new transmission system possible.

Ralph W. Bugli
The Bugli Co. Inc.
New York City

More on mnemonics

To the Editor: As a chemist who is trying to keep up, the suggestion that mnemonics be defined in each article [Aug. 30, p. 6] seemed like a good idea, although a bit overdone. Now [Nov. 8, p. 83] that I see stack and silo defined and misdefined on back-to-back pages, I am more inclined to cast my vote with reader Jensen [Nov. 8, p. 6], who was appalled at the idea of such things appearing in a trade journal. Would it serve your readers on the fringes of the field—and not offend insiders—to publish in your magazine a well-proofed glossary of terms only once or twice a year?

E.L. Servoss
Prairie Village, Kan.

To the Editor: In the Aug. 30 issue, p. 6, I note that Mr. Strommen finds himself struggling with the modern electronics alphabet, and asks that you publish a decoding list with brief definitions of abbreviations. We are interested in this matter and wonder if you have, in fact, printed such a list.

B. Hofberg
Bo Palmblad AB
Stockholm, Sweden

■ *Reader Servoss' letter was the first in—regretfully not the last—to spot our inconsistency. For the record, a stack memory handles data on a first-in, last-out basis; a silo does it first-in, first-out.*

As for the request by Messrs. Servoss and Hofberg for a glossary, we'll continue to define jargon for the non-specialist, eschewing it for long-accepted terms in wide usage.



GE PRESENTS THE NEW POWER-GLAS™ SCR.

General Electric introduced the original SCR in 1957, and now presents a new SCR series that capitalizes on the General Electric **POWER-GLAS™** process . . . the C220 series. Rated at 10 amperes with blocking voltages up to 500 volts, the C220 series SCR's are available in three standard industrial packages—press fit, stud and isolated stud. Through the use of **POWER-GLAS™** passivation, General Electric now offers the most reliable SCR's available.

POWER-GLAS™ provides a proprietary glass formula and deposition process that improves upon normal passivation techniques. It creates an intimate void-free bond between the silicon chip and the matched glass. The resulting stable low level "off state" current significantly improves DC blocking life stability.

For the full story on **POWER-GLAS™** passivation, C220 reliability and a free sample write on company letterhead to General Electric Company, Semiconductor Products Department, Electronics Park, Bldg. #7, Mail Drop 49, Syracuse, N.Y. 13201.

GENERAL  ELECTRIC

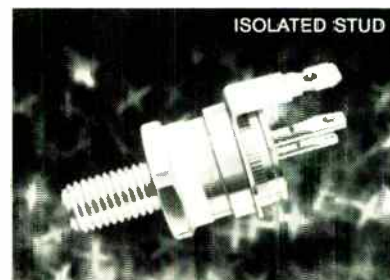
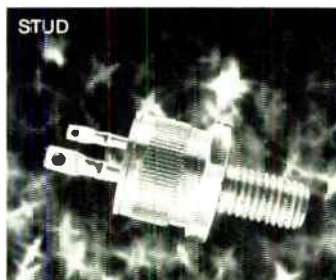
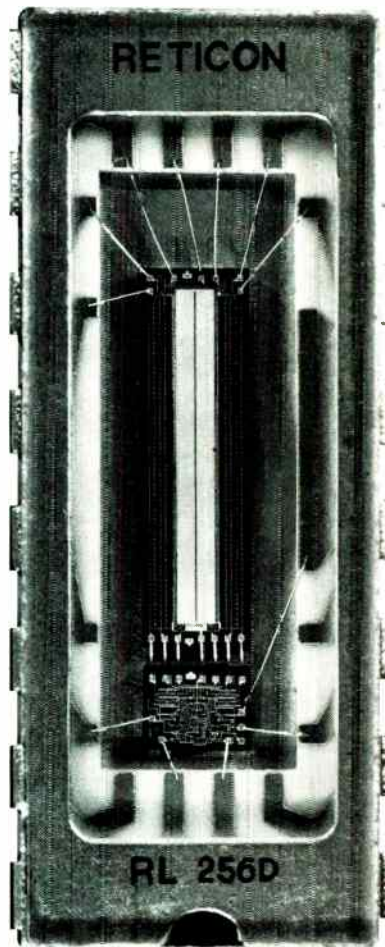


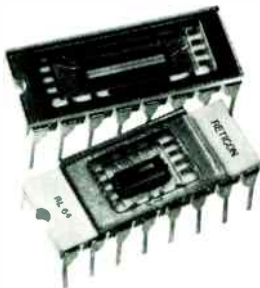
IMAGE RESOLUTION



Now . . . Obtain remarkably high resolution from an all solid-state image sensing device—the RETICON RL-256. Using silicon-gate MOS technology, this monolithic scanning array is designed for page reader, facsimile, process control and TV camera applications. As a major breakthrough in microelectronic image sensing the RL-256 offers:

- high resolution—256 elements on 1 mil centers.
- on-chip scanning for serial output on a single video line.
- charge storage mode operation for high sensitivity.
- choice of external or internal TTL compatible driver circuitry.
- choice of external or internal video amplifiers.
- scan rates from 1 KHz to 10 MHz.
- programmable resolution (128 or 256 mode).
- standard 16 lead dual-in-line package with sealed glass window.

Other devices, among RETICON's linear array family, feature 64 elements (RL-64) or 128 elements (RL-128) on 2 mil centers. All with single video lines. All units with or without TTL compatible driver circuitry. All in standard 16 lead DIP package with glass window. All available from inventory.



RETICON™

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(415) 964-6800

40 years ago

From the pages of *Electronics*, December 1931

The business index may be scraping bottom. Security prices may be testing new lows. International finance may be faltering as to its next move.

But never were human ingenuity and scientific resourcefulness more active. Out of the energies and advances now incubating are being created new industries and new arts. They in turn will create the new demands and new markets.

In the new 33-story home of *Electronics*, oscillating Pliotron tubes and relays level the five high-speed express elevators, and the four express passenger elevators. To cause the relay to close its contact, the car's travel brings a metal plate between grid and plate coils spaced one inch apart. When the plate has entered 1/16 of an inch into this space, the oscillations (200 kc) of the tubes have ceased, the plate current has increased and the relay started to work. Five triodes are used on the high-speed elevators.

The effect of light on the conductivity of metallic selenium was observed as early as 1851 and has been used in the production of light sensitive elements since 1873. From that time the construction and utilization of the so-called "selenium cell" has received much attention from both scientist and layman. The characteristics were slowly improved, but those familiar with the literature of these workers and their critics will understand the meaning of such terms as "time lag," "temperature effect," "instability," and others used to describe the deficiencies which have so hindered the practical application of these devices.

Now, the engineer has turned to selenium as a likely answer to the need for a rugged, stable, highly sensitive photoelectric device.

After long political delays, broadcasting powers of 50 kilowatts have just been granted to a number of important American stations by the Federal Radio Commission, but this still leaves the United States far behind other nations in point of the powers of its broadcasting stations.

The Digital Multiplier.

It can multiply two 8-bit signed numbers in 135 nanoseconds. But that's just the beginning. Look:

Delays and Package Count

We have a super-fast, super-flexible, monolithic digital multiplier. It is the only one in the world.

It's the Am2505. It multiplies a 4-bit number by a 2-bit number and adds the 6-bit product to another 4-bit number. $S = XY + K$.

An array of 2505s multiplies two signed numbers in 2's complement representation, adds a third number in 2's complement representation, and gives you a double-length signed result also in 2's complement form.

You can make any size multiplier you need. (For longer word lengths, build a bigger array. If you add a few of our high-speed ALUs, the Am9340s, you can go even faster.)

The Am2505 can multiply numbers in active HIGH level (positive logic) or active LOW level (negative logic).

The Am2505 is ideal in digital filters, Fast Fourier Transform Processors and minicomputers.

But the most important feature of the Am2505 is that it's here, in quantity, all you need.

If you're doing digital signal processing or even thinking about doing it, call us or Hamilton/Avnet.

Array Size	Number of Am2505s for 2n bit product	Number of Additional Am9340s	Typical Delay Times ns. at 25°C			
			Level of Adders Am9340			
			0	1	2	
8 x 8	8	0	135			
12 x 12	18	5	205	155		
	18					
16 x 16	32	7	275	185		
	32				16	180
	32					
20 x 20	50	9	345	220		
	50					
24 x 24	72	11	415	255		
	72				24	215
	72					
28 x 28	98	13	485	290		
	98					
32 x 32	128	15	555	325		
	128				32	250
	128					

Circle 240 on reader service card

Advanced Micro Devices, Inc.

Telephone 800-538-7904 toll free, and ask for Shel Schumaker, or in California 408-732-2400. In Los Angeles, Steve Zelencik at 213-360-2102. In Mid-America, Chuck Keough at 312-297-4115. In the eastern United States, Steve Marks at 212-343-2220, or in Boston, Vince Sabella at 617-861-1550. 901 Thompson Place, Sunnyvale, California 94086/TWX 910-339-9280/TLX 346306.

The GR Systems Family



GR Resistance Anodize Trim System
Circle 221 on reader service card



Micronetic's Laser Trimming System
Circle 220 on reader service card



Low-Cost Logic Circuit Tester
Circle 222 on reader service card



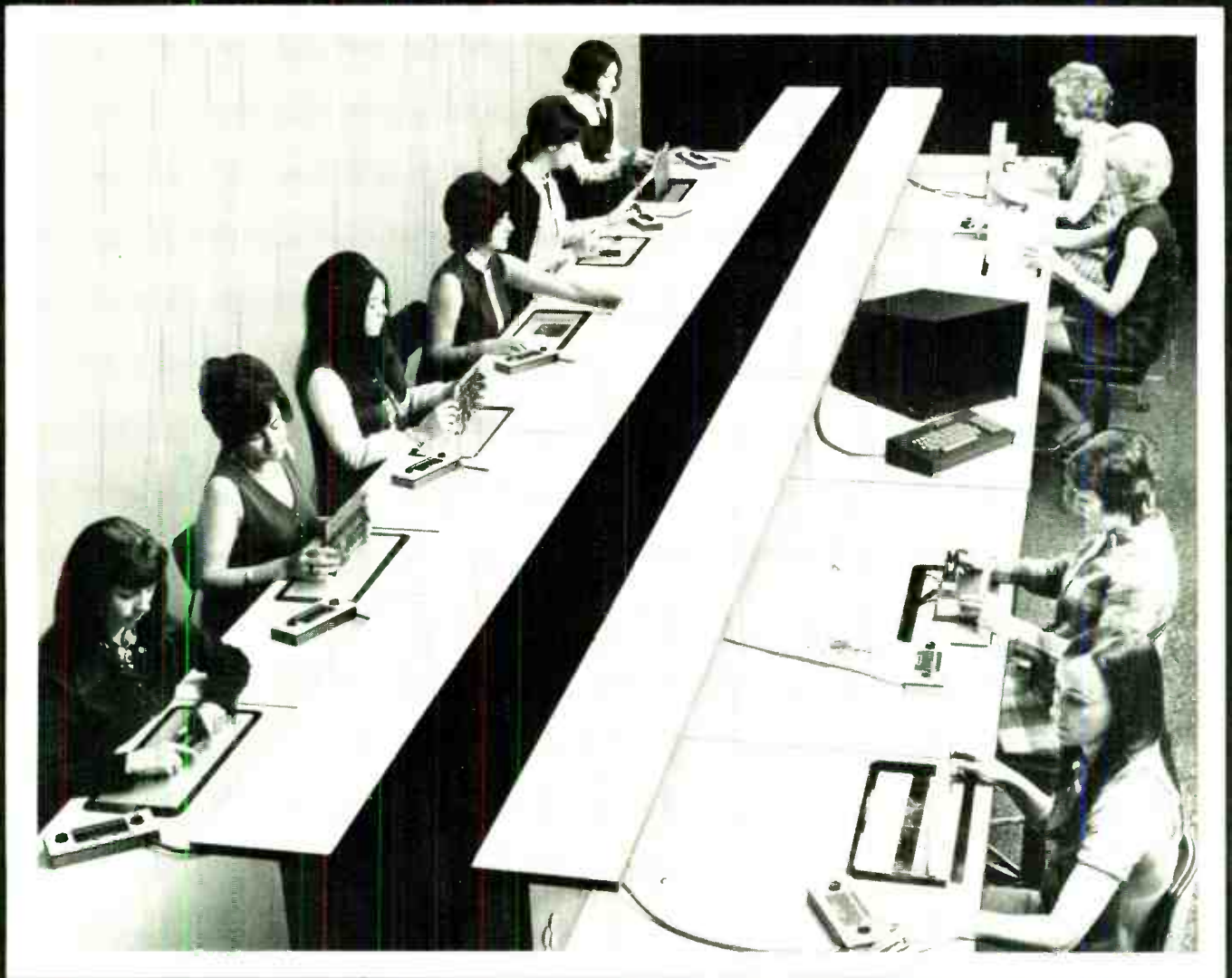
Full Capability Logic Circuit Analyzer
Circle 223 on reader service card



The Ultimate Network/Circuit Test System
Circle 224 on reader service card



Total systems capability from General Radio



The Ultimate Network/Circuit Test System There's something in it for you

... a faster, lower-cost way to perform analog tests, logic tests, and passive tests. Take your pick of any combination to measure (simultaneously, if you wish) analog, hybrid and digital pc boards; active and passive networks; hybrid IC's; active, passive and digital components. But, get only the capabilities you need now. Don't worry about adding more later; we've already made provision for expansion with modular hardware and software.

Here's the big difference between our system and others. The measurement units in GR Systems

2200 are modules, especially designed for computer control. They are not automatic instruments adapted for computer control but unique modules that do their jobs faster than instruments. There's no time wasted translating commands, driving readouts, and the like. You get faster testing, increased throughput, and over-all cost savings in your test operations.

The "ultimate" system illustrated was designed and built for a giant

electronics manufacturer who needed 10-station capability to handle a huge volume. Almost everybody's testing requirements, however, can be satisfied with a single-station system, selecting from the several modules already designed for the 10-station ultimate.

Let's talk about what GR can do for you. Write or call your GR sales engineer or GR, Concord, Mass. In Europe write Postfach CH 8034, Zurich, Switzerland.



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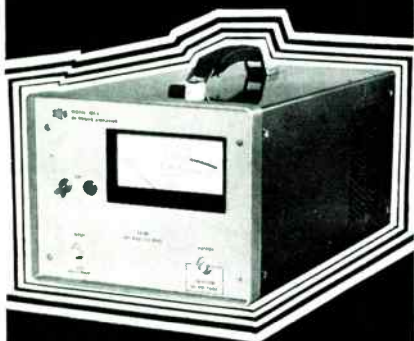
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In fact, our model 320L delivers the most power and widest bandwidth of any solid state instrument amplifier available. Easily mated with a wide variety of signal sources, it amplifies AM, FM, SSB, TV, Pulse and other complex modulations with minimum distortion. Constant forward power is continuously available regardless of load match (from an open to a short). The 320L provides over 20 watts of power from 100 KHz to 125 MHz with useful output all the way to 160 MHz... and there's no tuning.

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EN ELECTRONIC NAVIGATION INDUSTRIES

People

NRMEC puts its chips in Ebertin's basket

The man who first put it all together in electronics calculators at Autonetics in 1965 has surfaced as director of business machines development at North American Rockwell Microelectronics Co., the commercial MOS/LSI firm that evolved from Autonetics.

Michael Ebertin, 35, designed Autonetics' first MOS calculator more than six years ago using 28 chips that measured 156 by 165 mils. The machine still works, says Ebertin, "and we learned a lot through those circuits in gearing our process for big chips." That first calculator used four-phase logic, as do NRMEC's present calculator chips being supplied to, among other firms, Sharp Corp. of Japan and Victor Comptometer Corp. in this country.

Military start. Ebertin has a BSEE from the Polytechnic Institute of Brooklyn and an MSEE from the California Institute of Technology. He came to Autonetics in 1962 after first working at Caltech and then the Aerospace Corp., and went to work doing system and logic design on military computers. "But from the third year on at Autonetics," says Ebertin, who shows German shepherd dogs as a hobby, "I started on the bandwagon to exploit military technologies in the commercial world."

He was initially involved in trying to get Autonetics' approval to design a desktop computer in 1964, but that proposal never got off the ground because the division had just backed away from its first venture into commercial computers, the Recomp. Ebertin says Recomp was a commercial failure because there was no sales organization to back it up.

"So we backed away from the desktop computer and went to something simpler—the calculator," he recalls. "We lined up a customer, and got the design go-ahead, but we were ahead of the times with the circuits."

Ebertin concludes, logically

enough, that he was named to the new NRMEC calculator post because of his long experience in computers and computer-aided design, and because he "was responsible for spearheading the company into the calculator business."

Within five years, he expects the Anaheim, Calif., firm's business mix to be split 50-50 between calculator chips and circuits for such commercial hardware as electronic cash registers [*Electronics*, Nov. 22, p. 34], point of sale systems, and electronic scales. Ebertin is counting on NRMEC's programable calculator processing unit chips to ease the evolution from calculators to these other applications, and that's exactly why his office was established.

To NASA's Fletcher, it isn't just academic

When he left the presidency of the University of Utah last spring to become the fourth administrator in the history of NASA, the public assumed that because James C. Fletcher also looked like a college president he had been an academic all his life. Actually, the 51-year-old scientist has 20 years of electronics aerospace experience, during which he developed patents in such diverse areas as sonar devices and missile guidance systems.

Holder of a Ph.D. in physics from



Fletcher: With von Braun at Apollo 15.

New bi-polar power-dac* solves five major system problems in automatic test equipment TM

A new programmable power source from the John Fluke Company solves several big system problems. Appropriately called a Power-DAC, the Models 4250A and 4265A provide up to ± 65 volts at 1 amp, with a 100 micro-second settling time to 0.01% accuracy. A full complement of options provide needed flexibility in both price and performance.

1. Parallel or series operation — just like batteries

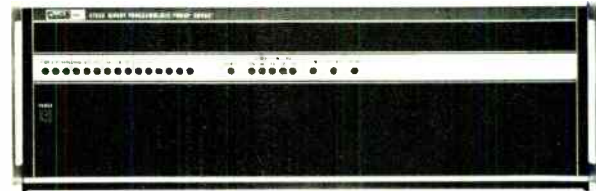
Have you ever needed just a little more current or voltage to test a new device? (Probably this slight extra capability is only needed for a very few tests.) With the 4200 Series Power-DAC, you can double, triple or quadruple your current or voltage capability by a simple parallel or series connection with external relays. No special hardware or software protection features are required. With several Power-DACs in your system you have both single unit control and unlimited power configuration at the discretion of the programmer.

2. AC or DC outputs provide versatility

In addition to the standard internal dc reference, an external reference option allows any external ac or dc signal to be used as the reference for the bi-polar D-to-A ladder network. The Power-DAC can perform many different functions within the test system. Operate it as a programmable amplifier, attenuator or multiplying DAC for either ac or dc signals up to 30 kHz. Amplitude of fixed level function generators and special purpose signal sources can be precisely controlled from microvolt levels up to 50v rms at 0.7 amp rms. By accurately controlling the level of the external reference, programming resolution can be varied from 1 millivolt to several microvolts. Either the internal or external reference is selected by a 1-bit control line. The 100 μ sec settling time includes polarity change, range change and selecting either the internal or external reference.

3. Fast programmable current limiting protects circuits under test

Standard models provide a gross 1.2 amp current limit as an overload protection feature. One option provides a programmable current limit in two ranges, 100 ma and 1 amp. Each range is programmable in 10 percent steps, yielding 10 ma or 100 ma resolution. When the overload occurs, transition from the constant voltage mode to the current mode requires less



Model 4265A

than 20 microseconds, the crossover time being a function of the load. The larger the overload, the faster the transition. This fast crossover capability minimizes the energy transients to the circuits under test.

4. Programming glitch reduction

A unique track-and-hold technique during the programming interval reduces the peak glitch and transient excursions to less than 50 mv in the 16 volt range, and less than 100 mv in the 65 volt range. Transitions from computer generated waveforms or incremental slewing operations take place smoothly.

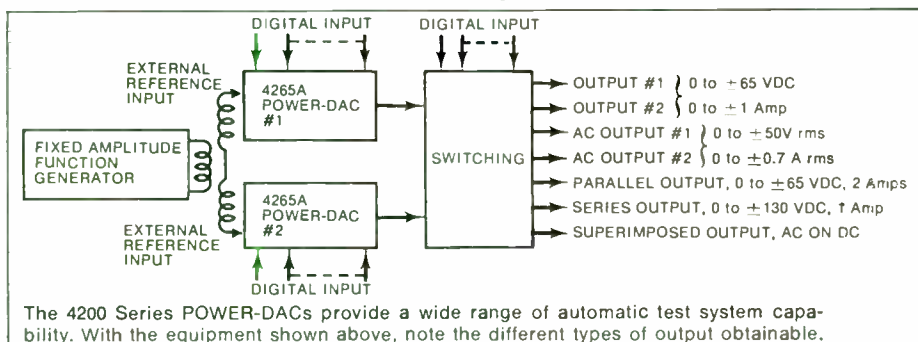
5. Isolation and guarding reduces noise and ground loops

Digital and analog portions of the 4200s are separated by a metal guard to eliminate both ground loops and digital noise which severely affect the system performance of conventional power supplies and D-to-A converters. With the isolated control logic option, impedance between the digital control logic and the analog circuits is 10^9 ohms in parallel with 3 picofarads. This isolation provides significant rejection of system noise on the analog output. Up to 1000 volts of common mode voltage can be applied between chassis ground and the guard terminal without harming the instrument, or causing severe common mode errors.

Prices and options

For \$1295, the basic 4250A and 4265A are equipped with direct coupled control logic and blank front panel. The isolated control logic option which also contains a memory register for storing the program command is \$300. The external reference, programmable current limit and front panel digital display options are priced at \$200 each. Delivery is 30 days. For complete specifications on all 4200 Series Power-DACs, write Fluke, P. O. Box 7428, Seattle, WA 98133.

FLUKETM



NEW! THE PRAM.™

The first 4-channel programmable op amp. With more application possibilities than we could possibly list on this page.

HA-2400/2404/2405

Take a good look at this new linear building block. It's unique and so versatile we keep discovering more and more applications for it.

Each PRAM contains four preamplifier sections, one of which is selected through the DTL/TTL compatible inputs and connected to the output amplifier. The selected analog input terminals and the output terminal form a high performance operational amplifier for just about any use you can dream up. And we hope you'll dream up some. If you do, send them along to us and we'll see what we can dream up by way of a reward.

Features:

Offset current 5nA

Voltage gain 150K

Slew rate

$A_v = +1 \quad \pm 15V/\mu s$

$A_v = +10 \quad \pm 50V/\mu s$

Gain Bandwidth Product

$A_v = +1 \quad 8MHz$

$A_v = +10 \quad 40MHz$

DTL/TTL compatible

0° to +75°C
-25°C to +85°C
-55°C to +125°C

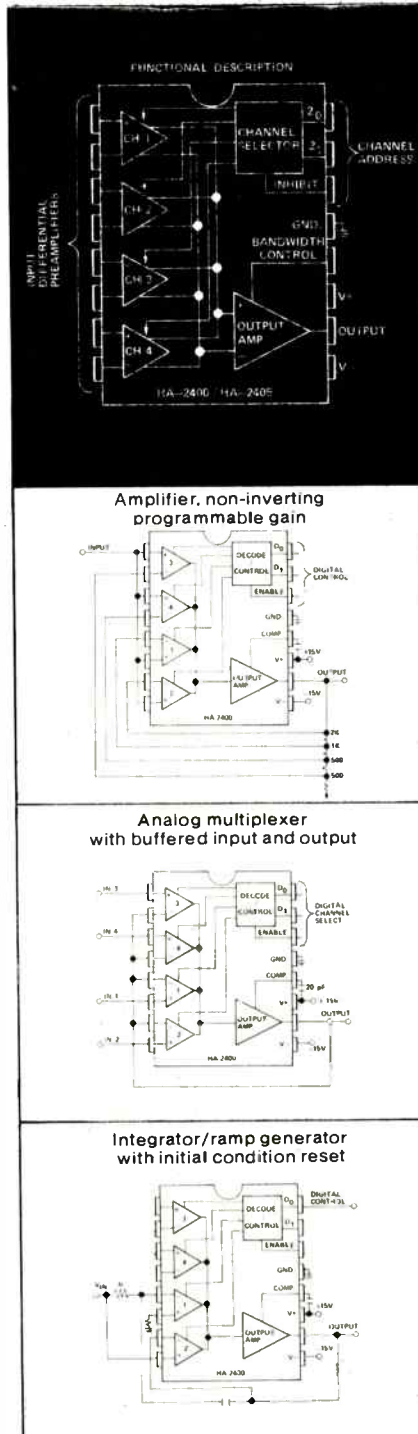
100-999 units

\$10.45

\$15.95

\$23.65

For more details on the PRAM contact your Harris representative or distributor.



More challenges:

The foregoing diagrams show just three of many applications we've designed using the PRAM. The following lists other possibilities we haven't had time yet to prove out. Why don't you try your hand at designing them or any other ideas you come up with, and send them to:

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People

the California Institute of Technology. Fletcher has been director of the theory and analysis Laboratory in Hughes Aircraft Co.'s Electronics division, director of electronics in the Guided Missile Research division of Ramo-Woolridge Corp., and board chairman of Space General division and systems vice president of Aerojet General Corp. He left Aerojet to become Utah president in 1964.

"I don't look on myself as an aerospace executive," the low-keyed, friendly administrator confides. "I'm not aggressive enough or the sales-oriented person that a typical aerospace executive would have to be." He likens himself to former Defense chief McNamara in that McNamara wasn't the typical auto executive. "But I don't want to compare myself to him."

Committee man. Although he is relatively new in his job, Fletcher has long-standing ties to NASA. He was a consultant to the President's science advisory committee from its beginning in 1958 until he was appointed to membership in 1967. He also continues his interest in science through national committee work, having served on more than 50 such organizations and having been chairman of 10 of them.

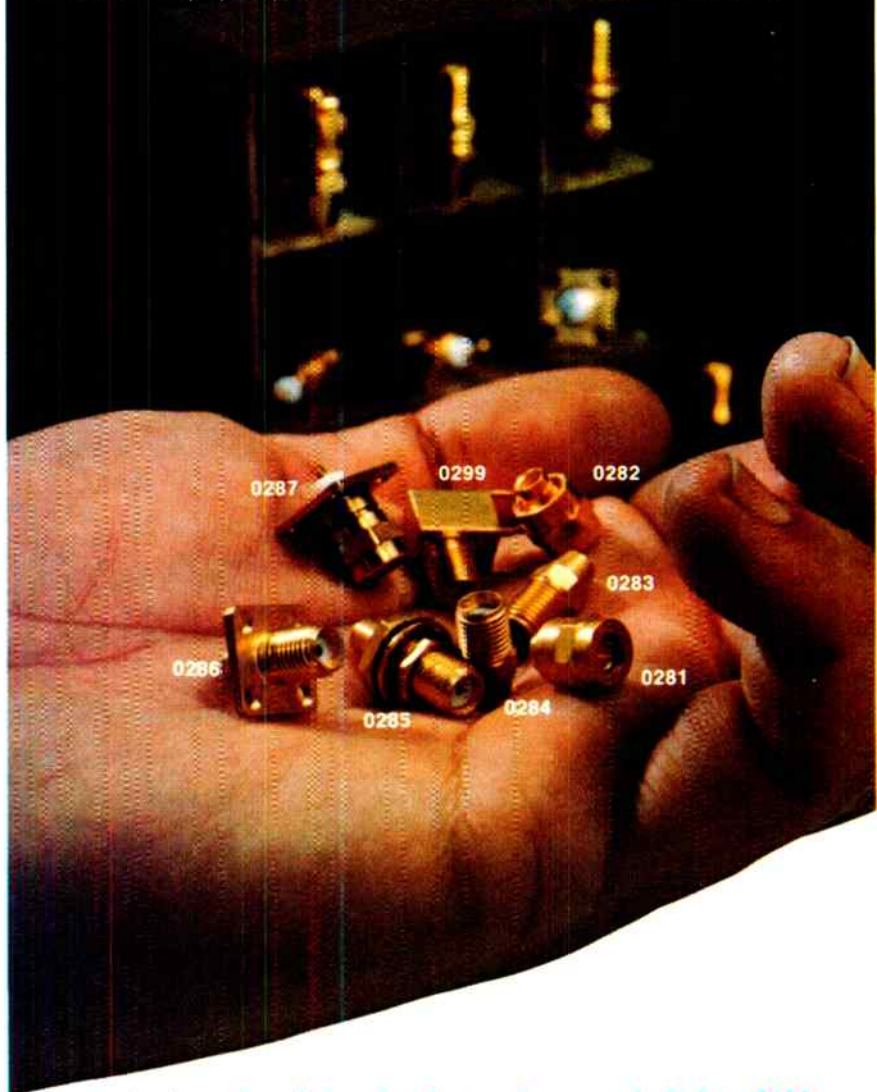
NASA will need Fletcher's pragmatic program-oriented experience as he attempts to steer the space agency through the shoals of White House and congressional funding pressures.

NASA's future shape will depend on how well Fletcher can win money for such important programs as the space shuttle, the Grand Tours of outer planets, and the inner-planet probes.

Looking beyond the immediate problems, Fletcher foresees a bright future for the post-Apollo agency. "Beyond the next decade, we may move back into manned space," he says. "We'll have the shuttle by then, and it will have proven itself. Maybe we'll return to the moon." Calling himself an optimist, Fletcher thinks there might even be international skylabs which could become a manned peace-keeping surveillance program.

A year ago we introduced 7 new JCM miniature RF coaxial connectors that "do the job for a fraction of SMA prices."

Here, by popular demand, are 8 more.



If you don't require all the electrical performance built into SMA type connectors, why pay for it? Up to 3 GHz for flexible cable assembly and even beyond 6 GHz for semi-rigid assembly, our new JCM series gives you the same electrical performance as the far more expensive SMA types. The series includes connectors for both panel and PC mounting. All are interchangeable and intermateable with the standard, expensive SMA connectors. So you can use them without making any changes . . . and without compromising required performance. There are JCM connectors to accept virtually any miniature size cable, so you don't have to stock a big variety. It's worth looking into, isn't it? All it costs is a stamp.

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Please check for technical information or test samples of our new low-cost series 142-0200-001 JCM connectors.

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I desire test samples. Please call me at _____

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E. F. JOHNSON COMPANY

Second In A Series

DIRECTIONS MOS

Many Faces of MOS

Display Mixed Performance, Cost, And Availability

MOS technology today includes varied approaches to structure and processing techniques. Some are converted to high volume production capabilities, others are in advanced development and offer great promise for improved performance and early implementation, and still others are experimental. All must be evaluated carefully for potential advantages.

P-Channel MOS Is Readily Produced

P-channel MOS isn't the most advanced, the fastest, the lowest power, nor the most versatile approach, but it is familiar and at several companies is in high-volume production. Hence, it is the prevalent MOS form for both standard and custom circuits. Achievable speeds are, conservatively, about 2 MHz — reconcilable with the requirements of many data-processing applications. Power dissipation, down to 0.5 mW/gate, presently is about the same as the lowest-power bipolar line, higher than other MOS forms, yet low enough for some really large-scale integration. The MCM1131L 2240-bit character generator, for example, has a maximum power dissipation of only 400 mW.

Representative PMOS circuits available now are MSI/LSI parts, with simple gates and flip-flops conspicuously absent. Why? Typical PMOS technology loses its price advantage as circuit complexity is reduced, giving way to the widely available, broad-line bipolar families. Since MOS generally is more appropriate for MSI/LSI, the more creative complex designs are usually in custom programs. Established PMOS process variations permit custom tailoring of circuits, even to the point of making them functionally compatible with bipolar logic. The two digital forms can be used together without extensive interface circuitry.

Two High Threshold PMOS Power Levels

Two power levels, medium ($P_D = < 1.7$ mW/gate) and low ($P_D = < 0.45$ mW/gate), are available with high threshold (V_T) PMOS. A 20% saving in active on-chip cell area is also achieved in the low power line, but the tradeoff is speed. It is some four times slower, at 300 ns typical propagation delay per logic level, than the medium power line. Nevertheless, where performance is adequate, this represents the quickest, least expensive, and least troublesome technology. High threshold logic offers the designer the advantage of high noise immunity, with turn-on voltages on the order of 3.5 volts making it relatively secure from noise spikes and spurious signals.

Low Threshold PMOS Has Advantages

Low-voltage MOS is faster and more economical in the system because of the lower power-supply voltage. It is compatible with the most popular bipolar logic forms such as TTL and DTL whereas the outputs of bipolar types are simply too low to turn on the high voltage PMOS devices. Of the methods used to lower the threshold, the <100> crystal orientation achieves good reduction of the threshold voltage and power supply requirements, but speed and packing density are not improved.

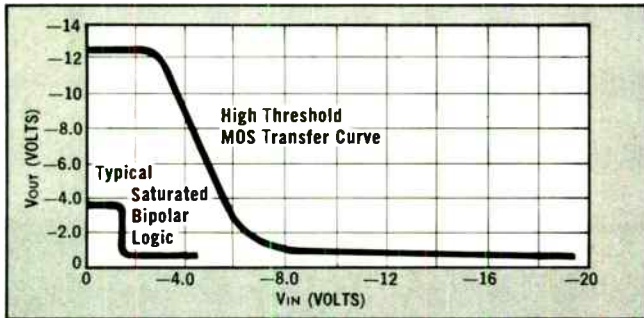
Another method, the Silicon Gate process, is preferred at Motorola. Not only is the threshold voltage reduced to an extremely low level, but circuit speed is increased, packing density can be increased, and manufacturing efficiency is greater. This technology has matured rapidly, and an impressive number of products is available off-the-shelf.

What About NMOS?

Everyone eagerly awaits the ready availability of NMOS for its speeds, potentially two/three times as fast as conventional high threshold PMOS. The Silicon Gate process is applicable too, and it considerably increases the packing density potential. NMOS yields generally aren't good enough yet to make this eagerly awaited technology available at viable prices.

CMOS — Developing Rapidly

Any MOS circuit exhibits significantly lower power dissipation than bipolar capability permits, but far and away the greatest power miser in sight is complementary MOS circuitry, known as CMOS at Motorola. In fact, with complementary MOS dc power dissipation can be



reduced virtually to zero — enviable where battery operation or battery backup is a requirement.

Matching comparable simple examples, a single-channel circuit draws current from the power supply during the entire “on” portion of the input signal. With the CMOS circuit, power dissipation occurs only during input signal transitions. Extreme low power designs are practical when frequency is less important, say for 100 kHz operation. Speeds in excess of 10 MHz also can be designed at the expense of some power dissipation increase due to the higher rate of signal transitions. Gen-

erally, the high speed and low power drain make CMOS a significant factor in the future of MOS technology, and by most indicators, a major logic form.

MOS PROCESS	THRESHOLD VOLTAGE	SUPPLY VOLTAGE V_{DD} (V_{CC})	PROP. DELAY (ns/gate)		FREQ. (min.)	POWER DISS. PER GATE	RELATIVE CHIP COMPLEXITY	NOISE MARGIN	
			"1"	"0"					
P-CHANNEL MOS High Threshold Medium Power Low Power	-3.5 TO -5	-17 TO -27	75 ns 300 ns	2 MHz 500 KHz	1.7 mW 0.45 mW	1 1.2	3	1.5	
Low Threshold <100> Silicon Gate	-1.5 TO -2.5	-12 TO -17	70 ns 60 ns	2 MHz 5 MHz	1.0 mW 1.0 mW	1 1.3	2	0.7	
Ion Implant. Depletion Loads	-1.5 TO -5	-12 TO -27	35 ns	5 MHz	1.5 mW	1.3	1.5	1	
N-CHANNEL MOS Metal Gate Silicon Gate	1 TO 2	5 TO 20		10 MHz	1.0 mW	1.3 1.6	1	1	
COMPLEMENTARY Metal Gate Silicon Gate	(±)1.5 TO (±)2.5 ±0.5 TO ±2.5	3 TO 18 1.2 TO 15	40 ns 25 ns	20 MHz 25 MHz	50 nW 50 nW	0.3 0.4	$V_{DD}/2$		
BIPOLAR LINES									
TTL		5.0 V ±20% -10%	10 ns	60 MHz	15 mW*	40	1.2	1.2	
ECL		5.2 V ±20% -10%	~1 ns	400 MHz	25 TO 35 mW	20	0.4	0.4	
DTL		5.0 ±10%	30 ns		8 mW	20			
RTL		3 ±10% OR 3.6 ±10%	24 ns		12 mW	10			

*A Special Low Power Line (54/74L) Has Power Dissipation of 1 mW/Gate

COMPARISON OF MAJOR CHARACTERISTICS OF MOS PROCESS AND BIPOLAR LOGIC LINES

erally, the high speed and low power drain make CMOS a significant factor in the future of MOS technology, and by most indicators, a major logic form.

Numerous manufacturers have announced standard CMOS products, custom capability, or both, and Motorola has invested heavily in this area. Lower cost, because of the basically simpler process, greater circuit density, and lower power dissipation, suggest CMOS will prosper at the expense of TTL. Penetration of the consumer market is anticipated in areas such as watches, clocks, various automotive applications, appliance controls, and even toys. Features such as high noise immunity, operation from an unregulated power supply, microwatt power dissipation, and low noise-generation are expected to make the industrial market another big CMOS user.

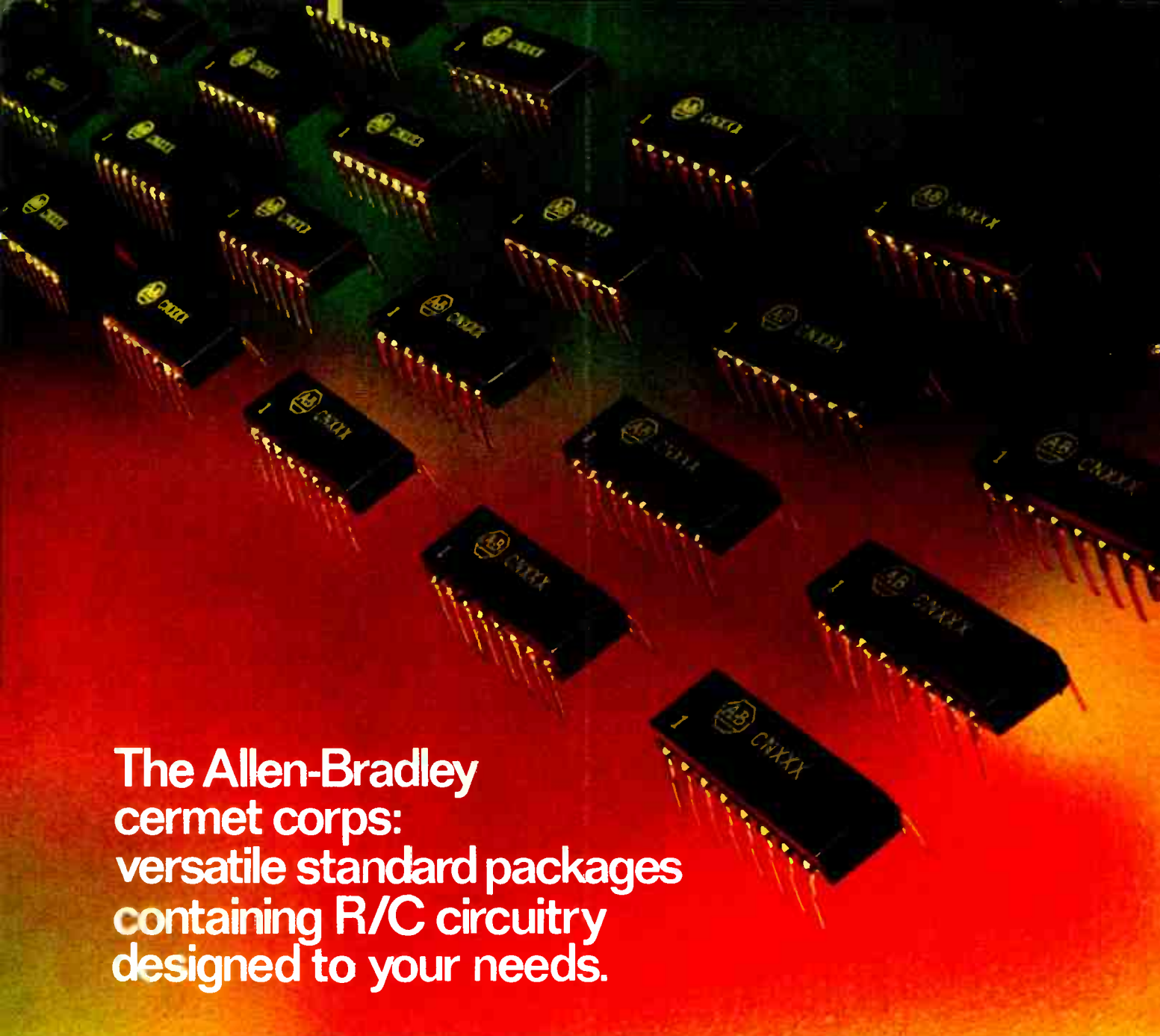
Summarizing, Silicon Gate PMOS shapes up as a leading MOS form with CMOS maturing rapidly to take its place as the second dominant approach, essentially extending PMOS capability rather than replacing it. NMOS will be built, but for the near term probably will not be widely available. How to evaluate suppliers? Published specifications probably speak for themselves in respect to standard products. For custom designs, consider carefully the total MOS capabilities of a prospective supplier. Those with many faces are probably the best bet.

This is the second in a series designed to present a realistic, objective analysis of MOS technology in a dynamic, competitive industry. For an examination of this and other aspects of the MOS technology in greater depth than is permitted here, circle the reader service number or write to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036.

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CALIBRATION	Abrasive or laser
LEAD SPACING	100 mil standard

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Meetings

Reliability Symposium: IEEE, El Cortez, San Diego, Jan. 25-27.

Power Engineering Society Winter Meeting: IEEE, Statler Hilton Hotel, New York, Jan. 30-Feb. 4.

Integrated Optics Meeting: IEEE, OSA, Sands Hotel, Las Vegas, Nev., Feb. 7-9.

Aerospace & Electronics Systems Winter Convention (WINCON): IEEE, Biltmore, Los Angeles, Feb. 8-10.

International Solid State Circuits Conference: IEEE, Sheraton Hotel, University of Pennsylvania, Philadelphia, Feb. 16-18.

International Geoscience Electronics Symposium: IEEE, Marriott Twin Bridges Motor Hotel, Washington, D.C., April 9-14.

International Conference on Magnetism (INTERMAG): IEE, Kyoto International Conference Hall, Kyoto, Japan, April 10-13.

Southwestern IEEE Conference & Exhibition (SWIEEEO): IEEE, Baker Hotel & Dallas Mem. Aud., Dallas, Texas, April 19-21.

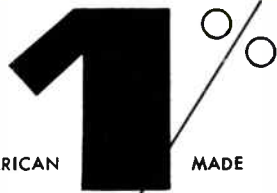
Off-Shore Technology Conference: IEEE, Astrohall, Houston, Texas, April 30-May 3.

Spring Joint Computer Conference: IEEE, Convention Center, Atlantic City, N.J., May 15-18.

CALL FOR PAPERS

27th Annual ISA Conference: IEEE, Coliseum, New York City, Oct. 9-12, 1972. Submission date of abstracts is March 27, 1972 to R. I. Gray, ISA Conference Program Chairman, 400 Stanwix St., Pittsburgh, Pa. 15222.

1972 SID International Symposium: IEEE, Jack Tar Hotel, San Francisco, Calif., May 23-25. Abstracts should be submitted to John L. Simonds, Eastman Kodak Co., Research Labs./B-81, Kodak Park, Rochester, N.Y., by Jan. 17.




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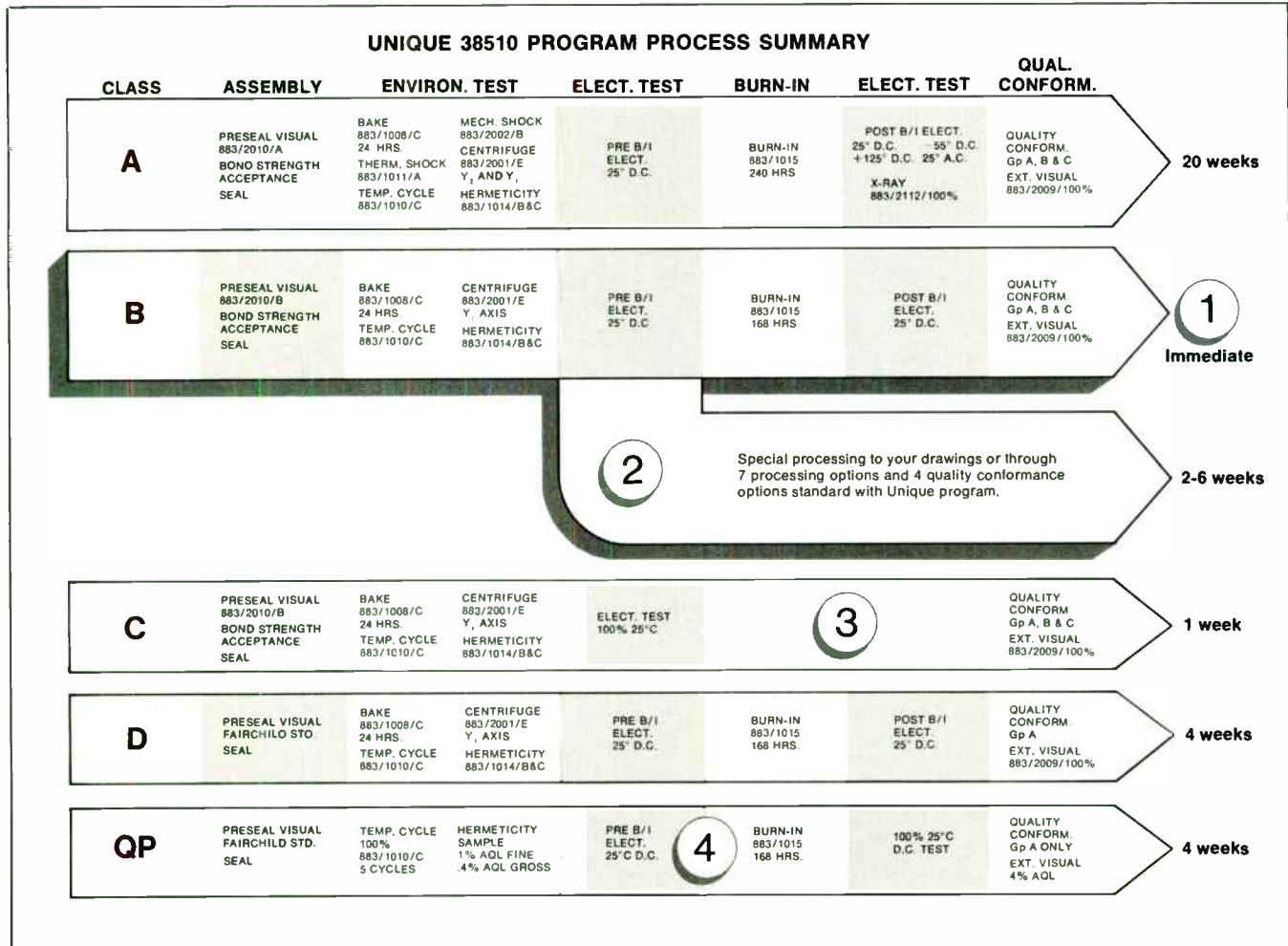
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CLASS D devices are essentially the same as Class B except pre-seal visual is to Fairchild standards. Delivery is 4 weeks.

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Electronics Newsletter

December 6, 1971

Litton preparing to make 20,000 MNOS RAMs monthly

A technology that was still in the R&D category a little more than three months ago—MNOS memories—has been turned into a business at the Guidance and Control Systems division of Litton Industries [*Electronics*, May 10, p. 40]. The division has geared to produce 20,000 random-access memory devices a month using the silicon-nitride MOS technology—but won't be its own prime source for the 1,024-word-by-four-bit RAMs, which are going into memory systems the division is both selling and using. Litton is negotiating with two of the top semiconductor companies to take advantage of their higher-volume production, and drive the price to 2.5 to 3 cents a bit—down from the 5 to 10 cents a bit it costs Litton to make the units.

Meanwhile, Litton already has sold 20,000 systems incorporating the device to a military customer that will use it to "remember" a precise frequency and repeat it on command much later. Nonvolatility is the big plus in MNOS: Litton is specifying 10^{10} "writes"—or roughly two years—on volatility. The devices also can be made resistant to radiation. During the past 3½ months, the division has lined up some 40 representatives in the U.S. and Europe to market the MNOS memory systems.

Magnavox to make 12-in. b&w sets here

Now even Americans are bringing monochrome television receiver production into this country. The Magnavox Consumer Products division has started tooling up to make 12-inch receivers at its Tennessee plant and phase out offshore production if the cost factors remain competitive. The firm already builds its 19-in. black-and-white sets here.

Magnavox previously returned its 12-, 14-, and 16-in. color sets to these shores, so that all of its color receiver production is now U.S.-based.

This move follows a recent announcement that Sony will erect a TV assembly plant in San Diego and a similar plant will be built by Matsushita (Panasonic) in Puerto Rico [*Electronics*, Nov. 8, p. 41]. According to Magnavox, the 10% surcharge on imports, plus the increasing value of the floating Japanese yen, will help make firm's American-built sets competitive.

Intel puts 8-bit parallel CPU on chip

The Intel Corp. has developed a complete eight-bit parallel central processing unit on a chip. Only four-bit sets are on the market now, including those made by Intel, Fairchild, and National Semiconductor.

The new Intel device contains an arithmetic unit, seven eight-bit data registers, a memory stack, and 45 wired-in, data-oriented instructions. It's TTL-compatible and employs time-division multiplex to reduce pin count to 18. Intended for use with standard RAMs like the 1101 and with such ROMs as the 1601 and 1701, as well as with 1400 series shift registers, the CPU can directly address 16,384 words by eight bits of memory.

With delivery to start next month, Intel points out that its new chip doesn't obsolete its earlier four-bit model because it was made for different applications.

SEMI says it's near new financing deal

Semiconductor Electronic Memories Inc., which had the financial rug pulled out from under it by its backer, Electronic Memories and Magnetics, isn't throwing in the towel yet. Donald Winstead, vice president

Electronics Newsletter

for marketing, says the Phoenix firm is about a week away from "finalizing something" with one of two new backers.

Winstead says further that SEMI booked \$100,000 in new business during the week of Nov. 22, but some potential customers have become nervous about ordering until new financing is arranged. SEMI shipped \$100,000 worth of bipolar semiconductor memory devices and systems in November—about \$100,000 less than its best sales month.

Meanwhile, it has cut back drastically—from 220 employees to 80—and top management has taken salary cuts. Winstead says the fallback position allows SEMI to have a positive cash flow. "We've cut back to the point where we can live on what we see, but we have to make our forecast," he notes, "and we're optimistic that we can."

Navy studying RCA's multicolor LEDs

The Navy is supporting research into a new class of light-emitting diodes made from alloys of phosphides of gallium and indium at RCA's David Sarnoff Research Center. The Navy's interest in the program, says the Office of Naval Research, is part of its long-range instrumentation program, which is aimed at substantially improving aircraft avionics with multicolor displays at no increase in power. The ONR points out, however, that the process "brings closer to reality" solid state color television that would eliminate cathode ray tubes. Still lacking, of course, is a blue light-emitting diode.

The LEDs can be made to produce "any color from red to yellow-green without increasing power requirements," say Navy researchers. Moreover, they say the RCA LEDs are "three times more efficient" than commercially available units which are also restricted to red or green, and are economically feasible since vapor epitaxy permits the entire structure to be fabricated in a single operation. The color emitted varies with the fraction of gallium phosphide used.

IBM, RCA seek price hikes from Nixon commission

Two major electronics manufacturers, IBM and RCA, want Nixon Price Commission increases on selected products that would continue the guideline-busting trend that has marked increases approved thus far. Where the commission guideline is 2.5%, IBM has asked for increases ranging from 3% to 8% on lease and purchase prices of its Series 360 and 370 computers, while RCA has asked for 6% on consumer and industrial replacement receiving tubes.

Both were previously planned, the companies say. With President Nixon's Aug. 15 announcement of a price and wage freeze, however, IBM suspended the lease price increases it had earlier announced for Nov. 1. RCA's increases were scheduled to become effective on Aug. 16, the company says.

ARTS may get radar backup

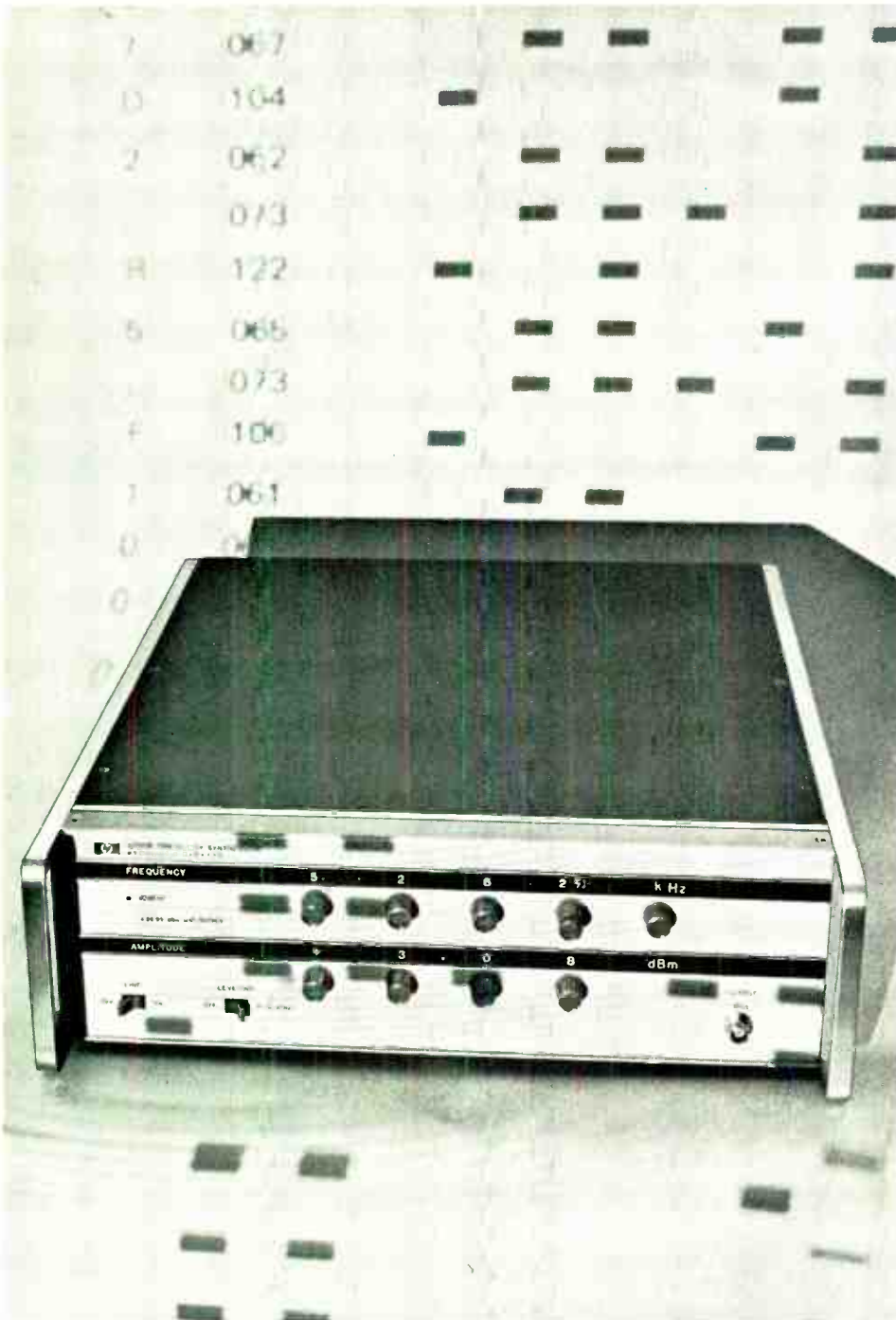
By late summer, the FAA's National Air Space Projects Office expects to be finished writing specifications for a back-up system for Automated Radar Terminal Systems. Part of the ARTS enhancement program, the fail-safe system would transfer data directly from radars to the scan converters and display units, bypassing the computers should they fail. Present plans call for purchase of a prototype in fiscal 1973 for \$5.5 million, plus expenditure of about \$15 million in the following year if the FAA decides to put the back-ups in all the ARTS centers. Adding redundancy capability to the units could increase the cost another \$20 million.



MEASUREMENT

information for better measurement

NEWS



in this issue

1300 MHz RF sweeper covers seven octaves

HP's "total solution" computing counter system

Low-cost digital 'scopes

Finally: a synthesizer anyone can afford

Get a quality frequency synthesizer at a truly low price, without sacrificing signal purity. Its many virtues include full digital remote control.

When HP was founded in 1939 its first product was an RC Wien Bridge oscillator invented by William R. Hewlett, now the firm's chief executive. Direct descendant of those first products (the 200 series RC oscillators), the new 3320A/B Frequency Synthesizer has the frequency accuracy and stability of synthesizers, and the spectral purity of oscillators—all at a very low price.

3320A/B stability depends on a single fixed-frequency oscillator, so you can tailor your choice exactly to the job. Standard equipment is an ambient crystal with drift below ± 10 parts in 10^6 per year. An oven reference is op-

(continued on page 3)

Sweep seven octaves of RF in 10 milliseconds flat



HP's newest RF Sweeper, the Model 8622A 10-1300MHz plug-in in an 8620B mainframe. The lap belongs to Miss Barbara Althoff of Microwave marketing.

Just some of the reasons we think you'll like our new 1300 MHz Sweep Oscillator are:

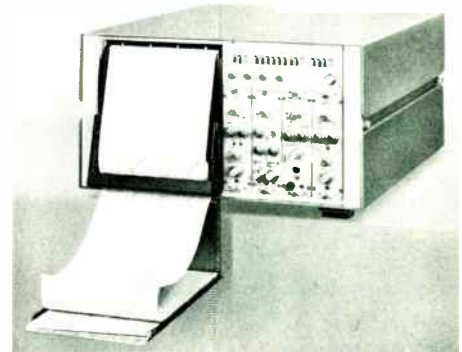
- 10-1300 MHz coverage—in one continuous sweep.
- 10 milliwatts calibrated output, leveled to ± 0.5 dB full range.
- Clean, stable CW signals—less than 5 KHz peak residual FM.
- Solid-state reliability and compactness.
- Low \$2750 price for the **complete** sweeper (RF plug-in and mainframe).

Calibrated start/stop and ΔF sweeps commend the 86220A (RF Unit) and 8620B (Mainframe) for both broadband and narrow band

sweep testing of RF components, networks and systems. And stable CW with low spurious, plus the capability for low distortion AM and FM permit this sweeper to be used in signal simulation applications. An optional 70 dB attenuator adds more flexibility of use.

Although we're talking about the value of the 86220A/8620B just for its 10-1300 MHz coverage, don't overlook the point that the 8620B mainframe also accepts our other solid-state RF plug-ins for coverage to 12.4 GHz. *Info on the 86220A RF Unit (\$1775) and 8620B Mainframe (\$975) is yours simply by checking the Reply Card.*

Make Z-fold recordings without ink



HP Model 7414A four-channel thermal tip oscillographic recorder.

Ever tried to find part of a chart recording on a 500-foot roll of chart paper? Compare with flipping the pages of a book and you'll see how much easier it is to handle the Z-fold charts from the new HP 7414A Oscillographic Recorder. It's a thermal (no ink), four-channel recorder featuring pushbutton chart speed change. Response is within ± 0.5 dB from dc to 50 MHz, and falls off less than 3 dB at 100 MHz. The full range of HP 8800 series plug-ins can be used. Price is \$4500 without plug-ins. *There's more; check the Reply Card.*

Meet the "Value Family" of HP sweepers



From the "simplest," low-cost sweeper to a sophisticated, multi-octave, programmable source, the 8620 family offers the highest value in solid-state RF sweepers.

And it's easy to select the precise configuration for **your** job; this attractive brochure presents the entire family in concise, logical format.

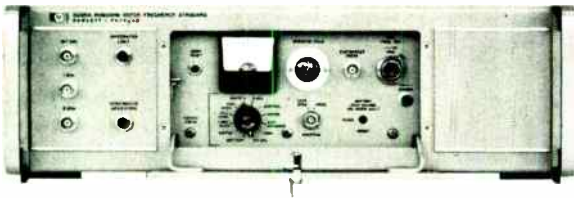
For your copy, check the Card.

Need more stability? Step up to rubidium

Quartz oscillators rank high in frequency stability, but many systems need something better, like the HP 5065A Rubidium Frequency Standard. This atomic standard has 100 times the long-term stability of quartz. Besides upgrading system performance, increased stability may simplify the design of other parts of the system. In PCM communications, for example, switching from quartz to rubidium may eliminate the need for "bit stuffing" pulses needed for synchronization when less stable frequency sources are used. Navigation systems, color television systems, and calibration labs can also benefit

by upgrading to rubidium.

The HP 5065A has the best guaranteed rubidium specifications available. Long-term stability is better than 1×10^{-11} per month. Short-term stability for a one-second averaging time is 5×10^{-12} . The 5065A is more rugged than a quartz oscillator, too. HP now gives an unconditional 3-year warranty on the rubidium vapor frequency reference—not just the gas cell, which hardly ever fails, but the *entire* module including oscillator, lamp, filter cell, and photo-detector. At \$7500, the 5065A offers unsurpassed price/performance. *For more information, check the Card.*



In frequency standards, the next step beyond quartz is rubidium. This one has the best guaranteed specs, plus an unmatched warranty.

Continued from page 1

tional and retrofitable. Or you can phase-lock to an external reference.

Both instruments have a range of 0.01 Hz to 13 MHz (the two lower ranges are optional).

3320A adds synthesizer quality to production and design work, yet keeps you out of trouble with the budgetmasters. It will put a volt rms into 50 Ω and it has a continuous +13 dBm-to-0-dBm vernier, so it's most useful where level control is not a critical item.

3320B is the super-synthesizer. It has a 4-digit leveling loop with 0.01 dB resolution of a calibrated output from +26.99 dBm to -69.99 dBm (-73.00 under remote control). It's flat ± 0.05 dB from 10 Hz to 13 MHz, and level accuracy is ± 0.05 dB absolute at 10 kHz.

Because the 3320A/B is a synthesizer with ranges, its signal-to-phase noise is improved as the instrument is downranged. Its low spurious content (>60 dB down) and low har-

monic distortion (-60 to -40 dB, depending on frequency) bespeak its high-quality spectral output.

Programmable/Remote Control

Digital remote control is an option on both instruments, and it can be a retrofit later. On 3320A Option 003 gives you parallel BCD remote control over frequency only. There are two remote control options for 3320B. Both give you control over all functions except the last vernier digit and the line switch. Option 004 is parallel BCD. Option 005 is a unique bit-parallel/word-serial ASCII option; with it, one program device can control several 3320B's. With Option 005, 3320B interfaces directly with the HP 3260A Marked Card Programmer, a photo reader, or any other 8-bit controller.

Price: 3320A ranges from \$1900 to \$2715, depending on options. 3320B prices are from \$2400 to \$3910. The 3260A Marked Card Programmer is \$750. *For further information, check the Card.*

Locate faulty IC's with less time and effort

HP's 10529A Logic Comparator is a clever gadget that's extremely useful in design, production testing, and servicing digital integrated-circuit equipment. The comparator locates faulty IC's in malfunctioning equipment as quickly as possible. It's simple to use, self-powered, adjustment-free, requires no tools, and costs only \$295.

The logic comparator clips onto powered TTL or DTL IC's and instantly identifies any pins where the logic states don't match those at corresponding pins of a known-good reference IC. Logic differences are indicated on the comparator's 16 light-emitting diodes. There's one diode for each pin of 14-pin or 16-pin dual in-line IC packages, and a lighted diode indicates a logic difference at the corresponding pin, therefore a faulty IC.

When the user also wants to see specific logic operation, the HP 10525A Logic Probe and 10528A Logic Clip nicely complement the comparator. The logic clip will display all the actual states of 14- or 16-pin DIP IC's at a glance. When pulses are involved, the logic probe is handy; it has pulse detecting and stretching capability. HP's 5010A IC Troubleshooting Kit consists of comparator, probe, and clip in a carrying case. Price is \$495, or \$20 less than if the three are purchased separately.

To learn more, check the Reply Card.

Here's a rapid, low-cost way to zero in on faulty IC's. The logic comparator simply clips onto your in-circuit IC's and lights LED's for any IC pins associated with faults.



Scan up to 1,000 channels without a computer



High-speed data acquisition doesn't always need a computer. Two new options enable this DVM to measure fast-changing signals, scan up to 50 channels at 1,000 per second, and then print.

There are two new options that give HP's 3480 DVM and 2070A Data Logger even **more** can-do for the dollar. 2070A is the little system you form by combining a fast 3480A/B DVM (1,000 readings a second) with a plug-in scanner and a digital printer. All in 7" of rack space, for \$4475 plus options, of which two are new:

For \$500, Option 001 **Sample and Hold** gives the 3480A/B DVM's the ability to measure fast-changing signals accurately. Trigger the 3480 now, and it will remember the value of the instant long enough to digitize it. Trigger it, if you like, with the delayed sweep on your scope, and digitize a

whole LF waveform, point by point.

For \$1000, Option 005 **Data Storage** makes the 3480's speed more usable. Store up to 50 complete readings at that 1,000/s rate, then tick them out later at 10 lines/s on the printer. Scan 50 transducers in only 50 milliseconds, yet preserve every digit.

To learn about all the options open to you with the 3480 DVM's—like true rms, multi-ranges and Ω , and to learn how a low-cost 2070A Data Logger might do the job of a \$10k or \$7.5k system for you, *check the Card for data sheets or three similarly relevant Application Notes.*

Programmable DC power line grows again

The 6129B is the most recent addition to the HP line of Digitally Controlled Power Sources (DCPS's), which along with HP D/A's and Multiprogrammer/analog power supply combinations, represents an extensive digitally programmable dc power capability.

The new addition (\$2700) is rated at $\pm 50V/5A$, five times the output power of the existing DCPS's (6130B, $\pm 50V/1A$; 6131B, $\pm 100V/0.5A$). All three of these DCPS's meet all requirements for systems use.

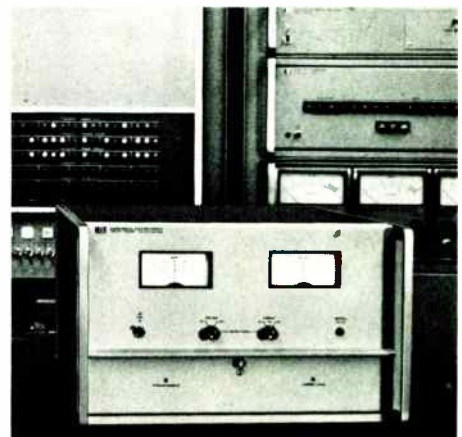
Typical applications for these DCPS's include stressing power semiconductor devices on high-speed production lines, and establishing signal and bias parameters on electronic modules under test.

For applications requiring more than 250W, or where the DCPS's 300 μ sec programming speed and 0.01% accuracy are not required, combining the 6936A Multiprogrammer with up to 240 standard analog power supplies can provide dc power outputs to 10kW, with 0.1% accuracy and programming speeds from 10msec.

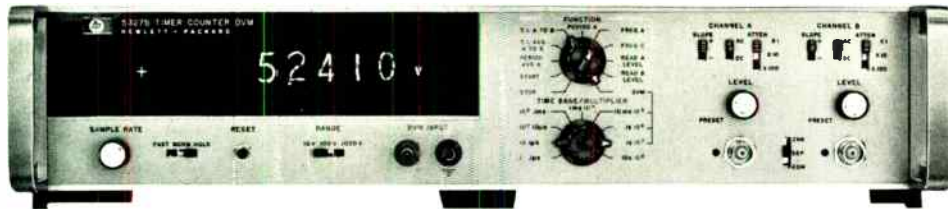
Finally, in applications where high programming speed and lower output power are required, HP DA's can provide 50 μ sec programming speed with power outputs of $\pm 10V/5mA$ (69321A) and $\pm 10V/20mA$ (6933B).

For more information, check the Card.

The 6129B extends HP's digitally programmable dc power capability with its 250W output, 300 μ sec programming speed, and 0.01% accuracy.



Timer/Counter/DVM team up for unique measurements



The HP 5327B universal timer/counter measures frequency to 550MHz, sub-nanosecond time intervals, and has a built-in DVM.

A universal counter and digital voltmeter in one package? Yes, but the HP 5326B/5327B Timer/Counter/DVM's are considerably more than that. They're really an entirely new type of counter, capable of making measurements no other counter can make.

First, there's the built-in 3-range integrating DVM. It'll measure external DC voltages, but, because of unique design it can measure the counter's trigger levels. Thus you can measure things like 10%-to-90% rise times, with the start and stop levels set with DVM accuracy. It's faster and more accurate than using a scope with intensity markers to show the start and stop points. Even without the DVM these counters are special. They **average** repetitive time intervals to get improved resolution—like 100 pico-

seconds, good enough to measure propagation delays in logic circuits and other short intervals. Unique synchronizers found only in these counters permit measuring sub nanosecond intervals! Try to beat all this performance at double the price of the 5326B and 5327B.

There are two new optional high-stability time bases: aging rates are $< 3 \times 10^{-9}$ /day and $< 5 \times 10^{-10}$ /day. Both change $< 1 \times 10^{-8}$ from -20°C to $+65^{\circ}\text{C}$. Prices: \$300 and \$450. Another option for the 5327 is high input sensitivity: 25mV rms, 0 to 50°C ; 10 – 15mV typical at 25°C . Price \$125.

Models 5326B (\$1595) and 5327B (\$2150) are members of a six counter family. Other models omit the DVM, time interval capability, or both. Prices are \$950 to \$1795. *Check the Card for full details.*

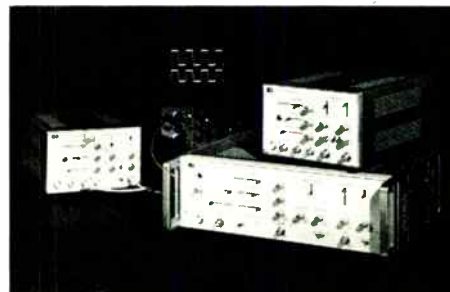
Low-cost, functional pulse generators

HP's budget-stretching family of pulse generators now offers repetition rates to 100MHz, amplitudes from 0.2 to 5V from a 50Ω source. These fast pulsers, with a wide range of pulse widths and transition times, are useful for testing both analog and digital circuits—including digital IC's. Newest:

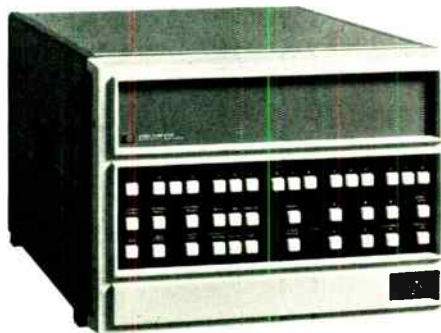
- **8007A.** 100MHz max rep rate; rise and fall times controllable from 2.5ns to 250μs; \$1600.
 - **8012A.** 50MHz max rate; transition times, 10ns–500ms; \$875.
 - **8013A.** 50MHz max, 3.5ns transition times; pos, neg outputs; \$625.
- All three models have an external input for reshaping and amplifying pulses generated elsewhere.

These generators are valuable performers; for more info, check the Card.

Three new members of HP's budget-stretching pulse-generator family—the 8007A, the 8012A, and the 8013A.



A computer that expands with your needs



The HP 2100A "thoroughly modern mini"

The HP 2100A minicomputer—more powerful and lower in cost than its predecessors—gives OEM's and end users new flexibility in tailoring a computer to specific needs.

Merely by plugging in more memory and adding peripherals, a 2100A can grow from an OEM controller to a multi-language stand-alone computer, or become the nucleus of time-sharing or batch processing systems.

The 2100A has a 16-bit word length and can expand from 4K to 32K of core memory within its 12-inch high mainframe. With a memory cycle time of 980ns, it is

40 to 100 per cent faster than previous HP models.

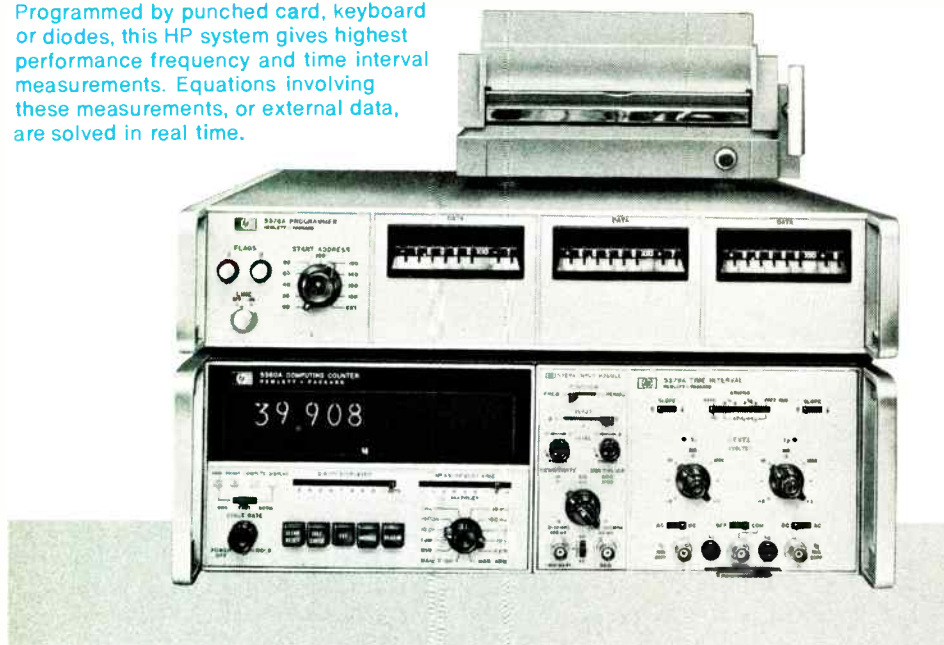
It's an entirely new design except for the instruction set and I/O structure. Keeping these the same makes the 2100A compatible with HP's existing peripherals and large software library.

Other features include FORTRAN, ALGOL, BASIC and Assembly software modules; 14 I/O channels, or up to 45 with an extender; plus floating point arithmetic and micro-programming capability. Prices begin at \$6,900.

This brief description only scratches the surface; for more information, check the Reply Card.

Desk-top computing counter system is versatile and economical

Programmed by punched card, keyboard or diodes, this HP system gives highest performance frequency and time interval measurements. Equations involving these measurements, or external data, are solved in real time.



Better measurements, plus a total solution to measurement and computation problems—in seconds, and economically. That's what the HP 5360A/5376A Computing Counter System—a desktop measuring and computing center for electrical measurements—gives you. It puts unmatched frequency and time-interval measuring power *and* real-time arithmetic capability at your fingertips. To duplicate its capabilities you'd have to buy a counter and computer, interface them and write software. Cost? About \$25,000, not including software. The 5360A/5376A does it all for \$7850!

It will solve equations involving its own measured data or that from other digital sources (DVM's etc.). For example, it will linearize transducers, calculate phase differences, calculate mean, standard deviation, and fractional frequency deviation, calculate maximum access time, and generate control signals. Final solutions are displayed directly on the 5360A Computing Counter readout. The 5360A Computing Counter portion measures frequency to 320 MHz (to 18 GHz with accessories) and time interval with a resolution of 100 picoseconds. Its frequency measurements are 10 to 1000 times faster than ordinary counters.

The 5376A Programmer automatically sequences the 5360A through a predetermined series of measurements and computations. Operations include $+$, $-$, \times , \div , and $\sqrt{\quad}$. It also provides facilities for the interchange of control signals and data between the 5360A Computing Counter and various other instruments and output devices, such as DVM's, signal generators, printers, and recorders.

Programs can have up to 200 steps, and may include branching, looping, subroutines, and constants. Programs are entered by punched card or by plug-in-diode read-only-memory.

The 5360A has 3 registers for accumulating data, 2 for storage. The 5376A can provide up to 6 additional storage registers. Program constants can be stored in up to three optional thumb-wheel switches. These are useful, for example, in production testing, for specifying upper and lower limits or nominal values and tolerances.

Optional D to A converters can provide analog outputs under program control for plotting results, or as test stimulus or feedback signals in closed-loop control systems.

5360A/5376A Systems start at \$7850. For full details, check the Card.

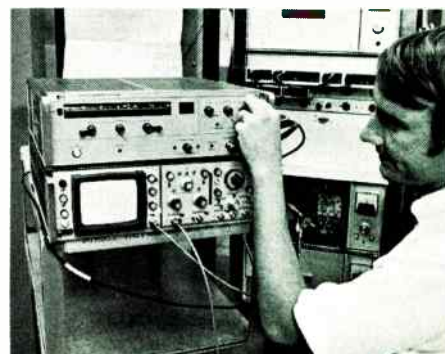
Communications links get IF/RF sweeper

For fast, efficient alignment of microwave radio links, use the HP 8605A Communications Sweeper, a CW and swept signal source, covering both IF (47-100MHz) and RF (up to three communications bands can be selected from within the 1.7-13.25 GHz range). The 8605A features the excellent frequency accuracy and flat power output needed for stringent communications systems measurements. This high-performance capability comes in a rugged portable package, making the 8605A equally suitable for lab and field tests. The RF (microwave) coverage employs economical microelectronic modules, which means you can tailor the sweeper just for the band (or bands) of interest.

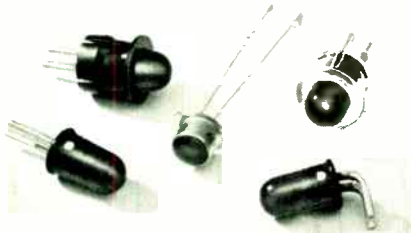
The 8605A is easy to use; IF and RF controls are separate and independently adjustable. The operator can shift back and forth between IF and RF measurements without readjusting any source settings or changing any cables or plug-ins. Output power is flat within 0.01dB via internal leveling for the IF band and via external leveling for the RF bands, using the recommended 784A Directional Detector (\$625) and 11675A Leveling Cable Assembly (\$50). Price of the 8605A varies from \$3875 up, depending on frequency and number of RF bands selected.

For specifications and more information on the 8605A Communications Sweeper, check the Reply Card.

Extremely flat-output Communications Sweep Oscillator offers both 70MHz IF and multiband RF (microwave) coverage in the same all-solid-state instrument.



A free LED is yours for the asking



Our gallium arsenide phosphide lamp is offered in both plastic and hermetic packages.

If you'd like to have one of our solid-state lamps to try, just ask. All we ask in return is that you tell us briefly about your application. You'll receive a free LED with a panel mounting clip. These HP light-emitting diodes have a 100,000 hour life with low power requirements—1.6 volts at 2 to 10 mA. They also have a wide viewing angle of 180 degrees with high brightness. For comprehensive data and order coupon, check the Reply Card. Try one, you'll like it!

Communications kit offers new components

Now, at paltry cost, you can get a solid handle on what those premium solid-state components can do for you. For just \$19.40 you get **seventeen** high-technology components, for breadboarding, that would cost you \$34 if you bought them separately.

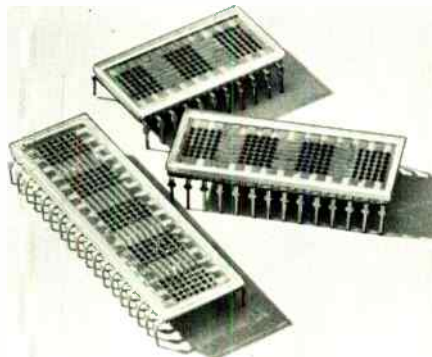
The kit (HP 5082-0051) contains a new transistor in a TO-72 can with 12 dB gain and a 3 dB noise figure at **1 GHz**. You also get eight fast-recovery (< 100 ps) Schottky diodes, good for low-noise UHF mixers, switches and clamps (HP 5082-2835), four high-breakdown (70 V) Schottky diodes for such uses as high-level detectors, and four 5082-3080 p-i-n diodes for low-distortion attenuation and switching at high frequencies.

For comprehensive data and order coupon, check the Card.



Here's the Communications Sample Kit that gives you a low-cost introduction to HP's high-technology semiconductors

Lower prices announced for alphanumeric



Lower prices are now in effect for HP's line of alphanumeric LED displays. For example, in quantities of 1,000, prices are cut from \$20 per digit to only \$11. These Model 5082-7100 series displays are 5 x 7 dot displays. They are IC compatible and come in dual-in-line (DIP) packages of three, four or five characters. Characters are 1/4-inch high on 1/3-inch spacings. Display packages are end stackable, thin and lightweight. Maximum voltage required is 1.6 volts.

Quantity	Price
1-9	\$22.50
10-99	18.00
100-499	15.50
500-999	13.50
1,000	11.00

For more specifics, check the Card.

Affordable radar: how to put it to work



The Doppler output and return signal is channeled through a single coupler in each of the packages shown here—one with X-band waveguide, the other with a miniature coaxial connector.

A mere palm-full of hardware is the heart of a microwave Doppler radar, lacking only antenna, power supply, and readout. Because it's a thin-film hybrid microcircuit (and all solid state), it's rugged and reliable. Inexpensive, too: \$200 for small quantities, significantly less in large volume.

To the designer who has the problem of detecting and measuring motion — or acceleration — the 35200 Doppler Radar module is the perfect prescription. Detect subtle movements of an unwelcome intruder, or track a diesel train. For traffic control, count passing cars and measure their speed. Build an anti-crash system to keep cars from colliding (trucks, trains or boats, too). Feed an airborne navigational system all it needs to know about landing velocity and deceleration rate.

Within the compact module is the microwave power source (i.e., transmitter); plus the circuitry to detect the return and generate an audio output containing all the motion information.

To see how 35200 can work for you, check the Card for our new 16-page engineering bulletin. Applications, system design considerations, readout needs, test procedures, options and detailed specs are presented.

HP's low-cost 'scope team exceeds your needs for digital IC design and checkout

Designing and maintaining digital equipment doesn't **always** need \$3000+ 'scopes — a big part of all digital work is MOS and TTL, and for these uses new low-cost HP plug-ins with the fast-writing 180C/D mainframes form a neat, more than adequate package for as little as \$1950. **35 MHz—for digital applications?**

Sure. In analyzing the performance of computers and peripherals you're mainly concerned with accurate measurements of **pulse timing**, rather than risetime. (It's true, of course, that for accurate risetime tests even 100 MHz is not enough!) Fast sweep speed—like 5 ns/div—is more than enough for accurate pulse time measurements. That, plus a mainframe which can write bright while it writes fast.

Take an HP 180C mainframe (the bench version) or a 180D (the lower, wider rack-mount version). It puts out a bright, clear trace at writing speeds of 1500 cm/ns. What else it's good for is **clean, bright traces on signals that recur only once or infrequently**.

Next, plug in a new low-cost time base and sweep expander with sweep speeds up to 5 ns/div (HP

HP 180C mainframe, 1808A or 1807A dual channel amplifier, and 1824A time base and sweep expander provide low-cost digital design checkout capability.

Model 1824A, \$550) and a new 2-channel 10 mV/div, 35-MHz amplifier (HP Model 1807A, \$450). Result: a digital journeyman—for a total of only \$1950. Or add \$430 and substitute the new 75-MHz Model 1808A plug-in, providing ECL capability too.

Fast-sweep, low-cost time base

Next best thing to an elegant delayed sweep generator, to study high-frequency pulses, is the new Model 1824A sweep-expand time base. Its TIME/DIV knob shows calibrated sweeps up to 50 ns/div, and then the expander takes over. It's interlocked to the TIME/DIV



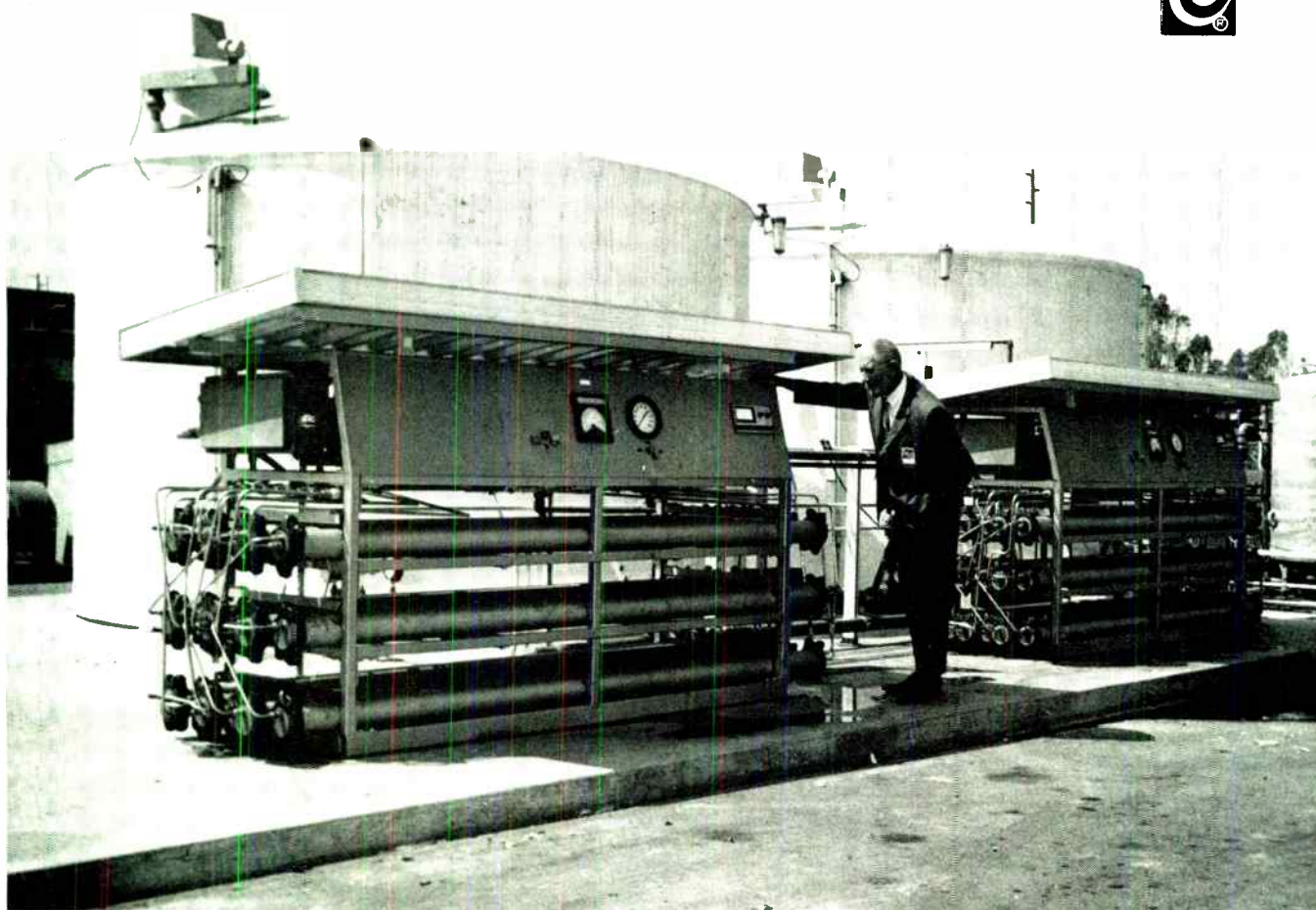
knob, so you **always** know what gear you're in. Expansions up to 100 times are available with direct readout. And accuracy, even at full expansion, is $\pm 3\%$. Speed limit: 5 ns/div! It triggers to 150 MHz and a trigger hold-off control makes possible stable triggering on complex waveforms or on a particular pulse in a digital word. What it doesn't give you, that a delayed generator would, is retriggering after delay and calibrated delay times. And it will save you \$250 or more.

To find out more about HP's lower cost digital 'scopes, check the Card.

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Twenty thousand times purer water is a lot purer water.

Water twenty thousand times purer than average drinking water is produced for the North American Rockwell Microelectronics Company (NRMEC) starting with the Culligan system shown above.

The final product water is zero in hardness, has zero total dissolved solids, 18 megohm resistivity, and a bacteria count less than 10 ppm.

This water is produced by our new Reverse Osmosis units and subsequent ion exchanges. Its high purity is vital to the efficient manufacture of the microscopically-small electronic devices made by NRMEC.

NRMEC devices incorporate circuit lines as narrow as .0002 inch. Thus, the most minute impurity could immediately short circuit adjacent circuits and ruin the entire device. To prevent this, NRMEC bathes the microelectronics devices with this very high purity water several times during processing to assure maximum

cleanliness. The water does not permit precipitation of impurities to the wafer surfaces.

Our Reverse Osmosis system has achieved two main objectives for NRMEC. First, water ready for deionizing is now dependable and consistent in quality. It is not affected by fluctuations in the local municipal water supply. And second, water costs have been substantially reduced from the previous method of starting with distilled water which was delivered daily by truck.

In addition to conditioning process and production water, Culligan capability includes equipment for softening, filtration, boiler water, cooling towers, and waste water treatment.

Call your local Culligan Man today for a consultation. He will evaluate your water needs as to flow, quality, application, and treatment equipment requirements.

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ION IMPLANTATION...

Your key to MOS performance – today!

Our revolutionary production process, ion implantation, has quietly come of age. Today it's the most uncomplicated method for achieving such sophisticated benefits as low threshold voltages for TTL compatibility and depletion mode devices for state-of-the-art performance. Want proof? Then take a look at some examples of the advantages offered by MOSTEK's ion-implanted product line:

(1) Threshold Adjustment. Take our MK 1007 P 4x80-bit dynamic shift register, for instance. Ion implantation makes possible a low threshold device for full TTL compatibility without the need for interface components or high voltage, high power clocks. Our clock is single phase, low capacitance and TTL compatible.



1) MK 1007 P
4x80-bit Shift Register

(2) Depletion Mode Devices. With ion implantation we have replaced enhancement type load resistors found in all MOS/LSI to date with constant current, depletion devices. Results? See for yourself:

Low power over a wide supply range for memories such as our MK 4007 P RAM is illustrated by the constant current drain versus supply voltage shown in Figure 1.

Power remains low with the depletion loads compared with the enhancement loads of the competitive 256-bit circuit.



2) MK 4007 P
256x1-bit RAM

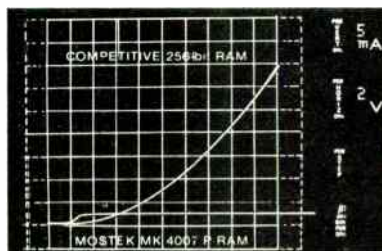
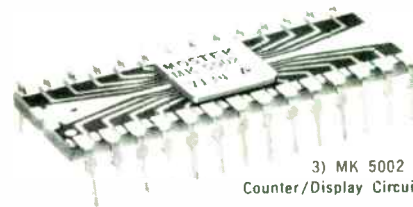


FIGURE 1

Single 5V supply operation. MOSTEK's MK 5002 P 4-digit counter/display circuit for instrumentation purposes can operate from a single +5V logic supply, drawing less than 25 mW, or from any supply from 4.5 to 20V! Ion implantation is the only processing tool capable of delivering this performance

from otherwise conventional, cost-effective P-channel LSI.



3) MK 5002 P
Counter/Display Circuit

Find out how easy it is to use the products and processes of the leader in MOS—MOSTEK. Call our home office at (214) 242-1494 and ask for marketing or applications assistance. Or contact your nearest MOSTEK sales office listed below, or your local Sprague office or distributor.

Ask for our new catalog!



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Kansas City to test digital patrol-car links

New IBM teleprinter to be matched against mobile terminal in competition for police data contract

Looking to link its patrol cars with the giant National Crime Information Center (see p.108), the Kansas City, Mo., police department will match a new and unannounced IBM teleprinter unit against a new digital mobile terminal built by tiny Kustom Electronics Inc., Chanute, Kansas, in tests beginning early next year. IBM will be paying its own way, while Kansas City is paying Kustom \$90,000 for its system.

Waiting in the wings with its commercially available Digicom 300 will be Sylvania Sociosystems division of Mountain View, Calif.—the third choice, principally because of the smallness of the Sylvania 32-character CRT display.

The size of the test hardware award to Kustom—a big one for law

enforcement electronics—indicates not only that Kansas City is serious about becoming a leader in exploiting technology, but also that Kustom has a clear lead in the competition. Kansas City police officials won't confirm, as competitors will, that IBM makes the terminal slated for January 1972 trial. IBM won't talk either, citing the Justice Department's prohibition against discussing unannounced products under the company's antitrust consent decree.

Nevertheless, IBM's participation is a subject of open discussion in the marketplace and indicates the giant computer maker is seriously considering entry into the field of mobile terminals for law enforcement agencies.

No voice. "With capabilities of the device we're seeking, we'll probably stop using voice communications, except in emergency situations," a Kansas City police official explains. The department expects eventually to pay about \$3,000 apiece for some 250 mobile units,

and will have decided by July 1972 which company can do what needs to be done.

Kustom's synchronous phase-shift keyed system uses a 256-character Burroughs plasma display [*Electronics*, July 5, p. 36]. That avoids the potentially hazardous high-voltage and implosion problems plaguing CRT displays, says Charles E. Gilliam, manager of the company's data communications division.

The purchase price includes six mobile terminals, and the computer interface and associated equipment that allows the officer in the car to access his data base directly; up to 200 additional mobile terminals can be added to the package for \$3,200 per unit.

The system moves messages at 1,200-plus bits per second on top of the rf carrier, says Gilliam, 224 characters at a time in a burst mode of less than one second. It also has a carrier sense that avoids breaking into voice transmissions, using a random retransmission technique. For security reasons, to avoid having hard copy in an unoccupied car, the system queues messages in the computer, to be retrieved when the patrolman returns. Gilliam says.

Motorola, too. Meanwhile, Motorola's Communications division in Schaumburg, Ill., is demonstrating its first system tied to the national data base. Patrolmen of Allen County, Ind., in 10 cars equipped with the company's VP-100 teleprinter unit speak their inquiries to the county's radio dispatcher, who punches the request into the IBM 360 regional data base, which can access state and Federal crime information centers. The system responds directly to the vehicle initiat-

Picture talk. Kansas City police expect digital links to replace voice. Shown is Kustom Electronics MCT-10, which will be tested against a new and unannounced IBM teleprinter.



ing the request, bypassing the dispatcher, via the central encoder of the printer system and a network operating on a frequency different from the voice system's.

Packaging

MOS/LSI plastic package for 20 cents

Under steady pressure to reduce cost of packages as the price of MOS/LSI chips themselves comes down, semiconductor houses are coming up with their own designs for low-cost packages. [*Electronics*, April 12, p. 75]. The latest is MOS Technology Inc. of Valley Forge, Pa., with a premolded, cavity-type plastic package.

According to manufacturing engineering manager Allen McDoulin, a 40-lead package will cost about 20 cents, far below the 90 cents to \$1 that's currently the going price for 40-lead ceramic packages.

The new version is only two or three cents higher than transfer-molded plastic packages for LSI, according to McDoulin, but its advantages in eliminating possible chip contamination or lead-bonding failures due to thermal expansion far outweigh this slight cost difference.

The package construction begins with a Kovar lead frame selectively plated with gold on the die attach

pad and the tips of the leads where bonding wires will be attached (the rest of the lead frame will be plated with tin in the final steps of the process).

In the MOS Technology fabrication scheme, the lead frame is placed in the mold, the pad is bent down below the plane of the leads, and silicone compound is added to the mold. The die attach cavity in the center of the package is left free of silicone on both sides of its pad.

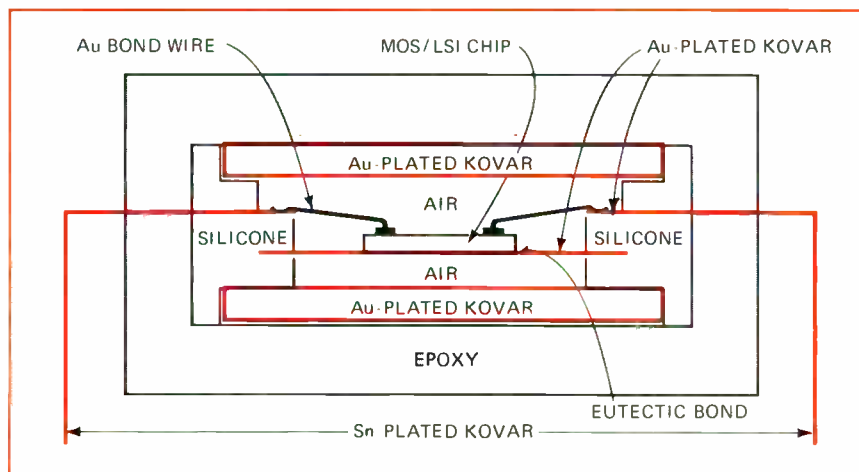
The cavity is made as large as 210 mils now, and could eventually go to 250 mils square.

The chip then is attached to the pad and lead wires are bonded. Gold-plated Kovar inserts are snapped in place on each side of the chip cavity and the whole assembly is molded over with epoxy to complete the package.

The exposed lead frame is tin-plated for soldering into the printed circuit board. Silicone is used to prevent any contamination of the chip (which is even more unlikely here since no silicone is in contact with the chip) and epoxy is used for the outside coating because of its moisture resistance.

Future look. McDoulin estimates that about 40% of the total production of MOS Technology will soon be shipped in this form, and when the company tools up for 24, 28, and 36-pin packages, almost all devices going from Valley Forge will use the package, he says.

Give it air. Plastic package developed by MOS Technology avoids complete encapsulation of chip by first molding cavity around die-bonding pad and then over chip with epoxy.



TI anxious to move with Minimod

Texas Instruments, in signing its cross-licensing agreement with General Electric for the Minimod integrated circuit packaging and bonding system, is showing the same enthusiasm and optimism that GE showed when it introduced the scheme almost a year ago. TI, while purchasing all the equipment, must allow GE to use any improvements it makes. And in the process of making the announcement, TI admitted for the first time that it had been working on variations of the Minimod.

The Minimod approach involves an etched copper lead frame laminated on a sprocketed strip of polyimide film, about 35 mm wide, allowing reel-to-reel handling for automated production of the ICs and also automated insertion in the user's plant [*Electronics*, Feb. 1, p. 44].

Problems solved. James H. Peterman, who is manager of TI's linear/computer interface circuits, is obviously pleased with his catch. "Not only has GE done much market and technological development on the Minimod, but they were much further along than we had suspected. They have already solved many of the problems we have been grappling with." GE, in fact, had been working with many of the same customers TI had been courting, and Peterman hopes to be able to snare some users already buying from GE, plus others who were hesitant to commit themselves to the package because of the limited resources GE was devoting to the effort.

Two production equipment manufacturers—Kulicke & Soffa, Fort Washington, Pa., and Universal Instruments Inc., Binghamton, N.Y.—had been working with GE to develop the machinery that users of the Minimod would need. Although Universal vice president John Hohl says he was disappointed to see GE drop the project—"I feel the action set the concept way back," he says—

it now appears that still other semiconductor manufacturers may step into the picture. Motorola Semiconductor and Signetics are among those most often mentioned by industry observers.

TI's Peterman feels that one important area where the Minimod will be a hit is hybrid circuits, where it could serve as a beam-lead-like package once the device is punched out of the plastic carrier strip. The scheme's easy adaption to a large number of leads, such as 32 in a circle less than 1 inch in diameter, should make it popular for use on ceramic substrates applications where present molded dual in-line packages are too bulky.

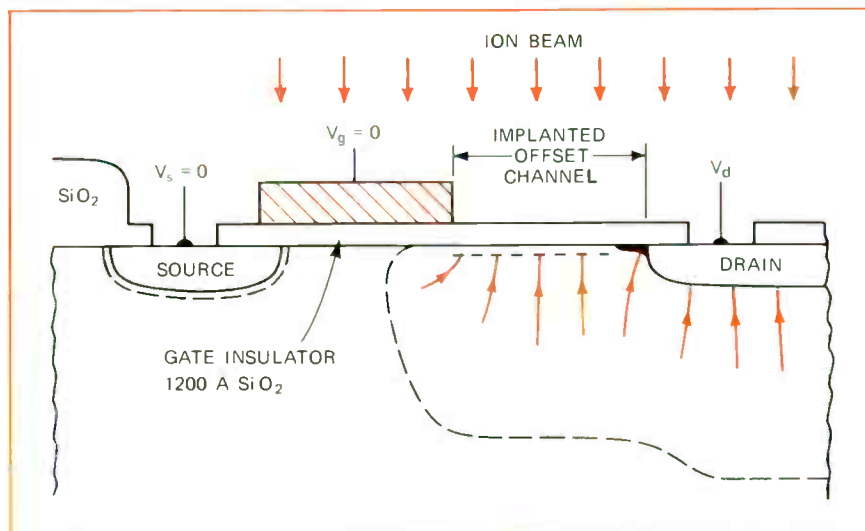
No second source. TI now is in the position of first source with no second sources immediately available, but Peterman says he isn't concerned: "The backup to the Minimod parts may not look exactly the same." He points out that since others are working on similar schemes, it may not be necessary to have a direct second source. The scheme is so flexible that it wouldn't be difficult for anyone to produce at least a compatible package. Peterman also doesn't think that the Minimod will necessarily be limited to large-scale users, but is adaptable to relatively simple and inexpensive mounting equipment.

He expects to have the line set up and running "pretty quick," probably in TI's Houston IC plant. He feels there shouldn't be any abnormal delays. "As soon as GE finishes some production commitments, they'll just put the equipment in some boxes and send the boxes on to us."

Solid State

Ion-implanted MOSFET ups breakdown to 200 V

Circuit designers using conventional MOS field effect transistors are limited to maximum breakdown voltages of about 40 volts. But researchers in the solid state research department at Hughes Aircraft Co.,



MOSFET with a backbone. Researchers at Hughes Aircraft say their ion-implanted MOSFET with breakdown in the 200-300 V range permits directly driven external devices.

Newport Beach, Calif., have overcome that limitation and extended MOSFET breakdown voltages to the 200-to-300 v range. They say this makes it possible to directly drive external devices, such as electro-luminescent displays, which require high voltages. Another possibility is the potential to fabricate one-chip calculators with the decoders and drivers on the same chip.

Close controls. They're doing it with closely controlled ion implantation, says Darrell Erb, a member of the technical staff. Dosage control is critical, and the team only recently has been able to control the implantation dosage to the required 2×10^{12} ions per square centimeter.

The tight control over the dosage is required to regulate the threshold voltage of the device. Erb reports: it must be maintained within 0.5 v of the theoretical threshold level of approximately 2 v to extend breakdown voltages into the 200-to-300-v range. The implantation dosage for the high-voltage MOSFETs compares with dosages of 10^{11} ions per square centimeter for the self-aligned gate MOSFETs that have been produced at the Hughes facility.

Erb stresses that the high-voltage units are made with just one additional step beyond standard p-channel MOS processing—implantation. The ion beam is directed at an entire wafer, in which the source and drain areas have been diffused, and

over which a silicon dioxide gate insulator 1,200 angstroms thick has been grown. The gate metal has also been deposited, but slightly offset, rather than being centered between the source and drain regions. That way, the implanted channel is slightly offset; it's closer to the drain region.

But with the gate separated from the drain by the implanted channel, the Miller feedback capacitance usually encountered between the gate and drain in nonimplanted MOS devices is minimized. The drain is completely enclosed by the ringlike gate metal and the implanted channel is formed inside this ring.

Erb says: "We've done extensive reliability studies that include tests at 150°C for a month, and we've found that the degradation in breakdown voltage can be less than 10%. We've tested and looked at thousands of devices, and have found that getting good reliability hinges on achieving good threshold control on the device."

He adds that the same techniques, minus the ion implantation step, are being used at Hughes to make high-voltage MOSFETs that are radiation resistant—"devices that maintain their high-voltage capability greatly beyond those of bipolar radiation-resistant devices." He maintains these are the only high-voltage, radiation-resistant devices

Electronics review

available; the bipolar units that operate at high voltages and are radiation-resistant have large base widths that absorb radiation, degrading them in a radiation environment.

Space electronics

NASA nervous about shuttle cash

Officials at NASA, who are hanging their post-Apollo manned space program primarily on the space shuttle, are worried that there may not be a long-range program at all.

The White House's Office of Management and Budget hasn't yet approved the approximately \$200 million for fiscal 1973 to rush even a pared-down shuttle program beyond the study stage—and the longer the budget office takes before the requests go to Congress in January, the more justifiably anxious NASA becomes.

NASA Administrator James C. Fletcher frankly admits that "manned space is in trouble if the shuttle isn't funded." The freshman administrator (see p. 14) says that if it isn't funded, "it can be construed as a warning from the White House and Congress that they're not interested in manned space." Fletcher says NASA has "a lot of support from Congress," but only, he adds, "if they're convinced of the programs' worth."

Small is better. Budget beagles, facing problems of a deficit budget, sluggish economy, and high unemployment, shy from funding large programs like manned space flights. Fletcher and other NASA officials, however, argue that NASA programs are "labor intensive." Most of NASA's money goes into industry and the biggest portion serves to create aerospace jobs. Fletcher points out.

To help sell the shuttle to White House and Congressional accountants, NASA now is offering a simpler version of the booster and piggyback orbiter with a much lower price tag. Originally, it wanted a

C-5A-sized, fully reusable, piloted booster with orbiter for \$10-billion to \$13 billion. NASA's latest version carries a price tag of \$5 billion but the agency hasn't chosen between concepts for piloted, partially reusable, or disposable boosters.

Although NASA favors reusable boosters, Fletcher explains that "we would prefer to get going on a less optimal system to prove the device." Later, he hints, the initial version could evolve into a more optimal craft. This also would mean that NASA could try to lock the White House and Congress into the program and then try to expand it.

Cheap costs more. The problem with the cheaper shuttle version, NASA tells the budget office, is that it will cost more to operate over the long run, depending on how the number of operational flights is counted. The Defense Department supports the shuttle concept, but not enough to help fund it.

The fiscal 1973 budget appears to be safely above \$3 billion, although the White House hasn't confirmed it yet, but NASA would have to give up the shuttle if the budget were to shrink much, Fletcher says.

He flatly rules out compressing science programs to make funding room for the shuttle. The budgets for scientific and planetary programs will rise slightly in the new budget, Fletcher says, but "they have reached their approximate dollar level" and will remain at that level for years to come. "They're big programs anyway," he says. "Viking is reasonable at that cost (\$800 million). You can do a fair amount at that level."

Fletcher emphasizes NASA's increasing trend toward applications both "in absolute dollars and relative dollars." The space agency's administrator mentions aeronautics research and applications, "a reassertion, if you like," in communications and meteorological satellites. Besides Earth Resources Technology Satellites and the \$2 billion Skylab programs, Fletcher says NASA also would be developing more techniques in transoceanic communications for Intelsat and direct broadcast satellites.

Companies

Hogan completes Fairchild alignment

C. Lester Hogan, who often has turned to reorganization to improve his operations and management teams, finally may have come up with a lineup that could be a permanent one—or, as permanent as one can get in the churning semiconductor industry.

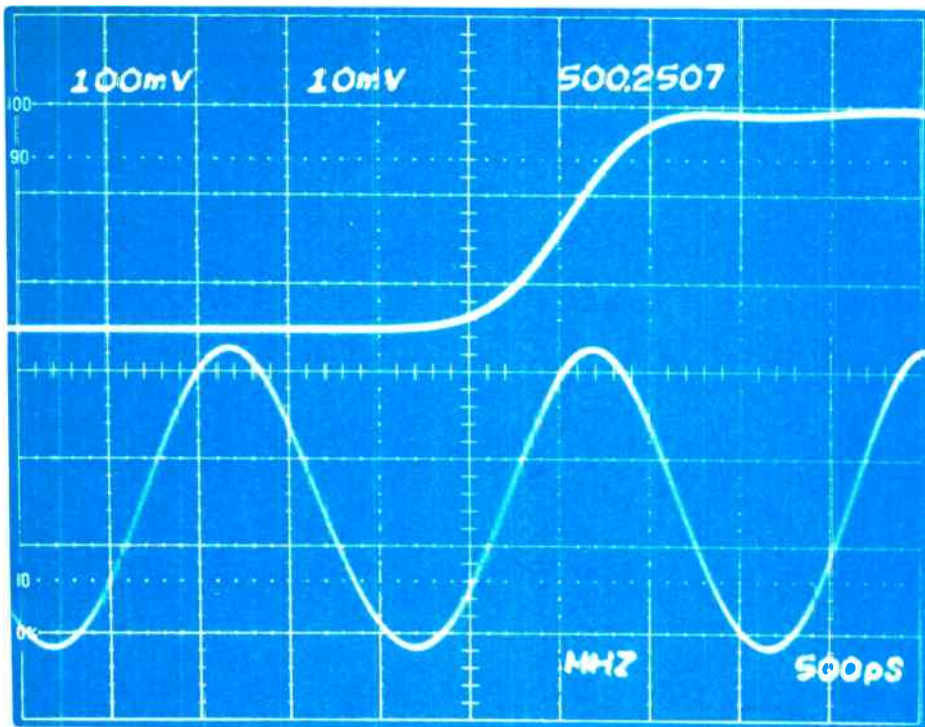
The president of Fairchild Camera and Instrument has sharply reduced the number of people reporting to him and has reorganized Fairchild Semiconductor into a new group of five operating divisions. While it may appear that his move was partly in reaction to the continuing loss picture at Fairchild [*Electronics*, Nov. 8, p. 42], the reorganization actually winds up a plan of action he started early this year.

In fact, the restructuring has its genesis as far back as 1969 when Hogan began planning to phase himself out of running the old semiconductor division and naming one of his team to head it. Winner of the job is Wilfred J. Corrigan, who will lead the new Semiconductor Components group. The new organization looks good on paper, though the evolutionary changes leading up to it have, in part, caused the loss of several senior managers.

MOD change. Hogan took advantage of the reorganization to do something about his Microwave and Optoelectronics division, which is not doing as well as was expected.

Reorganizer. Fairchild's C. Lester Hogan now has five-division operation.





CRT READOUT

CHAR. SET ABCDEFGHIJK LMNPQRSTUVWXYZO123456789mnpnd</.>Δ+-Ω
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TEKTRONIX 7000-Series Oscilloscope Systems

CRT READOUT, unique to the *TEKTRONIX 7000-Series Oscilloscope Systems*, provides a combined display of waveforms, measurement parameters and symbols on the CRT for direct reading.

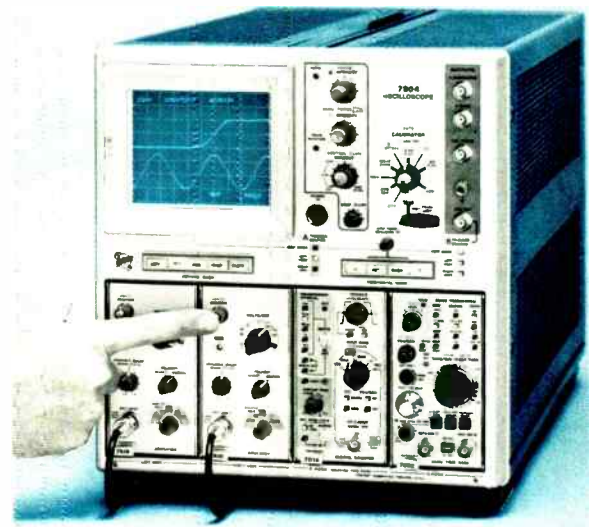
Wrong answers because of overlooked control settings are now passé. CRT READOUT tells you the full story. Speed, perception and convenience are available because the scale data is printed right on the display. These values are automatically corrected for both probe attenuation and sweep magnification. There are also special symbols for identifying trace position (IDENTIFY), amplifier polarity (↓) and uncalibration (>).

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CRT READOUT responding to various functional instructions and generating up to 50 symbols is shown using the 500-MHz 7904, a four-plug-in Oscilloscope with a pair of 500-MHz, 10-mV 7A19 Amplifiers, a 525-MHz 7D14 Digital Counter and a 500-ps/cm 7B92 Dual Time Base.



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Joseph Van Poppelen, whose job was wiped out by the reorganization, was named to run the division, which has been merged into the Semiconductor group. John Atalla, former division manager reporting to Hogan, is now an assistant to Hogan, a post which recently has been the jumping-off point to other companies.

Separate units. The five divisions in the semiconductor group will be separate operations with profit responsibilities and their own marketing, manufacturing, and development sections. Each will be responsible, for example, for new product planning, product design and development, reliability and quality assurance, and pricing.

In addition to Van Poppelen's Microwave and Optoelectronics division, the divisions and their managers are: Digital Products under Tom Longo; MOS under Roy Pollack; Analog Products (linear ICs and hybrids) under John Husher, and Discrete Products under Greg Reyes.

The division split also reflects the efforts that Hogan has been making to move Fairchild in faster growing, larger semiconductor markets where the firm wasn't getting its share of business. Part of Fairchild Semiconductor's problems in the past year or two has been that the division wasn't much of a factor in such markets as MOS and plastic-packaged TTL circuits. Markets areas where the company had been strong were in some of the older IC logic families where sales were declining and to the computer mainframe makers, which sharply reduced their component buying when the EDP market turned soft.

Fast mover. To get moving in MOS, Fairchild earlier this year hired Pollack away from the RCA Solid State division after 20 years there. Pollack, who was charged to take Fairchild to a "leadership" position in MOS, already has made several moves, including getting his own wafer fabrication line. He moved fast, and even though the money was not in the 1971 budget, Pollack will have his dedicated line running by Christmas—or just four

months after he proposed it to management. He says he also believes he's stopped the "massive turnover" of personnel in Fairchild's MOS operation, which has hurt it badly over the past four years.

For a variety of reasons, Fairchild moved slowly into plastic-packaged TTL and because of that wasn't participating in the fastest-growing part of this business. But that was until this summer, and at the same time TTL business started moving upward, Fairchild turned on its dual-in-line, plastic-packaged TTL production.

Creation of the Semiconductor Components group follows the consolidation of Fairchild's equipment division last July into two new groups: Federal Systems and Commercial Systems. And in November, the Central Research and Development Laboratory, which had been a separate group, was put under the Semiconductor group. Two other posts no longer at the corporate level and reporting to Hogan are planning and marketing. Now only three operating groups and four staff functions report to Hogan, who says the move "completes the reorganization of the company into three major profit centers."

GI moves R&D east,
says it's in MOS to stay

General Instrument Corp. has decided to transfer the activities of its small R&D facility in Salt Lake City to its main semiconductor operation in Hicksville, N.Y. The decision, which immediately sparked doubts within the industry about GI's continuing position as a supplier of MOS devices, was made because of the "problems encountered in transferring processes developed in the R&D atmosphere of the Salt Lake facility to production in Hicksville," explains Rein Narma, group vice president, semiconductors. We felt the process development and implementation needed to be considerably closer than 2,000 miles apart."

No top level management changes are contemplated, he says.

GI is definitely in the MOS business to stay "across the board," declares chairman Moses Shapiro.

All of the professional staff in Salt Lake City—about a dozen people out of 35—have been offered positions in Hicksville, where equivalent facilities for process development and pilot production have been constructed, Narma says.

As for the general MOS business picture for GI, Narma concedes cutbacks in orders by Japanese manufacturers, particularly by calculator manufacturer Sanyo, had a "temporary impact," but, he adds, it was not a major one. GI was able to fill in with business from other sources, he says. One such area is the new calculator from Royal Typewriter division of Litton Industries that uses a single MOS chip from GI and is in volume production. It lists for \$139.95. And two other single-chip calculators are coming in very short order, he says.

GI is also in production with all of Intel's silicon gate products, including the 150-nanosecond version of the 1103 random access memory, which, Narma admits, took a "little longer than expected" to bring into production. Over the year, however, Narma is looking for MOS sales to be up over the previous fiscal year's figures.

North American merger
with Collins nears

While the term "affiliation" has been used by both North American Rockwell Corp. and Collins Radio Co. officials to describe the former's investment in Collins, it appears that a merger [*Electronics*, August 16, p. 26] is closer than expected. The reasons: Arthur A. Collins, founder, president, and chief executive officer of Collins, has stepped down in favor of Robert C. Wilson.

Honorary chairman. Wilson has been executive vice president for the industrial products and electronics groups of North American Rockwell. He assumes the former chief's title, with Collins becoming honorary board chairman. Because Col-

In Answer To Your Gripes About Every Other Portable Recorder

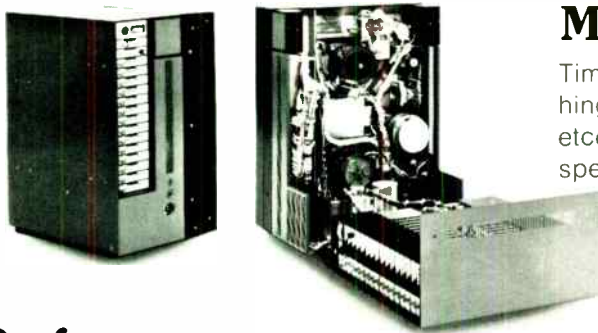
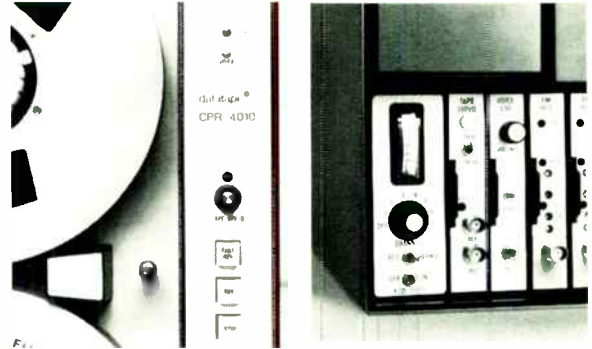
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Old Clichés Revisited

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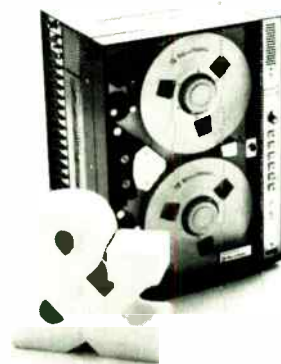


Maintenance and Servicing

Time for the annual P.M.? It's no big deal. The back panel's hinged. Just flip it down. All motors, power supplies, electronics, etcetera, are right there. (It even runs in this position.) Nothing special needed. How's that for simplicity?

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Briefly, from the top: 7 speed transport, 15/16 to 60 ips; 7 speed direct, all automatically switched. 300 kHz at 60 ips; 7 speed FM record; 40/20 kHz, automatically switched. Any 2 speeds of FM reproduce; low tape flutter and TBE; isolation from reel perturbation via dual capstans and tension sensors. Low mass, closed loop IRIG servo system. The same electronics design as our top-of-the-line VR-3700B.



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Electronics/December 6, 1971

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Circle 45 on reader service card 45

lins was so personally involved in managing his company, it had been conceded by many that any merger would be problematical as long as he ran the company.

With Collins out as chief executive officer, and with North American Rockwell controlling the majority of the Collins board, acquisition is almost a certainty. When the most recent move was announced, Willard F. Rockwell, North American Rockwell's chairman and chief executive officer, said that acquisition "could be a good possibility down the road, but at this moment, I just couldn't say."

Collins announced first-quarter sales down \$24.7 million, and losses of \$8.8 million.

Medical electronics

Pacemaker recharged from outside source

An electronic heart pacemaker has been developed with batteries that can be recharged from outside the patient's chest. In other pacemakers, worn-out batteries have to be replaced by surgery.

Developed by a team of Israeli researchers and a Columbia University engineer, the device relies on nickel-cadmium batteries recharged by rf power from an external transmitter. Robert I. Bernstein, professor of electrical engineering at Columbia's School of Engineering and

Heart throb. Israeli-American pacemaker gets recharge current inductively.

1 18 011 6 9 4 19 15 17 16 12 11 10 9 8 7 6 5 4 3 2 1



Applied Science, predicts the batteries could last as long as 25 years. In contrast, the mercury cells ordinarily used must be changed every two years or so.

The advantage of having a power source for pacemakers which does not have to be replaced by a surgical procedure has long been obvious. Besides the cost of the operation, a patient also must endure the risk of the operation and exposure to infection. Nuclear-powered pacemakers that can run for years are one solution. For example, Medtronic, Inc., Minneapolis, Minn., said to have the largest share of the pacemaker market, is working with a French concern on a unit powered with plutonium 238. And AIL division, Cutler-Hammer, Deer Park, N.Y., developed a unit that placed the batteries and timing circuitry in an accessible pack that is carried directly on the patient's chest. The patient received the pacemaking jolt inductively.

Generated in Israel. The new pacemaker took shape in Israel while Bernstein was a visiting fellow at the Weizmann Institute in Rehovot. Power for the batteries in the device is received by induction from a 100-kilohertz signal emanating at a continuous level of "a few watts" from a transmitter held against the patient's chest, Bernstein says.

The transmitter's signal is coupled to a coil of wire, about 1 inch in diameter, mounted on the pacemaker. This coil has enough turns to produce sufficient voltage to charge the batteries after the signal has been rectified and passed through a regulator, reports Bernstein. The regulator circuit, he explains, prevents excessive current from being fed to the batteries.

It takes anywhere from 8 to 10 hours to charge the battery, and this must be done every four to six months, Bernstein says.

There is nothing unusual in the pacing circuitry itself, which is unaffected by the 100-kHz battery charging signal, says Bernstein. A free-running multivibrator set somewhere between 60 and 80 pulses per minute triggers a switching circuit. This, in turn discharges a set of

electrolytic capacitors into a stimulating electrode buried in the heart muscle.

The new pacemaker is triangular in shape, about 2¼ inches long on a side, and about ⅝ inches thick. Its three batteries—supplying 3.6 volts—are about the size of a 25-cent piece but several times as thick. The pacemaker is built using discrete devices because ICs are too expensive.

So far, the unit has been tested only in dogs, with three more animal tests scheduled for the next six weeks. Clinical testing in humans is expected to begin after the first of the year at the Tel Hashomer Institute. The American manufacturer of the pacemaker will be Electro-Cather Corp., Rahway, N.J.

Communications

Frequency monitor gets Government contracts

The first contracts for a system that meets FCC requirements for studying mobile radio spectrum usage have been awarded to Fairchild Electro-Metrics Corp. The computer-controlled system, called Fairs (for Fairchild automatic interceptor and response system), scans the spectrum and displays the status of channels in use on a CRT.

Using knowledge acquired designing and developing ground intelligence and frequency management systems for the military, NASA and other Government agencies, Fairchild is building two prototypes, both scheduled to be operational in June 1972. One is being made for the FCC under a \$250,000 contract, and the other is covered by a \$220,000 contract with the Navy's Pacific Missile Range, Point Mugu, Calif.

Wide range. A typical system operates from 5 kilohertz to 12.5 gigahertz and consists of an antenna array for surveillance, a digitally controlled receiver system, a minicomputer, the CRT display, and input/output devices. Hardware is off-the-shelf equipment. The FCC system, for example, will include a



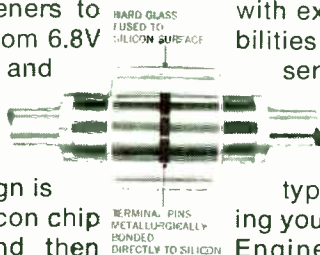
Whiskers are out.



The new military standard for 1.5 watt power zeners is Unitrode's double pin bonded design.

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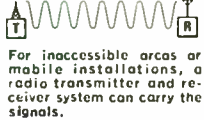
UNITRODE

World Radio History

Circle 47 on reader service card

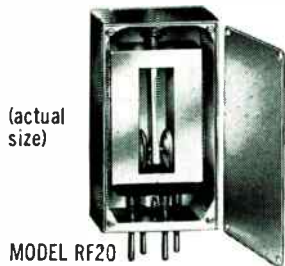


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Hewlett-Packard 2116B computer with a 16K memory and a Fairchild BRT-35 digital control synthesized receiver.

Fairs uses a synthesized local oscillator system and swept intermediate-frequency output, which eliminates the need for a synthesized first oscillator. Both FCC and Navy versions will have a crystal reference for their synthesized local oscillator systems. H. Dean McKay, government marketing manager for Fairchild Electro-Metrics in Panorama City, Calif., notes that police communications systems normally use crystal oscillators and it is important to have a source at least as stable.

Intermediate-frequency data is demodulated and signal-processing circuitry modulation characteristics are provided for signal analysis. The analog signal amplitude data then is converted to digital data at the signal processor and routed to the computer for analysis.

The contracts could be the forerunners of considerable business for this type of equipment. In the case of the FCC, the prototype will be housed in a mobile van used to monitor all allocated channels in Chicago. The idea is to test the system to manage all allocated frequencies, not just police channels.

The Navy installation will be used by the western area frequency coordinator at Point Mugu, who regulates Government-used frequencies.

While Univac's agreement with RCA to take over RCA customers will move Univac closer to IBM in the Government market, it adds 171 machines to Univac's total.

However, the Honeywell acquisition of General Electric's computer operations was enough to move Honeywell up to fourth place from sixth; Honeywell's installed base was 299 computers last year and 465 at the end of June 1971. The shift moved Control Data Corp. down to fifth place despite CDC's increasing its Government base from 404 computers to 498.

National Cash Register was knocked out of the top five by the shifts and the fact that instead of 321 computers in Government use it now has 298.

Surprising rise. Overall, the surge of minicomputer buying caught the Government's General Service Administration unawares. The GSA has predicted that computers in government inventory would drop from 5,277 in fiscal 1970 to 5,235. Instead, the total jumped to 5,961 and likely is now well over 6,000.

Minicomputers accounted for 640 of the 648 computers added to the Federal inventory. This was 100% of the growth attributed to the so-called special management category that the GSA exempts from its direct control when used by individual scientists and engineers for laboratory instrumentation, controlling communications and processes, replacement of analog computers, and for input to larger computers. Purchase of the minis also accounted for the apparent increase in government-owned computers to 72.1% of the inventory, up from 63.9% last year. The Atomic Energy Commission, for example, increased its computers by 200, half purchased from DEC.

Although the big money lies in the large computer systems, the influx of minis may bring a tightening of GSA controls.

George W. Dodson, chief of computer procurement, says the \$50,000 exempt purchase limit was arbitrary and could be revised by the Government. The house subcommittee on government activities, whose chairman, Jack Brooks (D., Texas), set

Computers

U.S. agencies turn to minis, boost DEC sales

Guess which company has the hottest computer sales in the Government market?

It's Digital Equipment Corp., whose sales of its PDP series of minicomputers in fiscal 1971 jumped its listings in the Federal inventory of computers from 499 to 710. This gives DEC a solid hold on third place behind IBM, with 1,428 computers, and Univac, with 1,053.

DESIGN

IDEAS

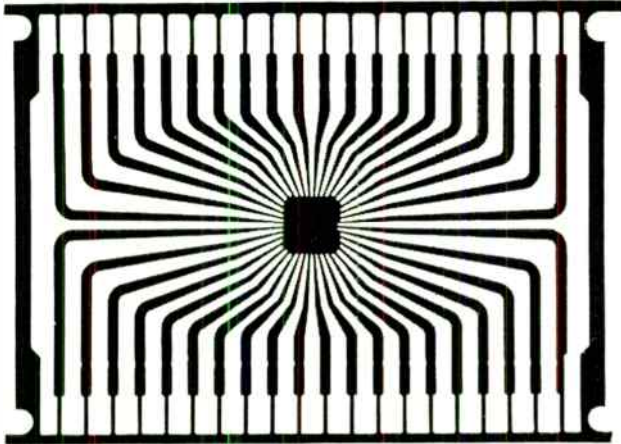
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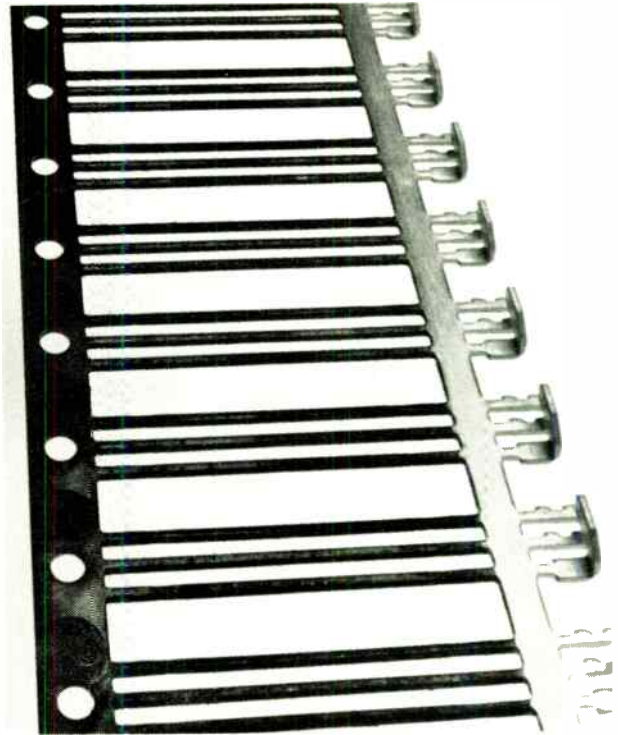
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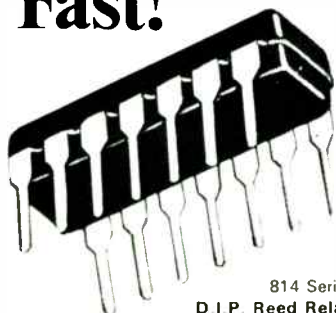
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Electronics review

the new competitive bidding rules for government computers, also will look at the growth of minicomputer sales to see if a loophole has been found in laws aimed at getting price discounts by consolidating many purchases into large-quantity orders

Univac could become No. 2

For 2,500 people at RCA's defunct computer operation facing jobless Christmas season, the red letter day is to be December 17. That's when the final agreement will be executed under which Sperry Rand Corp.'s Univac division will assume responsibility for RCA's existing customers for general purpose computers in the United States, Canada, and Mexico. And Univac has indicated its interest in hiring some 2,500 RCA computer personnel, including engineers, systems analysts programmers and sales representatives to continue servicing RCA customers. When RCA pronounced in September it was going out of the business, its computer division employed about 9,500 people.

Once the agreement is approved by both companies, Sperry Rand will pay RCA approximately \$70 million on Jan. 7, 1972, plus a varying percentage of future revenues over five years. Estimates are that the total value of these additional payments could reach from \$30 million to \$60 million.

New markets. Acquisition of the RCA customer base—in excess of 500 customers with more than 1,000 installations worth \$1 billion—could vault Univac into the position of the number 2 computer company, behind IBM and ahead of Honeywell Information Systems. Univac itself has more than 8,700 installations worth, it estimates, some \$3.2 billion.

Moreover, Univac will gain better penetration of some markets—government, education, and manufacturing. And says Sperry Rand chairman, J. Frank Forster, the company hopes the new acquisition, shorn of

the marketing and development costs faced by RCA, will be profitable in the first year of operation. Of particular importance, he continues, is "how much it does for us in the long term," alluding to the good will which could be created among RCA customers who might eventually switch to machines in Univac's lineup.

Univac will "service customers with RCA machines for as long as the customers want them," adds Sperry's executive vice-president Robert E. MacDonald, until technological innovation begins to overtake the RCA machines and make them obsolete.

Still waiting hopefully in the wings and trying to "leave the door open to negotiations," however, is Mohawk Data Systems, the company which said it bid some \$10 million more than Univac's \$70 million offer not only for RCA's customer base, but its equipment line, and one of its two plants.

For the record

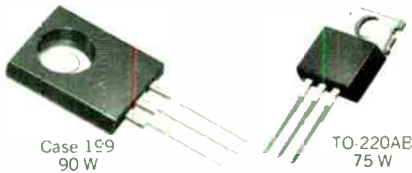
Winner. The first two of NASA's four High Energy Astronomical Observatory satellites will be built under a \$70 million contract by TRW Systems group, winner in a competition with Grumman Aerospace Corp. of Bethpage, N.Y.

The 21,600-lb spacecraft will include 12,500 lb of experimental hardware to measure cosmic radiation, X-rays, and gamma rays over a minimum orbital lifetime of one year. First launch of the 30 ft. long, 9-ft.-diameter satellites atop a Titan 3 rocket is scheduled for 1975, with the second planned for one year later.

Autonetics in. The Autonetics division of North American Rockwell Corp. has joined the bidders for the B-1 bomber avionics interface contract despite the fact that its parent organization has the prime contract for the airframe, which many felt would have ruled Autonetics out of the avionics contract. The division joined IBM, General Dynamics, Boeing, and Hughes in the competition.

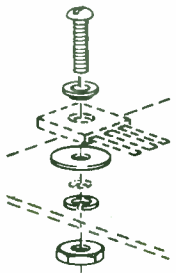
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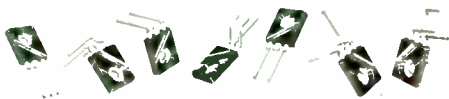
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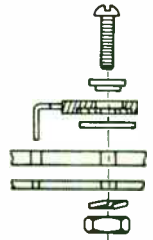


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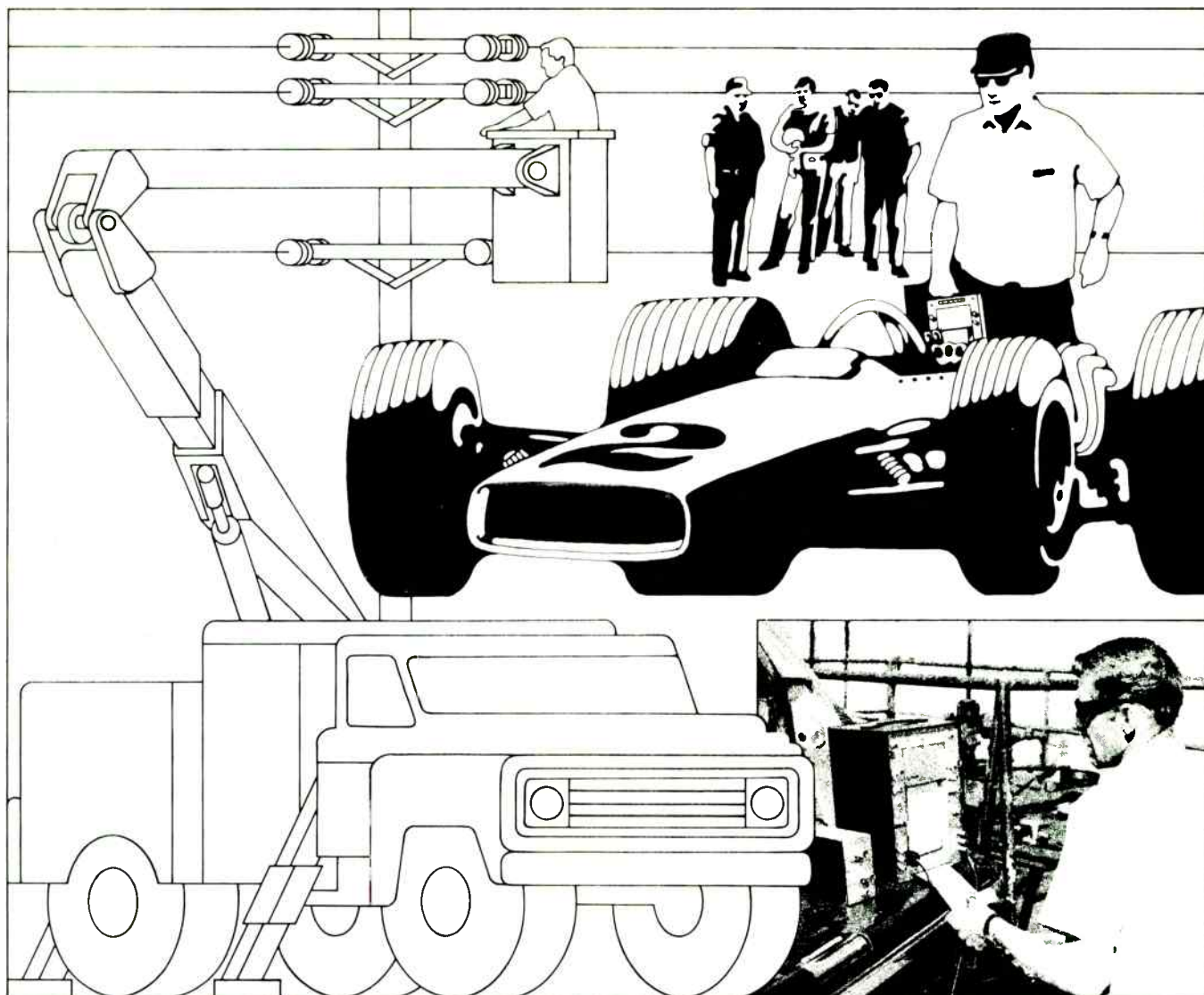
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BRUSH INSTRUMENTS

 **GOULD**

Washington Newsletter

December 6, 1971

White House okay on Aerosat delayed until New Year

Major stumbling blocks continue to delay the long-awaited aeronautical services satellite. The Office of Management and Budget, the Office of Telecommunications Policy, and the State Department have not yet resolved some key issues about the proposed FAA-European Satellite Research Organization's system. For instance, they question whether the production-sharing provision (interpreted to mean that a company must have 50% international participation before bidding) would yield the best or lowest-cost system if one company should come up with an outstanding design. The OTP also objects to the precedent the production-sharing might set. Another problem, also stressed by the Air Transport Association and the Communications Satellite Corp., is whether the system should be government-owned, leased, or privately owned.

Meanwhile, FAA officials express concern that the Europeans, said to be ready and able to build their own system, may cool at the delay and pull out of the joint venture, which the FAA says is favorable to the U.S. White House indecision has caused the bidders' conference scheduled for early December to be postponed until a memorandum of understanding can be signed between the U.S. and Europe—possibly a time-consuming diplomatic exercise. "Clear, definitive word" on the system is therefore not expected before the first of the year, informed sources say.

Congress to vote on funds for SST spinoffs

Congress, which shot down the supersonic transport earlier this year, will shortly decide whether to allow the survival of 10 development projects from the SST program by approving a fiscal 1972 supplemental appropriation of \$15 million. Three of the projects are avionics systems—a variable-speed, constant-frequency generator, a flight control system, and an pilot display system.

But the Federal Aviation Administration's SST projects office and Boeing, both of whom are still reeling from the aftershock of the vote that crashed the SST, are trying to discourage publicity for fear that Congress might think they are trying to relaunch the SST program. A Senate aviation subcommittee staffer, however, doubts whether the SST projects will face any trouble when his subcommittee votes on the matter shortly.

Army moves to counter House questions on Stano

The Army is working hard to counter the first congressional criticisms of the Surveillance, Target Acquisition, and Night Operations effort before it becomes a big issue in fiscal 1973 budget hearings next year. In the 1972 budget just passed, the House cut nearly 30% from the service's R&D request for surveillance and night operations, dropping it to \$6.4 million. And, though the Army may be able to reclaim some of those lost funds, it is proceeding cautiously in view of the appropriations bill report doubting whether remote sensors that were useful in remote parts of Southeast Asia will also be of use in Europe.

Future Navy subs to use hull-mounted electronics?

The Navy, looking to "the submarine of the future," is beginning seriously to explore mounting much of the boat's electronics between the pressure hull and outside shell, or fairings. But this goal will become feasible only if industry can come up with a new class of ultrareliable components that can perform without maintenance or adjustment under

Washington Newsletter

water for 90 days, the projected length of a nuclear submarine cruise. Industry interest is growing, and Raytheon Corp., currently in the second phase of a study contract with the Office of Naval Research, has invested company money in the program in an amount "equal to or more than" the contract's \$60,000 value.

Ideally, hull-mounted hardware in pressure-hardened (gas-filled) or pressure-compensated (water-filled) boxes would contain everything except "those things you need to get your hands on and repair like navigation, fire control and weapons systems," says an ONR man.

FAA interested in associative processor

Air traffic control tests using an Air-Force-loaned associative processor have gone so well that the FAA wants to buy a second-generation, solid state unit of its own for more extensive tests beginning in September, 1972. The unit would be installed in an air traffic control system at either Minneapolis-St. Paul or the FAA's Atlantic City experimental center as a follow-on to the plated-wire Goodyear Aerospace unit now being tested at Knoxville, Tenn. [*Electronics*, July 6, 1970, p. 40].

Then, after eight to 10 months of tests and evaluation, the FAA plans to evaluate a comparable unit at an O'Hare-sized airport in 1973. Expected to compete for the \$1 million, 4,000-word processor (in which each 256-bit word can handle one airplane) are Goodyear, Honeywell and Texas Instruments. If the evaluation program proves out, the FAA could buy the larger processors for its big airports.

Rf device rules change

Not entirely satisfied with electronics manufacturers' voluntary testing of rf equipment that doesn't require individual FCC licensing, the Federal Communications Commission has proposed rules requiring bilateral certification. That is, it will not be legal to operate low-power communications devices, and industrial, scientific, and medical equipment until certification is received from the FCC.

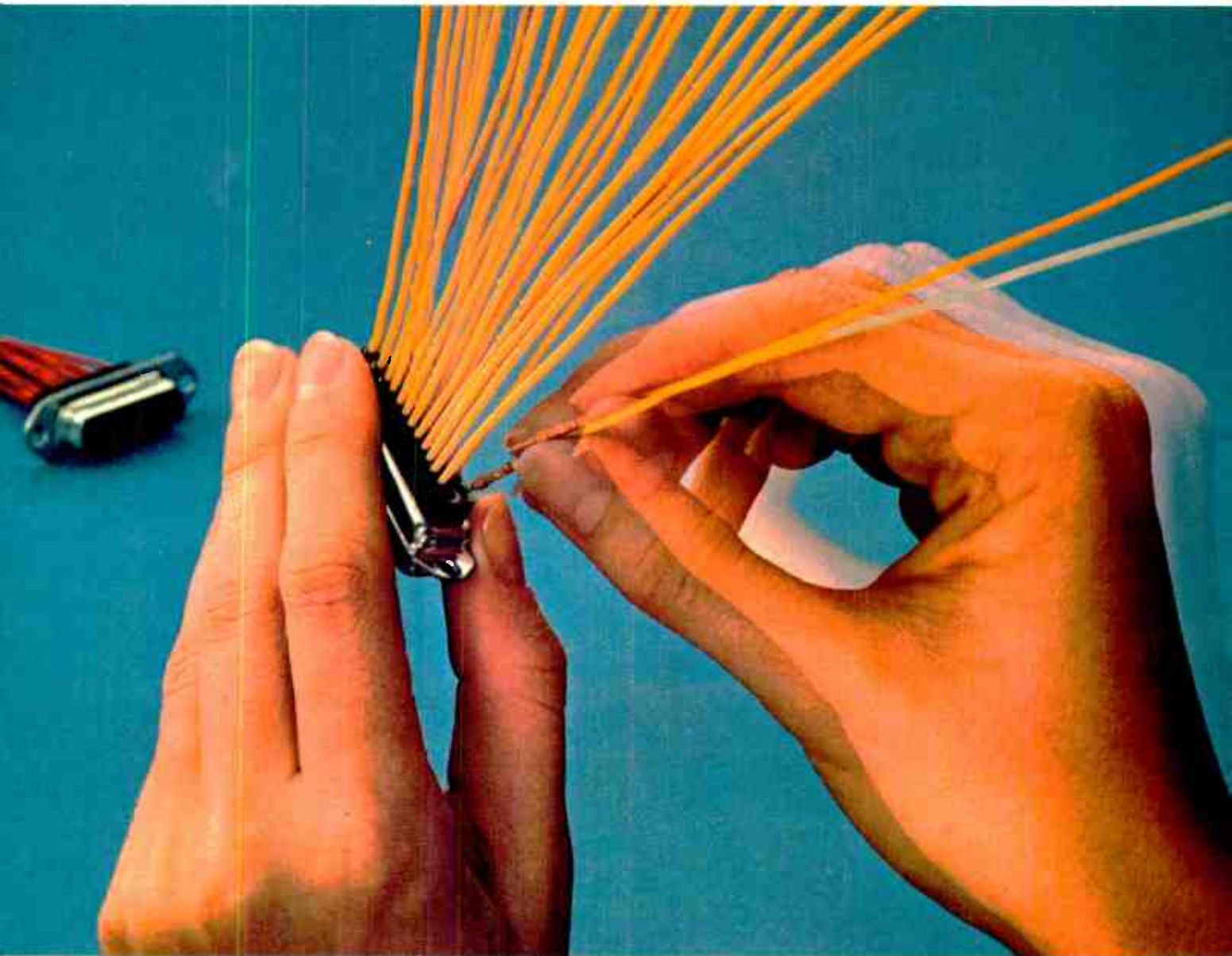
The rules, which are open for comment until Dec. 31, do not alter technical or performance standards, but say that FCC test measurements and technical data submitted with applications will be made public when the FCC authorizes the equipment—"which will probably precipitate industry comment," says an electronics industry spokesman.

DOD's "think tanks" on the way out? Yes, says Congress

Talk among the nation's think tanks such as Rand Corp. is that efforts to find new Federal and local customers outside the Defense Department will have to be accelerated in order to offset congressionally-ordered cuts in Pentagon support of the private, not-for-profit operations. Rand lost about one-quarter of its \$11.2 million Air Force budget request, the Research Analysis Corp. dropped back from the Army's requested \$7.4 million to \$5.6 million, the Center for Naval Analyses was cut back from \$8.6 million to \$6.5 million, and the Institute for Defense Analyses lost \$2.5 million of its \$11 million request.

Though some of the organizations—formerly called Federal Contract Research Centers—have publicized their nondefense activities recently, DOD sources say, "Much of that is window dressing. Most are still heavily dependent on us for money." Strongest argument within the affected companies for continuing their defense efforts is that "it gives the customer an independent judgment, rather than that of Federal employees who may be inclined to tell their bosses what they want to hear."

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DTS 402	700V	3.5A*	325V		*I _c Peak = 10A Horizontal magnetic CRT deflection, features fast switching time, high reliability under horizontal sweep fault condition.
DTS 410	200V	3.5A	200V	80W	Voltage regulator, switching regulator, DC to DC converter, class A audio amplifiers.
DTS 411	300V	3.5A	300V	100W	
DTS 413	400V	2.0A	325V	75W	*I _c Peak = 10A High V _{CB0} and V _{CEO} ratings make it practical to operate directly from rectifier 117V or 220V AC line.
DTS 423	400V	3.5A*	325V	100W	
DTS 424	700V	3.5A*	350V	100W	*I _c Peak = 10A High V _{CB0} , V _{CEO} (sus) ratings make them ideal for use in deflection circuits, switching regulators and line operating amplifiers.
DTS 425	700V	3.5A	400V	100W	
DTS 430	400V	5A	300V	125W	Voltage regulators, power amplifiers, high voltage switching.
DTS 431	400V	5A	325V	125W	
DTS 701	800V	1A	600V	50W	Vertical magnetic CRT deflection circuits.
DTS 702	1200V	3A	750V	50W	Horizontal magnetic CRT deflection circuits operating off-line.
DTS 704	1400V	3A	800V	50W	
DTS 721	1000V	3A	800V	50W	High voltage DC regulators.
DTS 723	1200V	3A	750V	50W	Very high voltage industrial and commercial switching.
DTS 801	1000V	2A	700V	100W	Color vertical magnetic CRT deflection circuits.
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2N5157	700V	3.5A*	400V	100W	For general use in electrical and electronic circuits such as converters, inverters, regulators, etc.
2N5241	400V	5A	325V	125W	
2N2580	400V	10A	325V	150W	
2N2581	400V	10A	325V	150W	
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K. COMPUTER MFR.: Computer control cable: 55 conductors, stranded copper conductors, PVC insulated, formed into 7 groups of 7 conductors, cabled, PVC jacket; U/L listed.

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Electronics/December 6, 1971

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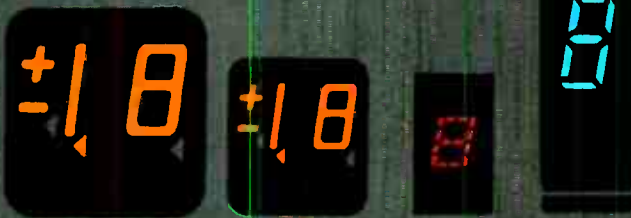
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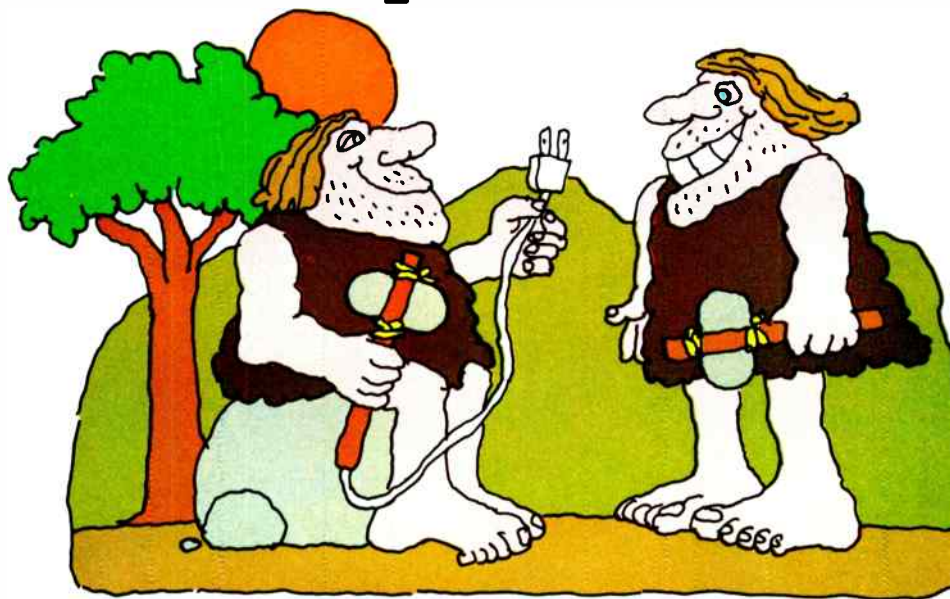
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To meet compatibility requirements of IBM System 360 I/O interface specs, channel to control unit. When tying on any peripheral equipment such as core memory, discs, graphic terminals, etc.	8T23 Dual Line Driver. 8T24 Triple Line Receiver. The first and only interface driver/receiver pair proven totally compatible with IBM 360. Replaces discrete components.
To conform with EIA-Std-RS232, MIL-Std-188 and CC-ITT-V24 specs, when transmitting and receiving digital data.	8T15 Dual Line Driver. 8T16 Dual Line Receiver. EIA/MIL communications devices.
Digital data transmission and receiving, using coaxial cable, twisted-pair, or other low impedance lines. Party-line data transmission. Schmitt trigger. One-shot.	8T13 Dual Line Driver. High current driver with short-circuit protection and DOT-OR capability. 8T14 Triple Line Receiver. High input impedance receiver with Hysteresis.
Data transfer in bus-oriented systems. Modular systems design. Minicomputer design. Multiplexing.	8T09 Quad Bus Driver. Tri-state logic configuration to increase system performance. High speed (10ns) and high current (40mA) capability. 8T10 Quad D-Type Bus Flip-Flop Tri-state outputs with input and output disable. 50MHz typical toggle rate.
Driving seven-segment numerical displays, LEDs or incandescent lamps.	8T04, 8T05, 8T06 BCD-to-Seven Segment Decoder/Drivers. For driving almost any type of display — LEDs, Numitron, etc.
Low voltage (+5V) to high voltage (40V) level translation.	8T80 Quad 2-Input NAND Gate. 8T90 Hex Inverter. Low-to-high voltage interface gates.
High voltage (10V-50V) to TTL (+5V) level translation.	8T18 Dual 2-Input NAND Gate. High-to-low voltage interface gate.

SIGNETICS CORPORATION — A SUBSIDIARY OF CORNING GLASS WORKS

Technical articles

Special report, Part 2: Lasers fight pollution: p. 64 (cover)

The mounting outcry over air pollution has reached optoelectronics engineers, who are designing an assortment of laser equipment to combat it. With infrared sources operating at the absorption wavelengths of pollutants, says author Laurence Altman, scientists can monitor automobile exhausts or industrial smokestacks from safe distances, and bypass the lengthy and unreliable procedures inherent in chemical methods.

The cover: Texas Instruments Inc. developed a lead-tin-telluride laser diode (shown mounted on a gold heat sink) specifically for air pollution monitoring. Below it is a crystal of PbSnTe material.

A system designer demands better digital ICs: p. 70

Semiconductor manufacturers have been very busy developing new technologies and exploiting them to their limits, but is all of this work relevant to the systems designer? Not really, asserts author Bert Forbes, an experienced minicomputer designer: in his opinion, the IC houses are putting the chip design before the system, and it's high time they were making circuits that are more functionally useful to the logic designer.

Digital system picks off nanosecond transients: p. 80

Any designer knows how frustrating it can be to set up an elaborate experiment whose result is a microsecond-or-faster transient, and then lose the signal because his recording equipment isn't up to the task. But a dual-gun storage tube is the basis of a new data acquisition and display system that, according to authors Glenn Mills and Keith Treece, can record transients of less than 500 nanoseconds, and digitize and store them for leisurely analysis.

Know your charge transfer device tradeoffs: p. 86

There's no question that charge transfer technology can be very useful for building solid state memory and imaging systems, says a trio of authors from General Electric Co. What is in question, however, is which of the three ways of building the devices is best. The only way to find out, the authors assert, is to know the advantages and tradeoffs among MOS bucket brigades, charge coupled devices, and surface charge transistors, and match them to your application.

How to get out of the path of avalanche damage: p. 92

How many times has a circuit designer watched his transistors (or his entire circuit) degrade or go up in smoke just from a turn-on or testing transient? Weep no more, asserts author C.D. Motchenbacher; he tells how you can avert loss of gain and increases in transistor noise due to avalanche damage by preventive design or protection via diodes.

And in the next issue. . .

Special report on electronics markets in Europe . . . C/MOS and PCM combine for remote data acquisition . . . Planox process boosts MOS performance . . . six ways to pulse injection laser diodes.

SPECIAL REPORT

Optoelectronics engineers pit lasers against air pollution

Part 2 of a three-part special report on optoelectronics focuses on how companies are building semiconductor and spin-flip Raman laser systems that can be tuned to the exact wavelength of air pollutants for on-site monitoring

by Laurence Altman, *Solid State Editor*

□ Only rarely does a still-emerging technology find an immediate and urgent calling, but it's happening right now in optoelectronics. The technology is tunable lasers and the calling is air-pollution monitoring.

With lasers, airborne pollutants—whether from industrial smokestacks or automobile exhausts—can be measured with accuracy in the parts-per-billion range. This degree of accuracy is essential as a first step toward controlling the increasing dangers of pollution. Moreover, the laser detection approach offers a significant advantage over present sampling techniques: pollution can be monitored on-site, but safely out of the way of a severe environment, such as the inside of a smokestack. And the air sample does not have to be removed for a leisurely inspection in a laboratory, during which time temperature or chemical changes can reduce the actual amount of pollution.

The basis for laser measurement of pollution is general enough: pollutants can absorb or scatter coherent light energy; by passing the laser beam through an air sample and by observing either the degree to which the beam's energy is absorbed or the resulting Raman scattered spectrum, the amount of contaminants present can be gauged accurately.

In practice, the requirements on the laser are specific. Either it must be of fairly high power, so that Raman scattering can be detected, or it must be tunable, because then the beam can be tuned to the precise absorption wavelength of the pollutant. In this case, it must emit in the infrared band, because the absorption spectra of almost all the known pollutants fall within the 3-to-15 micrometer area. According to E.D. Hinkley, P.L. Kelley, and co-workers of MIT's Lincoln Laboratory in Lexington, Mass., of the four types of tunable lasers—optical parametric, dye, semiconductor, and spin-flip Raman—only the latter two are suitable because they emit in the infrared.

Semiconductor lasers shape up

Activity is humming in infrared semiconductor lasers. At Lincoln Labs, diode materials under consideration for the new lasers include such binary compounds as indium arsenide, indium-lead, germanium-lead, lead selenium, lead sulfide, lead telluride, and pseudo-binary alloys such as PbSnTe, PbS₂Se, HgCdTe, and InGaAs.

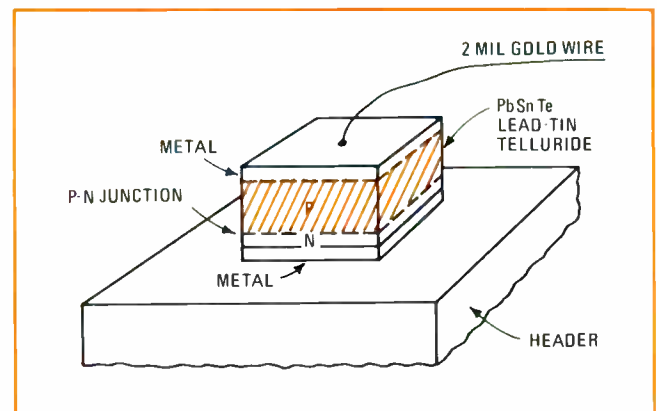
As for the lasers themselves, lead chalcogenide diode lasers fabricated at Lincoln Lab have produced about 1

milliwatt of continuous, tunable, narrow-line radiation at liquid helium temperatures, and 10 watts pulsed at 77 K; materials operating at shorter wavelengths should lase continuously at higher temperatures as well. Coarse tuning within the infrared frequencies has been achieved by adjusting the chemical composition (Pb^{1-x}Sn_xTe PbS^{1-x}Se_x lasers), which changes the energy gap of the semiconductor.

Although continuous tuning is essential for spectroscopic studies, quasi-continuous tuning of diode lasers is adequate for pollution-detection applications. However, before these lasers can be universally used, the problem of the low temperature presently required for their operation must be solved. Liquid helium temperatures are now needed for continuous operation of these ir diode lasers; liquid nitrogen conditions are required for pulsed duty. What's needed is development of more efficient diode materials and refrigeration methods.

Lasers and auto exhausts

One of the most exciting pollution applications of diode tunable lasers is for automobile exhaust control. Texas Instruments, Dallas, one of the first to work with diode lasers in this connection, is developing diodes (a cross-section of one is shown in Fig. 1) to achieve emission in the required band. Ideally the diode would emit at the absorption wavelength of common exhaust pollutants; if the laser beam is absorbed, the pollutant is present. By correlation techniques, the kind and amount



Light weight. TI's proposed system could be used for across-the-stack monitoring of gases. TI sees a 10-lb-or-less system to beam energy through gas for detection and analysis of reflection.

GE and bad air

General Electric Co., one of the earliest companies to study pollution measuring techniques, recently developed an infrared-laser atmospheric monitoring system that could be basic to measuring pollution in both rural and urban areas. GE, in a joint effort by its Electronics Laboratory in Syracuse, N.Y., and its Ordnance Systems unit in Pittsfield, Mass., has built a breadboard system for field evaluation and is testing its performance under sponsorship of the Federal Environmental Protection Agency. The present breadboard is being tested at a rural location near Cazenovia, N.Y.; urban measurements also are under way at Syracuse.

The system, which operates in the middle region of the infrared spectrum, measures average pollution concentrations over long ranges at what the company considers relatively safe power levels (about 1 watt). It comprises a CO₂ laser that can be scanned over a designated spectral range; a transmitting and receiving optical system; a signal processor, and a retroreflector that returns the laser beam to the receiver for monitoring after it has traveled through the air.

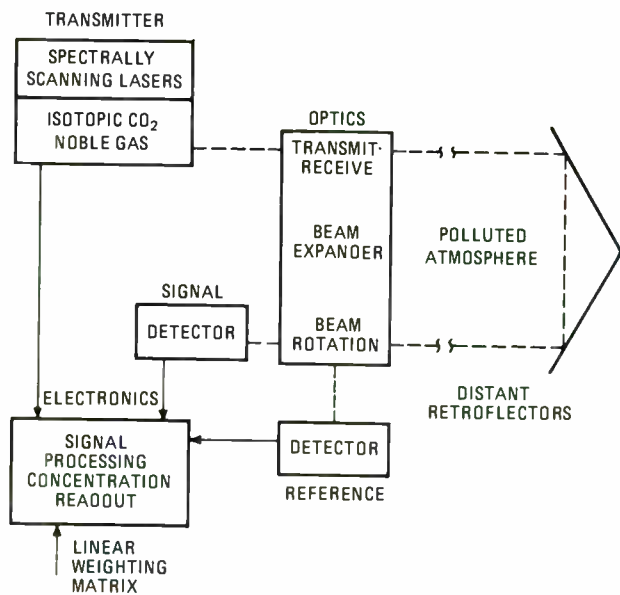
Using a laser configuration that allows the system to transmit energy at several wavelengths in a rapid sequence, the beam is directed to the remote retroreflector located from one to 10 miles away. Energy returned from the retroreflector is collected in the receiver system and referenced to the laser output energy to compensate for power differences at each wavelength. Once detected the degree of energy attenuation is determined at the selected wavelength and a pattern of absorption-vs-wavelength is obtained. That's how the average concentration of the pollutant over the path length is determined.

The system can be aligned to four wavelengths—9.505, 10.532, 10.675, and 10.719 micrometers. At these wavelengths the system is designed to measure the ethylene and ammonia content of the atmosphere.

If the breadboard technique proves out, GE hopes to develop a general system concept for multipollutant monitoring of a large urban area. This general system is shown in a block diagram. The setup system would add beam rotation and multiple retroreflectors to the breadboard concept. A spectrally scanning laser would emit multiple wavelengths to provide its energy over the spectral range (3 to 12 μ m to detect gases such as ozone,

sulfur dioxide, ammonia, nitric oxide, nitrogen dioxide, ethylene, carbon monoxide, and carbon dioxide, as well as representative hydrocarbons. With such a range of detectable pollutants, researchers at GE feel their system concept could meet operational needs in ambient air-monitoring and provide new data for atmospheric research.

Clearly, safety is a watchword in the implementation of any laser pollution monitoring system. In this regard, the system designers feel they have a winner because of the system's ability to operate in the middle or at low-power levels. The eye, the part of the body most vulnerable to radiation, is opaque to radiation above 1.3 micrometers. The shortest contemplated system wavelength is 3 μ m which makes the possibility of retina damage remote. And because the system's output levels are 1 watt or less, the total system power density is about 0.01 w per centimeter—hardly a general menace when compared to the Air Force permissible exposure level of 1 w/cm for a 50-to-250 millisecond exposure.



of pollution can be determined.

TI's central research laboratory is working under a contract from General Motors Corp. [*Electronics*, Sept. 13, p. 29]. The job is to develop a compact diode laser emitting throughout the spectral range of the major pollutants found in automobile exhausts—4.2 to 10 μ m—to help GM meet the stringent government pollution standards by 1975. The pollutants are carbon monoxide at 4.2 μ m, carbon dioxide at 5 μ m, and unburned hydrocarbons and sulfur gases at the longer wavelengths. TI researchers selected the type of PbSnTe diode laser developed by Lincoln Labs because its wavelength emission can be tailored simply by varying the amount of tin: the smaller the tin concentrations, the shorter the wavelength.

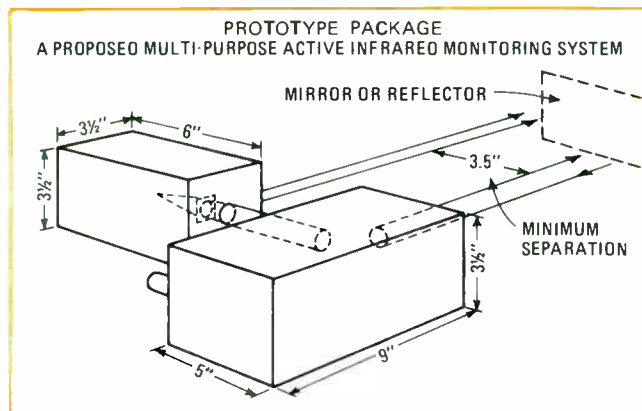
In the GM scheme an array of lasers will be put together with a suitable one-for-one array of detectors in the path of the exhaust. Each PbSnTe laser diode would

be doped with enough tin to make it emit at the absorption line of one of the pollutants that are being subjected measurement.

TI has built several experimental models and has made diodes that lase at the required wavelengths. However, the focus is to make the diode laser operate in the cw mode, which is best for spectroscopy—and it's very difficult with this material system. TI engineers are cooling the laser to about 28 K and hope to be able to run cw at higher temperatures—liquid nitrogen, for example.

In addition, TI researchers, in a separate effort, have been considering the feasibility of a prototype package (Fig. 2) which could be used as a multi-purpose infrared monitoring system. It would be an inexpensive active system suitable for across-the-stack or ambient monitoring of sulphur dioxide (SO₂), nitric oxide (NO), or other smokestack gases. This monitoring system would em-

SPECIAL REPORT



Spinning and flipping. In Bell Labs' experimental setup, a spin-flip laser beam passes through gas sample cell. NO gas as low as 10 parts per billion can be detected in integration times of 1 s.

ploy an infrared diode laser and detector mounted in inexpensive expansion coolers, as shown in the figure. The system would make use of the wavelength tuning capability of diode lasers; its weight would be less than 10 pounds.

Researchers at TI are developing the tunable ir laser diode approach for pollution monitoring because they feel it offers them the capability of monitoring pollution gases without the need for employing high laser power. They feel this may turn out to be the primary stumbling block of other monitoring methods, which rely on Raman scattering—requiring fairly high-powered laser sources. Although the radiation level from these sources probably would be below the threshold of harmful emissions, it's felt that public sensitivity to even moderate levels of laser power being used in crowded urban environments could well produce a situation that could lead to regulatory snags. These, of course, would hinder system implementation.

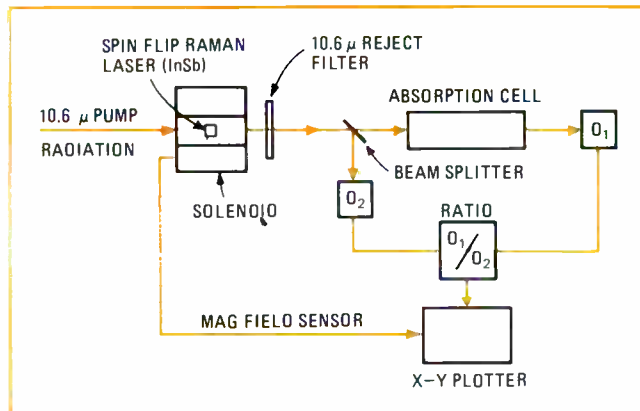
Raman lasers tackle bad air

Tunable spin-flip Raman lasers offer another approach and this is being actively pursued at Bell Laboratories, Murray Hill, N.J. In work aimed at air-pollution detection, Bell scientists have made measurement of nitric oxide (NO) concentrations as low as 1 part per billion in measuring times of about 1 second. Moreover, the technique is general enough to be used for detecting various other gaseous pollutants.

Nitric oxides are important pollutants in automobile and power plant exhausts. The relationship of these oxides to smog production because of their absorption of ultraviolet radiation is well established.

Wet chemical techniques are the traditional methods of detecting gaseous air pollutants. In particular, NO is checked by its conversion to NO₂ and its final absorption in an acid permanganate solution. Of course, in wet chemical systems, each pollutant requires a different set of techniques; a relatively large volume of the gas to be analyzed is needed; and achieving reasonable sensitivity requires a good deal of time.

That's why there's so much interest in measurement via infrared absorption. In this method, developed by C.K.N. Patel and his colleagues at Bell Labs, a cell containing the gaseous pollutant receives periodically inter-



Infrared eye. Work on efficient pn junctions for new laser materials that emit in the infrared is progressing. Shown is cross-sectional view of a PbSnTe diode, developed by TI, mounted on heat sink.

rupted infrared radiation. If the wavelength of the infrared radiation coincides with the wavelength of an absorption line, a periodic heating of the gas takes place. The resulting pressure fluctuations are detected by a capacitor microphone placed in the cell. With this approach, absorbed powers as small as 10⁻⁹ w can be detected.

For very low gas concentrations infrared radiation of high intensity and monochromaticity is required. The spin-flip Raman laser yields tunable radiation in the 5- to 6-μm range and in the 9- to 14-μm range.

The experimental setup is shown in Fig. 3. Amplitude modulated pump radiation is obtained from a liquid nitrogen-cooled carbon monoxide laser; average pump power is about 0.7 w. This radiation is focused with a lens into a 2-by-2-by-4-μm indium antimonide sample placed in a magnetic field as shown.

A number of gas samples have been analyzed with this technique at Bell Labs. Again, concentrations of nitric oxide as small as 0.01 part per million were detected in an integration time of 1 s.

And in the stacks

In an independent effort, the Bendix Corp., Southfield, Mich., is developing pollution-sensing equipment for monitoring point sources of pollution—public utilities, industrial stacks, cement processors, and other large individual sources of air pollution. Fewer in number and easier to identify than the sources, the pollutants are more readily investigated.

Bendix feels that mobile remote instruments, incorporating a radiation-detection system, are the best approach. Such instruments monitor stack effluents by looking for an identifying electromagnetic radiation from remote locations. Microwave radar is unsuitable because of its relative insensitivity. Similarly, infrared and visible light techniques for detecting characteristic emissions or absorptions suffer from noise and drift problems and are in the uncontrolled background of hot stack gases or sky conditions. As such, they are either night-only or day-only oriented. Malcolm Johnson, the key researcher in pollution monitoring at Bendix feels the technique of Raman spectroscopy makes such analysis possible.

The Raman effect essentially is an inelastic inter-

action of light with a molecule. When photons of moderate energy strike a molecule, the scattered light usually has the same frequency as the incoming light. Occasionally, however, the vibration of the electric field associated with the light couples into one of the natural modes of the molecule, and the scattered photon leaves with its frequency shifted up or down, depending on whether energy is gained from or lost to the molecule. This shift in frequency and wavelength is specific for molecules of a particular chemical.

The Raman effect is relatively weak—probability of occurrence is about 1,000 times smaller than elastic or Rayleigh scattering in a gas. It also requires a highly monochromatic source to prevent overlap of lines, particularly in a gas mixture.

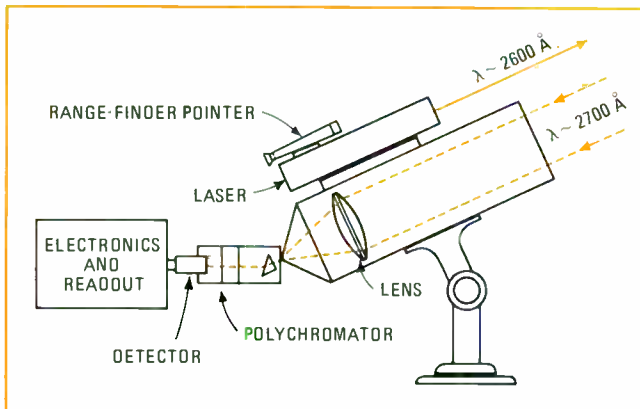
High resolution

The new monochromatic lasers are such a source, and they transformed, in Johnson's view, the Raman effect from a laboratory curiosity into a practical instrumentation technique. If a gas sample is irradiated with the single wavelength of the laser and the scattered radiation is examined with a high-resolution monochromator, one sees, along with the very large Rayleigh peak, a series of much smaller peaks at other wavelengths nearby. The frequency of each peak identifies the molecule; the intensity of each peak indicates the number of molecules being irradiated. Since most pollutant gases of interest— SO_2 , CO , and NO in particular—exhibit well-separated Raman lines, the Raman effect may provide a universal technique for monitoring stack gases if the problems of low signal-to-noise ratio can be overcome.

A laser-Raman system proposed by Bendix for monitoring stack gases is shown schematically in Fig. 4. It consists of a laser source (operating at 2,600 angstroms); a detector that receives the returned light beam (reflected at the Raman-scattered wavelength of 2,700Å); a polychromator that separates the incoming beam into its wavelength components and acts as a filter to remove all extraneous wavelengths, and a computer and read-out console.

Signal-related parameters that can be varied to optimize the signal-to-noise ratio include laser wavelength,

Scatter brainstorm. In this Bendix system, the laser emits at 2,600 angstroms; the wavelength of the scattered light is shifted to reveal the presence of molecules of the polluting gases and materials.

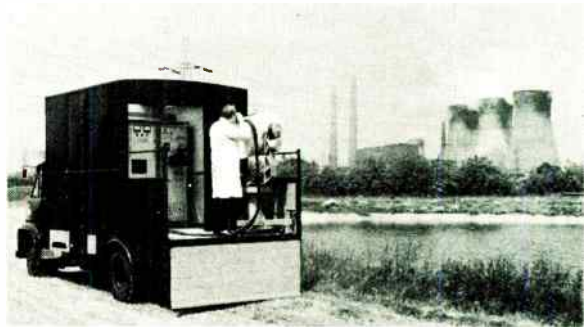


power and operating mode; transmission and receiving optics, and signal handling in the detection system. Sources of noise include solar background, shot noise (statistical fluctuations at low signal levels), scattered light at other wavelengths, detection-system electrical noise, laser intensity fluctuations, and wandering of the stack gas out of the beam. Finally, the signal can be weakened by attenuation through the atmosphere between the laser and the detection system, by divergence of the laser beam over an area larger than the stack plume, and by inefficiencies in the transmission and detection system (the lenses, reflecting surfaces, and photocathode).

Needed: ultraviolet wavelength

Laser wavelength should be considered first because most other sources of noise and attenuation depend on it. The Raman effect intensity is proportional to the inverse fourth power of this wavelength (halving the wavelength increases the signal intensity by a factor of 16). This relationship indicates selection of a

And in smoggy Britain



Americans don't have a corner on concern over air pollution. To meet the pollution threat in principle cities in the United Kingdom, Laser Associates has just delivered a \$45,000 truck-mounted system for detecting atmospheric pollutants and detecting and measuring the amount of water vapor in the atmosphere. The system will be used by Central Electricity Research Laboratories for tracking emissions from smokestacks and cooling towers, detecting temperature inversions in the atmosphere, and tracing the dispersion of hot water from power stations.

The system will measure the water vapor in the atmosphere just above the surface. Range is normally up to three or four miles but can reach 10 miles.

The system has two ruby laser transmitters, one tuned to the peak water absorption wavelength of 6,934 angstroms, and the other tuned just clear of the water absorption band. Lasers are pulsed alternately up to a maximum rate of one pulse per second and the backscattering compared; the difference provides a measure of the water content at that point.

The backscatter is collected in an eight-inch Newtonian telescope and detected by a photomultiplier. Maximum output from each laser is 100 millijoules with a pulse length of 25 nanoseconds. For detecting common pollutants like smoke, only one laser is used (the one clear of the water absorption band). Detected backscatter indicates presence of the pollutant.

SPECIAL REPORT

Characteristic	Laser			
	Argon ion	Neon ion	Neodymium-YAG	Nitrogen
Fundamental wavelength	5145 Å	2678 Å	1.06 μ	3371 Å
Ultraviolet wavelength	2572 Å	2678 Å	2650 Å	3371 Å
Mode	continuous-wave	continuous-wave	continuous-wave	pulse
Ultraviolet power (average)	40 mW	1 W	4 mW	100 mW
Average output (photons/second)	5×10^{16}	1.3×10^{18}	5.3×10^{15}	1.7×10^{17}
Average received signal (photons/sec)	1.9	140	0.13	12.0
Price	\$10,000	\$25,000 (proposed)	\$15,000	\$10,000

wavelength as far into the ultraviolet as is possible. However, two other factors enter into the choice. First, at about 2,500Å, atmospheric attenuation becomes significant for path distances of less than 1 kilometer. Second, ozone in the upper atmosphere cuts off all solar radiation with wavelength below 2,950Å.

To assess the ozone effect, consider that at a wavelength of 3,400Å, solar flux onto a collector 20 cm in diameter is 3.9×10^{12} photons/s-Å looking near zenith but not directly at the sun at midday. This is 11 orders of magnitude greater than the return signal from the 100-mw pulsed nitrogen laser at that wavelength. Even using gating techniques with this laser, the background can be reduced only to 4×10^6 photons/s-Å, still five orders of magnitude greater than the signal. At a wavelength of 2,700Å, on the other hand, the ozone attenuation coefficient through the upper atmosphere is 10^{30} , so that background flux is zero at sea level.

Signal-to-noise ratio depends not only on laser wavelengths but also on power availability. The table lists power outputs and other important characteristics for several ultraviolet lasers in the wavelength range of interest. Right now, the nitrogen laser has the highest average photon output though its signal-to-noise ratio is very much lower than those of lasers operating below the ozone cutoff.

Since very high peak powers of the nitrogen laser occur in very short pulses, some researchers have tried to use pulsating techniques in conjunction with the middle-ultraviolet pulsed ruby and pulsed nitrogen lasers to overcome high background noise levels. Although the approach does significantly increase the signal-to-signal ratio, and although these lasers have powers exceeding those presently available at wavelengths below 3,000Å, solar background is still so high that only night operation would be practical in a realistic stack-monitoring situation.

Checking on O₃ and SO₂

An alternative system that has been proposed would operate below 3,000Å, but would use the relatively strong Raman backscatter from atmospheric nitrogen, oxygen, and water to construct absorption curves for ozone (O₃) and sulfur dioxide (SO₂), both of which have strong absorption peaks in this wavelength region. Such a system, if feasible, could serve as a relatively sensitive atmospheric sensor but would not be practical for stack-gas monitoring.

The neon laser, with a 1-w output at 2,678Å and a signal-to-noise ratio six orders of magnitude greater than

that of the nitrogen laser, would—if it becomes available—be the logical choice for a Raman system.

In such a system, the detection and optical portions must be highly efficient in this wavelength range and should, if possible, reject other wavelengths. A reflecting telescope (Cassegrain), 20 cm in diameter, would be suitable if focused onto a small Czerny-Turner monochromator and used with a low-noise photomultiplier detector. To expedite rejection of scattered visible light through the monochromator, oxygenated cesium telluride (CsTe)—which is solar blind—would be used for the photocathode; this material has a peak quantum efficiency of up to 10%, and when combined with 50% optical efficiency, it results in an overall photon-to-output-pulse efficiency of 5%.

On location

In a typical monitoring situation, a stack plume 10 meters thick might be located 1 kilometer from the monitoring instrument. (A measurement-accuracy requirement of $\pm 10\%$ and a measurement-time requirement of 10 s or less can reasonably be assumed.) Under these circumstances, a 1-w neon ion laser operating at 2,678Å can detect a sulfur dioxide (SO₂) concentration of 5 parts per million in the stack plume, a level well within existing monitoring levels (SO₂ concentrations in stack gas are typically 100 to 1,000 parts per million and will not drop much below 100 parts per million even after planned improvements have been implemented).

According to Johnson, these results seem to indicate that more power is available than is required, and that less expensive, less powerful, doubled-frequency laser would be adequate. However, the excess power offers two advantages: it permits measurement even under poor atmospheric-visibility conditions, and it provides an area-monitoring as well as a point-source monitoring capability, since a background of 0.05 ppm of SO₂ over an area of 1 kilometer gives the same 10 counts readout as a 5-ppm stack concentration in a plume 10 meters thick. Indeed, in area-monitoring applications that permit longer integration times, this technique promises to be one of the most sensitive.

Present prices (in the range of \$10,000 to \$25,000 depending on the laser used) would seem to rule out use of this kind of setup on a practical large-scale basis. However, prices traditionally drop dramatically as these components become more widely available.

Part 2 of a three-part series on optoelectronics. Reprints of Part 1 are available at \$2.00 each; reprints of the entire series will be available at a later date. Write to Electronics Reprint Department, P.O. Box 606, Hightstown, N.J. 08520. Copyright 1971, Electronics, A McGraw-Hill Publication.

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UTO-501	5-500	14	4.0	-2
UTO-502	5-500	14	5.5	+7
UTO-503	5-500	9	7.0	-13
UTO-504	5-500	6	11.0	-17
UTO-521	5-500	27	5.5	+6
UTO-522	5-500	23	7.0	+12

Model	Frequency Response (MHz)	Gain (dB)	Noise Figure (dB)	Output Power (dB)
	Minimum	Minimum	Maximum	Minimum
UTO-1001	5-1000	14	5.0	-2
UTO-1002	5-1000	14	6.5	+7
UTO-1003	5-1000	9	8.0	+13
UTO-1501	5-1500	9	5.5	-3
UTO-1502	5-1500	9	7.5	+6
UTO-1503	5-1500	6	9.0	+12
UTO-2011	1000-2000	7.5	5.0	-3
UTO-2001	1000-2000	7.5	6.0	-3
UTO-2002	1000-2000	8.0	7.0	+3
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A system designer's lament: give us better digital ICs

Reviewing the evolution of available digital IC functions, an experienced minicomputer designer concludes it's about time that chip manufacturers became more responsive to user needs

by Bert Forbes, *Hewlett-Packard Co., Cupertino, Calif.*

□ Semiconductor manufacturers should stop being chip-wise and system-foolish. For the last decade integrated circuits have been justified by what could be done within the available technology, rather than by what should be done to streamline the logic. But it's about time this data sheet specmanship gave way to a realization of what system designers actually need.

Obviously, that's not to say that today's off-the-shelf ICs have no desirable features. Some do. But often these same ICs suffer from other features that the system designer could well do without.

For digital-logic-oriented electronic engineers, the problem began with the advent of ICs. Before then they used whatever kind of circuit they wanted, if necessary designing it from scratch. For instance, most had learned in college how to build ac-coupled flip-flops out of discrete transistors. But when they began using ICs, they didn't need to design such circuits any more (unless they became directly involved in laying out ICs), and they also found that the characteristics of the technology largely precluded the use of ac coupling—although some ac flip-flops, such as Motorola's MECL 1013 and 1027, are available.

The need for dc coupling, however, required new and different storage elements. The simplest—a pair of cross-coupled NOR gates—is plagued by clock skew, or slight time displacement, and by spurious input pulses, so it was quickly replaced by clocked set-reset flip-flops and master-slave pairs driven by a single-phase clock.

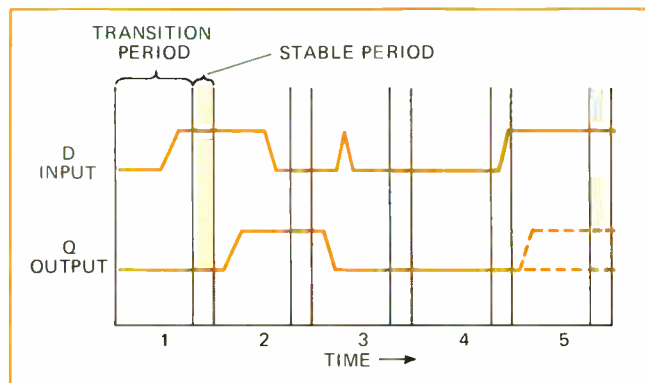
A limited utility

The usefulness of the master-slave pair is limited by its absolute dependence on the clock phase. In the circuit that drives the pair, nothing can happen except between clock pulses, and the possibility of clock skew narrows these limits even further. Nevertheless, it makes a clocked synchronous machine easy to design. Such a machine can exist in any one of a series of states for an interval of time called the "state time." In general, the first part of the state time is a transition period, during which the inputs to flip-flops in the machine can change, and the remainder is a stable period, during which no change occurs in their inputs. Usually during part of the stable time, a clock pulse or other signal transfers the condition of these inputs into the flip-flops, which store it and collectively in their new condition define the next state of the machine. Then during the sub-

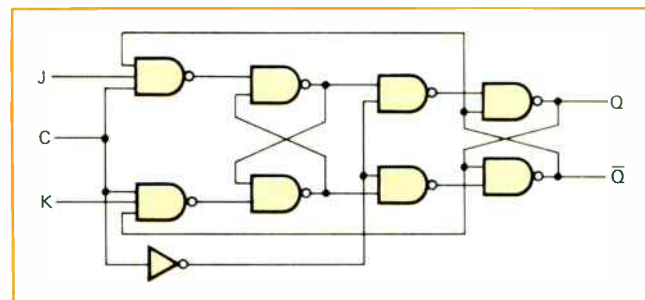
sequent transition period the new condition propagates through a series of logic blocks to define flip-flop inputs for the next stable period. (In fact, only the masters change state during the stable time—the first events of the transition time are the state changes of the slaves.)

In a clocked-synchronous system the allowed transition time must be greater than the longest path from the output of any flip-flop to the input of any other flip-flop. If this transition period is too short, the input signal to a flip-flop may change during the stable period, rendering its output logically indeterminate (Fig. 1).

Another problem with a simple set-reset flip-flop, whether single or in master-slave pairs, is its indeter-



1. Uncertainty. The output during state time 5 in this timing diagram of an arbitrary flip-flop is logically indeterminate, because the input changed during the stable period of state time 4. During stable periods all inputs should remain unchanged.



2. J-K flip-flop. This collection of eight NAND gates is an early version of one of the most widely used IC flip-flops. Its distinguishing characteristic is that it changes state when both J and K inputs are simultaneously positive—unlike a set-reset flip-flop, which under similar conditions has an indeterminate state.

minate state following the input of simultaneous or overlapping set and reset signals. To overcome this difficulty, the J-K flip-flop was devised. This circuit, in its simplest form, is merely a pair of master-slave flip-flops with the set input gated by the reset output and vice versa (Fig. 2). Opposite phases of the clock pulse drive the master and the slave; the master is set or reset depending on which of the two inputs, J or K, is positive when the clock rises; if both J and K are positive, the pair changes state either way.

In this form, however, the J-K flip-flop has an undesirable property, sometimes called ones catching; if it is intended to remain off during a particular clock cycle, but a spurious transient, or binary 1, appears on the J input while the clock input to that gate is positive, the master "catches" the transient, turns on, and the slave follows it when the clock input goes negative.

Unwanted instability

This characteristic is also visible in the flow chart (Fig. 3), which is one way of defining the behavior of a sequential machine. In the flow chart each rectangular box represents a stable state of the machine, and each diamond represents an equation of conditions determining whether the machine will transfer to one of several sequential states or remain in a prior state.

For example, the flow chart shows that the J-K master-slave flip-flop remains in state A as long as either the clock or J is negative, and transfers to state B only when both these inputs are positive. It then remains in state B as long as the clock is positive, regardless of whether J stays positive or not. But when the clock drops, the flip-flop enters state C. The idea is that J is necessary to enter state B, but not to leave it.

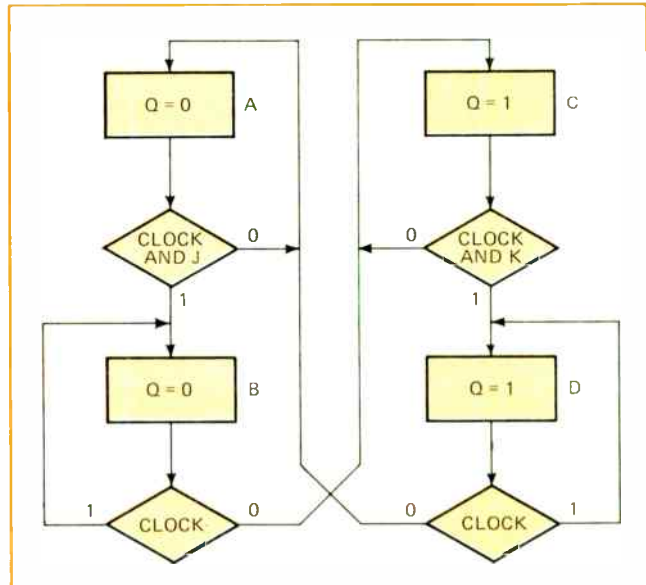
Of course, the flip-flop can also "catch zeros"—it can turn off spuriously. This is evident from the symmetry of both the logic diagram and the flow chart.

One way to minimize the difficulty of ones catching is to use a very short clock pulse. But such a narrow pulse is often difficult to generate and propagate to all parts of a system.

A better solution is to use an edge-triggered flip-flop—a design that, while not new, has only recently appeared in a variety of configurations in commercially available ICs. It permits the use of a symmetrical clock pulse—one with equal up and down times—and the inputs need be stable for only a short time before the arrival of the transition that sets the flip-flop.

The flow-chart for an edge-triggered J-K flip-flop (Fig. 4) shows that the J input is no longer a condition for the transition from state A to state B. Instead, this transition occurs whenever the clock pulse goes positive; the reverse transition occurs at the fall of the clock pulse, if J is down. Only if J is positive when the clock pulse falls does the flip-flop transfer to state C.

Consequently, J is a condition for the transfer from state B to state C, and the circumstances that cause J to go positive need exist only for short intervals before and after the fall of the clock pulse, known as the setup time and the hold time respectively. Not only does this eliminate the danger of ones catching, but it gives the system designer more time to bring up J—from the end of one hold time to the beginning of the next setup time, in-



3. Master-slave flip-flop. Flow chart defines the behavior of a simple flip-flop circuit. This flip-flop transfers from state A to state B when clock and input J are high, and then to state C when the clock falls, whether J is high or low. Thus it can sometimes make these transitions incorrectly when spurious J signals occur.

stead of just the down time of the clock.

This flow-chart shows the inverse of the clock, as an input, thanks to a convention that edge-triggered J-K flip-flops are sensitive to a pulse's negative-going edge.

A minor inconvenience

Having separate lines to set and reset a flip-flop isn't always convenient. Stated another way, a system designer may wish to take advantage of the J-K flip-flop's state change when both inputs are positive, by redefining the K input as \bar{K} and connecting the two inputs together. Semiconductor designers recognized the need for this circuit early in IC development, and filled the need with what has become known as the delay or D-type flip-flop. Fortunately, it was originally designed as an edge-triggered device. Had it not been, it too would have suffered from ones catching.

Its flow chart is akin to that of the edge-triggered J- \bar{K} flip-flop; the 0 and 1 outputs of the K block at the lower right of Fig. 4 would be reversed. It also uses the true clock instead of its inverse. In short, the conventions that apply to D and J-K flip-flops are different.

Unfortunately, the D flip-flop has no way of holding stored data beyond a single clock cycle, but requires valid data on the input every cycle. (This problem doesn't occur in the J-K flip-flop, because the J and K inputs can be kept negative to prevent the data's changing on subsequent clock pulses.) But in many applications of the D flip-flop, valid data in every cycle just isn't possible.

One solution, shown in Fig. 5, is to add a gate to the clock input. But this is likely to create a host of timing problems. For one thing, it adds skew to the clock pulse. For another, it adds phase sensitivity just like that encountered in the simple master-slave pair.

In the diagram, this sensitivity arises from the circuit's positive-edge triggering, indicated by the small

symbol inside the flip-flop block, and from the use of an OR gate as an inhibit gate. In an edge-triggered circuit, good practice calls for the triggering signal to be inhibited at its post-triggering level, to reduce the likelihood of false triggering. Thus a positive-edge signal would be inhibited by holding it at its positive level. With a positive-going clock pulse, the inhibition is obtained with a positive signal and an OR gate. However, the inhibit signal must be timed to appear only when the clock itself is already positive, or it will generate its own false triggering edge.

Reverse situation

If a negative-going inhibit signal were used with an AND gate, the reverse situation would arise: the removal of the inhibit signal while the clock was at its positive level would generate a false trigger. But because it is likely to be generated by another flip-flop set by the same clock pulse that is to be inhibited, the inhibit signal normally rises while the clock pulse is positive, and can perform its function without generating false edges through the OR gate.

A better solution than gating the clock is either a D-enable flip-flop or its complement, a D-inhibit flip-flop. Like the simple D circuit, this one sets the circuit to the state of the D input, with every clock pulse—but only when the enable signal is present (or when the inhibit signal is not present). The clock is not gated, and the D and E inputs are edge-sensitive, and therefore do not catch ones. Figure 6 is a schematic of the concept, in the form of external logic blocks plus an IC flip-flop. In all edge-sensitive circuits, the inputs must be stable a short time before triggering—the setup time—and in Fig. 6 the setup time is rather long.

Building everything into the chip, however, reduces the setup time for a D-enable flip-flop. Details of such a wholly integrated arrangement are likely to differ a little from the one shown. Its principal characteristic

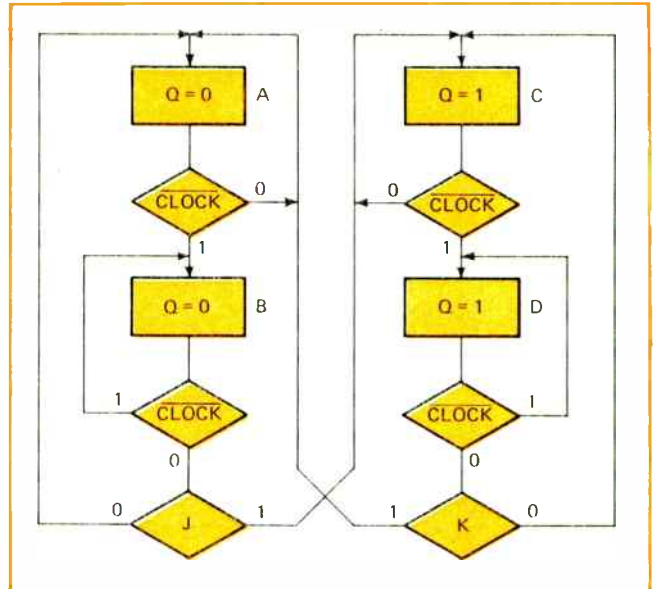
Where do we go from here?

Other circuits that would delight system designers if they were available include: a flip-flop combining the advantages of the D-enable and J-K flip-flops, for use with TTL (one such device already exists for CTL); a counter with an edge-sensitive hold state; and a three-port expandable register.

The last is especially badly needed. Comprising several registers, each with a limited number of bits, it would have one input and two outputs—to permit its use on the two major data buses of a minicomputer. Several units could be laid side by side to provide different word lengths, and stacked vertically to provide different numbers of registers.

A device that almost meets these specifications is Fairchild's set of eight two-bit registers, with an internal wired OR that, though the registers are expandable to any length, permits only eight to be stacked.

Despite its disadvantages, the Fairchild device goes a long way toward the "bit slice" concept, that is, the use of several identical ICs to make up to a processor of any word length. Such a bit slice is already available in MOS. It's time it became available in TTL or ECL.



4. Edge-triggered J-K. Here the J input controls only the transition from state B to state C, and therefore can change any time before clock C falls, allowing only brief setup time. As in the other flow-charts, reverse transitions controlled by K are symmetrical.

would be the absence of a gate on the clock input. But inverting amplifiers should still be included on the chip, for the clock and perhaps also for the enable line. They can reduce the load presented to external drivers and introduce less skew than would an external buffer.

A flow-chart of the D-enable flip-flop (Fig. 7) shows that the rise of the clock pulse causes a transfer from state B to C, or from D back to A, only if enable signal E is present and data signal D has the appropriate level; and E takes priority over D in both transitions.

Most users are sophisticated enough to realize that edge-sensitive logic and buffered signal lines offer considerably increased flexibility in the shape of less setup time, an easier design task, and increased reliability in not catching ones. These advantages more than offset the slight increase in cost and propagation delay.

Both edge-sensitive logic and buffered signal lines are present in the National Semiconductor DM8551 quad D flip-flop (Fig. 8), which also has a two-input D-enable signal active at its more negative level. The signal matches the characteristics of TTL decoders, and the two inputs permit an additional level of decoding on the chip. Most other quad and hex D flip-flops on the market are ordinary flip-flops with a common clock line, and will be unsatisfactory for some applications.

Problematic variety

Many of the TTL medium-scale integrated circuits available today have some of the problems discussed above. For example, Texas Instruments Incorporated's SN7495 four-bit shift register with parallel-load capability has buffered signal lines and edge-sensitive parallel inputs. But the line that signals whether the register is to load new data or to shift old data is not edge-sensitive, with the consequence that the mode cannot be changed from LOAD to SHIFT while the clock is positive without causing a false clock edge. A similar device is Fairchild Semiconductor's F9300 shift register, which has an

edge-sensitive mode line but long setup times.

Moreover, these two shift registers both lack a hold state in which they would neither load nor shift. Yet this would be a useful capability in many computers, where paradoxically much of the circuitry is often idle. TI's SN74198 eight-bit parallel-load shift register, which can shift either left or right, comes close to this capability—it has a gated clock. But an edge-sensitive hold state in place of the gated clock would make it more flexible.

Counter country

MSI has given the world all varieties of counters—up, up-down, parallel-load, binary, decimal, and so on. One of these, TI's SN74193, is typical of a design that may have been all right for its original purpose—an electronic calculator—but is not well suited for computers.

This counter can be loaded in parallel, and has two clock inputs with which it can count either up or down; but its parallel loading is accomplished by a jam transfer that defeats one of the principal advantages of a master-slave flip-flop: no direct path from input to output. Such a loading method forces the system designer to use multiphase clocks or additional machine states, since otherwise race conditions could occur and either start the machine on an unpredictable sequence of states or set up uncontrolled oscillations. The SN74191, also from TI, is somewhat more useful in that it has a single clock line and an up-down mode control.

Among the simpler up-only counters, Fairchild's F9316 has edge-sensitive parallel loading, but the mode controls are not edge-sensitive. It can be placed in a hold state if both parallel-enable and count-enable lines

are kept inactive before the middle of the cycle. If this circuit had edge-sensitive mode controls, it would be well suited for use in small computers.

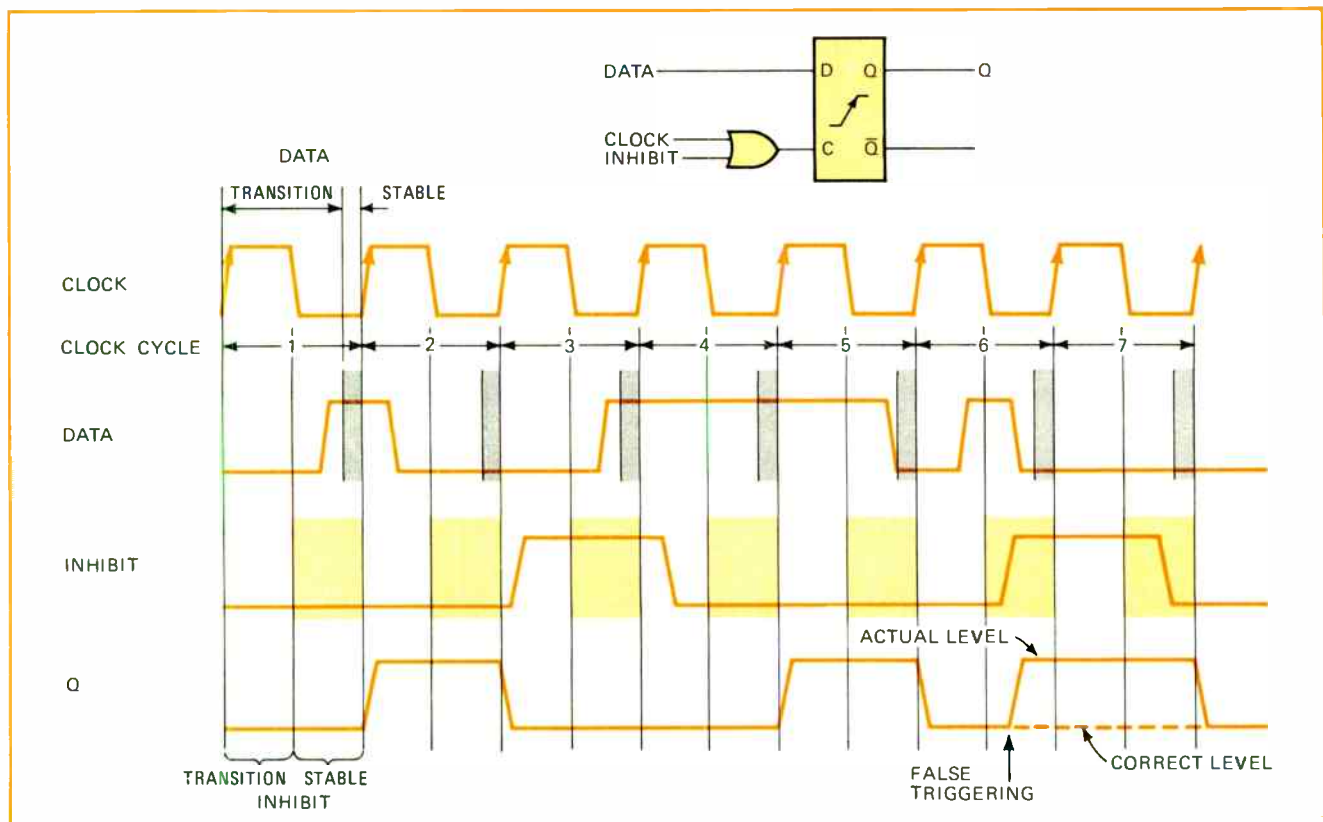
Most work being done today is on medium- and large-scale ICs. But an improved single flip-flop for a computer's control section can also be useful. Even microprogramed computers need a substantial number of such flip-flops, both J-K and D types, as well as some unit logic ICs and some MSI.

The most desirable features of both types of flip-flops can be combined in a single device that is more powerful than either type alone. Fairchild's F9828, part of the CTL family made for Burroughs Corp., is such a device. All its inputs are edge-sensitive, the DE input serving both as a mode signal and as an enable line for the D mode. When DE is high, the D input is active and the flip-flop behaves like a D-type circuit. But when DE is low, the J and K inputs are active and the device behaves accordingly. This circuit's power lies in its ability to change from a D to a J-K or vice versa at any time during the clock cycle.

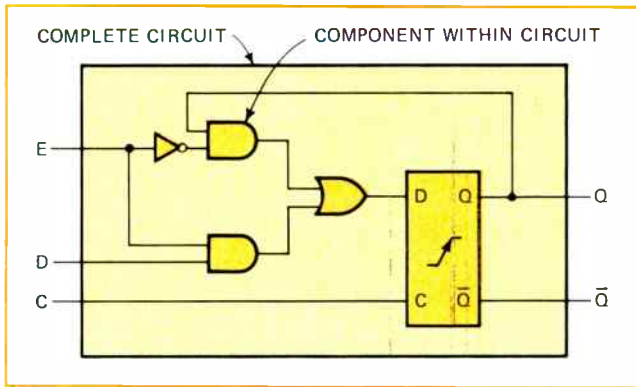
Switching functions

Such a flip-flop can be used in counters, where MSI circuits don't provide the desired function, loading through the D input and counting with the J-K inputs. Alternatively, it can be used in a computer's status register, where some of the bits must be set and cleared under very varied conditions. Two of these flip-flops easily fit into a 16-pin dual in-line package.

The organization of a typical small computer imposes some additional requirements on the design and use of



5. False trigger through gate. Gating clock removes need for a valid D every cycle, but imposes new problems—possibility of false triggering, as during clock cycle 6, and restrictions on timing of inhibit signal, which must rise during first half of clock cycle.



6. Edge-sensitive enable. Adding a little logic to basic flip-flop, either on or off the chip, makes the enable line edge-sensitive and obviates gates in the clock line. It's called a D-enable flip-flop.

ICs. Such a computer usually has two external buses, one or more internal buses, and several registers or other data sources multiplexed onto each bus.

Of the external buses, there is one for the memory and one for input/output. (Some recently introduced computers, notably Digital Equipment Corp.'s PDP-11, have combined the two external buses into one.) The memory bus can be either synchronous or asynchronous, but the input-output bus must as asynchronous so that it can service both fast and slow peripheral units. For internal buses speed is essential.

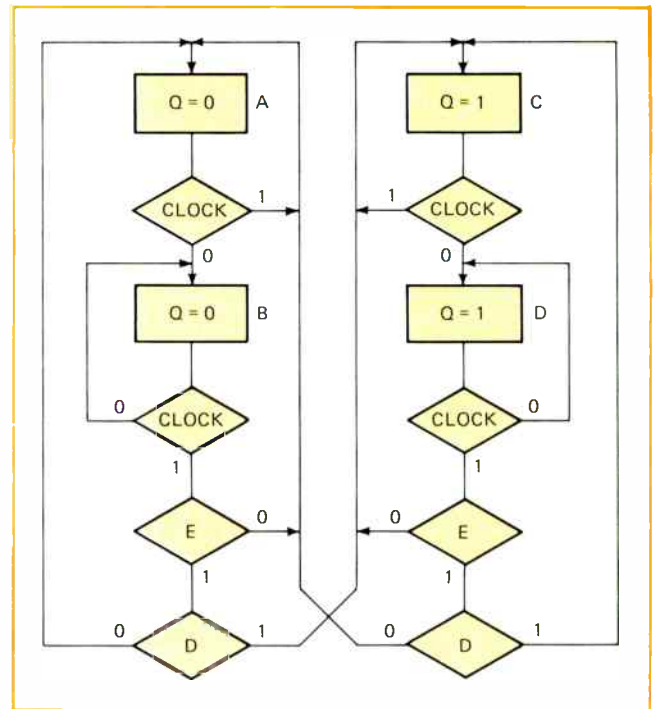
Register tie-ups

One of the major design problems in a minicomputer is multiplexing several registers onto a single bus. With emitter-coupled or complementary-transistor logic families, the register outputs can include an enable gate that has electrically common outputs. The common connection provides the equivalent of an OR function, known as an emitter dot (from its representation on logic or wiring diagrams) or a wired OR.

A wired OR is not possible in conventional TTL circuits because of the "totem-pole" output that provides both active pull-up and active pull-down (Fig. 9, left). If such a connection were attempted, a low-impedance path would exist between the V_{cc} supply and ground when the two register output states were different. Not only would a heavy current flow along this path, possibly damaging or even destroying the transistors, but the logic output would be indeterminate. (Usually the pull-down transistor has a lower saturation voltage than the pull-up transistor. This means that the common connection can't reach a sufficiently positive level to represent a 1 unless both pull-up transistors are on, so that the common connection is effectively a wired AND. But it's dangerous, and safer to call it indeterminate.)

Some designers get around this problem by not using the totem-pole output, and accepting the consequent speed penalty. In its place they put an open-collector gate on the output of each register, with a single collector resistor serving all gates, as shown at the right in Fig. 9. This is again a wired AND, with a slow rise and a fast fall, and is inefficient in terms of signal delay, package count, power dissipation, and output signal waveshape.

The most satisfactory solution uses the new three-level TTL gate, which has the conventional high- and



7. Edge-triggered D-enable. Flow chart shows how enable signal E takes priority over data line D in turning flip-flop either on or off.

low-level outputs, plus a high-impedance "off" state. This gate's principal restriction is that only one data source on the bus can be active at any one time. But this limitation is characteristic of most bus-organized systems. Within these limits, conventional totem-pole TTL outputs can be connected to a bus as long as all but one of the totem-poles are in the third state—that is, with both output transistors turned off.

The circuit is placed in the high-impedance state by pulling down on the base node of the Darlington pair Q_3 - Q_4 (Fig. 10), which turns it off and simultaneously deprives the phase splitter transistor Q_2 of collector current. In addition, the same signal provides a sink for the normal TTL input current through a connection to an extra emitter on the input transistor.

The threefold way

This circuit's main characteristics are its leakage current in the high-impedance "off" state, its output capacitance in the same state, and its maximum source and sink current in the two normal high and low states. The leakage current limits the number of outputs that can be connected together, because the one active gate has to supply the leakage for all the inactive gates in addition to the input current for the normal loads. The output capacitance adds to the capacitance of the bus to limit the circuit's speed.

Though the objective of the three-state design is to avoid presenting a low-impedance path from voltage source to ground through the bus, such a path can still occur momentarily as a result of clock skew and differences in component delays. It can be minimized by shaping the enable/disable waveform so that the enabling delay is longer than the disabling delay. There is a momentary current surge anyway, but in this it is no different from conventional TTL and a small capacitor

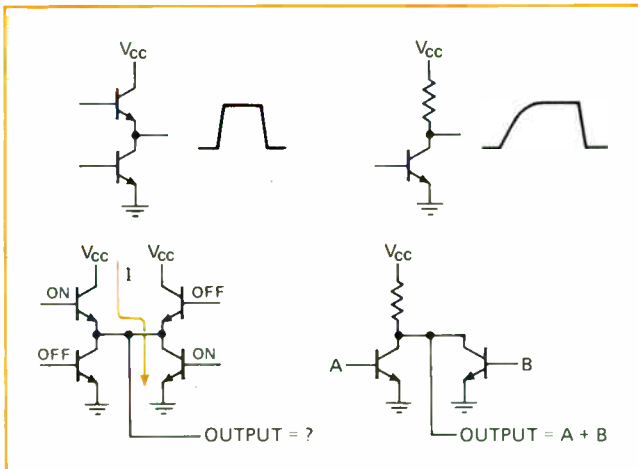
between the voltage supply lead and ground minimizes the resulting noise.

A storage element that has this three-state output is National Semiconductor's DM8551—the same quad D flip-flop referred to previously as attractive because of its edge-sensitive logic and buffered signal lines. It also has the D-enable feature that is ideal for a bus-structured computer. Additional MSI functions with the same characteristics are badly needed—such as shift registers and counters, which are presently obtainable only by connecting three-state gates (National DM8094, for example) to the output of two-state TTL circuits.

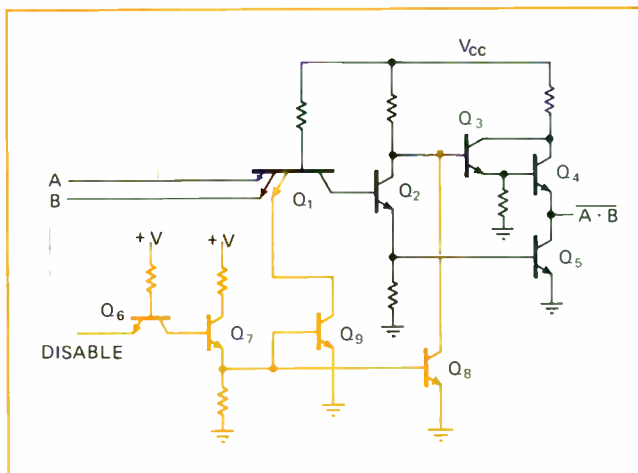
Added advantages

Three-state logic also benefits other areas besides the CPU data path—for example, read-only and read-write semiconductor memories. Because one chip usually does not contain the required number of words, many chips with extra address decoding and bused outputs have to be connected together and are likely to have a rather large output capacitance which a three-state output could drive much faster than can a typical open-collector output.

To put this in perspective, consider a read-only memory of 1,024 words by 32 bits. It can be assembled from 64 chips, each storing 128 words by 4 bits, plus an address decoder. The 1,024 words would require 10 address bits with full binary encoding. Three of these bits would be decoded to select one of eight columns with eight chips in each column, while the other seven would be identically decoded on all 64 chips to select one of



9. Wired OR in TTL. Usual output circuit of TTL logic block (left) has both active pull-up and active pull-down, which precludes common connection of outputs in a wired-OR configuration. But substituting passive pull-up for upper transistor in totem-pole (right) permits wired OR but sacrifices speed.

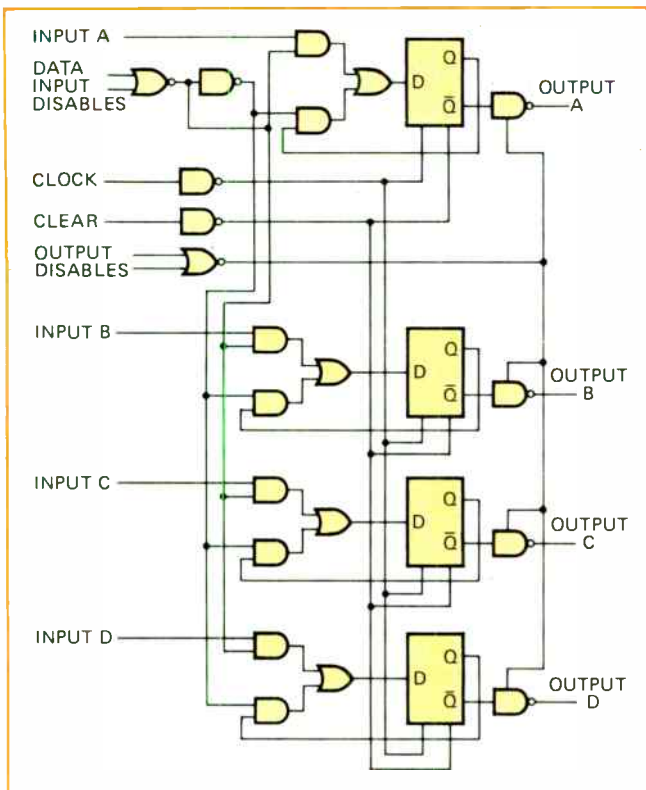


10. Three-state logic. Disable circuit (color) clamps both transistors of totem-pole output into "off" state, permitting wired-OR connection at output and relieving input of load it presents to driving circuit.

the 128 words on the chip. (Of the 64, only eight would be selected by the first three address bits, but the connections to all 64 are obviously permanent so that the 56 disabled chips also load the address lines.) For an address line to drive 64 loads requires buffering to provide enough power.

On the other hand, if the memory had three-state outputs, the three address bits could control the enable/disable circuits, reducing the actual address load to only eight.

In sum, then, three-state logic has related characteristics that fill the needs of a bus-organized small computer very well. It is the result of a cooperative effort between IC technologists working for a manufacturer and computer designers working for a user, and it therefore points the moral of this article: that integrated circuits can and should be made that are functionally more useful to the logic designer than most of those currently available. Although adding some of the desired capability may increase the cost of a single chip, it often decreases the overall cost of a system using that chip. □



8. Quad D flip-flop. This diagram, of National Semiconductor's DM8551, shows the circuit's edge-sensitive logic and buffered signal lines, as well as the disable gate that makes the circuit suitable for use in a wired-OR configuration in bus-organized computers.

Designer's casebook

Interrupt register secures all data signals

by D.J. Plummer and T.E. Zinneman
Indiana University, Bloomington, Ind.

A real-time computer frequently must respond to signals produced by such devices as counters and timers. If a latching interrupt register is used for detection, register dead time can be eliminated so that valuable data signals are not lost.

Normally, an interrupt register consisting of several flip-flops is used. The outputs of the flip-flops are wire-ORed together onto one interrupt line. When it receives an interrupt signal, the computer reads the interrupt register to determine what device requires service. The register then is reset to remove the signal from the interrupt line.

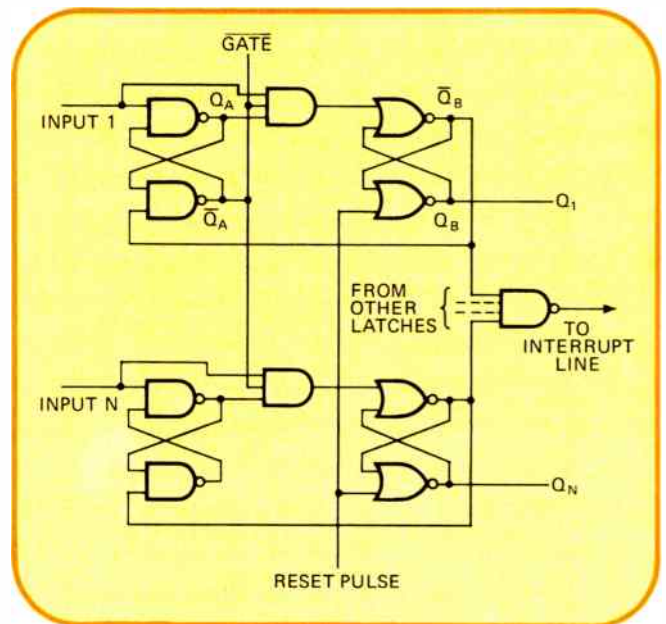
However, if a signal occurs on another input line during the reading and resetting of the register, it is highly probable that the computer will not detect the signal. Although this "dead time" may only be several microseconds, important device interrupt signals can be lost.

The interrupt register shown overcomes this difficulty. Basically, it accommodates N inputs, and consists of a NAND gate latch, an AND gate, and a NOR gate latch. For a logic 0 input, the NAND latch is set ($Q_A = 1$), and the NOR latch is reset ($Q_B = 0$). When an input goes high, the level transition enables the AND gate, setting the NOR latch ($Q_B = 1$). This triggers the interrupt line and resets the NAND latch ($Q_A = 0$) to prevent the interrupt line from being triggered by the same signal.

The gate signal, which is normally high, only goes low during the reading-and-resetting sequence, an operation that takes only a few microseconds. When the gate

signal is low, all NOR latches are isolated from the inputs and cannot be set by incoming signals. As soon as the gate goes high, a new input signal sets the NOR latch.

To avoid missing any interrupts, the duration of an input signal must be longer than the time the gate signal is low. The gate and reset signals may be obtained from one-shots that are triggered by a strobe signal, which is generated when the computer is ready to read the register.



Safeguarding multiple data. Interrupt register allows wire-ORed data signals to be gathered by computer, while register is being read or reset. NAND latch is initially set. Input signal enables AND gate and sets NOR latch; this triggers interrupt line for computer readout and resets NAND latch. All inputs are read as long as time that gate signal is low is shorter than duration of input signal.

Voltage-frequency converter uses four-layer diode

by T.C. O'Haver
University of Maryland, College Park, Md.

By using a four-layer diode to reset a conventional dc integrator to a fixed potential, a voltage-to-frequency converter (or voltage-controlled oscillator) can be built with only one operational amplifier and four other components. The circuit offers a conversion linearity of bet-

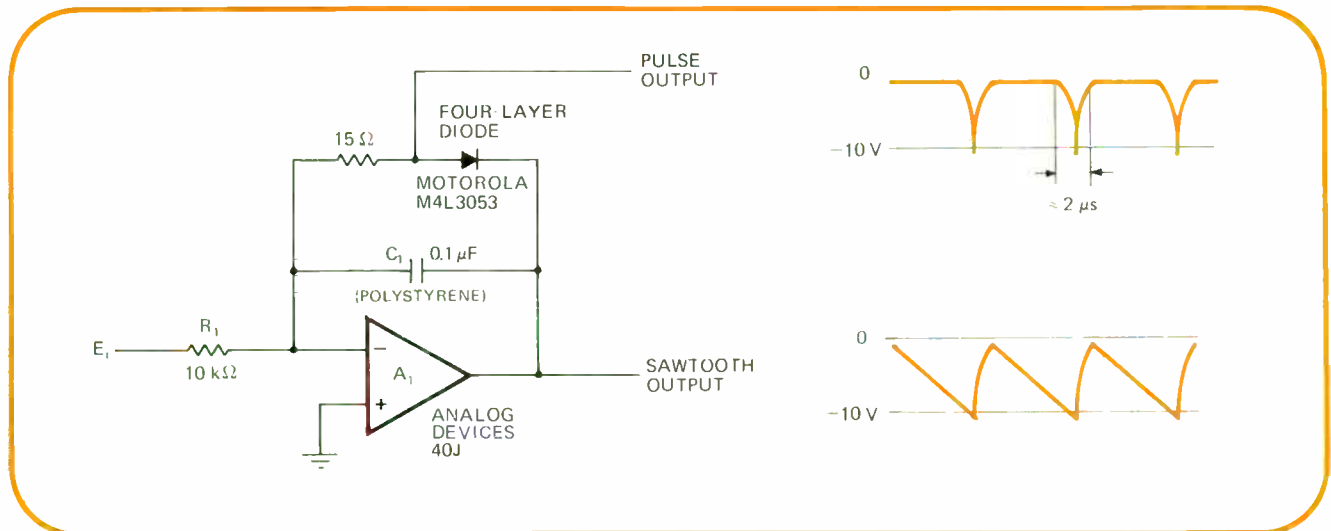
ter than $\pm 0.2\%$ of full scale from 0 to 10 volts. In addition, both sawtooth and pulse outputs are available.

The dc input voltage is integrated by amplifier A_1 , resistor R_1 , and capacitor C_1 , producing a ramp with a slope of $-E_i/R_1C_1$ volts per second. When this output sawtooth exceeds the forward threshold voltage (E_t) of the four-layer diode, the diode switches into its low-impedance stage.

Capacitor C_1 now discharges until the voltage across it is approximately 1 v (diode recovery voltage). The diode then recovers and the cycle repeats. Because of the switching action of the diode, a pulse output is also produced at the diode's anode terminal. The frequency of the output sawtooth is about $E_i/R_1C_1(E_t - 1)$.

Any general-purpose operational amplifier will perform satisfactorily; total parts cost is about \$6 to \$20. For the components shown, output frequency is about 100 hertz per volt, with a linearity of $\pm 0.2\%$ of full scale for inputs from 0 to 10 v and less than $\pm 0.2\%$ of reading from 0.2 to 2 v. Similar results can be obtained with capacitor values of 0.01 to 1 microfarad.

Better linearity can be obtained by using a 1- μF capacitor, but at the expense of reduced output frequency. The circuit operates well up to 5 kilohertz; however, it becomes limited at higher frequencies by op amp slew rate. The value of R_1 should be chosen to keep amplifier input current above 10 microamperes to avoid errors due to diode leakage current.



Switching integrator. Four-layer diode serves as voltage comparator and reset switch for voltage-to-frequency converter. A_1 , R_1 , and C_1 produce sawtooth output by integrating dc input. When output ramp reaches diode threshold voltage, the diode conducts and discharges C_1 . Cycle repeats when capacitor voltage drops to diode recovery voltage. Pulse output is due to voltage drop across 15-ohm resistor.

IC transistor array compensates for temperature

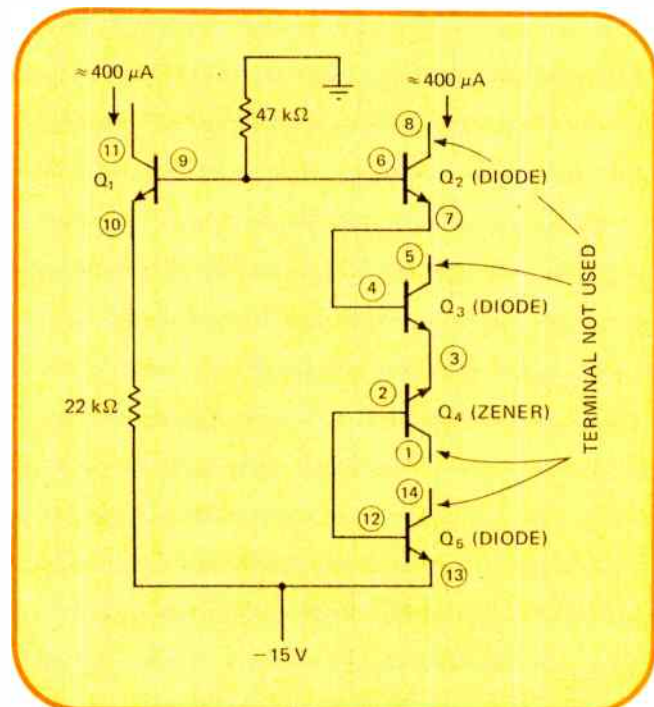
by Arthur Chace
Mount Holyoke College, South Hadley, Mass.

An inexpensive integrated transistor circuit can supply a constant current while providing its own temperature compensation. This combination of characteristics is especially useful when a differential FET-input amplifier has to be biased at its zero-temperature-coefficient point [*Electronics*, June 21, p. 76], because the amplifier's constant-current source should be temperature-compensated for optimum performance.

All five transistors in RCA's type CA3046 package are used. Transistor Q_1 operates as a conventional transistor, but the other four are employed as diodes— Q_2 , Q_3 and Q_5 as forward-biased diodes, and Q_4 as a zener diode.

The temperature coefficient of diode element Q_2 matches that of transistor Q_1 . And the positive temperature coefficient of the zener element is compensated for by the identical, but negative, coefficients of Q_3 and Q_5 . Since all circuit elements are on a common substrate, temperature tracking of individual elements is good.

The emitter of Q_5 is connected to the substrate and should be the most negative point in the circuit.



Compensating a FET amplifier. Five-transistor integrated circuit array can be used as temperature-compensated constant-current source for FET-input differential amplifier. Q_1 operates as a conventional transistor; elements Q_2 through Q_5 are diodes. Q_2 compensates Q_1 , while Q_3 and Q_5 compensate zener element Q_4 . IC package pin numbers are indicated by circled numbers.

A-d converter provides real-time error correction

by Marvin K. Vander Kooi*
National Semiconductor Corp., Santa Clara, Calif.

By adding comparator logic to an analog-to-digital converter, the latter can be stopped from producing an "illegal" output code due to noise pulses or voltage drift.

Whenever a converter with a binary-coded-decimal (BCD) output operates on a signal having adjacent digit 9s, a code error may result. If the last 9 contains a noise

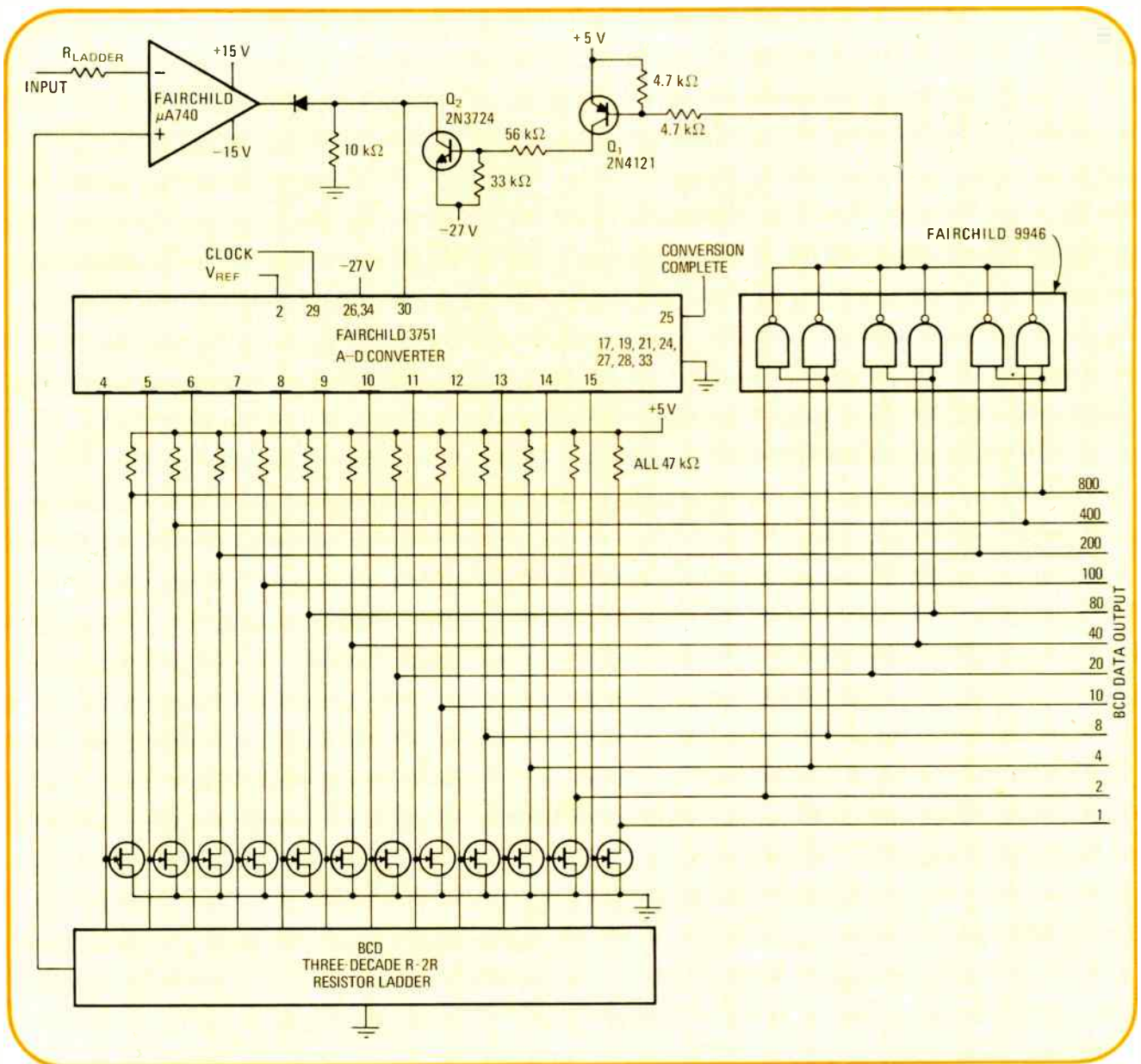
pulse equal to only 0.001 of the full-scale signal, the BCD output may become 10-0. The "illegal" 10 cannot be handled by a BCD input to a computer, nor can it be displayed as a single digit on a readout device. With a successive-approximation a-d converter, these "illegal" codes can be detected since the converter is always comparing its output to its input.

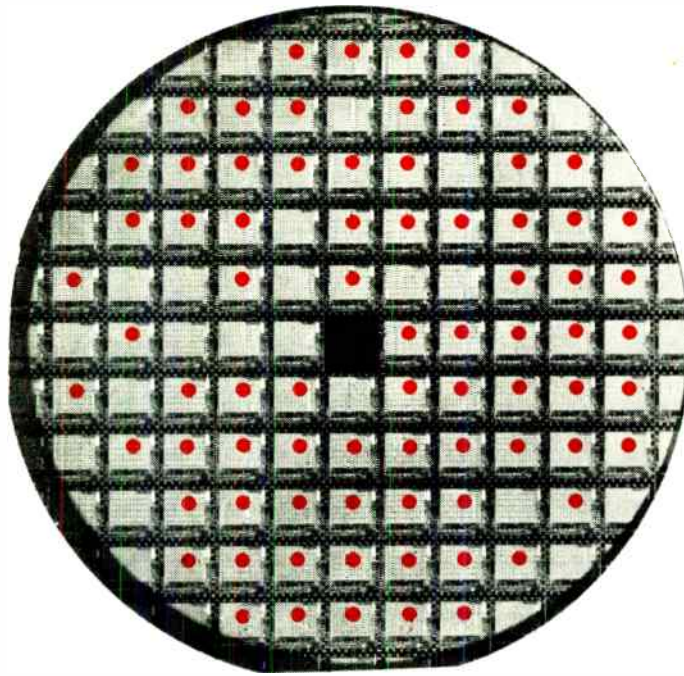
In brief, the converter's output is detected by the NAND gates and changed to negative-voltage logic by Q₁ and Q₂. When Q₂ conducts, it overrides the comparator output, causing the converter to reject the "illegal" bit. On the next clock pulse, the converter moves to the next bit.

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*Formerly with Fairchild Semiconductor, Mountain View, Calif.

BCD code correction. "Illegal" BCD output codes caused by noise or drift are detected by NAND gates and converted to negative-voltage logic. When transistors Q₁ and Q₂ conduct, they override comparator output, preventing analog-to-digital converter from accepting "illegal" bit. An "illegal" bit, a 10, usually occurs when signal containing a 9 also carries small unwanted noise or drift voltage.





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Digital system transfixes nanosecond transients

Centered around a dual-gun storage tube, a data acquisition and display system records transients less than 500 nanoseconds long, and digitizes and stores the data for leisurely analysis

by Glenn S. Mills and R. Keith Treece, Sandia Laboratories, Albuquerque, N. M.

□ When the entire result of an elaborate experiment is contained in one signal lasting less than 2 microseconds, the equipment for recording that signal had better be good. Fast-transient experiments occur commonly in shock and vibration testing, sonar applications, electronic troubleshooting, explosives testing, radar signal analysis, plasma research, and many other fields.

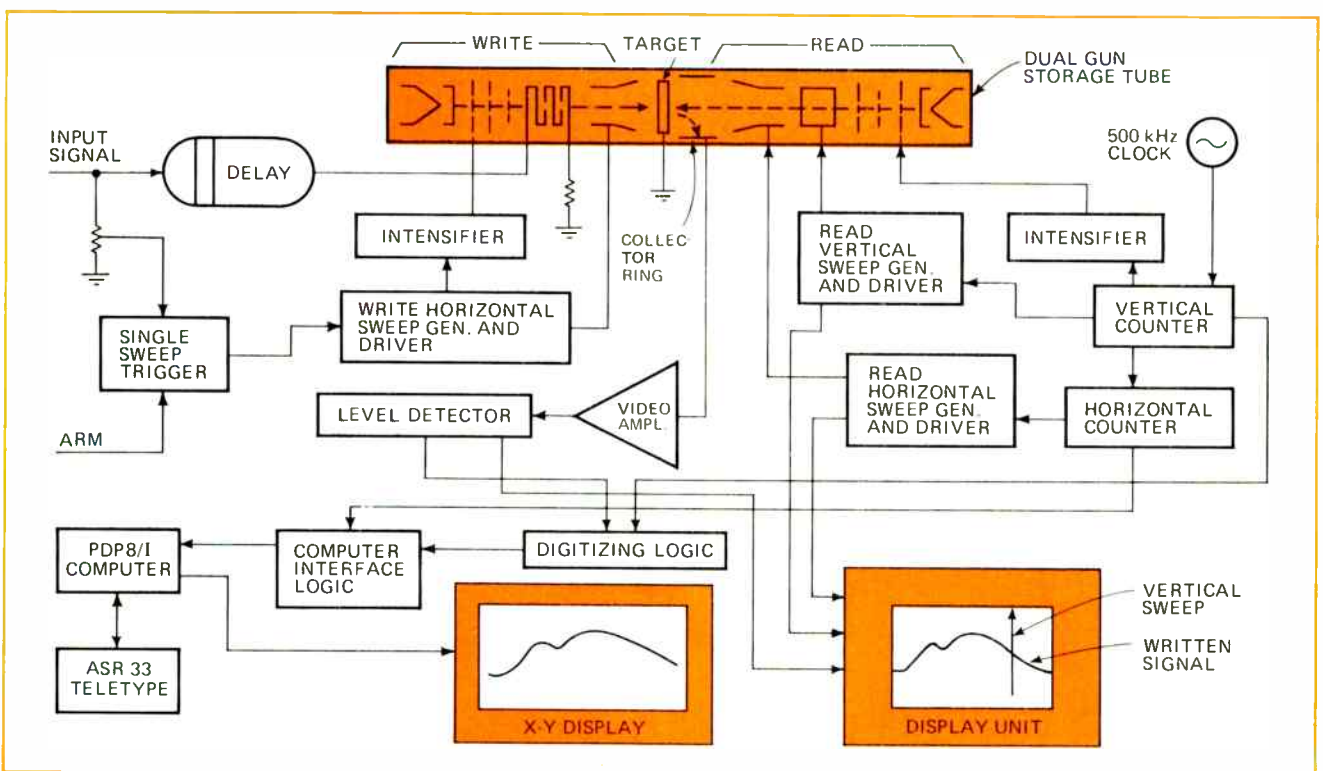
Sandia Labs often needs to record two fast transients simultaneously, however, and has developed a two-channel data acquisition system that captures microsecond signals, translates them immediately into digital form, and stores the data in a digital computer for display at the experimenter's convenience. All this takes the system only 3 seconds, in contrast to the hours, if not days, that it takes to produce a comparable analysis of a photographic trace.

Operation is unique but straightforward. The input signal deflects the write beam of a dual-gun storage tube

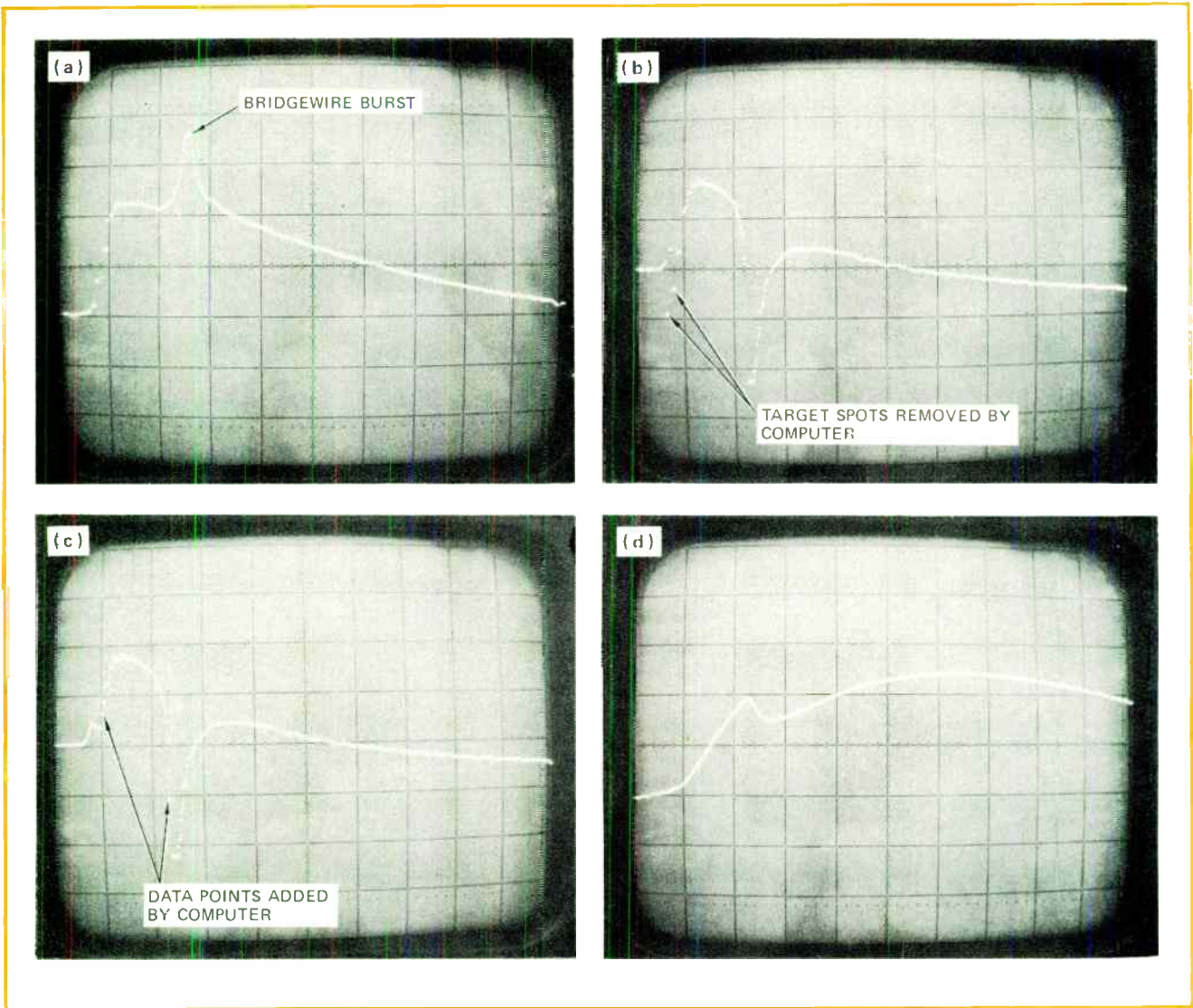
which traces it onto a semiconductor target. The trace remains there long enough for a read beam to scan the target (fast sweep vertical) and generate a dot signal each time it intersects the stored signal. Digitized values on the first X (time) and each Y (amplitude) of each intersection are then transferred to memory. The computer also calibrates the system automatically, corrects for nonlinearities, and detects invalid data.

Because the trace lasts some time, the read scan can take about a third of a second, even though the original write time may be only a few microseconds. This relatively slow reading cycle permits high-resolution digitization: amplitude resolution is one part in 256, and time resolution, one part in 512.

A block diagram of one channel of the system is shown in Fig. 1. The dual-gun storage tube's write-deflection circuit resembles that of a conventional oscilloscope, except that the vertical deflection field is gener-



1. Capture and hold. In fast-transient data acquisition system, dual-gun storage tube (top) writes a transient trace as fast as 500 nanoseconds full scale. Then electronics circuits (center) read out and digitize trace at slower rate, and store digital data for display (bottom).



2. Boom, boom. In each of these four scope photos of an actual bridgewire explosion transient, sweep time is 2 microseconds. (A bridgewire is an electrically energized wire that detonates a bomb by exploding inside its detonator.) Display (upper left) shows untreated data of bridgewire voltage on one of the two input channels. Other channel (upper right) records differentiated (di/dt) bridgewire current, also shows spurious data points produced by noisy spots on target. Corrected scope display (lower left) shows interpolated data points that computer substitutes for invalid points. From this trace further processing derives final bridgewire current waveform (lower right).

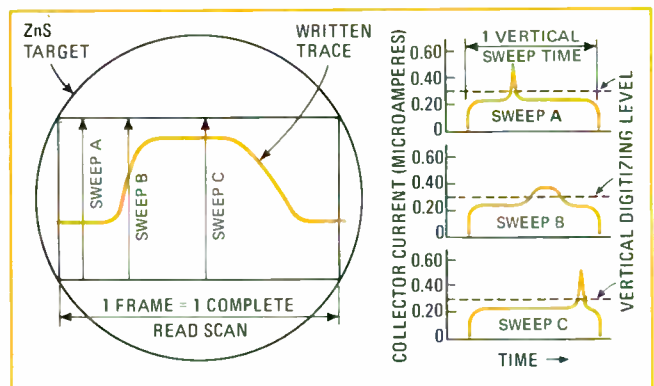
ated by a stripline circuit inside the tube. The input-signal channel bandwidth extends from 700 hertz to 37 megahertz (3 decibels down), and is limited by the signal delay line. The write horizontal sweep is controlled by a single-sweep trigger, armed before the test. A square intensifier pulse, synchronous with the horizontal sweep, turns on the normally cut off write beam. The write sweep can be set for full-scale times of 0.5, 1.0, and 2.0 microseconds.

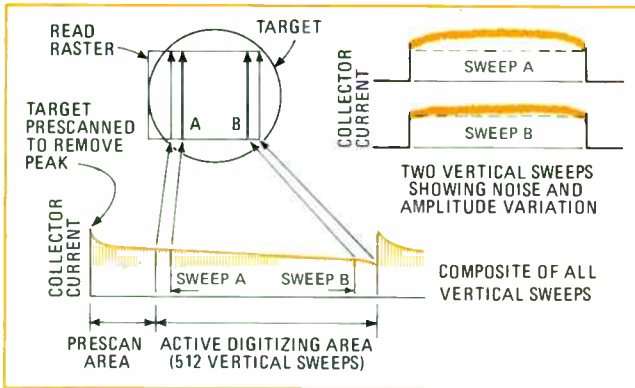
Part of the input signal is fed to the trigger, and starts the beam moving before the rest of the signal, which is momentarily delayed, can reach the vertical deflection structure. This delay, standard in high-response scopes, prevents any loss of the signal's leading edge.

On the read side, a 500-kilohertz master clock pro-

3. On the level. Horizontal trace intersected by vertical read scan produces sharp video data pulse breaking through the digitizing threshold level, but fast rising trace yields broader, shorter pulse.

vides vertical and horizontal blanking and counting pulse trains, which generate synchronous analog sweeps on both channels for vertical and horizontal deflection. An intensifier pulse train turns on the read beam only during the proper vertical sweep intervals. Since the tar-





4. Prescanning. Part of the target is swept by the read beam to reduce unequal collector currents, due to surface charge leaks.

get trace is not visible to the operator, a separate X-Y display operates from sweep and Z-axis (dot intensity) signals going to the digital subsystem.

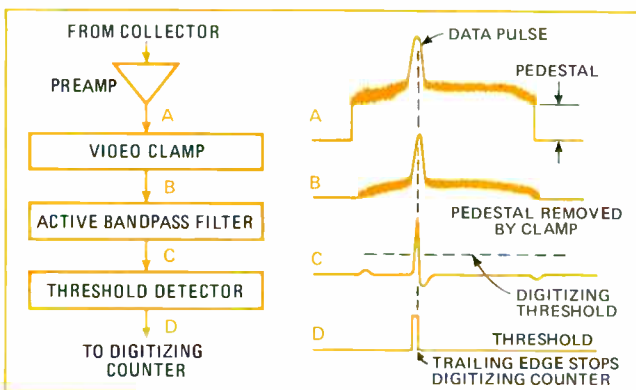
As the read beam scans the target and crosses the written trace (Fig. 3), the secondary emission current at the collector increases, and brightens the Z signal at the X-Y intersection on the display unit. Because the dots are very close to each other, they form a trace that looks almost continuous to the operator.

Separate signals

For the digital subsystem, the low-amplitude Z signal, also called the video signal, goes through some extra steps to improve digital counting of clock pulses. For example, because surface charge leakage makes the amplitude of the collector video signal vary horizontally across the target's scanned area, part of the target is prescanned to bring the background video signal to an acceptable level within the normal raster area (Fig. 3).

Digitizing starts with threshold detection of the Z-signal pulse produced when the read beam crosses the written trace. As Fig. 3 showed, the amplitude and width of this pulse vary with the slope of the written trace: when the vertical scan intersects the fast-rising part of the pulse, the resulting video data pulse is broad in time and low in amplitude; when the trace is more horizontal, the data pulse is narrower and higher.

Since the most important information may be in the fast-rising part of the transient, the detection threshold is set as low as possible, yet higher than the varying

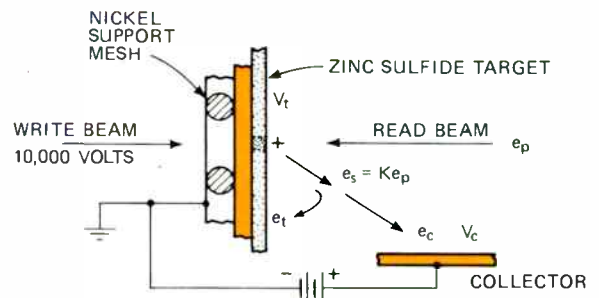


5. Enhancement. Video signal circuit clips pedestal from data pulse, removes noise and differentiates pulse in filter, and then passes to counter only those pulses that exceed preset threshold level.

Speed reading—and writing

The dual-gun storage tube used in the transient analyzer produces electrical signals, not the visible image of the conventional cathode ray tube. The read beam electrons (or the primary beam e_p) are accelerated by about 600 volts toward the zinc sulfide target. For each primary electron impinging on the target, about two and a half times as many secondary electrons, e_s , are emitted and attracted to the collector ring. That is, there is a gain, K , of 2.5. As the collector ring, which is initially at a higher potential than the target, collects all the secondary electrons, the zinc sulfide loses its charge, or becomes more positive, at a rate equal to $(K-1)$ times the read beam current. The target continues to become more positively charged until its potential, V_t , essentially equals the collector's potential, V_c . In equilibrium, the excess electrons, e_t , return to the target. In this way the read beam continuously scans the target and maintains it in a positive state, waiting for the write beam, the input transient, to come along.

The 10,000-v write beam has enough energy to ionize a small dot on the target and discharge the positive surface charge. Consequently, as the write beam sweeps across the target, it produces a continuous trace on the target surface. Then when the read beam intersects the discharged written trace, the collector current jumps to about two and a half times its equilibrium value. This increased signal, called the video signal, is detected, conditioned, and measured in time and amplitude to become one of the 512 digitized readings of the input transient.

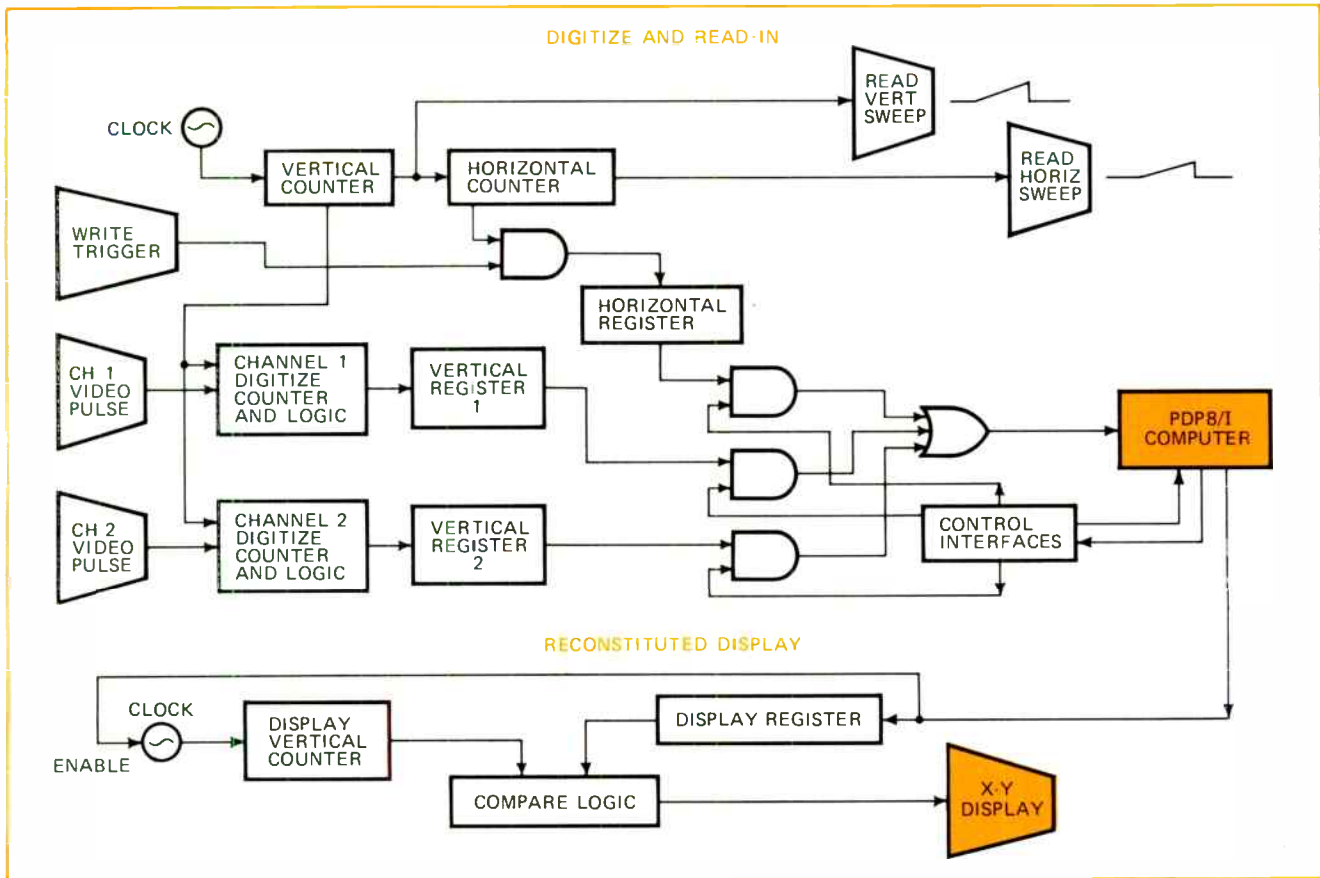


background. Figure 5 shows how this is done: the video clamp removes the signal pedestal; the bandpass filter removes the high-frequency noise and low-frequency background bow; and the filter also differentiates the data pulse. Stopping the digitizing counter on the trailing edge of the differentiated pulse effectively digitizes at the center of the written trace, eliminating error due to differences in write beam width.

The digital subsystem is contained on a single chassis, and is built with commercial TTL logic. It has two independent functions, served by the digitize/read-in section and the reconstituted display (Fig. 6).

The digitize/read-in portion includes its own 500-kHz clock, which feeds a counter for generating the vertical sweep and blanking-pulse train. Another counter divides the vertical pulses by 512 to provide the horizontal sweep and blanking timing. That is, each 256-pulse vertical scan results in one horizontal timing pulse, 512 of which make one frame scanning sequence.

Since the trace is erased by the continuously scanning



6. Read in, read back. With the computer serving as the system director, video pulses from two channels are counted and move into computer memory. Then, at a faster frame rate, the digitized traces are reconstituted on the X-Y display (lower right) for review by experimenter.

read beam, digitizing of the written trace must start immediately. However, the read beam may be anywhere in the raster pattern when digitizing begins. Thus the first data value read into the computer memory is the horizontal pulse count accumulated in the horizontal register at the point in the frame at which the write beam is triggered. The computer recognizes this count as the address of the memory location for the first vertical count which had been shifted into the vertical register, and the program places subsequent incoming vertical counts in their proper memory locations. Thus, no matter where the writing starts in the read scan, the computer organizes and stores the read data *as if* it actually started at the beginning of the transient.

At the end of each vertical sweep the accumulated pulses, representing trace amplitude, move into the vertical register. Then the register is cleared when its content is read into the computer memory.

The reconstituted display, using a conventional cathode ray tube, creates the input signal from the digitized data stored in the computer memory. The computer and electronics generate a scan raster similar to, but faster than, the read scan of the storage tube—its speed is about 12 frames a second, to minimize flicker and to make the transient appear permanent and stationary.

At the start of a display frame, the computer loads into the display register the count for the first vertical (amplitude) point, and the clock counts are fed into the display vertical counter. When the display vertical count equals the count stored in the display register, the

compare logic outputs a pulse to the display's Z axis—which brightens the raster at that point. Pulse counts are stored octally: thus a full-scale register store of 400₈ equals 256 pulses. Sequentially, each vertical sweep results in a bright dot on the face of the CRT. But because a new horizontal sweep starts automatically at the end of each frame, and the frames follow one another very fast, the sequence of dots appears as a continuous-trace reproduction of the original transient signal.

Self-help

One important feature of the data acquisition system is automatic self-calibration just before data read-in, providing an accuracy of $\pm 1\%$ of full scale. Calibration takes less than a minute and includes: scaling the digitized data to engineering units (time, volts, amperes, etc.); and correcting for nonlinear sweeps, nonlinear vertical sensitivity (gain), system drift, differences in trigger delays between channels, and misalignment of the tube's read and write deflection systems.

Calibration starts with the operator pressing one switch, which introduces three precise calibration signals—time, amplitude, and fiducial—into each channel.

During amplitude calibration seven dc voltage levels—30, 20, 10, 0, -10, -20, -30—are impressed on the vertical deflection system, one at a time. Across the target of an ideal tube with perfectly linear sweeps, the seven levels would be equally spaced and perfectly flat. In this ideal situation the vertical sensitivity would be characterized by one number, N volts per vertical count,

Also in the picture: stand-alone ultra-fast digitizers

Building a two-channel, fast-response data acquisition system is worth it when the amount of testing and the need for rapid and accurate conversion of data to engineering units can justify the \$50,000 cost, not counting the online computer. Sandia Laboratories has built three, and was planning to build a six-channel system soon.

However, the dual-gun storage tube is no longer available. Zenith Radio Corp. sold its Rauland Tube division, maker of the R-6288A tube, to Texas Instruments, whose plans for marketing its products are as yet undecided. Consequently, future Sandia systems will probably have to be adapted to incorporate an equivalent tube.

Also, it should be recognized that there are other ways, less costly but perhaps less comprehensive, to capture one-shot and slow-cycling repetitive transients.

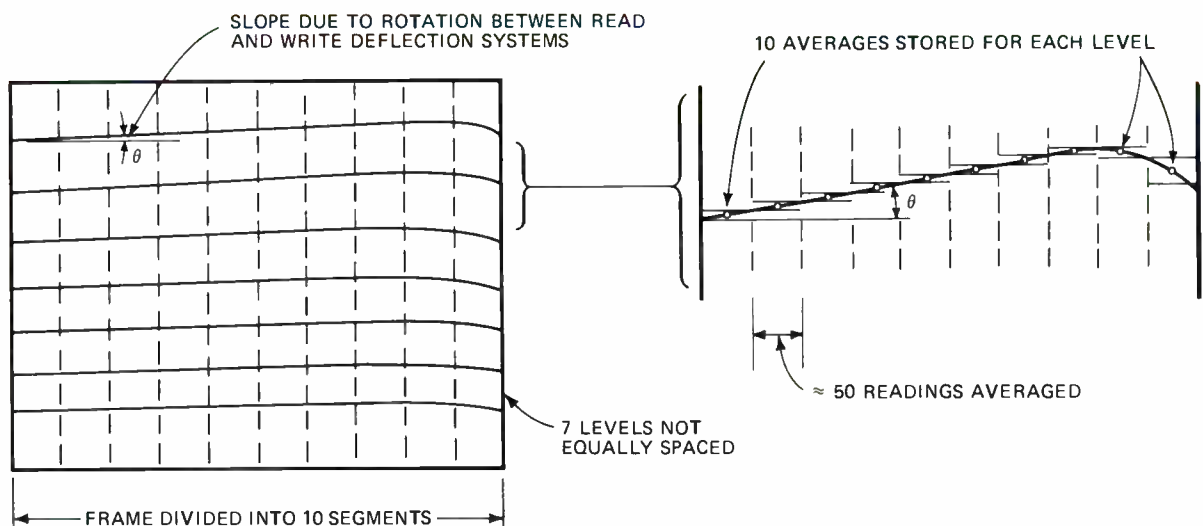
Time-honored and relatively inexpensive, a snapshot of a CRT trace is good for learning a transient's general shape and characteristics. Specific information can be obtained from manual and semi-automatic measurements of the traces on the photo. But when experiments require statistically confident results in engineering units for such parameters as peak value, points of maximum slope, and integrated areas, then obtaining quantized data from a photograph is tedious, time-consuming, and prone to human errors. If computer processing of such quantized data is also needed, another set of complications and time delays arises. Basically, then, photography has its place in low-volume testing situations that can't support a large capital investment.

But there are other ways of digitizing waveforms electronically besides the method in the Sandia system, which relies on temporary storage of the input signal on the storage tube's target. Stand-alone electronic transient recorders perform the analog-to-digital conversion in real time by sampling the input signal directly. These devices are currently being produced commercially by a number of firms, such as Biomation, Palo Alto, Calif., LeCroy Research Systems Corp., West Nyack, N.Y., and Computer Labs, Greensboro, N.C.

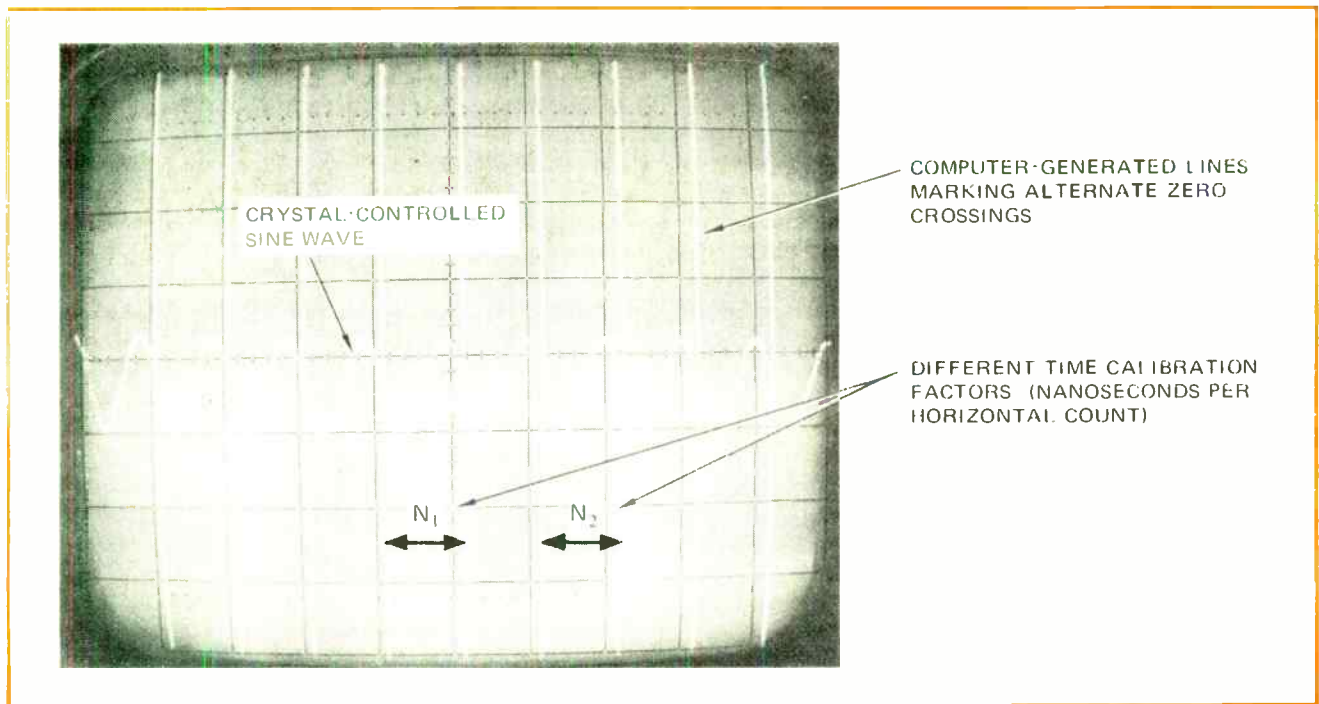
Biomation's Model 610B transient recorder uses a 6-bit analog-to-digital converter, with the digitized data stored in a 6-bit- \times -256-word MOS shift register. Output is both digital, for input to a digital printer or computer, and analog through a digital-to-analog converter and a filter to smooth the signal, for readout on a scope or X-Y recorder. For \$1,850, the user gets one part in 256 time resolution and one part in 64 amplitude resolution. Sweep time can be set to intervals of from 20 microseconds to 10 seconds. Model 802, at \$2,950, offers one part in 256 amplitude resolution, one part in 1,024 time resolution, and sweep ranges of 500 ns to 20s. Model 8100, Biomation's most recent development, has an 8-bit amplitude resolution, an input bandwidth of 100 megahertz, and stores 2,000 data points internally. Price is \$9,800.

LeCroy Research System's wd2000 waveform digitizer features a built-in 3-inch oscilloscope display and 19 pushbutton-selectable time ranges from 20 nanoseconds to 20 milliseconds. A program board permits the 20 samples in each time sweep to be set for linear or nonlinear (for example, logarithmic) distribution. Amplitude resolution is one part in 256. The instrument, at \$16,800, has facilities for communicating with digital computer and printer. Interface options cost extra: for example, a factory-installed interface to an ASR33 teletypewriter-printer-punch costs \$1,450.

Computer Lab's Lab 210 Transiverter is a 2-MHz, 10-bit, analog-to-digital converter with an input bandwidth from dc to 40 MHz and a sampling aperture time of less than 0.5 ns. The unit, at \$4,900, includes a four-place numeric display. A plug-in memory, at \$310, stores 100 of the 10-bit words from the Transiverter. Together, these units can record and store one-shot transients of 50 μ s to 50 milliseconds depending on preselected encoding speed. Amplitude resolution is one part in 1,024, and time resolution one in 100. A digital-to-analog converter, optional at \$510, permits analog plotting of (unsmoothed) digitized transient information stored in the memory—Ed.



7. On the average. Ideal tube would have perfectly linear sweeps. During automatic calibration cycle before test run, therefore, computer injects amplitude calibration voltages and calculates, stores and applies correction factors for each of 80 segments in target area.



8. Timely. Accurate sine wave generator and zero crossing detector help computer calculate, store, and apply correction, in nanoseconds per horizontal count, to the horizontal sweep that establishes input transients' time base.

over the entire target. Actually, however, as shown in Fig. 7, the levels may have some slope, be slightly non-linear, and be unequally spaced.

To compensate, the computer calculates correction factors. It divides each level into 10 segments, finds the average level of 50 readings in each segment, and stores these 10 averages for each of the seven levels. These 70 numbers stored for each channel provide amplitude correction factors corresponding to 80 different areas on the target. The computer reproduces the seven calibration levels by straight-line interpolation between the 10 average numbers stored for each level, and the operator views them for correctness on the X-Y display.

A new angle

The computer also calculates the angle of read-write deflection misalignment (Fig. 7) from the average slope of the first level. With the angle known, it makes a rotational correction to each data point. (A recent modification, which eliminates computer rotational corrections, is an alignment coil that rotates the read raster and aligns it with the tube's write deflection axes.)

Time calibration occurs by writing 10 cycles of a crystal-controlled sine wave, accurate to $\pm 0.02\%$, across the tube (Fig. 8). The computer detects zero crossings of the sine wave, using the zero reference from the amplitude calibration. The display logic turns on the beam for an entire vertical sweep when a high order bit in the data word is set. The computer sets this bit for every other crossing, one word per cycle, and the display shows the detected crossings. Then the computer calculates a time correction for each interval between the crossing for each cycle. This technique scales the write horizontal sweep properly, and corrects for any time nonlinearities in both read and write sweeps.

Fiducial calibration allows both channels to be corre-

lated to time zero, even when each channel has a different time delay at the input. A pulse with a very fast rise time is written simultaneously on each channel. The computer then finds where each leading edge occurs, and stores the corresponding horizontal count for each channel. These stored counts allow the traces on both channels to be referenced to a common starting time. Like the other two calibrations, the validity of the fiducial calibration may be verified by the operator from the marked fiducial pulse on the X-Y display.

If spurious data occurs during an experimental or calibration run—whether from an undetected video signal or from a noisy spot on the target—the computer applies an algorithm that detects it and substitutes calculated data. An invalid data word is detected when a count is driven to or reaches 400_8 (the full-scale count of 256_8 pulses). When the computer program receives one or more invalid data words, it interpolates linearly between the nearest valid data. During printout of data, interpolated points are identified with asterisks.

Failure to detect a video signal occurs when the leading edge of a transient is especially fast-rising, as from a fiducial calibration pulse, and the write beam moves too rapidly to discharge the target fully. Thus, the resulting video signal may be too small to be read. If so, the vertical counter doesn't receive a signal to stop and thus counts up to 400_8 . The computer detects the 400_8 bit, ignores its value, and instead interpolates linearly between the nearest valid data points.

In contrast, a noisy target spot may generate a video signal during a vertical sweep, in addition to the valid signal from the intersected trace. The digital logic detects the occurrence of two signals in one sweep and sets the 400_8 bit in the data register. Again, when the computer sees this, it ignores the data and calls for linear interpolation between the nearest valid data points. □

The pluses and minuses of charge transport devices

Understanding the different tradeoffs offered by bucket brigades, charge-coupled units, and surface charge transistors will ease their introduction into various memory and imaging applications

by R. D. Baertsch, W. E. Engeler, and J. J. Tiemann, *General Electric Co., Schenectady, N.Y.*

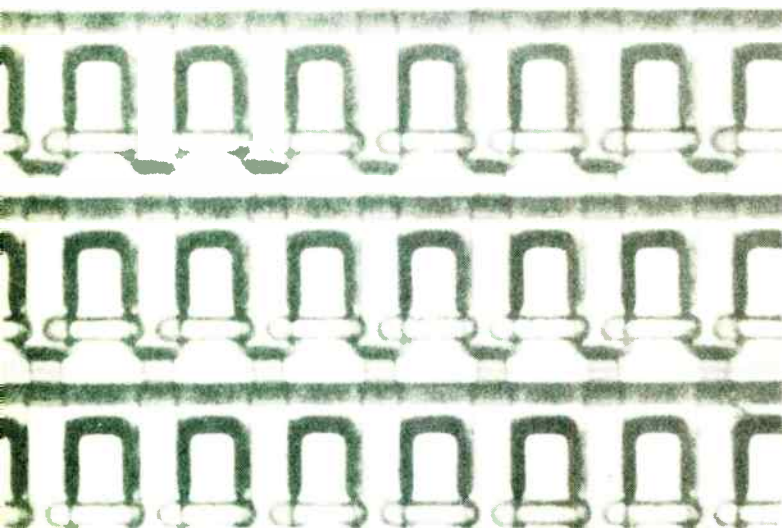
□ It is now firmly established that transferring charge along the surface of a semiconductor offers an attractive approach to memory and imaging systems. But there is more than one way of building a charge transfer device, and the structure of each must be closely analyzed.

The differences between conventional MOS devices and the three types of charge transfer devices now available—MOS bucket brigades, charge coupled devices, and surface charge transistors—turn into advantages or disadvantages, depending on the application for which the designer intends it. Unless he knows the tradeoffs, he's likely to be forced into undesirable compromises in other aspects of system performance and unlikely to benefit fully from surface charge technology.

In brief, the MOS bucket brigade manipulates packets of charge by means of conventional transistors and capacitors, a CCD uses moving potential wells, and an SCT gates surface charge between reservoirs with control electrodes. All differ from previous MOS structures in that they manipulate signal charge without requiring contact with the silicon.

This basic difference has several important implications. Since fewer contacts to the semiconductor (called vias or dig-downs) will be required to implement a sys-

1. Watching its image. One of the most promising applications of surface charge transport is in imaging devices. The close up of this one shows the SCT elements built into an array.



tem with charge transport devices, yields should be significantly higher, particularly in larger devices, and costs should be lower, again particularly for large memory and imaging arrays. Because of their generally simpler structure, surface charge devices can be made smaller for a given mask resolution and realignment tolerance. This means both a higher device density than is possible with other techniques, and a higher operating speed (the transfer time increases as the square of the length of the storage electrode). As an example of an imaging device, Fig. 1 shows a photomicrograph of an early device fabricated to show the feasibility of the SCT for imaging use.

A second basic difference is that charge transport devices have no threshold voltage that the signal must overcome, a difficulty with conventional MOS devices. In surface charge devices, the electric charge is merely a working fluid, and the voltage swing it produces has no significance except at the very end. For example, if a particular signal is represented by 1 picocoulomb of charge, it makes no difference (except for speed) whether the working stages of the device use 10-volt or 1-v clock pulses. In either case, the same picocoulomb of charge will be finally dumped into the output capacitance, and the same output voltage will be observed.

Because lower voltages are feasible, it's possible that the depletion width margins between adjacent devices could be made narrower than at present, so that still more devices could be packed in per unit area. Possibly lower power levels per function may also be reached.

The other side of the coin is that conventional devices generally reference the signal to a specific dc level at each stage, so that no problems are caused by the charge thermally generated within the depletion regions that surround the devices' active portions. This is not the case with surface charge transport, where any thermally generated charge is carried along with the signal charge, and the signal may become severely degraded if many functions are performed before a reference is re-established.

Consequently, surface charge devices cannot work in a low-power, static mode and, more importantly, they cannot function at as low a frequency as conventional MOS shift registers with refresh at each stage.

Clearly, then, surface charge devices will have their greatest impact in systems where there is a premium on device density and speed, but not on low-frequency per-

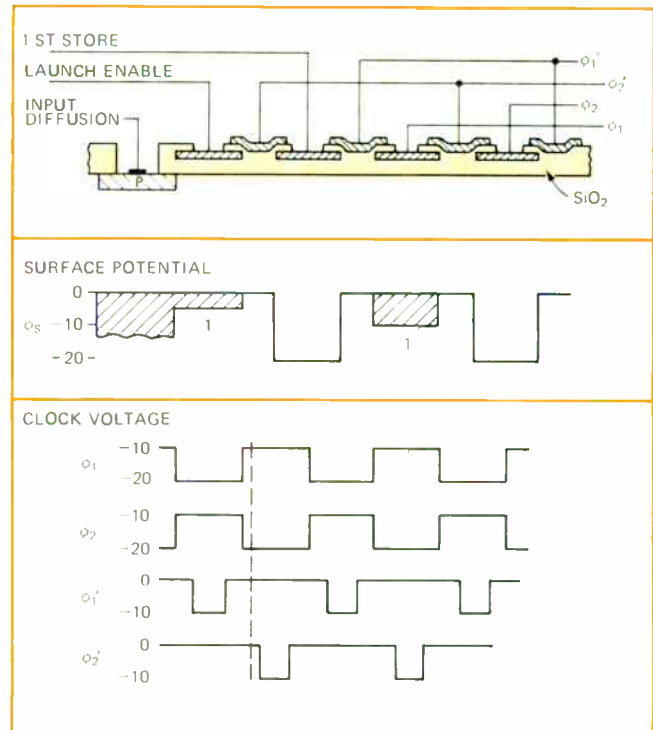
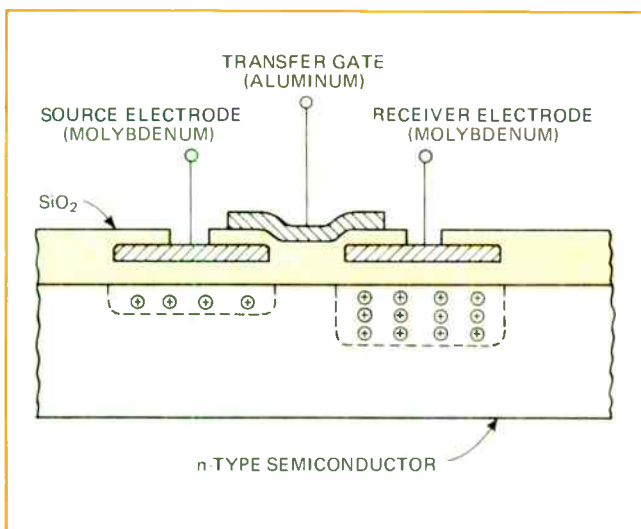
formance. Further, because conventional circuits are necessary to provide the input, output and refresh functions, the processes used to fabricate both the surface charge structures and the conventional transistors ought to be compatible. A comparison of the three types of surface charge structure and their physical characteristics is given in Table 1.

The two-level, refractory metal (RMOS) process, with its low-resistivity buried gate, is an ideal technique for building surface charge devices. This process enables the SCT to be built with overlapping gate electrodes and therefore eliminates the gap problems associated with single-level bucket brigade and CCD structures. It also allows the entire structure to be completely shielded and protected from ambient conditions. In addition, like the equivalent silicon gate process, RMOS is self-aligning and minimizes the need for close photolithographic tolerances. Most important, RMOS can be used to build both surface charge devices and auxiliary MOS structures on the same chip—in fact, an entire memory subsystem can be built with this one process.

How an SCT works

A cross section of the physical structure of a surface charge transistor is shown in Fig. 2. The three electrodes, which are separated from the semiconductor and from each other by thin insulating films, are called the source electrode, the transfer gate, and the receiver electrode, respectively. Depletion regions capable of storing minority carriers can be formed in the semiconductor under these electrodes by application of the appropriate voltages, and the transfer of this charge from source region to the receiver can be controlled by fixing the surface potential of the space between them with the transfer gate voltage. Since these depletion regions can accept, store, and return the charge stored in them,

2. The key. Forming the heart of all charge transfer applications are these surface charge transistors. They differ from other charge transfer devices (both CCD and bucket brigade) by virtue of their transfer gates, which control the flow of charge from the source electrode to the receiver electrode. When built into arrays, these elements operate like conventional shift registers, and become the basis of almost all memory, delay line and imaging applications.



3. The shift register. A SCT shift register operates like a conventional MOS register, transferring ones and zeros as logic functions. Here the silicon surface potential ϕ_s is shown along with the appropriate clock waveform; the value given applies at a time corresponding to the dotted line on the clock voltages (ϕ_1, ϕ_2 , and ϕ_1' and ϕ_2'). The upper line of the surface potential profile indicates the actual surface potential, the lower indicates its value at full depletion.

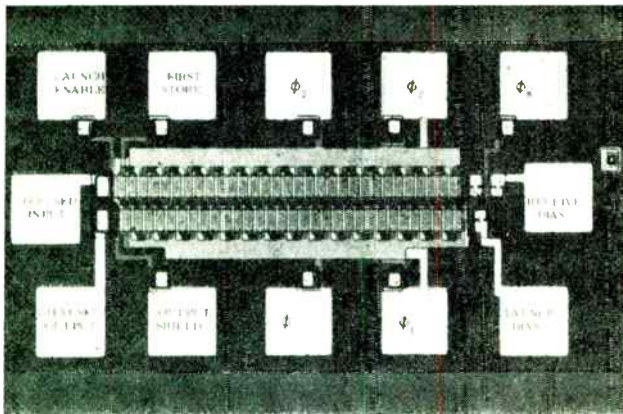
they are referred to as charge storage reservoirs, or simply as reservoirs.

A linear array capable of continuously transporting charge along the surface of the semiconductor can be formed from a row of these units, with each storage reservoir serving first as the receiver and then as the source for the next element in the array. When diffused regions for injection and collection of charge are added, the array becomes a shift register—the basis of almost all present surface charge transport technology applications.

The cross section of a shift-register structure is shown in Fig. 3, together with its typical operating waveforms. An n-type substrate is assumed, to make the fabrication process compatible with p-channel FETs.

To introduce the charge into the shift register, the input is held at ground potential, and the voltage on the launch-enable electrode is set above the MOS threshold, creating an inversion channel that extends all the way from the p-region to the transfer gate connected to the ϕ_1' bus. Since the carriers in this channel are in contact with the input diffusion, they are also at ground potential.

Now, if a relatively large negative potential has been applied to the first store electrode, and this region is empty of charge, then the carriers in the inversion channel under the launch-enable electrode will flow over to the first store as soon as a clock pulse occurs on the ϕ_2' bus. This will continue until the surface potentials have reached complete equilibrium. At that time



4. A little bit of saving. The strength of charge transport devices lies in smallness of cell size (one-third conventional MOS) and paucity of dig-downs. In this 32-bit shift register, no dig-downs are required to transfer charge along an entire 16-bit line. A refresh-turnaround circuit at the end of 16-bits sends renewed charge packets along the lower row to the output diffusion.

the charge transfer has then been accomplished.

In this example, the final potential of the carriers under the first store will be at ground. If the input diffusion had been held at some moderate negative potential, however, the first store would have had a similar negative final potential, and there would have been a smaller quantity of charge and a smaller signal at the end of the line. On the other hand, if the input diffusion had been at a negative potential large enough to stop the charge from travelling to the first store, then the first store would have remained empty.

Furthermore, if the launch-enable voltage had been below the MOS threshold, the inversion channel would not have existed, and the holes would not have been able to transfer, no matter what their potential. Thus, the launch enable serves as an on-off control, while the potential on the input diffusion serves as a continuous control on the amount of charge transferred.

This arrangement adds an extra control mechanism, since the amount of charge required to reach equilibrium with the input diffusion depends on, and is therefore controlled by, the first store potential.

In this system the reservoirs are driven by a two-phase clock, and the array has no built-in sense of direction. In contrast to the bucket brigade structure, the charge can be transferred in either direction, being shifted solely by the voltages that are applied to the transfer gates. As a result of this bidirectionality, FILO (first-in, last-out) is possible.

Charge can transfer out of a region only when it is energetically favorable for it to do so, namely, during the time when its potential has been raised by the clock voltage. This transfer occurs only, however, when the surface potential of the barrier region between the reservoirs involved has been reduced by applying the appropriate voltage to the interposed transfer gate. For example, the structure shown in Fig. 3 propagates charge from left to right with the voltage waveforms shown. If ϕ_1 and ϕ_2 are interchanged, the propagation direction will reverse, and since this can be accomplished merely by offsetting the electrodes, it is possible to construct an array in which adjacent rows propagate

in opposite directions manage to do so without requiring any dig-downs or cross-overs between rows.

This bidirectional aspect of the SCT structure has been utilized in the shift register shown in the photomicrograph of Fig. 4. The input structure, which is exactly the same as that shown in Fig. 3, is at the upper left-hand side of the chip. The data moves to the right in the upper row, enters a refresh-turnaround structure at the right-hand end where the data is recovered and refreshed, and then moves to the left in the lower row to be finally recovered at the lower left-hand end.

The refresh-turnaround circuit consists of a node comprising a diffused charge collector and a launch gate on the lower row, plus a field effect transistor for precharging the node. The gate of the FET is pulsed at the beginning of each clock period, to empty it of any previously collected charge and leave it at a large negative potential. After the gate has been turned off and the node potential has been allowed to float freely, the signal charge is delivered to the node. This charge causes the node to discharge toward ground, the size of the voltage drop being determined by the amount of charge collected.

The voltage of the input diffusion to the lower row is set at a point midway between the two potentials that represent a binary one and a zero and that appear at the node after all the charge has been collected. Thus, the potential on the refresh gate will either block the flow of charge, or it will allow complete equilibration of the first reservoir with the lower-row input voltage. In this way, the levels of charge representing the binary information in the register are reset to their desired levels, and thermal degradation is eliminated.

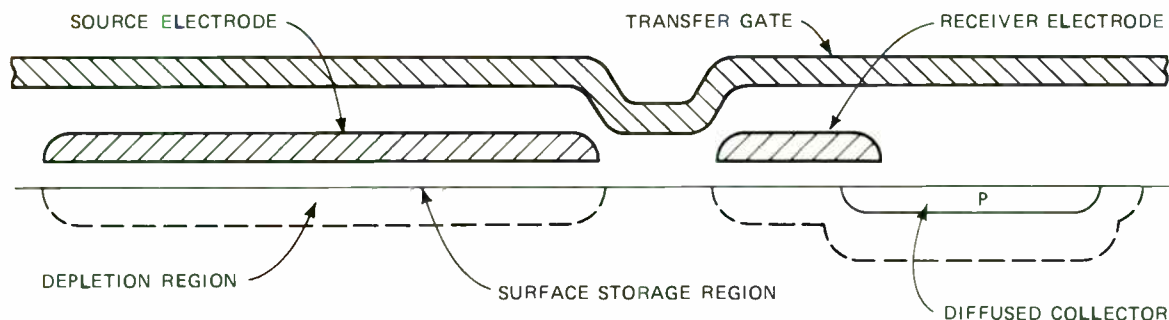
SCT vs CCD

The significant differences between this SCT array and a CCD array derive from the transfer gate electrodes. First of all, a two-level metalization system is required to fabricate the SCT array, whereas a single level of metal can be used for the CCD. This makes the CCD structure compatible with conventional MOS processing, while the SCT array is not.

The additional process complexity of the SCT, however, results in a structure whose performance can be more easily controlled. Since the surface potential nowhere depends on the fringing fields between adjacent electrodes, the details of the etching process that defines the spacings between the electrodes in a SCT are not of the same crucial importance as they are in CCD structures, where these fields must be minimized and the spacing between electrodes made as small as possible.

Another advantage of the two-level structure is that its active portions are shielded both electrically and chemically from the ambient. In fact, the two-level structure may actually be simpler to fabricate reproducibly than the single-level one. Secondly, because the transfer process can be controlled by the waveforms on the transfer gate electrodes, it's possible to provide bidirectional propagation structures, or even structures, where some charges are held static when others are allowed to move. This last feature is particularly significant in optical imaging applications. In these applications it may turn out to be desirable to allow only one

SCT STORAGE CELL



5. Picture It. An array of these SCT charge storage cells could make up an imager. The diffused collector would serve many sources; the image would be scanned element by element onto the collector for X-Y access. CCDs are sequentially accessed only.

row at a time to output its signal charge.

The advantage that SCTs offer in circuit packing density is illustrated in the shift register cell layout, shown in Fig. 4. There only 1.3 square mils of chip is required for each bit when the cell is fabricated with present day mask tolerances and processing. Despite its smallness, the cell has enough capacitance to store 0.5 picocoulomb of charge with an applied voltage of 10 v.

In addition to the real estate advantage provided by this layout, the circuit functions as a much higher (above 10 MHz with p-channel devices) frequency than a conventional MOS shift register. Most significantly, the number of dig-downs per bit has been reduced to zero. (Of course, there must be dig-downs in the refresh stages, but if these occur only once every 16 stages, their number is still reduced by a factor of 32). Even higher speed could be obtained with n-channel devices, but this improvement would probably require a slightly more complex cell structure.

The implications of these advantages for low-cost, high-performance shift registers are quite clear. But are the improvements sufficient to make this type of memory competitive with other types? Certainly, wherever a system requires high-speed serial memory, surface charge transport should be a winner over conventional MOS. But it should be pointed out that bulk memories are another matter.

In bulk memories, the problems associated with refreshing the memory are very important. Whereas a standard shift register has to be clocked only once to refresh all of its stages, it is necessary to cycle the surface charge shift register repeatedly—that is if it has 16 stages between refresh stages, 16 memory cycles will be necessary to refresh it. This means that if both memories have roughly the same maximum time interval between refresh cycles, then the surface charge device will require a standby clock 16 times higher in frequency. Moreover, since power and frequency are directly proportional in MOS-type systems, it will require increased standby power. Since standby power is a very sensitive system parameter in bulk memory applications, this could offset the density advantages of devices for this use.

The SCT structure can be used as a clocked analog de-

lay line, where it functions exactly like a transistor bucket brigade. In this function it appears to offer advantages that could give it the edge over competitive structures. Delay lines made with bipolar integrated bucket brigade structures require both diffusions and dig-downs, though they do have good high-frequency performance (say 50–100 MHz). The MOS bucket brigade delay line, though it has no dig-downs, requires diffusions and has not as high an operating frequency. The CCD operates at high speed (say 20 MHz) and requires no diffusions, but dig-downs are necessary to its three-phase clocked array. The surface charge transistor structure, however, requires neither dig-downs nor diffusions, and is as fast. Both could even be pushed to a higher operating speed—up eventually to a gigahertz—and should provide a larger dynamic range.

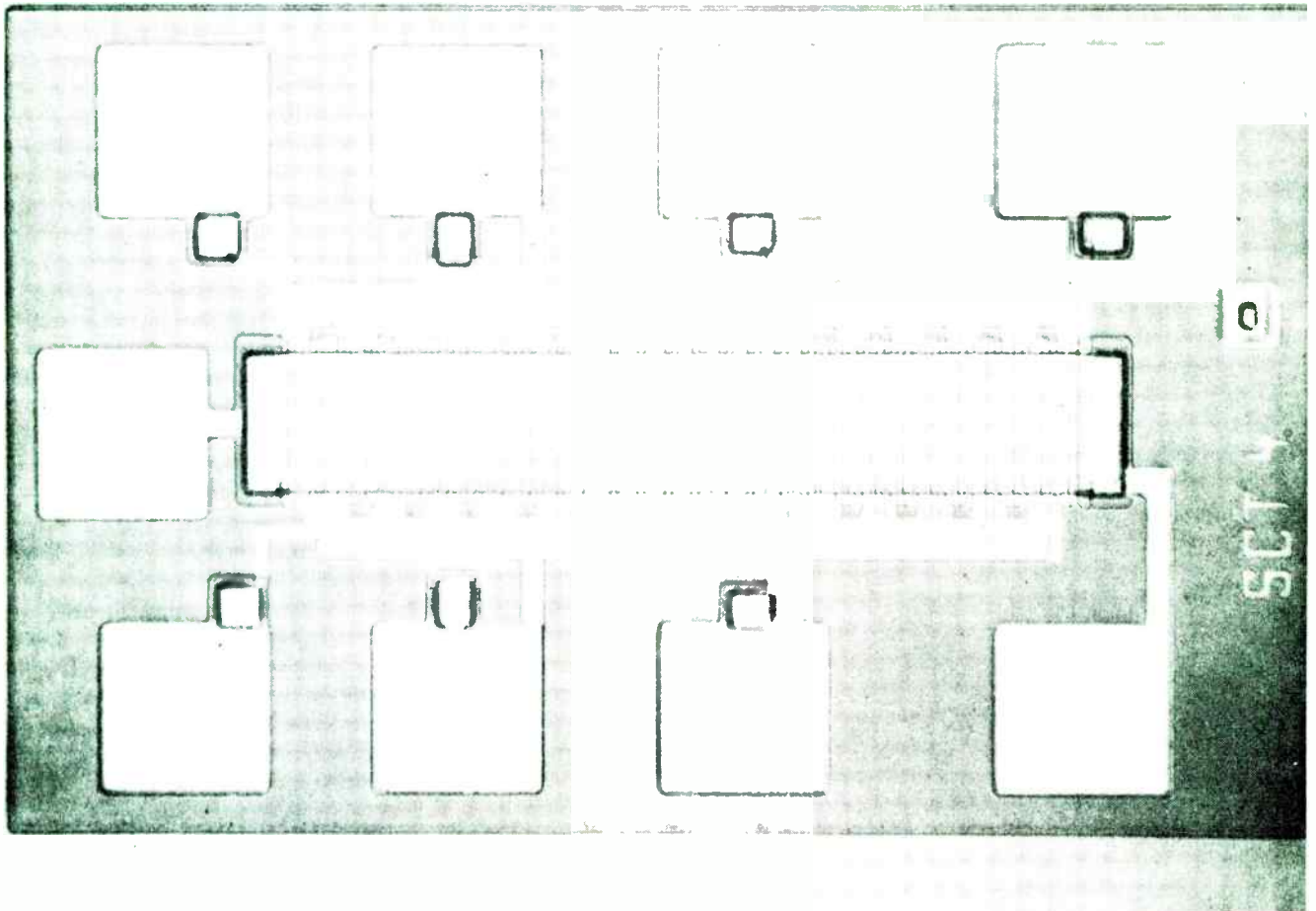
The image application

Solid state arrays for scanning optical images have been very difficult and expensive to build. But surface charge transport systems not only promise an improvement in the density and cost per elements but also, by delivering signal charge from many image sites to a common port, reduce the interconnection problem common to other types of array. They open up at least two approaches to optical imaging systems.

The shift register approach as exemplified in CCD image devices is conceptually the simpler, and has the advantage of requiring only a single output stage for the entire array. Its major disadvantage is that the signal charge from the optical sensing elements at one end of the array must undergo a large number of transfer operations, while those near the output end undergo fewer. Since some of the signal charge is left behind at every transfer, there will be differences in resolution and level across the image.

This nonuniformity is not a problem for short linear arrays, and does not become serious until several hundred stages are contemplated. But it is a problem for long, high-speed linear arrays and large two-dimensional areal arrays. In fact, at present it is still uncertain whether arrays suitable for studio-quality TV pickup applications can be developed with the CCD approach.

The other approach attempts to circumvent this limi-



6. Fast work. This 14-bit shift register can be operated at 10 MHz in the complete charge transfer mode; higher speeds are contemplated when it's operated in a charge bias mode. Since it is built with a refractory-metal-gate process, its fabrication is compatible with that of conventional two-level MOS structures and can therefore form a subsystem in an LSI memory configuration.

tation, and is depicted in Fig. 5, where a cross section of a single storage cell is shown. In this system, the storage cells are arranged in an X-Y array and interrogated individually and in sequence. A single diffused collector serves each row of the array, and the optically generated charge in one of the storage cells is simply gated to it. Thus, only one transfer is required to deliver the signal charge from any sensing element to the output collector, and all the image cells therefore have the same characteristics.

Re-arrangement

In such a structure, the source regions become the storage elements, and source electrodes are formed wherever the lower-level metalization crosses a thin-oxide region. The transfer gates are formed by the upper-level metal, which runs in the orthogonal direction. The receiver regions, which are of course connected directly to the diffused collector, do not actually have to store the charge coming from the sources, and therefore need not be as large as the sources, and even can be eliminated entirely.

The signal charge is selectively read out of a single storage element at the intersection of the row where the

voltage on the storage electrode has raised the potential energy of the stored charge, and the column where the transfer gate potential has been lowered. Since both actions must occur simultaneously before charge will transfer, only one element is active at a time.

Suppose, for example, that the storage electrode is connected to -20 v so that a depletion region forms beneath it. When an image is present, this depletion region will, after a time, collect some optically generated charge, and the potential will fall towards ground—say to -15 v.

Suppose further that all of the transfer gate lines are at ground potential, except for one held at -10 v. Then the ground potential will completely prevent charge in the unselected lines from transferring to the diffused collector. Even the selected transfer gate line will have only -10 v applied to it, which is not enough to permit the stored charge to transfer.

But if the potential on one row of the storage electrode is suddenly changed from -20 to -10 v, the potential energy of the stored charge will suddenly be raised from -15 v to -5 v. The charge in the selected cell, being at a higher potential than its transfer gate (-10 v), is now free to transfer to the collector. Charge will not

COMPARISON OF CHARGE TRANSPORT DEVICES

Charge transport device	Basic unit gain	Metalization layer(s) required	Storage phases	Diffusions	Cell vias and dig downs	Clock vias and dig downs	Direct compatibility of process
MOS bucket brigade	Active	1	2	Yes	No	No	Standard MOS (p-channel n-channel)
CCD	Passive	1	3	No	No	Yes	Standard MOS (p-channel n-channel)
SCT	Active	2	2	No	No	No	Self-registered MOS (p-channel n-channel)

transfer in other unselected columns because the transfer gate potentials in the unselected gates are still higher (i.e. at ground) than that of the stored charge.

This system is by no means the only possible x-y addressable optical imager. It differs in several respects from previous charge integrating structures. Not only can it be fabricated at very high element density, but also the optically generated charge is not read out by injection into its bulk. This means that response time is not limited by the lifetime of the minority carriers in the bulk, nor need it compromise sensitivity. Also, the optically generated charge is removed from the device as signal charge, and there is no chance that it will be collected together again with subsequently generated charge.

The approach has several advantages over the two-dimensional CCD shift register. The entire active area has uniform characteristics; the same region serves both as the charge integrating area and the readout area, and one reservoir instead of three is required per active element.

But this imaging approach requires that the total capacitance of the collector diffusion should be kept low. For small arrays or low-frequency systems this is not a

problem, but for larger arrays with high scan rates it would be advisable to break up the collector into several smaller units, each with its own output amplifier or shift register. This must be accomplished without compromising row density.

Making a good start

The major significance of surface charge transport is that it permits tradeoffs to be made that were not possible with previous techniques. In many cases the tradeoffs could result in significantly improved system cost and performance. The major disadvantages stem from the fact that the technique utilizes a non-equilibrium effect, and the signals cannot be maintained indefinitely without being refreshed. Although other dynamic MOS approaches have the same problem, it is magnified in surface charge memories which, if large, require a lot of power.

Basically, then, the question is whether the low frequencies, lower standby power, and higher temperature operation that characterize conventional MOS systems can be traded off against higher frequencies, high power requirements and lower chip cost of charge transport devices. □

Protect your transistors against turn-on or testing transient damage

Lower gain, higher noise are the price of avalanche damage to a transistor's base-emitter junction; annealing can restore some performance, but preventive design and use of protective diodes can avert circuit failures

by C.D. Motchenbacher, Honeywell Inc., Hopkins, Minn.

□ The specter of transistor avalanche damage caused by transients constantly haunts the circuit designer, usually without his knowledge. Turn-on signal transients are the usual culprits, but even routine reverse-bias tests can inadvertently ruin a transistor, degrade its performance, or even result in total circuit failure. For instance, a bipolar transistor's gain can be drastically reduced and its noise increased by a factor of 10 if the base-emitter junction is reverse-biased beyond the knee of the current-vs-voltage (I-V) characteristic where avalanche occurs.

Fortunately, the designer has some straightforward solutions to apply to his problems. The transient can be tracked down and eliminated, or the transistor base-emitter junction can be protected with a diode. What's more, some of the damage can even be partially repaired by annealing.

Before looking at the solutions, the designer should have a clear understanding of the problems by looking at transistor performance factors. Noise is probably the most sensitive measure of a transistor's performance; gain is second. A small percentage of carrier recombination, centered in the base depletion region, can significantly decrease gain and increase noise. Performance degradation is usually attributed to the effects of fast surface states caused by the hot carriers created during an avalanche stress.

On the other hand, an avalanche voltage (a majority carrier effect) is virtually independent of minor defects. This, apparently, is the reason why an avalanche junction can be operated as a reference or regulator diode without destruction. (Field effect transistors are immune; they're majority carrier devices).

Effects of avalanche damage

Figure 1 illustrates the progressive increases in noise and the reduction of dc gain (h_{FE}) when the base-emitter junction of a type 2N4250 pnp transistor is continually avalanched. A 10-millisecond pulse with a 10% duty cycle supplies the reverse base current.

Since the avalanche effect is proportional to total charge flowing, a continuous current causes the same damage as the pulsed current in one-tenth the time. Even though reverse-biasing a transistor below its avalanche point causes no damage, just a few microamperes of reverse current can degrade performance.

Noise current increases, as shown in Fig. 1(a), with

increasing base current and because of a large rise in excess of $1/f$ noise. While noise voltage may double, noise current (i_n) frequently increases by a factor of 10. This noise characteristic creates the most problems at low frequencies and when the transistor is driven from high impedances.

The reduction in h_{FE} is due to a rising dc base current while collector current (I_C) remains constant, as can be seen in Fig. 1(b). This drop is less pronounced when the transistor is biased at a high collector current.

Prevention techniques

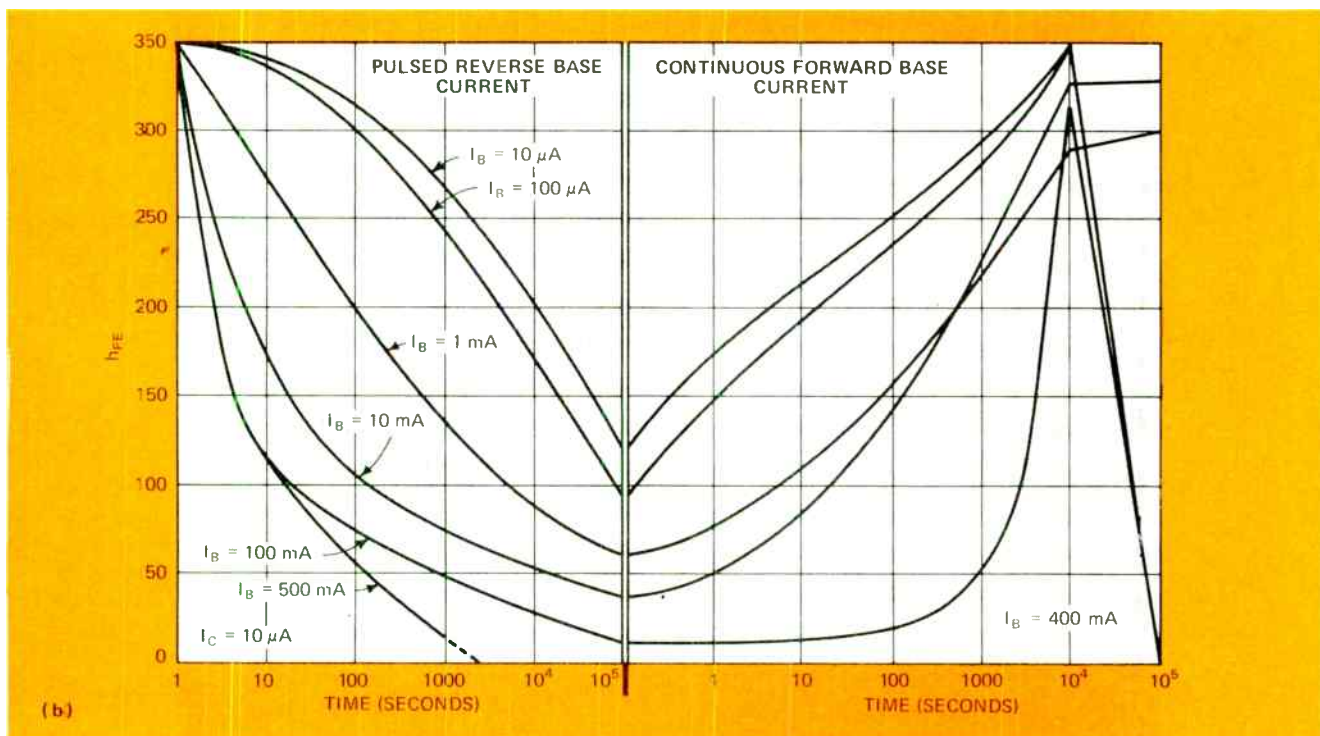
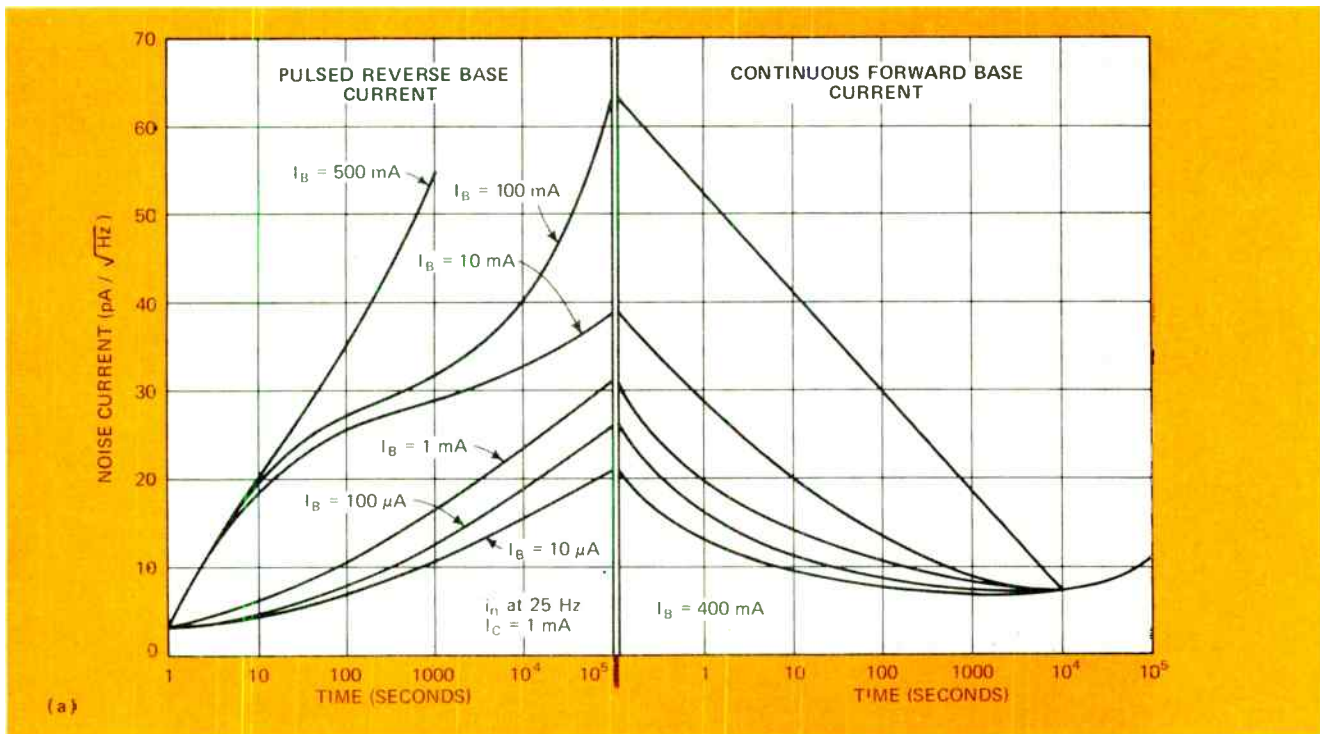
Gain reduction can even become catastrophic with continuous pulsing or at very high reverse currents. Rather than simple thermal failure, damage to the base-emitter junction is caused by a high electric field. (Reverse pulsing with a 500-mA current will cause the base of a 2N4250 transistor to open after 1,000 seconds).

Avalanche-induced damage can be partially repaired by temperature or current annealing: heating the transistor to approximately 300°C returns both gain and noise figures nearly to their original values.

The curves of Fig. 1 show the results of annealing with a continuous forward current of 400 mA through the base-emitter junction. After 2.5 hours, h_{FE} is almost fully recovered and noise is decreased to about its initial level. But further annealing destroys the transistor.

Even though a transistor is avalanched during normal operation, it will not necessarily fail within the lifetime of the system in which it is operated. Since the rate of gain degradation generally decreases with time, a short-term test will indicate long-term affects. To estimate long-term transistor performance, the procedure is to measure gain and/or noise degradation, plot it against the log of time, and extrapolate the data over the expected life of the system.

As an example of a turn-on transient causing base-emitter junction avalanching, consider the direct-coupled complementary amplifier of Fig. 2(a). When the circuit is first turned on, transistors Q_1 , Q_2 , and Q_3 conduct, charging capacitors C_1 and C_2 . In this condition, avalanching of Q_2 's base-emitter junction due to transient capacitor charging currents is possible. Although Q_1 will not burn out, its $1/f$ noise current is significantly increased. Since Q_2 usually is driven from a large source resistance, R_1 , avalanching can substantially increase total amplifier noise. A similar situation



1. Noise and gain degradation. Noise current (a) increases and gain (b) decreases with continued base-emitter junction avalanching (left side of plots). When base current (I_B) is 500 milliamperes, noise current becomes 10 times initial value and gain (h_{FE}) goes to 0. Although annealing damaged junction (right side of plots) almost restores initial specifications, over-annealing can destroy transistor.

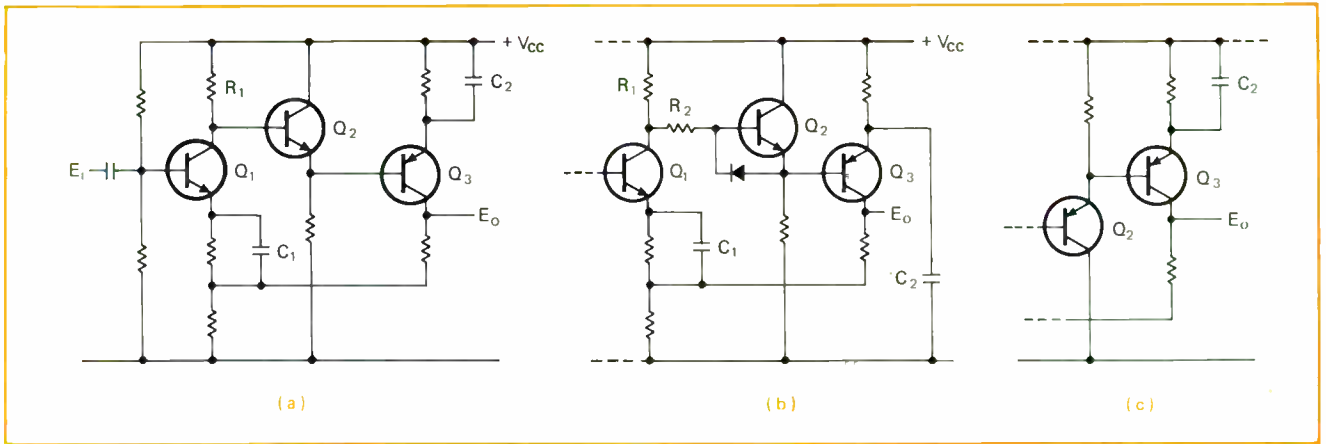
can occur if a signal transient overloads the amplifier.

There are three solutions to the turn-on transient problem, and they apply to all types of amplifiers. The first, indicated in Fig 2(b) shows capacitor C_2 connected to ground instead of the supply so that a damaging charging transient cannot pass through Q_2 's base-emitter junction. Another solution, also illustrated in Fig. 2(b), is to place a diode across Q_2 's junction, adding a

series current-limiting resistor, R_2 . Now the charging transient no longer back-biases the transistor, but passes through the diode without affecting the gain or noise.

A third solution, illustrated in Fig. 2(c), is to replace npn transistor Q_2 with its pnp complement. The transistor then stays on without being avalanched.

Avalanching also can occur when a circuit is operated from a biased source, such as the one shown in Fig. 3(a).



2. Amplifier protection. Turning on complementary amplifier (a) may cause avalanching of Q_2 's base-emitter junction because of charging currents of C_1 and C_2 . Transistor damage can be prevented (b) by returning C_2 to ground rather than supply and adding diode-resistor shunt to Q_2 . Another approach is substituting pnp transistor for Q_2 (c) in configuration of (a).

where capacitor C_1 charges to a high voltage through resistor R_1 . If point A is grounded or if the power is turned off, C_1 's discharge could cause avalanching at the base-emitter junction of Q_1 . The diode is added to protect the transistor against any reverse-bias transient.

A decrease in h_{FE} due to avalanching is a special problem in differential amplifiers. A transient may avalanche one of the matched input transistors and increase dc offset. Even a small current can cause a significant unbalance.

Other protection circuits

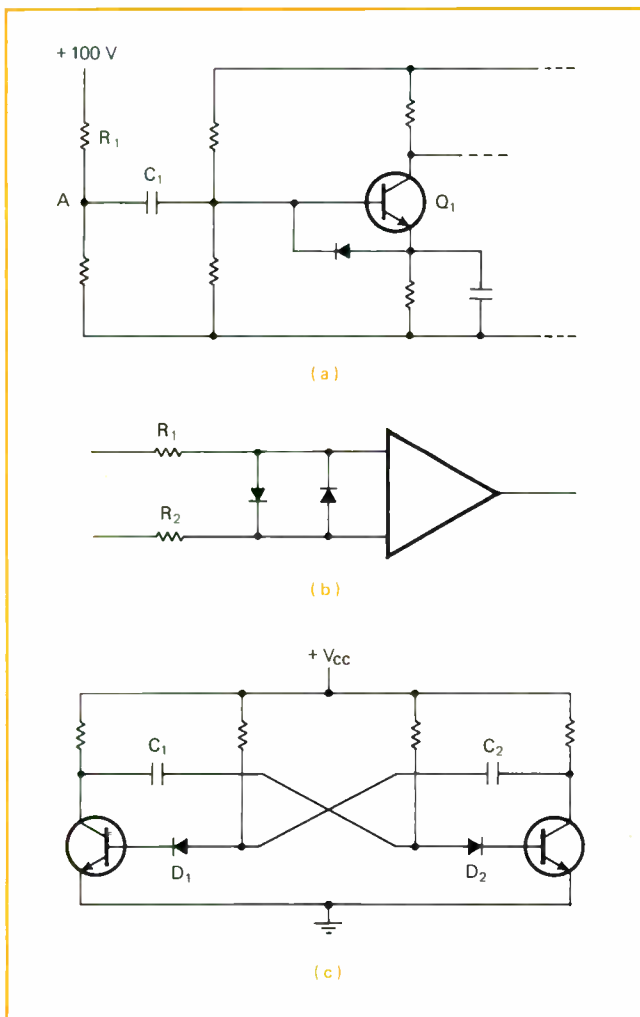
Figure 3(b) illustrates how a differential amplifier can be protected with two diodes. Resistors R_1 and R_2 must be large enough to absorb the transient's energy, yet must be smaller than the source resistance, lest they increase thermal noise.

Nonlinear circuits, such as the free-running multivibrator of Fig. 3(c), also are subject to avalanche damage if the supply voltage is greater than transistor base-emitter breakdown voltage. Without protection diodes D_1 and D_2 , each transistor's base-emitter junction can be avalanched in every cycle by the charge stored in capacitors C_1 and C_2 . If this continues, transistor beta will decrease until oscillation stops. The diodes must have a breakdown voltage greater than V_{CC} , and a lower leakage current than that of the transistor base.

The increase in $1/f$ noise, due to testing, can become a significant problem in low-frequency circuits. Measuring transistor emitter-base breakdown voltage generally is nondestructive under limited test current. In fact, damage may go unnoticed since a 1-second, 1-mA pulse reduces h_{FE} by only 21%.

There are two ways to measure V_{EBO} . One is to measure the breakdown base-emitter voltage drop; this causes junction avalanching. A better method is to look at transistor data, specify a minimum V_{EBO} , then test for current flow (or breakdown) at that voltage.

Each transistor in a circuit can be operationally tested by monitoring its base-emitter junction with a differential scope and watching for reverse avalanching voltages during turn-on, during continuous operation, and under saturating overloads. □



3. Other circuits. Diode protects Q_1 (a) when C_1 is charged by biased source. Pair of diodes and resistors (b) stop transients from unbalancing differential amplifier; dc offset increases if input transistor becomes avalanched. Every cycle of astable multivibrator (c) may bring transistor avalanching due to stored capacitor charge; diode safeguards each transistor, maintaining circuit oscillation.

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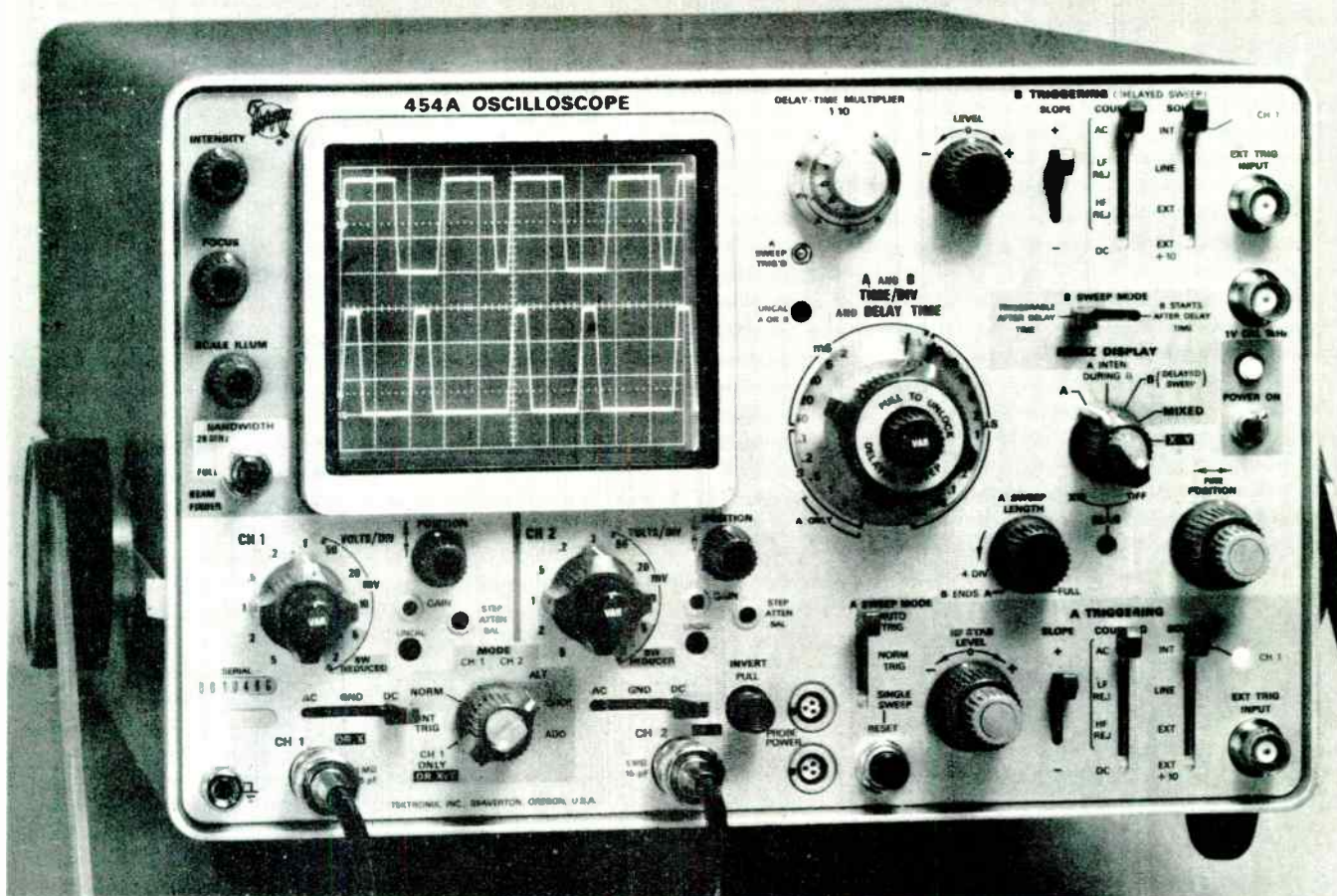


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Digital cassette standard under fire

Long-awaited standard is useful only for computer-tape replacement, say detractors; they want incremental feature for paper tape-type applications

by Paul Franson, Dallas bureau manager

Now that digital cassette equipment manufacturers are on the verge of adopting a long-debated standard, what are they going to do with it? Many feel the standard, proposed by the American National Standards Institute, New York City, is relevant only for computer applications, making it virtually worthless for the incremental (character-by-character) recording jobs that make up the bulk of the market.

The standard before the International Standards Organization, and very similar to one being considered by ANSI, comes from the European Computer Manufacturers Association (ECMA), which predictably sees cassettes as a low-cost replacement for conventional 1/2-in. magnetic tape (see panel p. 100).

But few manufacturers have had experience with this system, and even Philips Gloeilampenfabrieken, The Netherlands, which originated the 1/8-in. tape cassette, does not have machines conforming to the system in the field. What's more, most of the 15,000-odd digital cassette recorders in use in the U.S. aren't generally aimed at central-processing-unit applications.

Complications. To complicate matters further, IBM has proposed a 1/4-in. tape cassette, but sources in the industry doubt that IBM is pushing it actively. BASF/ICL has a similar proposal in Europe.

One manufacturer happy with the proposed ANSI standard is Ampex, Los Angeles, which already is making an ECMA/ANSI tape deck. Jay Cronen, product manager, says, the major uses will be in terminals, key-to-tape, and the like. He sees little business in replacing 1/2-in. tape with a Philips type cassette.

But for computer applications, Jerry Allen, sales administrator for Wang Computer Products Inc., Santa Monica, Calif., says "We've picked the IBM standard as ours and are committed to it." Allen says that no other version would be quite as reliable and "guesses" that the IBM standard has a good chance of being adopted "primarily because its coding insures data reliability and high packing density." The IBM standard proposed is for one-, two- or four-channel tapes using asynchronous phase-encoded recordings.

On the other hand, Wang Laboratories in Tewksbury, Mass., is hopeful that the ANSI standards will produce rugged, more reliable cassettes. That company has looked for suitable tapes for its own calculators and minicomputers without success and has decided to make its own.

One company that has already introduced an ANSI machine is Kybe Corp., Waltham, Mass. Its Kydek meets all ANSI and ECMA standards, and costs \$3,495, quite a bit higher than most of the current cassette equipment. Kybe claims its cassettes can be used with almost any drive for precision recording.

And one manufacturer dissatisfied with the standard is Lloyd S. Peltier, systems design engineer at Dicon Industries, Sunnyvale, Calif. He says: "the spec was written around the data processing industry." Peltier, a member of an ANSI ad-hoc committee opposing the cassette standard, will express this view when that committee meets in San Diego in January.

Peltier would like to see asynchronous phase encoding by character. "In synchronous transmission, if you lose a bit, an entire block will

be lost," he asserts. He would also like to see the standards less time dependent so that they can tolerate lower packing densities—he'd like to see them below 800 b/in. "There is a lot of dissension on ANSI standards," he says, "and my feeling is that they won't be accepted."

The majority of the systems in the field are character framed, non-time-dependent systems, unlike the ECMA/ANSI proposals. The ad hoc committee feels that this approach

Eliminator. Bell & Howell digital cassette has an automatic drive system external to the cassette and eliminates pinch rollers, belts, solenoids, and mechanical links.



Probing the news

is best for data collection, key entry, and data communication, and is working on another proposed standard. It would like to see the present standard split, and for the standards on the mechanical configuration of the cassettes themselves to be accepted while the recording method is given more study.

Is this standard necessary? A standard has long been considered a necessity for growth of digital cassettes. Philips, which developed the cassette for audio use and has a sizable share of the market for cassettes and recorders, has been steadfastly pushing the standard.

Standardization, says Robert N. Miller, vice president of International Computer Products in Dallas, Texas, and a member of the ANSI committee on cassettes, "will allow replacement of the noise, bulk, and inconvenience of much of the interchangeable and compatible papertape market by a cassette that is interchangeable and compatible."

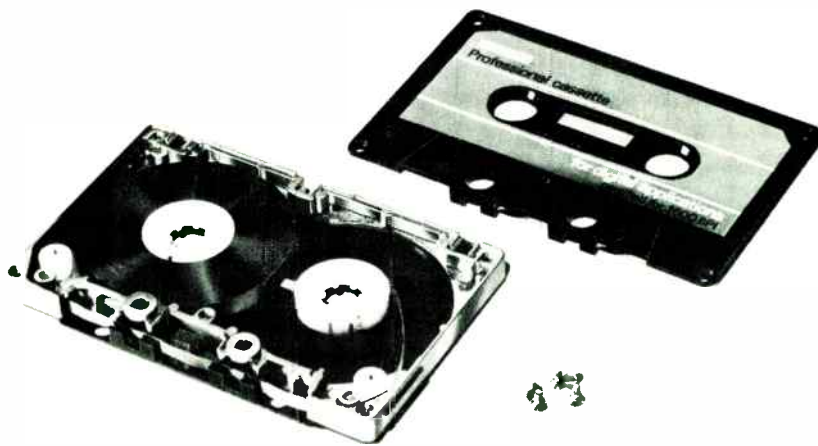
But Miller has his doubts about the actual format decided upon: "There's a need for a computer-type cassette, but it's only 10% to 15% of the market (though the richest

Will it be standard?

The standard adopted by ECMA and proposed to the International Standards Organization is for 1/8-in., single-track, phase-encoded synchronous recording in blocks with no space between characters. Density is 800 bits per inch, requiring input buffer memory and complicating high-speed bidirectional search.

The ANSI version of this proposal is still in a subcommittee; the main differences between it and the ECMA proposal are in the preamble and error checking.

The newest digital cassettes follow the ECMA standards in dimensions, and add two new features as well. One is an off-center hole in the rear of the cartridge so that the deck can sense which side is up (and hence which track is in use), and the other is two small holes at the beginning and end of the tape for accurate start-and-stop sensing by photoelectric means.



Certified but not standardized. Norelco's digital cassette is certified at 800 bits per inch and holds 282 feet of high-coercivity tape. Latest model has metal frame.

part). Estimates for market size vary widely, centering around \$5 to \$10 million in 1971, to \$50 to \$100 million in 1975.

Useful alternative? The markets Miller refers to outside the main-frame environment include key-to-tape, meter reading, point-of-sale, data communication, numerical control, data collection, and accounting. Many of these applications now use paper tape, which is bulky (2 pounds of paper tape equals one cassette, according to Miller), and inconvenient to store and correct. But the proposed standard doesn't offer a useful alternative to paper tape: it's not inexpensive, it's not incremental, and its high density, according to Miller, suggests problems in any field environments outside clean computer rooms.

Robert L. Borshay, product manager for cassette products at Kybe and a fellow member, with Miller, on the ANSI committee, says his company is concentrating on papertape replacements for minicomputers and also is exploring use of digital cassettes as communications-type buffers for displays, teletypewriters, and numerical control.

Decks under fire. Controversy also surrounds the tape decks as well as the recording techniques, with the proliferation of approaches to tape handling attesting to the attempt to overcome the problems encountered in adapting a low-cost audio cassette technique to digital applications.

So though sophisticated and improved decks much like audio machines are produced by some manufacturers, others take more radical approaches. One is Bell and Howell Instruments in Pasadena, Calif., which uses special Teflon-coated "snatchers" to pull the tape out of the cassette and around a large capstan by the head. This eliminates the need for pressure pads and avoids contact of the oxide-coated surface with anything but the head.

Another approach is taken by Dicon, which uses a vacuum column, somewhat like that on many larger tape drives, to pull the tape out of the cassette. Electronic Processors Inc., Englewood, Colo., pulls the tape out and around a large rotating disk containing two heads, for stationary read after write.

No Capstan. A different approach is taken by International Computer Products, which eliminates capstans: ICP uses reel drive with consequent constant bit density per rotation, as in phonographic recorders. This is possible because ICP's recording method, called bit-mark sequencing, or BMS, is independent of speed.

Canberra Industries, Meriden, Conn., uses a tape deck made by Raymond Engineering, Middletown, Conn., to interface a series of minicomputers. According to Leslie Daniels, project manager at Canberra, a standard for tape cartridges would inhibit technology now. He feels the ANSI standards committee doesn't have enough customer feedback to really set a pattern. □

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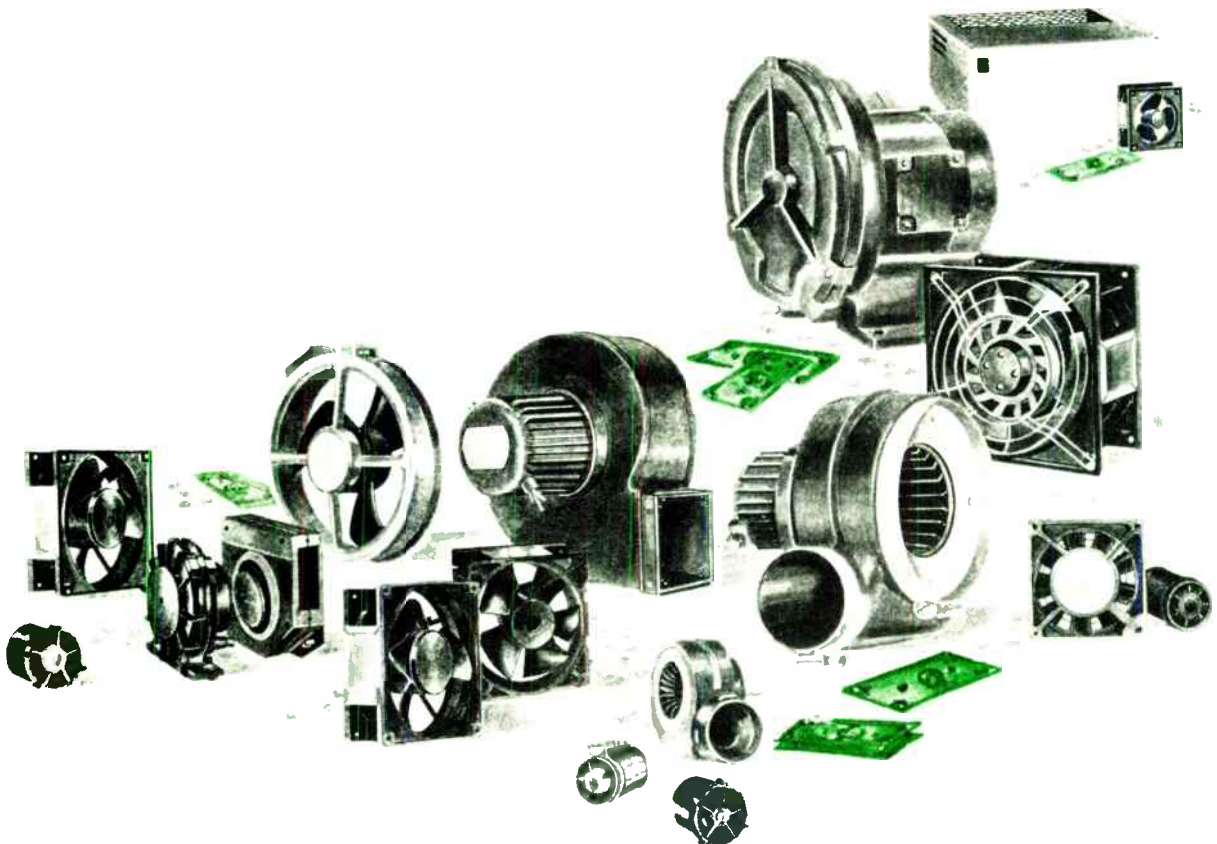
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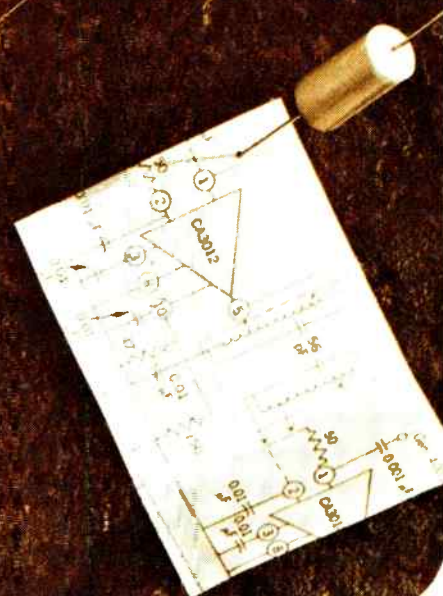
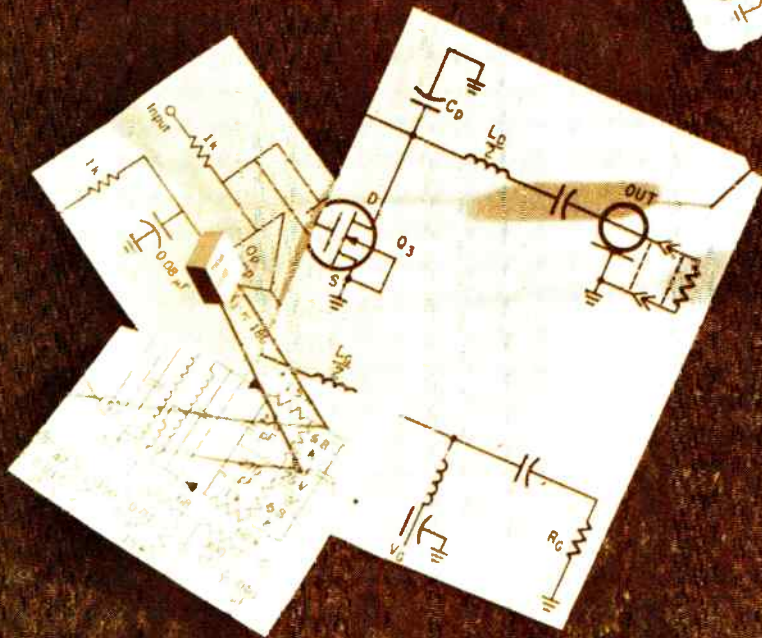
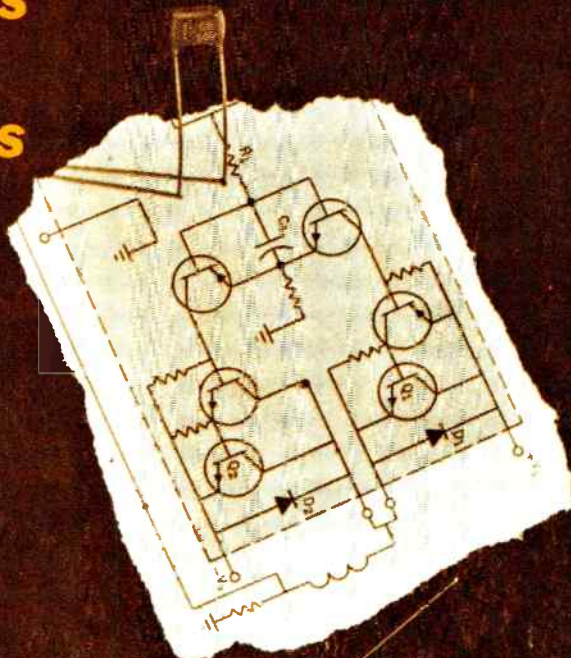
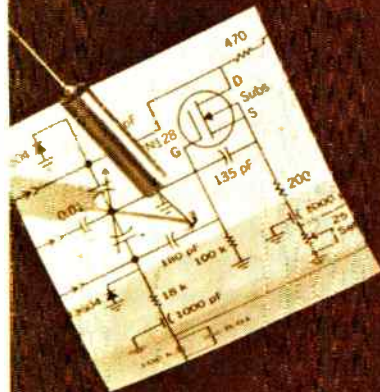
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Manpower

Illinois engineers major in survival

Chicago Circle campus reorganizes curriculum to stress fundamentals and broad backgrounds; graduates feel flexibility helps them hold jobs and succeed.

by Jane Shaw. McGraw-Hill World News, Chicago

Can an engineering school turn out a recession-proof engineer? The University of Illinois at Chicago Circle is trying to do just that by radically reorganizing traditional engineering disciplines and steeping its students in fundamentals, theory, and design.

Though the verdict isn't in yet, the 761 students who graduated in three classes since the Circle campus opened in 1965 are showing signs of riding out the recession somewhat more smoothly than other new engineers. Dr. George Bugliarello, dean of the College, credits this survival to the flexibility provided by the school's innovative curriculum, and a cross-section of students who generally did well at Circle bears him out.

Most graduates show an appreciation of their broad background in engineering, and feel that as a result, they can move more easily from one field to another. The emphasis on fundamentals, they note, helps them get into areas reserved for those with advanced degrees.

The engineering school at the Circle campus has done away with civil, mechanical, electrical, and aeronautical disciplines, and replaced them with information, energy, materials, and systems departments. Administrators also are experimenting with a heavily theoretical core curriculum.

At the core. All engineering students (except those who take the Engineering Science degree, which has less emphasis on mathematics) get a B.S. in engineering. Their core curriculum during the first two years is heavy in mathematics and physics courses, and builds a foundation in mechanics, materials, thermody-

namics, electronics, and systems analysis. The core curriculum comprises about 113 credits out of a total of 198. Students can move among the departments if necessary to fulfill the requirements of their specialization. In addition to such conventional focal points as applied mechanics and structural design, they can choose from bioengineering, urban systems, water and air resources, and transportation systems engineering.

Pitfalls and response. This program has run into some obstacles. The school failed to achieve accreditation in 1970 because of insuffi-

A curriculum redesigner. Dean George Bugliarello stresses fundamentals to help students avoid engineering obsolescence.



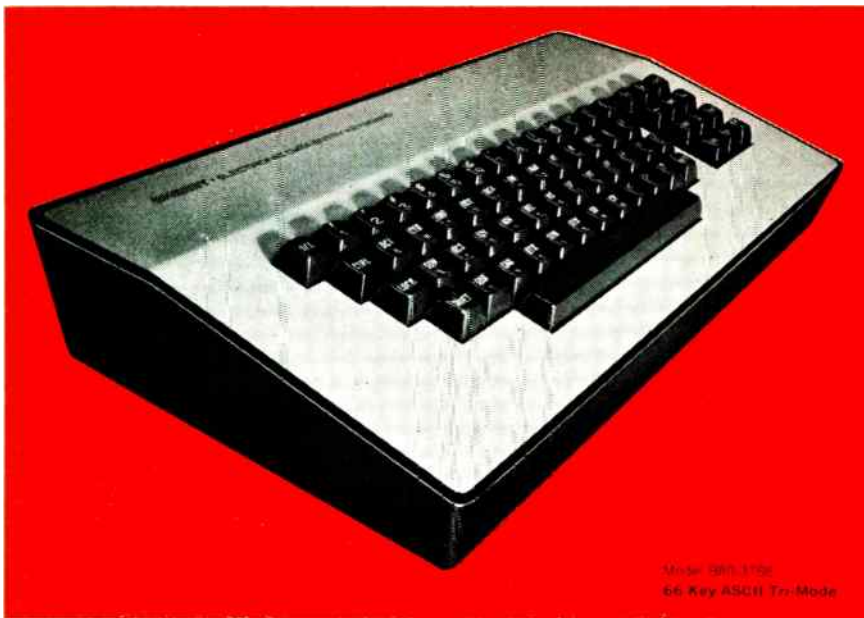
ciencies in its bioengineering and chemical engineering specialties. The school's growth also has been stunted by a lack of funds. Although the number of students has been increasing rapidly to 2,200, the faculty roster has remained steady.

Design needed. Dean Bugliarello admits that the core curriculum is somewhat weak in design, and next year two common design courses will be compulsory. Other changes include more interdisciplinary projects, joint curricula with the School of Social Work and the College of Business Administration, and a biomedical engineering center in conjunction with the university's medical center.

The students who have picked up the undergraduate ball and run with it in industry say Circle's unorthodox curriculum helped them to score good jobs. Michael Sedlar, '69, is working for Zenith Radio Corp., Chicago, designing military radar. "Some of my courses were so theoretical I still don't know what I studied," he says with a laugh, but adds that that was what he just needed.

Overlapping. Many engineering schools, adds Sedlar, fail to teach computer science as a specialty, and those that do teach it do so with a mathematical orientation and avoid the hardware; but he studied both. "At Circle, your specialty contains overlapping traditional fields, yet you have a real-world-type position. I think the fields at Circle are closer to the slots available in industry."

This favorable analysis is not totally shared by Sedlar's project manager. He calls Sedlar an excellent engineer, but thinks he would have done just as well if he had studied electrical engineering at an-



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other school and taken a communication power option. He points out that all new recruits have slightly different emphases—some have more electromagnetic theory, others more circuit theory—and all must fill in the gaps. How well they do, he says, depends more on the individual than the school.

Sam Reisenfeld, '69, specialized in communications; he's now working on applying probability theory to complex digital communication systems—as well as on his Ph.D. He finds that his "very broad base in engineering" helps him to relate to other engineers' problems, and understand the difficulties in their assignments.

Dennis Stephens, '69, works on classified projects for Teletype Corp. His background, he notes, posed no problem in his control theory work. He did find he was deficient in electromagnetics but claims he quickly picked up what he needed. Stephens thinks that the school at Circle has eliminated things that are "relatively easy" to pick up in favor of more theory.

Recession takes the rap. Those graduates who have run into trouble in job-hunting blame the market, not the school. Dr. Henry Stein, associate dean of the college, says, "Our graduates are finding jobs, but they've got to look for them. We have a marketable product here."

One woman spent a year looking for work after graduating in 1970 and finally joined Women in the Air Force, where she's working in aeronautical engineering. Another 1970 graduate got a job in September of that year, only to be laid off in December, but he found a new one last February.

The area where Circle's program doesn't seem to have helped greatly is salary. As of last December, graduates responding to a school survey indicated they were earning an average of \$10,632, essentially the same as EE graduates of the more traditional University of Illinois campus in Urbana. And annual raises have averaged only about \$600 or \$700, thanks largely to the recession. The wage-price freeze, of course, isn't helping. □

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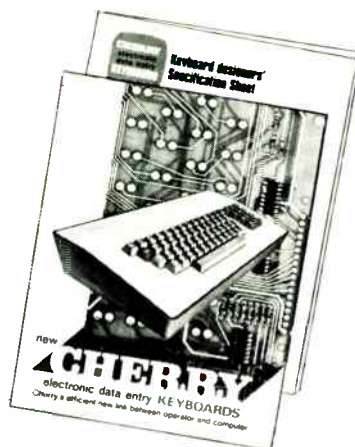
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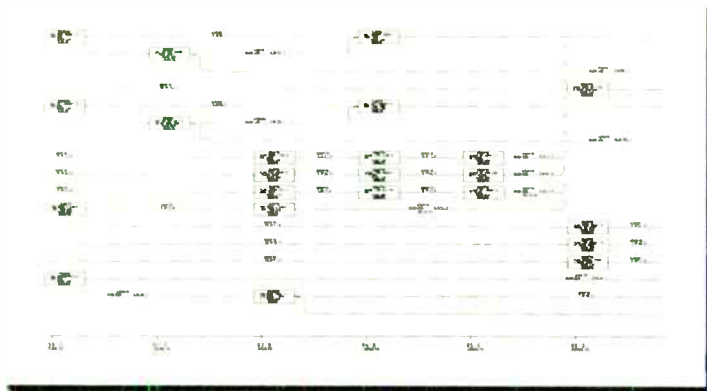


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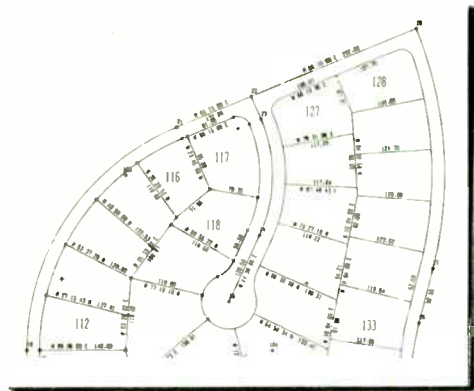
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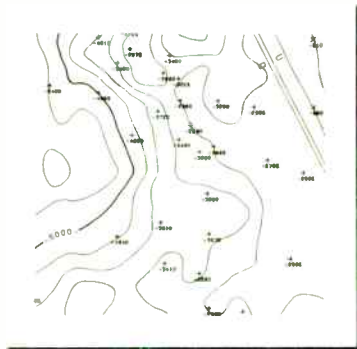
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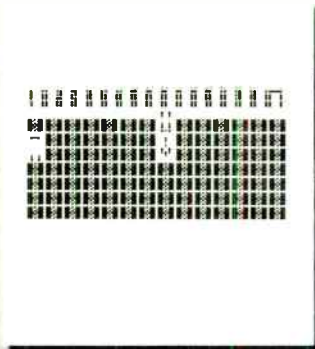
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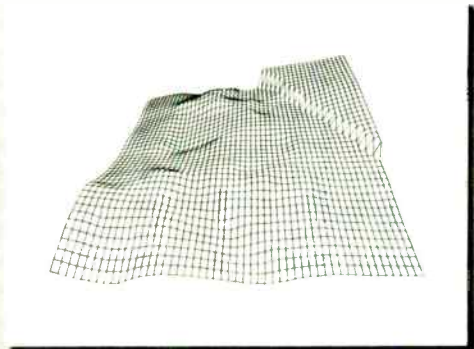
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Commercial electronics

Calculators that do more, sell more

Because of technological leadership, U.S. makers of programmable calculators are set to seize huge, new commercial markets

by Gerald M. Walker, Consumer Editor

While the Japanese have the edge in the desktop calculator business, the U.S. looks to outmaneuver them in programmable calculators with superior technology and software know-how. A big jump forward is set for next year, when, according to the most optimistic industry forecasts, domestic sales of programmable calculators—now \$60 to \$70 million—will double.

The push in programmable calculators is largely due to advances in U.S. technology. Though prices of programables have remained relatively flat over the last three years, capability has jumped tremendously, because of the use of ICs and LSI RAMS and ROMS. A \$2,000 unit that a few years ago might have had two memories and 30 to 60 program steps now boasts 10 to 12 memories and more than 300 steps.

Today, \$5,000 can buy a 2,000-step machine with keyboard and magnetic tape and card inputs. At this level of complexity, it becomes competitive with minicomputers or time-shared computer terminals for repetitive tasks in banks, brokerage houses, and medical laboratories. In addition, simple programables at the low price level, around \$1,000, are vying with less powerful, standard calculators for desktop space.

When the going gets tough. It's taken U.S. marketing ingenuity as well as technological advances to arouse the interest of the huge commercial market. That ingenuity was developed under the stress of economic factors—the drop in the sales of programmable calculators for scientific and engineering applications, when R&D money stopped flowing in the recent financial drought.

Some estimates of the growth of

programmable calculators are more moderate than the 100% jump anticipated by Wang Laboratories Inc., Tewksbury, Mass. Jack Podd, national sales manager for SCM, New York, N.Y., projects 55% growth a year, thanks to the opening of commercial applications. Frank Elardo, assistant U.S. marketing manager for Tektronix Calculator Products, Sunnyvale, Calif., predicts a 15% to 20% increase next year. And Ralph H. O'Brien, senior vice president for Litton Industries, feels his company's share of the programmable market will grow at a rate of 50% over the next five years.

Typical of the shift that has taken place in the last year is Wang Laboratories, which found itself in a

profit skid in 1969, an indirect victim of the nationwide R&D cuts. The firm swerved to selling programmable calculators to utilities, banks, auto dealers, and others, and in 12 months its commercial sales went from 7% to 40% of its business.

The same changeover has occurred elsewhere. Computer Design Corp. (Compucorp), Santa Monica, Calif., basically an OEM calculator supplier, last spring came out with its own line of programables with MOS/LSI. And Hewlett-Packard's Calculator Products division, Loveland, Colo., though still committed to the scientific trade, has also increased its percentage of commercial sales.

The low-priced market opportu-

Good for business. 600 Series Wang calculator is expected to attract commercial users. The 312-step machine can expand to 16,000 steps with \$400 cassette peripheral.



nity has not escaped the Japanese. Sharp, Sony, Canon, Seiko, Busicom, Casio, Hitachi, and Toshiba have added programables to their lines but may not have as easy a time dominating the U.S. market as they did in electronic calculators.

Headstart. The Americans have a head start in the technology, particularly in LSI use, and more importantly, an inside track on backing up these complex machines with software service.

"The Japanese have the technical capability to produce programable machines, even if they have to buy LSI chips from the U.S., but they lack the software and are not oriented to the market," explains SCM's Podd. Toshiba's U.S. sales manager Russell H. Johnston agrees. "Programable calculators are much like computers—our success will depend on how quickly we can develop software and train dealers to sell them."

As a consequence, the Japanese have so far conceded the upper end of the market. These are the \$3,000 and above units, with 250 or more steps of keyboard, punched card, or magnetic cassette input.

No scare machines. The main reason the programable calculators have become attractive for commercial applications now, says one user, is that programing no longer scares people. It's easy enough to handle the routines to make an input card or tape, thanks to the larger capacity of today's machines. After that, a clerk can key in the variables, just as on any desktop calculator.

Banking and brokerage applications can be handled by 300- to 500-step machines, while more complex jobs, such as statistical analyses, may go into 1,000-step models. The key factor is that, as manufacturers have filled out their lines, users can match machine to application.

In addition, another user concedes, a programable machine encourages going deeper into a problem—playing with alternatives, simulating results—which is not possible with a time-shared computer or using pencil calculations.

The Wang 700 series, for example, has 16 changeable, special-operation keys—multiple program storage and call-out keys—that can be altered to fit a number of appli-

Japanese oriented?

U.S. programable calculator makers are looking over their shoulders at Japanese competitors in this country, but the Japanese may be doing the same over the market in Japan. Prodded by the U.S. Government, Japan's Ministry of International Trade and Industry has liberalized its interpretation of rules that require approval for imports of digital equipment with internal memory capacity of more than 2,000 bits.

This change in policy, which applies only to calculators, not minicomputers, has opened the way for U.S. firms, such as Wang, to develop Japanese sales. According to Tokyo importer C. Itoh and Co., rules will become more liberal for programables, even the larger units that now require individual import approval.

cations. It's a 1,920-step machine. The 600 Series just announced has the same 16 user-definable keys, 312 program steps, and the ability to increase memory in three increments by adding 512-byte RAMs at \$300 per increment.

Compucorp has taken an entirely different design tack. Each machine is "microprogramed" with MOS/LSI logic specifically for each application. ROMs produced by Texas Instruments and AMI to Compucorp specs control the keyboard functions pre-programed by the manufacturer. Groups of calculators bearing family names such as Statistician, Scientist, Accountant, and Treasurer, are thus tailored to the user.

Modularity. Hewlett-Packard, like Wang, stresses changeable function keys, but is also strong on input-output peripherals. H-P's high-end models have teleprinter, X-Y plotter, digitizer, memory, and card-tape reader options. The basic Model 10 features alphanumeric printout using a heat printer and paper roll.

SCM, now in the process of adapting MOS/LSI circuits to an entirely new line, recently updated its \$2,495 Model 1016 PRAS to give it more capacity. By adding the IOTA III, an \$800 plug-in peripheral, the six-register, 100-step machine can be boosted to 1,000 steps.

One foreign competitor on the upper price line is Olivetti Computer Products, New York, with its P602 Microcomputer. The basic unit sells for \$3,980, and has 16 registers for operation, storage, and program instructions. The company also offers a \$1,985 endless loop magnetic cartridge, which provides random access memory for numeric data and programs.

The low-priced programables,

while less sophisticated, may provide more of a horse-race in the next year or two as the Japanese attempt to gain ground on U.S. turf. Sharp Corp., Osaka, Japan, the acknowledged leader in desktop electronic calculators, has one programable on the market now—Model Cs-363P—which sells for \$1,395 in the U.S. It's got 144 steps and a magnetic card memory. Logic for the numeric memory is handled by six four-phase MOS/LSI chips produced for Sharp by North American's Microelectronics Co., Anaheim, Calif.

Though not strong in the mini-calculator business, Sony Corp. Tokyo, is aggressively pushing its two bipolar IC programables in this country. Priced at \$1,950 and \$2,400, they've got 125 to 253 steps with keyboard or magnetic-card input and offer a \$550 electrostatic printer.

Canon also has two programables—Model 165P, a four-memory, 64-step unit selling for \$1,295, and Model 167, which will be sold in the U.S. in two or three months. Model 167 is priced about \$1,033 in Japan. Neither has special trig or log functions that can be keyed in, but use punched card programs.

Programable desktops. Another desktop leader getting into programables is Seiko, Tokyo, whose Model S301 is being touted as a desktop computer for \$2,300. Seiko uses Mitsubishi bipolar ICs and MOS/LSI for its external memory peripheral. The external memory consists of eight blocks, each of which can hold up to 95 steps. A block can also hold either five words, each consisting of 23 decimal digits plus sign, or 10 words, each consisting of 11 decimal digits plus sign. □

Government

Computer oils wheels of justice

Computers should help overhaul creaking courtroom machinery if Federal law enforcement agencies can convince jurists of EDP's benefits

by Larry Armstrong, Washington Bureau

Computers have not yet replaced trial by jury, but they're already moving in to help court stenographers and record clerks deal with the deluge of paperwork now inundating the nation's courts. The first market will open up as courts discover that complete records of arrest and prosecution ("rap sheets") are available in 12 hours on-line, summaries in 12 minutes, through the FBI's new national index. Until recently, this took 12 days by mail through the FBI's fingerprint files. Once this precedent is established, judicial systems will be following up with computerized case-scheduling, jury selection, and legal research.

"Work with computers in the courts and prisons is embryonic compared to what it will be in four or five years," says Ronald C. Allen of the System Development division in the Justice Department's Law Enforcement Assistance Administration. "As more operations go online, more courts will be showing an interest."

Cure-all. Courts have just begun to replace an archaic system of paperwork with reliable systems for indexing, docketing, and information-gathering. A Federal Judicial Center official estimates that there are some 50 ongoing attempts at partial court management by computer, principally supported with LEAA action grants to states. And judges and court administrators see computers as a real panacea. Judge Edward Allen Tamm of the District of Columbia court of appeals, for example, predicts that some day all relevant information about prospective jurors will be stored in a computer, lawyers will specify the kind of jurors they would object to, and the

selection process would take five minutes.

LEAA is also funding the National Center for Prosecution Management, created last month by the National District Attorneys Association. Besides prosecutor calendaring and control of cases, the center has software that analyzes the probability of winning cases.

The biggest boon to criminal justice information systems is the availability of computerized criminal histories from the FBI's National Crime Information Center. Originally developed and tested by LEAA's Project Search (System for Electronic Analysis and Retrieval of Criminal Histories), the criminal history file went on line last week. Rap sheets can be tapped directly from it to 102

controlled terminals, including 45 computers, using a combination of 150-baud and 2,400-baud dedicated lines. Through these 102 locations, more than 6,000 Federal, state, and local law enforcement agencies in the U.S. and Canada use remote terminals to access the central index.

Figure stretches. FBI project director Jerome J. Daunt foresees an expansion of that network to more than 15,000 terminals in U.S. law enforcement agencies, and 4,000 more in Canada. "But there are more than 45,000 non-police criminal justice agencies that should be on-line," says Daunt, "and big city and state agencies will have to have multiple terminals—so that figure stretches to 70,000."

"Only one other national system—

From NCIC to the courts. The IBM 360/65 multiprocessor with its 2 million byte memory can be accessed by state and local criminal justice agencies.



LET'S HEAR IT FOR IRV COOPER



Irv Cooper, one of the Bright Guys.

Irv is our new director of sales. He's been around semiconductors for a long time, which means either he's crazy or he does a good job. But since we hire only bright guys, Irv will help us outshine the competition. To help Irv get started, we're introducing a bunch of new LEDs. Here they are, the Irv Cooper specials:

The big DIPper at little dipper prices. Introducing the Data Lit 62 in a molded DIP. Now you can get twice the character height of the MAN-1. The Data Lit 62 is a .6 inch high—that's right, 6/10ths of an inch—display that can easily be seen from a distance of 25 feet. In the DIP version, the Data Lit 62 is a super-bargain at only \$9.45.*



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* All prices in 1,000 piece quantities.

Note: If you won't send an order for Irv, don't for Mrs. Cooper.

The bright guys litronix

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Probing the news

the health and medical network—will even approach the size of the public safety/criminal justice functional system.” Daunt adds.

In addition to the tie into the FBI data base being made by the criminal courts, some individual lawyers are beginning to use computers in their research. But as a whole, “the legal profession is still sitting on a high stool wearing a green eyeshade,” contends Col. Alexander J. Palenscar, a lawyer and chief of the special activities group in the Office of the Air Force Judge Advocate General, whose Legal Information Through Electronics (LITE) project has been doing Defense Department legal searches for years. LITE accesses statutes to obtain citations, keywords in context, or full text printouts.

Some private firms, however, have been set up to provide computerized legal aid. Aspen Systems Corp., Pittsburgh, specializes in state statutes—which are available for a fee to subscribing law firms. On-line with a more sophisticated system is the Mead Corp.’s Mead Data Central, a search and retrieval system for the full texts of decisions.

Mead spokesman Robert Bennett emphasizes that his company’s system is operating in a lab setting with only 15 operational high-speed color CRT’s and keyboard terminals. Nevertheless, Mead has all Ohio decisions—more than 600 million characters—on its IBM 360/50 system, and expects to move up to an IBM 370/155 with 3330 storage in February. The system operates over voice-

grade phone lines and can display citations, keywords in context, and full texts at 120 characters per second on 960-character screens. “We’re now looking for 2,000-character CRT’s, and hope to display a full page of text,” Bennett says.

A legal market. “Our market analyses suggest that there’s a very profitable market out there,” Bennett continues. “Given our precedent-based judicial system, a lawyer who does his own manual research can be less and less certain that his opposition won’t surprise him,” he says. “An electronic legal library will save time and be more comprehensive.” While most practitioners in Ohio see the system as a backup tool the first few times they use it, it quickly becomes an original research device, Bennett contends. “But it will be backup insurance until all precedents are on the machine base, state by state,” he says.

Mead also has an eye to future Federal subsidies for legal data bases, and hopes to implement its software on Government hardware.

The amount of information available to courts from NCIC is enormous and growing rapidly. Of the eight files at NCIC, seven—vehicles, license plates, articles, guns, securities, boats, and wanted persons—total more than 3 million active records. These are accessed by the FBI’s new IBM 360/65 multiprocessor. The eighth file, criminal histories—now about 150,000 records—is expected to grow to five to eight million in three to five years.

With daily transactions by mid-1972 to be double today’s 75,000, Daunt foresees that NCIC will need more hardware next fall. □

The case for hardware

Computer-aided stenographic reporting and videotape recordings of proceedings, expert testimony, and evidence will require hardware in the court. This need is being studied by the National Bureau of Standards under a grant from the Federal Judicial Center and LEAA.

Stenocomp Inc. of Bethesda, Md., has a computer-aided stenographic machine that automatically converts 99% of a court reporter’s phonetic symbols into English in a tenth of the time it takes to type them out manually. The editing process has to be done manually later.

Videotape recording could allow experts to give testimony in the courtroom without being physically present, and so save on travel costs. It could also be used to assist both the appeals process and the police in their execution of search warrants. The NBS will discuss the feasibility of such applications in a report due to be published in February.

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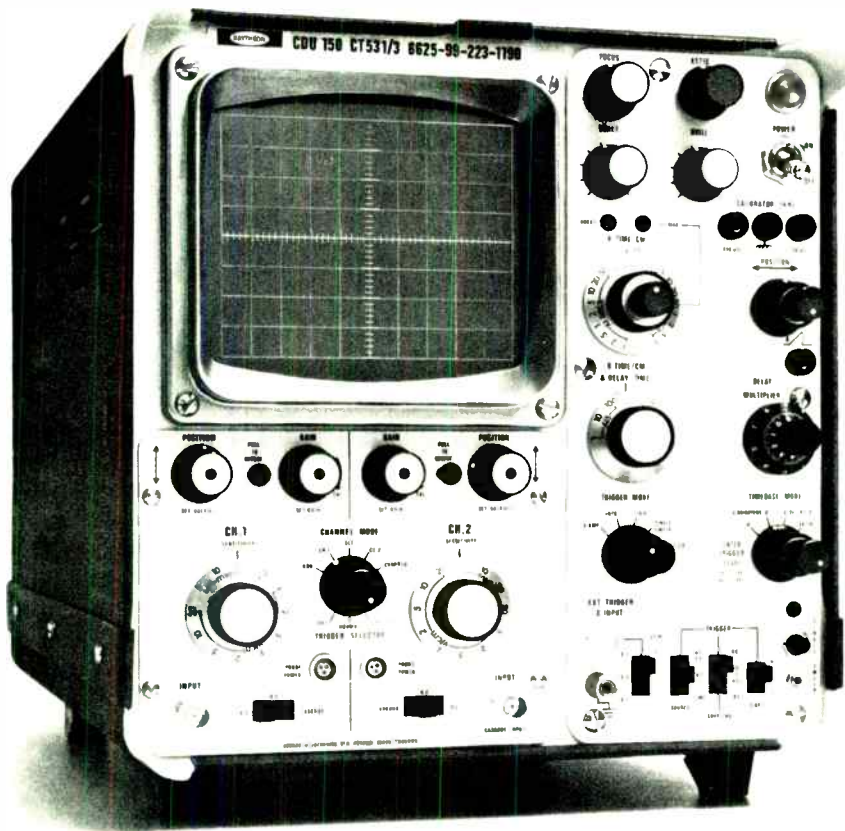
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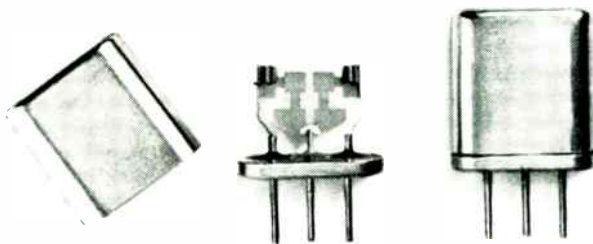


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Tester line is tailored to add-on capability

by Stephen Wm. Fields, San Francisco bureau manager

Fairchild '360-like' design makes 6 systems compatible in hardware, software for device, subassembly tests

"The explosion of semiconductor technologies, processes, device types and configurations has caught users and producers in an economic bind", says Gene White, vice president and general manager of the Fairchild Camera and Instrument Corp.'s Systems Technology division. "More and more demands are being made on the investment in testing systems, and the equipment has become so specialized that it is outgrown, out-technologied, or out of production and impossible to duplicate at a later date."

That's why, in developing a family of automatic test systems, Fairchild has taken an approach similar to IBM's with its System 360 family. Fairchild's Sentry series is based on system building blocks and on peripheral and software packages that enable a semiconductor manufacturer to start with what he needs now and yet be free to build up to the largest, fastest production tester available. Throughout, his software remains compatible.

Fairchild has its Sentry 400 testers in the field, and the company is now delivering high-speed MOS test stations to work with it. But with the introduction of the complete Sentry family, the combination of the 400 and a high-speed test station will take on a new name. The new models are the 100 through 600.

The Sentry family is built around the FST-1, a 24-bit central processor

specifically designed as a test system controller. The cards that interface the CPU with the "test instruments" are also common throughout the series.

Special cards. The test "instruments" themselves are specialized function cards that perform a specific system function and are designed to communicate with the CPU over its direct-memory-access bus. "All of the communication between the test instruments and the CPU is done over the DMA bus and not the I/O bus," says William Routh, director of marketing. This eliminates the necessity of translating the binary information into BCD.

The Sentry 100 is a high-throughput bipolar MSI production system. It will sell from \$70,000 to \$160,000 depending on the number of pins and the peripherals, such as disk for program store and a printer for data output. The 100 can handle 40,000 MSI packages per hour, or about 50,000 to 60,000 dies per hour at the wafer level. "In both cases, the speed is limited by the handling equipment and not the tester," Routh points out.

If the user wants to add the ability to do data analysis and manipulation, and so have an engineering tester as well as a production tester, he can update his 100 to a Sentry 200 and the update can be done in the field. The 200, says Routh, "is an extremely versatile analytical tool. It manipulates massive data, handles arithmetic computations, data logs every desired parameter of every device tested, reports statistical distributions, and provides the capacity to study in depth the effect of environmental and electrical stress." The additional hardware and soft-

ware and field installation expenses would add from \$35,000 to \$50,000 to the cost of the 100.

If the user next decided to get into the subassembly business and had to test digital pc cards as well as components, he could upgrade his Sentry 200 into a 300. This is done by adding a 120-pin test station and the fault-isolation software package. Combined cost is about \$55,000.

The Sentry 400, which has existed for about a year, remains the same. Though optimized for volume digital subassembly testing, it will also do 100-, 200-, and 300-type testing, and it becomes a Sentry 600 MOS/SLI tester if a high-speed test station is added. The 600 has a complete set of high-speed peripherals that lets it be used for engineering analysis, and it can handle both MOS and bipolar testing at the same time. It offers complete testing at the wafer stage and for devices in automatic handlers at a 5-MHz data rate, expandable to a 20-MHz data rate if necessary. A complete Sentry 600 costs about \$180,000.

Peripherals. The 500 is a production MOS/LSI tester that has all the capability of the 600 except for the extended peripheral set. There are two peripheral sets that can be added to the Sentry series. The production testers (the 100, 300, and 500) employ a low-speed, 80-line-per-minute printer and a cassette magnetic tape drive. The engineering testers (the 200, 400 and 600) employ a high-speed, 1,200-line-per-minute printer and an 18-megabit disk drive. Thus the 500 is a high-throughput system and not one for extensive data manipulation.

Fairchild Systems Technology, 974 East Arques Ave., Sunnyvale, Calif. [338]

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Components

Tying cable automatically

Tool applies tie to harness; tenses, locks, and trims it in less than one second

The scraped-knuckle crowd of cable-harness makers, accustomed to lacing cable nail heads, are in for some help from Thomas & Betts. It's an automatic cable-tying tool that applies the company's Ty-Raps



to a harness, tenses the tie, locks it, and trims it, all in about 0.8 second.

Several years ago, T&B introduced the Ty-Rap, a plastic cable tie that was applied to the bundle manually and then tensed and locked with a hand tool. This operation took about five seconds, the company says, and significantly speeded up the operation, compared with lacing the harness. However, even with the manually applied Ty-Raps, the operation still took more time than harness layout. With the new automatic tool, the cable-tying operation is only about 25% of the total time, according to William P. Miller, T&B vice president for marketing.

The new tool, which is pneumatically operated and weighs about

three pounds, takes a cartridge of 50 Ty-Raps that will handle a wire bundle from 1/32-inch diameter up to 5/8 inch. Tools still to come will handle larger bundles, says the company. A cord balancer can also be attached to the tool to suspend it over the work area and thus ease operator fatigue. A cartridge can be replaced in four to five seconds.

The operator simply places the open jaws of the tool-end around the bundle, pulls the trigger, and the tool feeds the Ty-Rap around the bundle, grips the end emerging from the locking head, and then tenses and trims it. A supply of air from 65 psi to 110 psi, regulated to 65 to 80 psi, is required.

The tool also can be ganged, with the jaws used in place of nails or other guides. After the bundle is assembled in the jaws, a switch can cause the complete bundle to be tied at once.

The Thomas & Betts Co., 36 Butler St., Elizabeth, N.J. 07207 [341]

64-gun cathode ray tube has diameter of 1.5 inches

A vacuum tube readout with the capability of displaying complete EBCDIC or ASCII code combinations measures only 1.5 inches in diameter. The unit, called nimo 64, will project desired characters ranging in height from 0.125 to 0.562 inch in addition to the full alphanumeric capability. Symbols, image combinations, and up to five line messages can be displayed with a brightness of 70 foot-lamberts.

The unit is a 64-floodgun, shaped-beam cathode ray tube. The structure contains eight grid control bars, eight grid apertures, eight filaments, a common anode, and rectangular mask etched with desired characters. In operation, the shaped beam collides with the phosphor screen at the viewing end of the glass envelope, displaying the required characters. Ideally, no focusing or deflection is needed.

Filament current is 0.8 ampere maximum, and anode voltage is 2.0 kilovolts dc. Typical applications in-

clude key-to-tape/disk displays, digital instrumentation, annunciators, message boards, keypunch readouts, and optical data scanning systems.

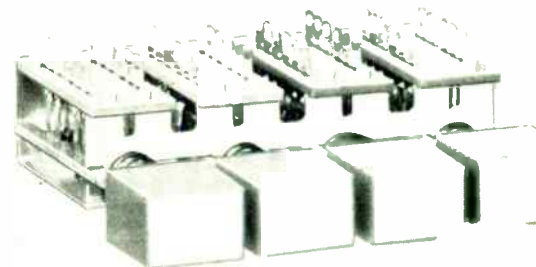
A decoder using MOS integrated circuits will accept any six-line binary code. A special anode power supply is an integral part of the mounting hardware located in the rear of the tube socket and electrically interlocked with the tube.

Price for the package, including tube, the mounting hardware, a driver/decoder, and anode power supply, is less than \$100. The tube alone is priced at less than \$40 in quantities of 1,000. Delivery of prototypes takes 120 days maximum.

Industrial Electronic Engineers Inc., 7720-40 Lemona Ave., Van Nuys, Calif. 91405 [342]

Slide switches built for boards, wired equipment

Multisection pushbutton, slide-type switches are available with up to four-pole, double-throw functions per modular section. The series 4136 is designed to meet the require-



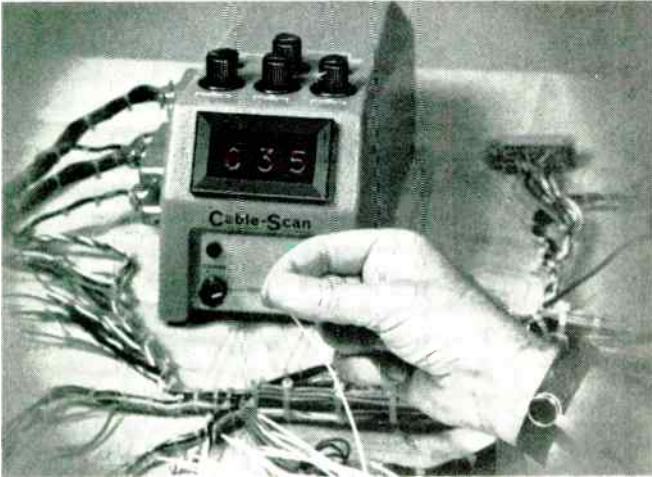
ments of conventional wired equipment and pc boards. The units offer an unlimited number of separate push-push or momentary action switch sections that can be mounted on a strong metal frame.

Littelfuse Inc., 800 E. Northwest Highway, Des Plaines, Ill. 60016 [345]

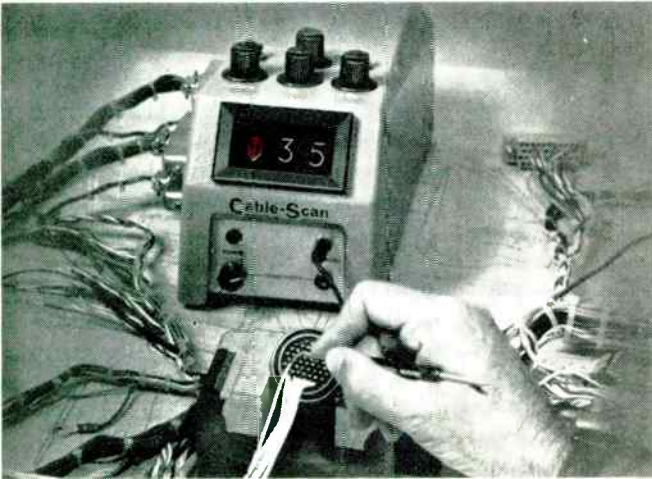
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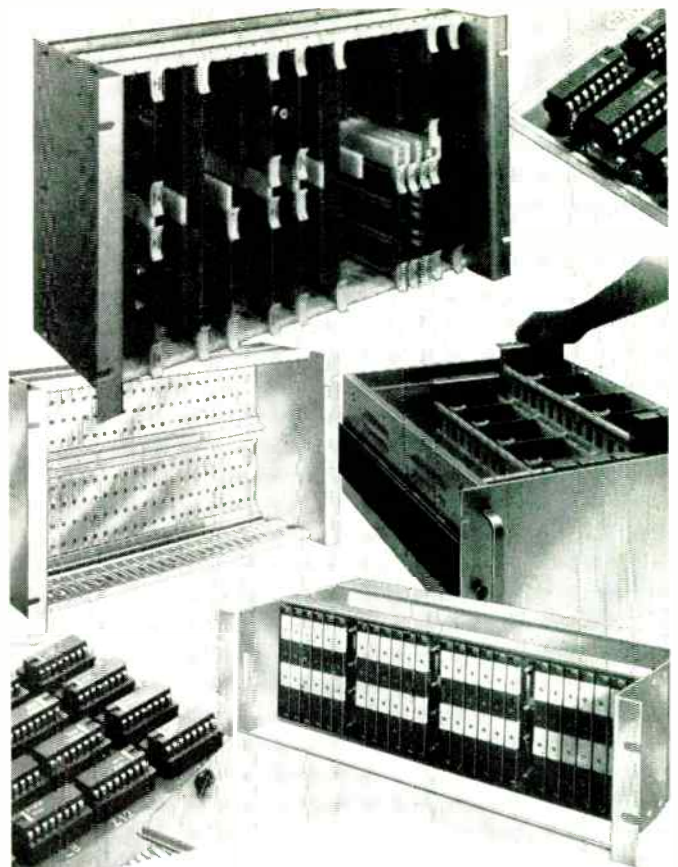
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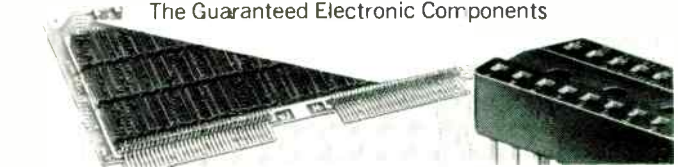
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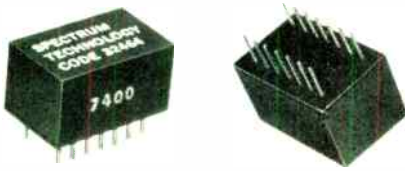
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0.45 inch. The series 7400 plugs into 14-pin TO-116 dual in-line sockets and operates over the range of 3 MHz to 20 MHz. The unit accepts inputs at 5 v dc, and the output for a logic 0 is 0.5 v maximum; for a logic 1, 3.0 v minimum. Operating temperature range of the series 7400 is -55° C to 105° C, and stability is $\pm 0.005\%$. Price is under \$15 each in production quantities.

Spectrum Technology Inc., P.O. Box 948, Goleta, Calif. 93017 [344]

Compensation thermistor offered in six values

A negative-temperature-coefficient, compensation-type thermistor called the K15 is suitable for solving compensation problems when lead



lengths are small. The unit is supplied without an enamel coat, and six resistance values $\pm 20\%$ are available: 4, 50, 150, and 500 ohms, 2 and 5k Ω . Nominal temperature coefficient of the 4-ohm device is 3.0%/°C. Price is 24 cents each for up to 500 pieces.

European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230 [347]

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New products

rise and fall time that blocks high-frequency transients. Isolation voltage is 5,000 v, and rise time is 3.5 ms. Applications are in computers, production machinery, appliances, and communications equipment.

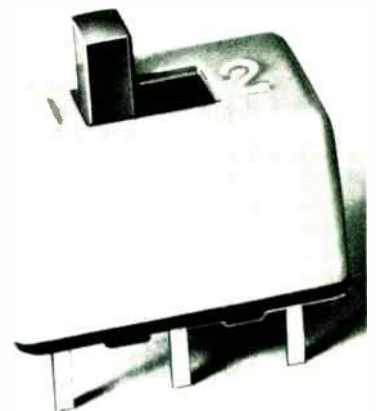


The PT-001 provides less than 1 pF coupling capacitance and less than 3 pF cell shunt capacitance. Price is \$2.80 each in 1,000-lots.

Electronics Div., Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204 [346]

Slide switch designed for direct mounting on pc board

A two-pole, double-throw slide switch is designed for direct pc board mounting on a 0.2-in. grid spacing. The top-actuated device has a break-before-make configuration, and gold plating is standard on the terminals and contacts. Contact



resistance is less than 20 milliohms, and the spring-loaded contacts are rated at 60 v ac/dc maximum with a maximum switching current of 0.5 A and carry current of 1 A maximum. Price is less than \$1 in 500-piece quantities.

Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830 [348]

Xerox Oscillographic Papers: 31 B.C. (Before Copiers)

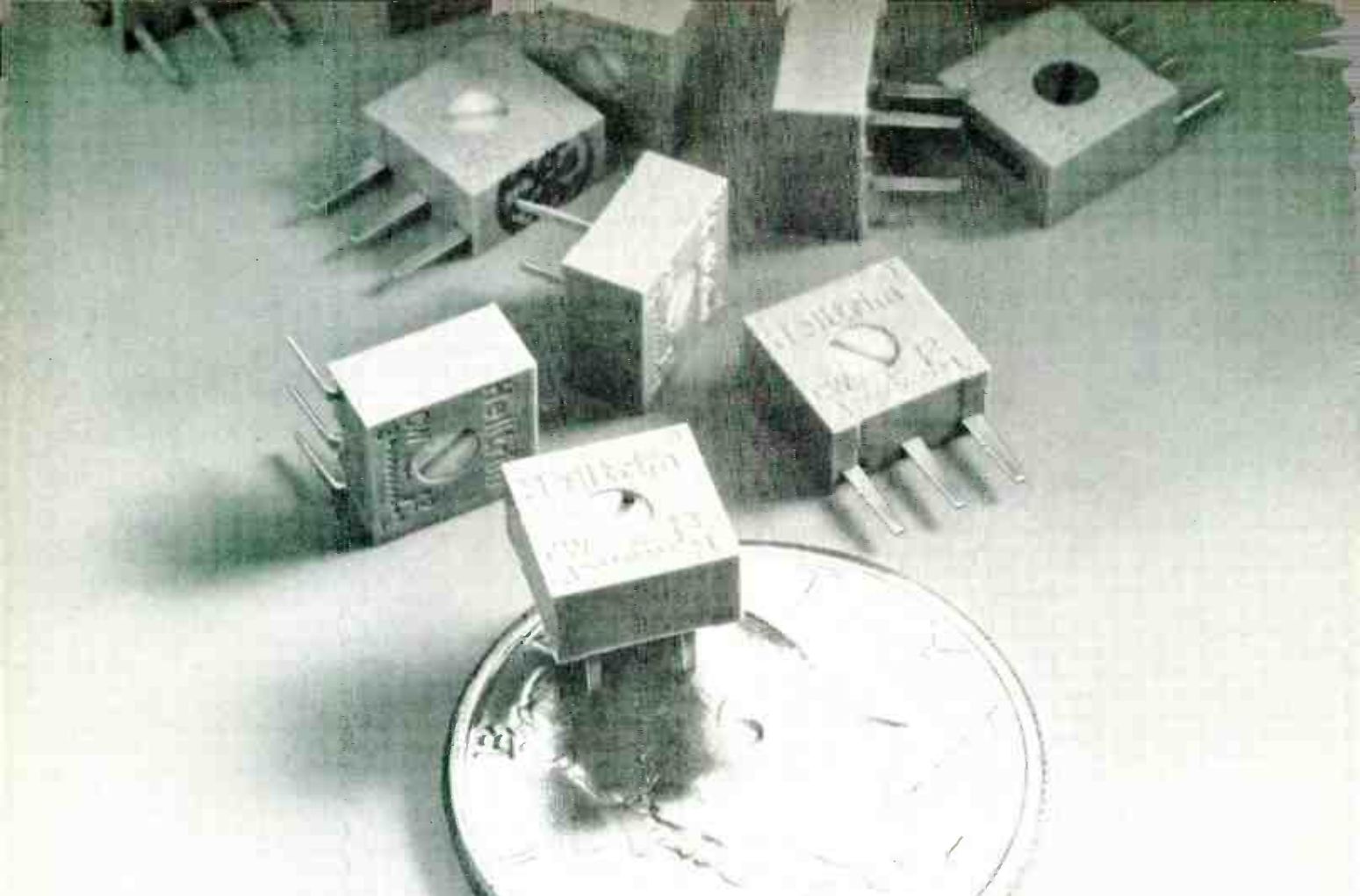


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Semiconductors

FET switches seek relay jobs

Programmable devices

challenge reeds in

low-power applications

About 50% of all relay applications are in the low-power region—a volt or less in 600-ohm lines using reed relays, say the marketing men at Teledyne Crystalonics. And since the company already is an established producer of field effect transistors, which are low-power devices, the firm has decided to attack the relay market with a FET switch specified in relay language.

The CS¹E-101/CS¹R-101 “solid state relays” combine four junction FETs, a control integrated circuit, and two control switching transistors in a 16-lead, ceramic dual in-line package. The devices are programable in the sense that their pins can be interconnected, either on the printed circuit board or electronically, to form relay types ranging from simple single-pole single-throw, upward in complexity through double-pole single-throw, double-pole double-throw, single-pole double-throw, to four-pole single-throw. Thus, there are six relay types in one 16-lead DIP.

Since there are no moving parts, switching time is faster than that of reed relays—a CS¹ switches in 1 to 3 microseconds, while the best reeds run at about 10 ms. And since there are no contacts, the CS¹ is immune to contact bounce and arc-over; this allows CS¹s to carry more current than some small reed relays.

Since the CS¹ isn't wrapped up in a switching solenoid as reeds are, power supplies are simplified and reduced in cost. The CS¹ operates under the control of MOS, DTL, TTL, or RTL circuitry and no extra, more powerful supply is required.

Also, reeds often need what's called a suppression diode to quench the back-emf generated in

the switching solenoid. Otherwise, this voltage spike could blow out the reed's switching transistor. With the CS¹s, the user does not need solenoid, diode, nor transistor.

Even isolation is close enough to infinity to run reed switches a close second, Crystalonics says. With its FET “contacts” open, the CS¹ achieves isolation of 10,000 megohms.

There are drawbacks. In some configurations, users will find it inconvenient that loss of negative supply voltage causes contact closure in the CS¹. Also, the open FET-relay still will show a few nanoamperes of leakage and, when closed, there is a 15 to 60 ohms “contact resistance” that reeds beat easily.

The CS¹s are more expensive, too. While reeds in large volume run in the \$1 range for spst types and about \$4 for four-pole double-throw units, the small-quantity price for these solid state substitutes is \$21.60 each, falling to about \$16 at 100 units—but each unit is a variety of relays in itself.

Marketing manager Joel Cohen feels that the new devices, though more costly, will replace relays in such areas as medical electronic equipment, checkout gear for complex electronic subassemblies, and ICs where test signals must be switched quickly, and in other applications where lifetime, size, and power supply are important.

Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. 02140 [411]

Schottky diode has turn-on voltage of 340 mV at 1 mA

Turn-on voltage of diodes is important to circuit designers because of its effect on performance of mixers and switching circuits. In uhf mixers, low turn-on reduces cross-modulation and thus improves signal-to-noise ratio. It is important for clamping circuits and low-level switches since offsets introduced by the diodes are lower.

A Schottky-barrier diode developed by Hewlett-Packard offers what is believed to be the lowest

turn-on achieved in a silicon diode. At a forward current of 1 milliamperere, the junction voltage is only 340 millivolts; and turn-on remains low at current levels above 1 mA, increasing to only 450 mV at 10 mA.

This compares with 700 mV for conventional silicon pn junction diodes and 410 mV for earlier H-P Schottky diodes, and is comparable to the turn-on of germanium diodes. The new silicon unit, however, has better temperature characteristics than germanium diodes—its operating range is -55° C to +125° C.

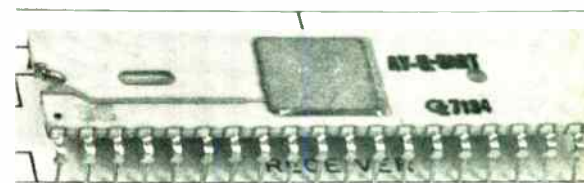
The device, called the H-P type 5082-2835, also has the fast recovery time, less than 100 picoseconds, of Schottky diodes. Junction capacitance is only 1 picofarad at 1 megahertz and zero bias.

The low turn-on voltage was achieved with a tradeoff in breakdown voltage, which is 5 volts, adequate for low-level mixers and most logic circuits. This compares with 10-70 v for other H-P Schottky diodes. Price of the 5082-2835 is 90 cents in small quantities, and 60 cents each in 1,000-lots.

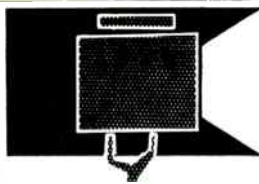
Inquiries Manager, Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. 94304 [412]

MOS/LSI package contains duplex receiver/transmitter

A full-duplex receiver/transmitter is included in a one-package MOS device. The LSI subsystem accepts asynchronous serial binary characters from a computer or terminal and converts them to a parallel format. It also simultaneously accepts parallel binary characters and converts



them to a serial asynchronous output, with start and stop bits added. All characters contain a start bit, five to eight data bits, one or two stop bits, and either odd/even par-



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General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11801 [413]

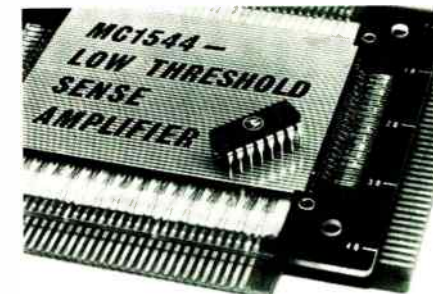
Micropower IC designed for crystal watches and clocks

A monolithic integrated circuit using bipolar construction and thin film resistor technology contains an oscillator, binary frequency divider, output pulse-width control, and motor drive buffer. Called the EWC-1000, it is designed for quartz-crystal watch and clock applications. The circuit operates on a 1.35-v battery, and dissipation is less than 10 microamperes. Optimum frequency is 32.768 kHz, but the performance range can be extended to allow crystal frequencies from 8.192 kHz to 131.172 kHz. Price is \$7.50 for quantities of 1 to 99 and \$5 for 100 to 999.

Microma Universal Inc., 855 Maude Ave., Mountain View, Calif. 94040. [415]

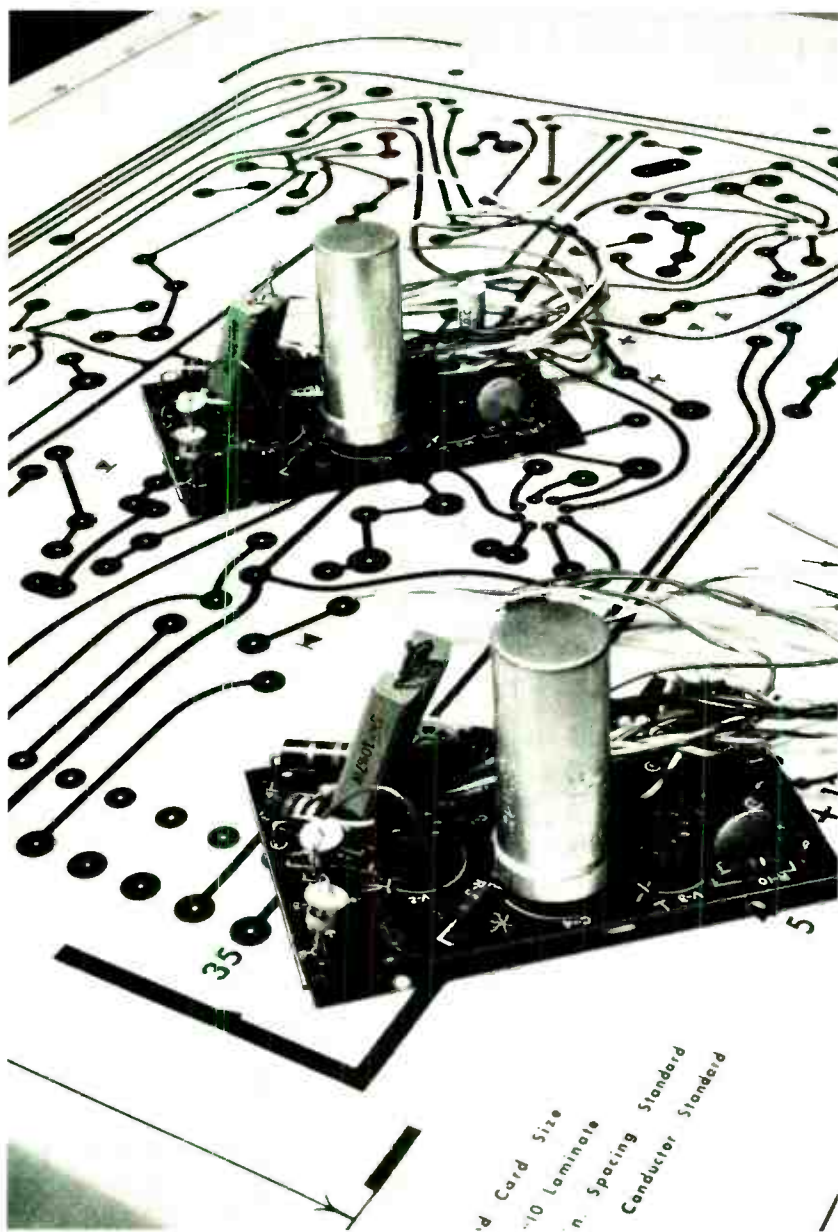
Four-channel sense amp allows faster cycle times

Plated wire memory systems place heavy demands on sense amplifiers, and the result has been slower cycle times than the memory system is capable of. The MC1544, a capacitively coupled, four-channel sense



amplifier, can sense the plated wire output pulses before the transient voltage has fully decayed, thus providing faster cycle times and better noise immunity. In addition to in-

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- Nikkei Electronics will begin publication with a paid Japan circulation of 15,000 in April and with a guaranteed paid Japan circulation of 20,000 within the first year of publication.
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New products

ternal coupling capacitors, the junction-isolated monolithic device employs Schottky-clamped output transistors that help achieve a propagation delay of 18 ns, and a dc level restore circuit to eliminate repetition rate problems. Price is \$9 in 100-quantities.

Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. 85036 [416]

Rf transistor delivers

100 W cw at 150 MHz

A line of rf transistors is capable of delivering in excess of 100 W continuous output at 150 MHz. The basic device is called the 3TE-610. Because of the low-inductance package, it is possible to develop broad



amplifier circuitry with this unit and to use combiners to provide power outputs to 1 kW. Price is \$35 to \$83 each for 100 to 999, depending on current and voltage ratings.

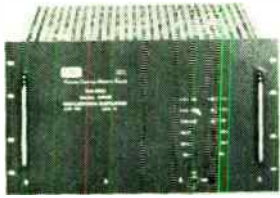
Kertron Inc., 7516 Central Industrial Drive, Riviera Beach, Fla. 33404 [417]

Static ROM is designed for repetitive data generation

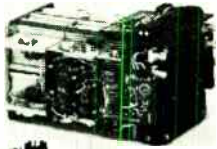
A read-only memory using p-channel MOS technology is designed for applications where repetitive data pattern generation is required. The sequentially addressed static memory operates via two input lines and an internal static counter. No external pullup resistors or special gates are required for interfacing, and the inputs and outputs are TTL compatible. Access time is typically 600 ns.

Solitron Devices Inc., P.O. Box 1416, San Diego, Calif. 92123 [418]

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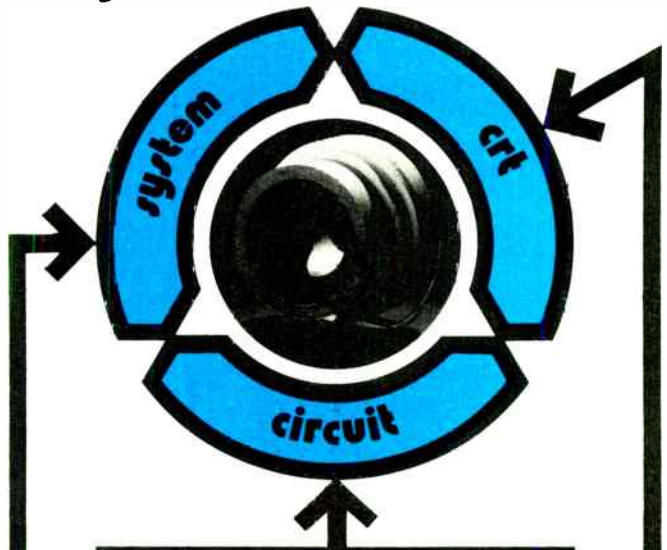


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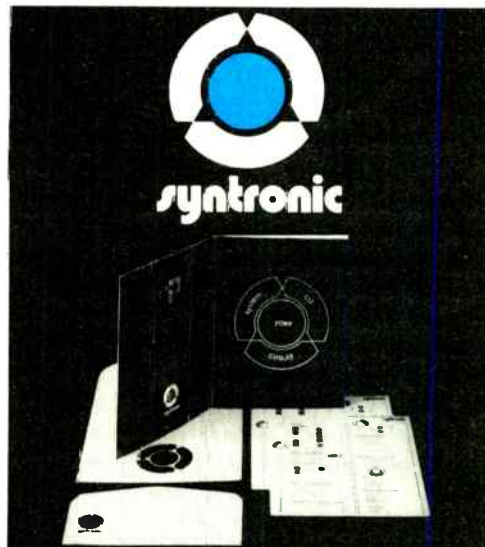
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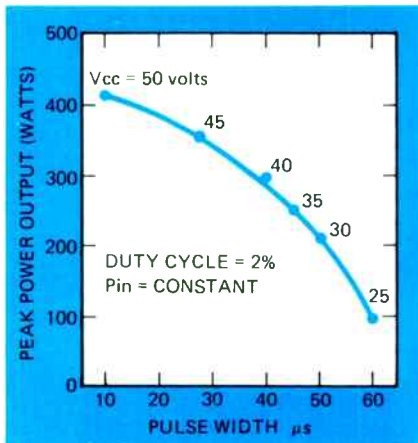
New products

Microwave

IC amplifier puts out 425 W

Avionics beacon unit runs at 1,030 MHz; second type delivers 400 W at 1,090 MHz

There are inherent limits to the reliability of pencil or planar triodes as airborne transponders or ground-based interrogators, says Ted Marks, senior engineer at Microwave Semiconductor Corp. With



this in mind, the company has developed two integrated circuit power amplifiers that deliver 400 and 425 watts peak output at 1,090 and 1,030 megahertz respectively.

"A 750-hour lifetime is typical for tube amplifiers," says Marks. "By using an all-solid-state approach with hermetically sealed power transistors, we are able to get the expected MTBF of our units to over 36,000 hours, based on calculations using MIL-Handbook 217."

The L-band beacon amplifiers are fabricated on thin film microstrip circuits. The high level of power is achieved through the use of highly efficient direct combining techniques that couple the outputs of four transistors in the final amplifier stage. The dividing network that feeds the inputs of the final amplifier allows simultaneous fixed tuning of the four transistors.

The amplifier is designed for a

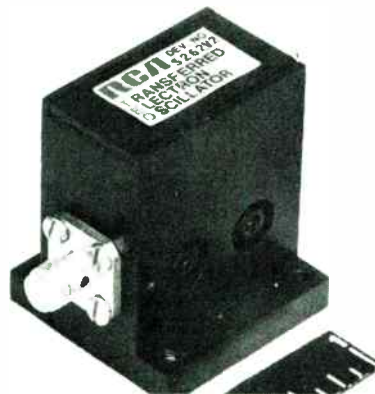
6-w rf input with a transistor bias of 50 volts. Maximum duty cycle is 2% with a pulse width of 10 microseconds. For a constant input power and a duty cycle of 2%, output is derated to 100 watts for a pulse width of 60 µs (see curve). Pulse rise and fall times are 100 nanoseconds. Efficiency is about 30%. The unit measures 2.25 x 5.25 x .75 inches.

Small-quantity price for the amplifiers is \$2,500.

Microwave Semiconductor Co., 100 School House Rd., Somerset, N.J. 08873 [401]

Gunn-type oscillator delivers 25 mW at 9,250 MHz

A solid state power source operating in X band is designed for applications requiring high frequency stability as a function of temperature. Called the S262V2, the transferred electron oscillator provides a minimum of 25 mW at 9,250 MHz, and it can be factory-adjusted for operation at other frequencies in the band. Power requirements are 12 v



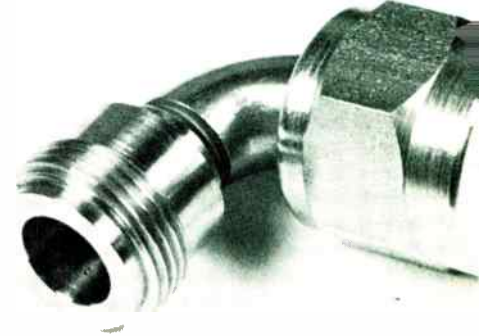
dc with a current of 500 mA maximum, and stability is ± 35 kHz/ $^{\circ}$ C. Price is \$300 each in quantities.

RCA Microwave Applications Engineering, Harrison, N.J. 07029 [403]

Right-angle adapter covers signals to 12.4 GHz

A right-angle connector designated the 5097-6002 is a male-to-female adapter that offers a VSWR of typically less than 1.10 from dc to 12.4

GHz. Selected units have a VSWR of less than 1.05 up to 12.4 GHz. The adapter is made from stainless steel, and its size is within the Type N



connector dimensions. Price is as low as \$15 each in quantity orders.

Solitron/Microwave, Connector Div., Cove Rd., Port Salerno, Fla. 33492 [408]

Power monitors cover 10 MHz-12.4 GHz range

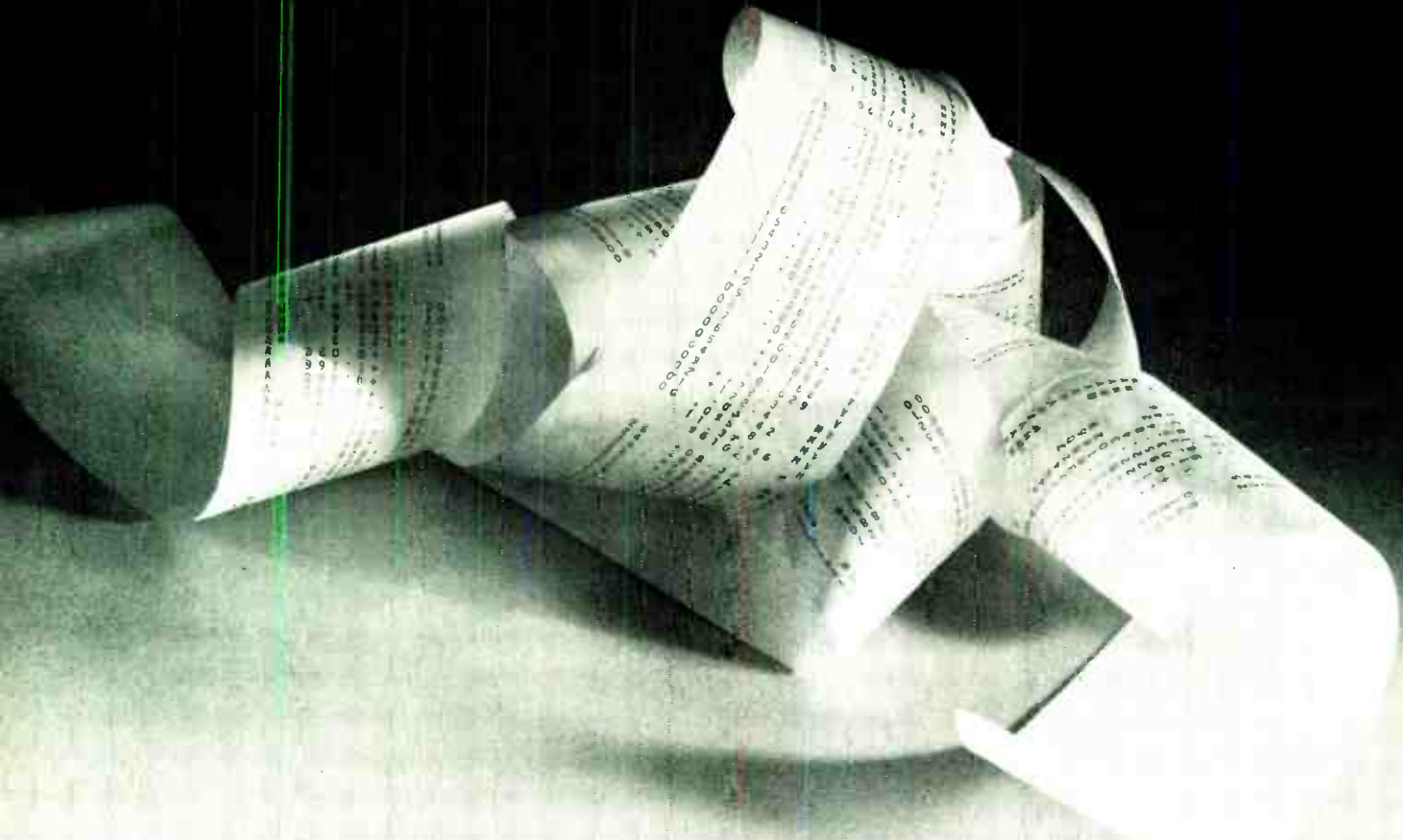
Thermoelectric power monitors are designed for system power measuring and monitoring applications. The integrated assemblies of rf power sensors and dc amplifiers measure modulated, pulsed, and cw signals from 10 MHz to 12.4 GHz over a 30-dB power range. Measurements of levels as low as -30 dBm or as high as $+20$ dBm can be made with the models N427 and N426, respectively, and the model N425



measures over an intermediate range. Price is \$275.

General Microwave Corp., 155 Marine St., Farmingdale, N.Y. 11735 [407]

Digitem's DAS-1 gets your data together. On paper. On tape. On time.

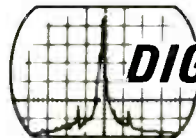


Digitem's new DAS-1 data acquisition system does what a good data acquisition system should. It accurately records all your data in real time. But it doesn't stop there. The DAS-1 has a combination of features that are remarkable for the price. To begin with, the basic unit has 10 channels and is expandable to 100 channels. Operating modes include: 1. Automatic scanning from start channel to stop channel (as selected

via thumbwheel switches) with a variable scan rate of 30 channels per second (magnetic tape) to one channel per two seconds, one scan per hour; 2. Single scan from selected starting channel to selected ending channel; 3. Continuous monitoring of selected channel. 4. Random selection of channels; 5. External trigger for single channel or single scan; 6. Manual channel advance. Other features include an easy to read 3½ digit LED display, with polarity and floating decimal point, that displays time or data by switch selection. DAS-1 has four programmable input ranges with resolution down to 10 microvolts. Its 200 volts common mode voltage lets you use it for floating guarded measurements. It has two ASCII outputs, serial for direct teletype connection and parallel for modems and paper tape punches. It has DTL/TTL compatible EBCDIC and BCDIC parallel outputs for seven or nine track incremental tape recorders.

The price? From \$3,000.

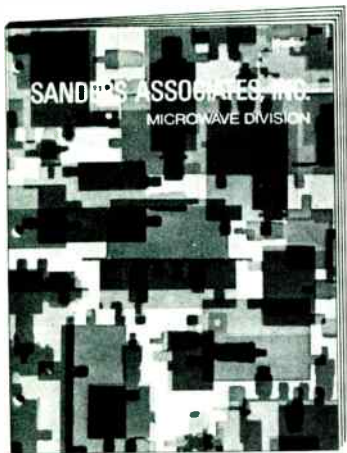
Get your data together. Write to Digitem, 1 Adler Drive, Syracuse, New York 13057, for complete information about the DAS-1.



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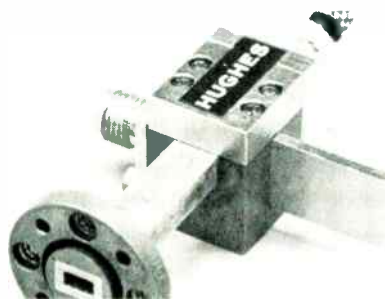
MICROWAVE DIVISION

*TM Sanders Associates, Inc.

New products

V-band detector has 15-GHz bandwidth

The model 44801H V-band detector uses silicon Schottky barrier diodes to provide a high-sensitivity (-200 mV/mW) millimeter wave unit that can be used with any of the company's series 44015H sweep generators. Bandwidth is 15 GHz and frequency range is 50-75 GHz. Other features include a cw burnout rating of 200 mw minimum, typical satu-

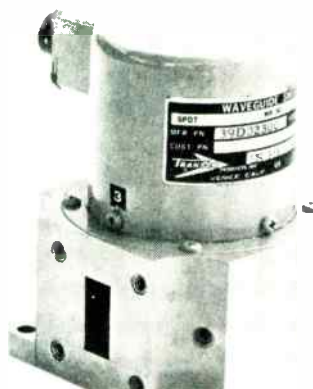


ration level of 100 mw, and mechanical tuning. Price is \$525. The Schottky diode can be ordered separately for \$275 and is field-replaceable.

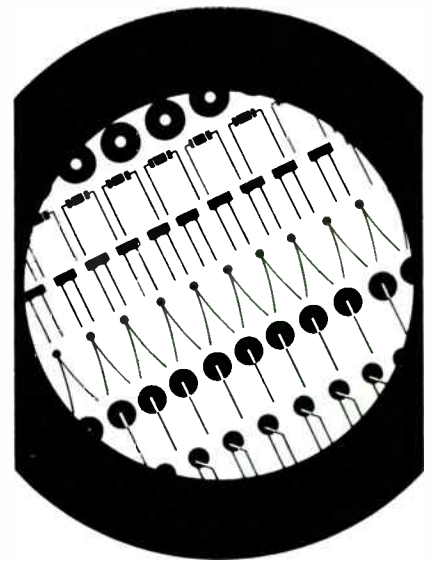
Hughes Aircraft Co., P.O. Box 90515, Los Angeles, Calif. 90009 [405]

Waveguide switch has low VSWR, acts as power divider

A waveguide switch designated the P/N 39D02300, an spdt device, switches under high peak and average rf power with a VSWR of 1.15 maximum, and its "variable" design acts as a power divider during operation. Frequency range is 8.20 to



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Thermistor Division
St. Marys, Pa. 15857
Phone: 814/781-1591

New products

12.40 GHz, insertion loss is 0.2 dB maximum, and isolation is 40 dB minimum. The unit operates from 28 v dc in a WR-90 waveguide.

Transco Products Inc., 4241 Glencoe Ave., Venice, Calif. 90291 [406]

Gunn flange oscillators are voltage-tunable

A series of Gunn flange oscillators are designed to allow users to replace klystron tubes with low-cost solid state devices. The models GFOV(X)100, -110, and -120 operate



in X band, and varactor tuning provides automatic frequency control or modulation. Units are available with output powers of 10, 25, and 50 mw. Price for 1 to 9 units is \$130 each.

Fairchild Camera and Instrument Corp., Microwave and Optoelectronics Div., 3500 Deer Creek Rd., Palo Alto, Calif. 94304 [404]

Directional couplers cover range from 0.95 to 13.1 GHz

Four miniature three- and four-port quadrature directional couplers are for use in 50-ohm systems. All have a frequency range of from 0.95 to +90° phase shift at the coupled output port because of their symmetrical design. The models 1536 through 1539 measure 4½ by 1 15/16 in., and are available with either 10- or 20-dB coupling. Features are high directivity, close tracking, low insertion loss. Price ranges from \$425 to \$475.

Weinschel Engineering, Gaithersburg, Md. [409]



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Instruments

Controller has 1- μ V stability

Off-shelf Airpax line also includes temperature-power controllers, SCR regulators

After custom-designing precision temperature controls for more than three years, the Controls division of Airpax Electronics has decided to offer an off-the-shelf line of controllers for applications in furnaces in the semiconductor and textile industries. The five units include the series 401 and 410 temperature controllers, the 510 and 520 silicon-controlled-rectifier power controllers, and the 300 series temperature-power controller combined in an integral plug-in package.

The 1-microvolt temperature stability in the series 401 controllers is maintained regardless of a $\pm 10\%$ variation in ac line voltage or a $\pm 10^\circ\text{C}$ change in ambient temperature, over a 30-day period. The stability of the best conventional controller runs somewhere between 5 and 10 μV , Airpax says. The 401, as well as the others in the line, can accept inputs from the usual variety of thermocouples, resistance temperature detectors, or other millivolt sources. Other features of the 401, which must be screw-mounted, include two- or three-mode control, a 10-turn setpoint potentiometer, deviation and output indication, and a deviation alarm. Outputs are either 0-1.65 v dc or 0-5 milliamperes into a 1,500-ohm load.

Higher outputs are available as options with the series 410 temperature controllers. Temperature stability here is less than $\pm 15 \mu\text{V}$ but the unit can deliver either a dc output signal (0 to 5 v) or, using plug-in output cards, 500 or 1,000 watts at 120 or 240 v respectively. In addition, the entire unit is of a plug-in construction for easy mounting in a control panel. Two-mode control is standard with the 410, but rate

mode is also available, and so is a deviation alarm relay with reset. Single- or 10-turn setpoint dials are optional, and the 10-turn potentiometer can be supplied with a digital dial. A common setpoint module, able to handle 180 controllers, and an SCR power controller are available as well.

Both temperature and power control are combined in the series 300 integral temperature controller, and the unit can be plugged in or removed while operating under rated load. The phase- or zero-fired control units come in current ratings of 30 to 50 A. They can control up to 12 kilowatts at 240 v ac.

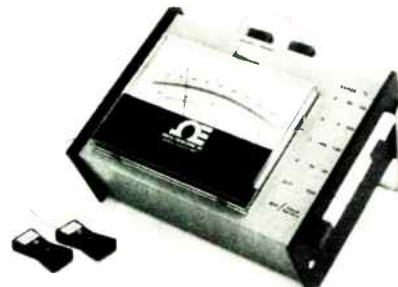
Rounding out the new Airpax line are the single-phase SCR power controllers. The series 510 comes in 30-, 50-, and 70-A sizes. A special power feedback circuit corrects errors and allows less than 0.5% output voltage or power change with 10% ac-line-voltage variation. Linearity is better than 1% between input dc voltage and rms power output. The series 520 power controller has all of these features as well as a plug-in design.

Prices of the series 401 and 410 range between \$160 and \$400, depending upon the precision; the series 300 is up in the \$300-to-\$600 range. The series 510 and 520 power controllers start at \$190 and go as high as \$500.

Airpax Electronics, P.O. Box 8488, Ft. Lauderdale, Fla. 33310 [351]

Thermometer can use probes of 0.001-inch diameter

A subminiature-thermocouple read-out meter measures the temperature of miniature electronic components, and incorporates a high-gain ampli-



fier. The instrument allows for multirange electronic thermometry with an accuracy of $\pm 1^\circ\text{C}$ on four ranges provided on each meter. Response time is 2 seconds. Probes as small as 0.001 in. in diameter can be used with the instrument, which has an automatic temperature reference instead of an ice bath.

Omega Engineering Inc., Box 40 47, Stamford, Conn. 06907 [353]

Positive, negative pulses are generated simultaneously

A compact generator designated the model 302A is capable of providing simultaneous positive and negative pulses. Each output has a separate amplitude control, and the pulses can be at rates varying from 10 Hz to 50 MHz with rise and fall times of less than 5 nanoseconds. Both out-



puts are at 50 ohms source impedance. External or manual triggering and double-pulse operation are selected by front-panel switches. Price is \$425.

Monsanto Commercial Products Co., Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006 [358]

Data system tester counts bit, block errors

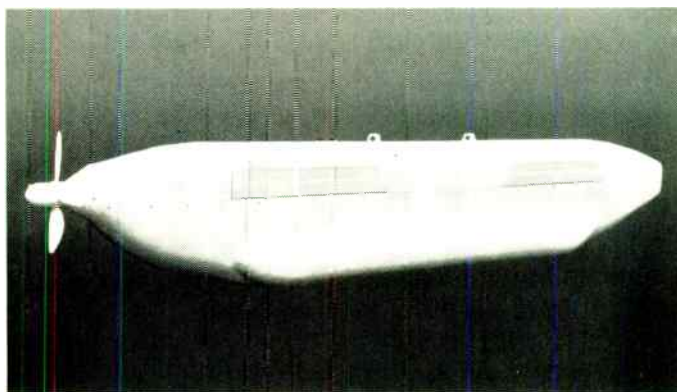
A portable bit-error-rate tester designated the BERT 901 also counts block errors to measure the true effectiveness of data transmission systems. Bit error count, block error count, and block count are displayed for each test, and bit rate selection is provided for 19 standard synchronous rates from 75 bits/s to 1.54 million bits/s. Asynchronous

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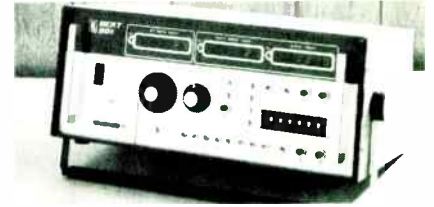


*Patents pending

Circle 155 on reader service card

New products

operation may be used to 9 million bits/s. Testing flexibility is extended by plug-in adapter modules for EIA-



RS-232, current, T-carrier, balanced, and logic level interfaces.

II Communications, Willow Grove, Pa. [354]

Lock-in amplifier offers 1-microvolt sensitivity

A lock-in amplifier called the PAR model 128 has automatic reference tracking and provides 1-microvolt sensitivity. The signal channel offers a flat frequency response of from 0.5 Hz to 100 kHz, and low- and high-pass filters can be switched in to attenuate noise or signal harmonics. A switch-selectable choice of true single-ended or differential input



with common mode rejection of better than 80 dB is provided. Price is \$1295.

Princeton Applied Research Corp., P.O. Box 565, Princeton, N.J. 08540 [355]

4½-digit multimeter offers 25 ranges and modes

Designed for a wide variety of measurement applications, the model 8120A 4½-digit multimeter provides 25 ranges and modes. Ac and dc ranges go from 100 millivolts to 1,000 v, current ranges from 100 microamperes to 1 A, and resistance ranges from 1,000 ohms to 10 MΩ. Overranging on all readings is 20%. Applications are in telephone and power utilities as well as traditional

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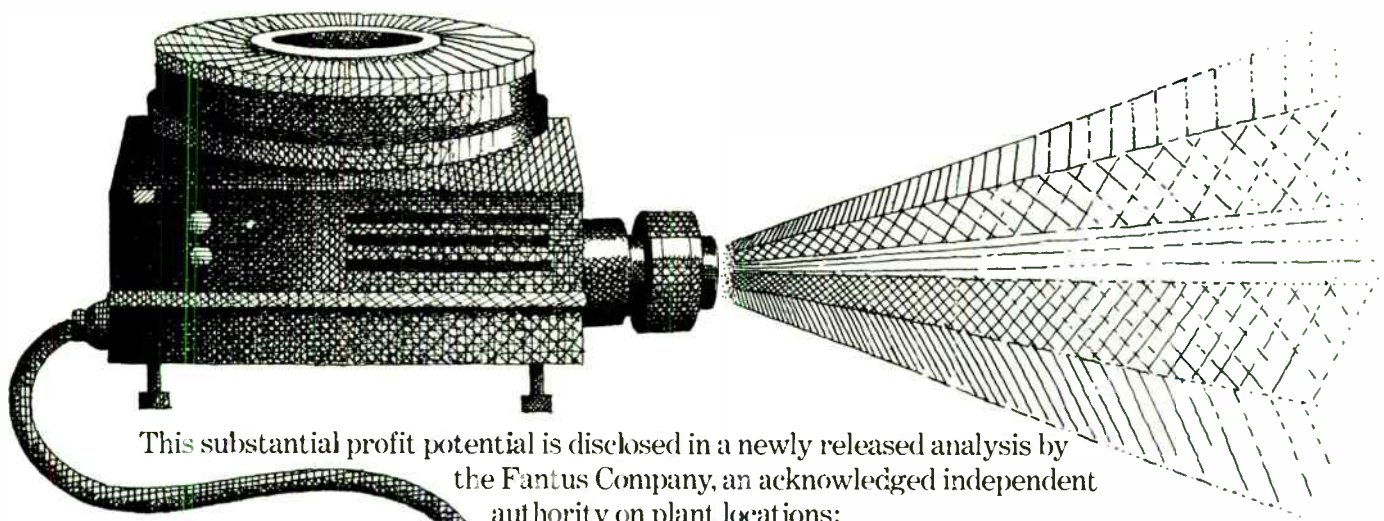


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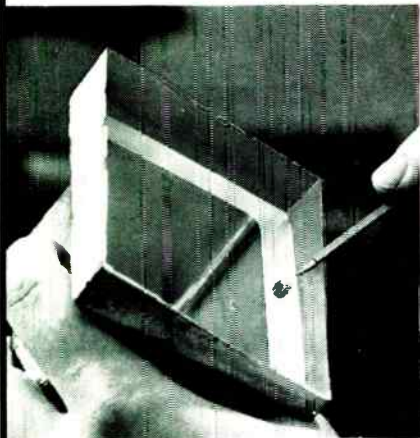
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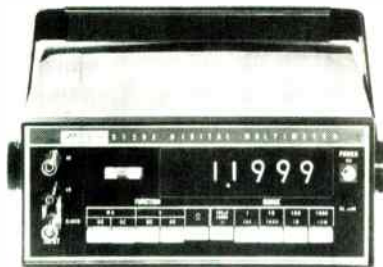
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In Europe, contact Mining & Chemical Products Ltd., Alperton, Wembley, Middlesex, England.

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New products



electronic markets. Price is \$795. John Fluke Manufacturing Co., Box 7428, Seattle, Wash. 98133 [357]

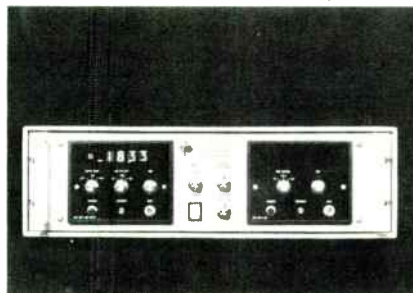
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Northern Precision Laboratories Inc., 202 Fairfield Rd., Fairfield, N.J. 07006 [360]

Digital-display ratiometer has wide dynamic range

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wide dynamic range of ± 70 dB in the ratio mode, make the series 1833 instruments suitable for antenna and microwave component measurements. Price is \$2,900 plus options. Scientific-Atlanta Inc., P.O. Box 13654, Atlanta, Ga. 30340 [359]

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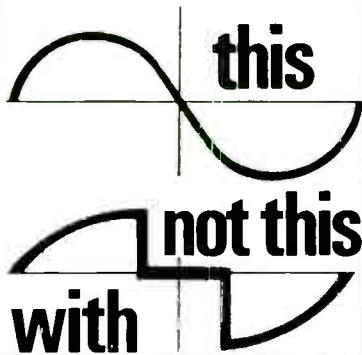
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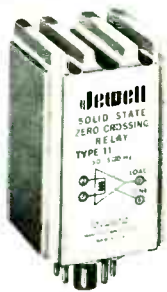
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New England Laminates Co., Inc., 25 Crescent St., Glenbrook, Conn. [476]

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Alpha Metals Inc., 56 Water St., Jersey City, N.J. 07304 [477]

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Zipertubing Co., 13000 S. Broadway, Los Angeles, Calif. 90061 [478]

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Epoxy Technology Inc., 65 Grove St., Watertown, Mass. 02172 [479]

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New Literature

Switches. Switchcraft Inc., 5555 N. Elston Ave., Chicago, Ill. 60630 has issued an engineering bulletin on its multiple-station pushbutton switches with common release capability at any station. Circle 421 on reader service card.

Pc relays. Printact Relay Div., Executone Inc., 29-10 Thomson Ave., Long Island City, N.Y. 11101. Printed circuit relays that plug in without sockets or soldering are outlined in an eight-page catalog that also describes pc board preparation aids and boards for prototype testing. [422]

Data converters. ILC Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801 has published a six-page summary sheet of specifications for a wide range of data converters and related accessories, including multipliers and amplifiers. [423]

Keyboards. A system of keyboard electronics using a scanning technique is described in a four-color brochure available from Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. 60085. A diagram shows the interaction between an eight-bit counter, two multiplexers, and a four- to 16-line decoder. There is also a chart of basic electrical specifications, and listings of standard and optional features. [424]

Magnetic recording. Nortronics Inc., 8101 10th Ave. N., Minneapolis, Minn. 55427. A 28-page design digest for digital magnetic recording features applications information for personnel working with mini-computers, programable desktop calculators, credit card verifiers, input-output systems, point-of-sale terminals, and other peripheral equipment. [425]

Capacitive memories. Integrated Memories Inc., 260 Fordham Rd., Wilmington, Mass. 01887 is offering a six-page technical bulletin on operational theory, system features, and performance characteristics of its capacitive read-only memory. [426]

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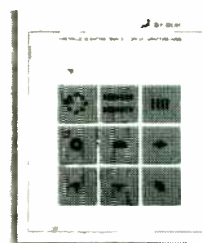
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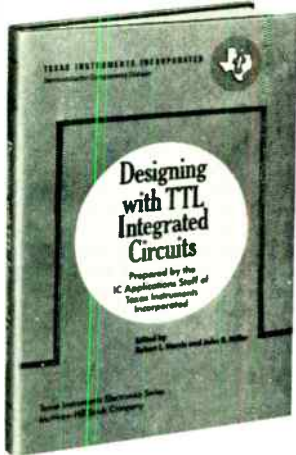


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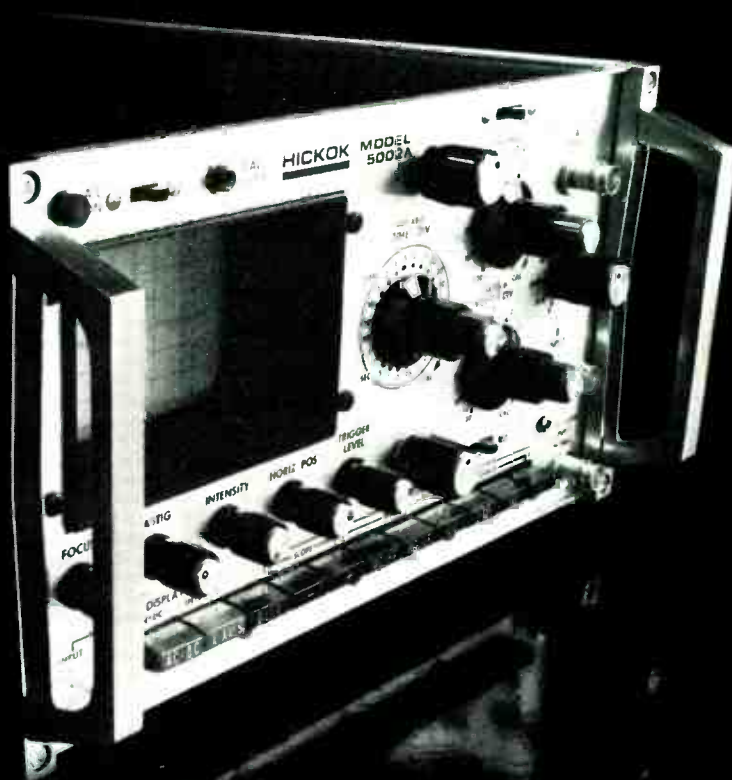
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International Newsletter

December 6, 1971

UK group asks more government support for computer industry

Noting that the present level of public funding for computer technology is much too low, an official committee of members of Parliament is asking for a boost in direct support to "not less than" \$125 million per year, a tenfold increase. The committee, whose recommendations for systemizing government support of the computer industry are not binding, also says that the government's practice of seeking computer bids from British-owned firms alone "is not in the best interests of the taxpayers or the computer industry." Instead, the group recommends that all comers submit tenders, with action favoring "those firms which contribute most to the economy and national objectives in the computer field." That would seem to give a boost to U.S.-owned companies manufacturing in Britain at the expense of International Computers Ltd., which dominates the native industry. But then the committee adds that "preference should be given to suppliers where the controlling interest is held by UK nationals."

Siemens, USSR sign electronics pact . . .

West Germany's efforts to ease relations with the Soviet Union are beginning to show tangible results in the electronics sector. Siemens AG has signed a deal with the Soviet State Committee for Science and Technology calling for future cooperation and the exchange of licenses, information, and patents. The partners will set up groups to determine likely areas of cooperation. According to Siemens, the Soviet Union is mainly interested in automated processes in both production and administration—an area in which the German company has considerable expertise—as well as medical electronics. Siemens, meanwhile, expects to benefit from Russia's highly advanced work in theoretical aspects of control engineering and from Soviet know-how in specific areas of medical technology. The new agreement also provides for electronics trade between the two countries.

. . . as SEL wins Greek network award

Greek telecommunications authorities have awarded West Germany's Standard Elektrik Lorenz AG (SEL) a \$2 million contract for erecting a nationwide network of 6-gigahertz microwave relay links. The system is designed to handle 1,800 telephone conversations on one channel, and one television as well as three radio programs on the other. One part of the five section-network will tie in Athens with the satellite ground terminal at Thermopylae. Another part will connect Greek telecommunications facilities with those in Yugoslavia.

British firms set to take six MRCA systems contracts

British avionics companies look set to be named prime contractors for six of the 10 major systems contracts still to be awarded for the British-German-Italian Multi-Role Combat Aircraft. Ian Gilmour, a junior minister in the defense department, has told Parliament that if contract terms can be agreed upon, Marconi-Elliott Avionic Systems Ltd. will make the autopilot and main head-down display; Ferranti Ltd. the inertial navigation system and a display combining radar data and a moving map; Smiths Industries Ltd. the head-up display, and Decca Radar Ltd. the doppler navigation radar. The head-down display will show pictorial and tabular data for the navigational attack system and flight instrumentation. The autopilot and inertial navigation systems are both expected

International Newsletter

to be digital. The awards will bring Marconi-Elliott and Ferranti some much-needed R&D work, but both companies say that it won't compensate for the loss of the nose-radar contracts to Texas Instruments.

Transitron closing French plant . . .

Continued heavy losses are forcing Transitron Electronic SA to shut down its semiconductor assembly plant in France after a five-year struggle to make the operation profitable. With the work force down to 120 from a peak of 300, Transitron's U.S. executives decided they had only two options left—massive investment or complete shutdown. In view of the flat French semiconductor market and low profit margins, they opted to close the plant at Vernon, northwest of Paris, before the end of the year. Transitron will maintain its sales force in France, while the production equipment that can be used again will be shipped overseas.

. . . but CII plans move into U.S.

Compagnie Internationale pour l'Informatique, the big state-subsidized French computer maker, will attempt to move into the lucrative American market by teaming up with Control Data Corp., Minneapolis. The two companies plan to sign an agreement early next year giving CDC exclusive sales rights in the United States for CII's medium-large Iris 60 computer. CDC engineers also will work with CII to set specifications for a new computer that CII will design and build, and both companies will market. The new machine, which probably will not be introduced before 1975, will be the successor to the Iris 60 and will be in the same size range. CII needs the new market to expand its base of operations, largely restricted to France thus far. CDC looks to gain from the deal as well by broadening its large-systems line with a minimum of R&D.

Ferranti builds CDI optoelectronic switch

By February Ferranti Ltd. expects to be handing out samples of an integrated optoelectronic light-activated switch using bipolar control circuitry built by its collector diffusion isolation process [*Electronics*, *Electronics International*, Oct. 25]. Researchers say its great advantage compared to established MOS-controlled switches is that it needs only one supply rail, not two. Bipolar-controlled photodiode chips have been built before, but they are big and proportionately expensive; the CDI device is more comparable in size and cost with an MOS-controlled chip. Further, Ferranti says the CDI process allows very low dark current. The switch is designed with variable hysteresis. It switches off at a lower light level than it switches on, and the difference is adjustable using an external resistor. It comes in a six-lead TO-5 can or plastic package.

Addenda

It's official: Japan's six general-purpose mainframe computer makers are now formally aligned as three groups of two companies [*Electronics*, Nov. 22, p. 119]. The three groups are Hitachi-Fujitsu, Nippon Electric-Toshiba, and Oki-Mitsubishi. They were pushed to pair off by the Ministry of International Trade and Industry in return for funding for development of a new computer to compete with the IBM 370. . . . The Swedish Telecommunications Board is inaugurating video telephone service, with public installations in the nation's biggest cities expected by next year, and at least 5,000 subscribers slated by 1980. Manufactured by I M Ericsson, the videophones operate on a 1-megahertz bandwidth.

Liquid crystal effect cuts power, ups contrast

AEG-Telefunken in Berlin discloses work on method that harnesses deformation of vertically aligned phases

A pair of scientists at West Germany's AEG-Telefunken have discovered a new optoelectronic phenomenon in liquid crystals that, because it cuts power needs, raises contrast, and eliminates crosstalk, is certain to have a big impact on future display technology.

Described at a colloquium the company held in West Berlin last month, the phenomenon can be exploited to provide contrast ratios of up to 1,000 to 1 between illuminated liquid crystal display elements and the surrounding area. Such a ratio is a 25-fold improvement over conventional liquid crystal displays based on the dynamic scattering mode: a ratio of 40 to 1 is the highest value achieved thus far.

Equally significant is the lack of crosstalk between individual display elements. In dynamic scattering liquid crystal displays crosstalk shows up by neighboring elements in a matrix becoming partly illuminated as a result of voltage coupling between them.

Deformation. Discovered by Manfred Schiekkel and Kurt Fahrenschon at AEG-Telefunken's Special Tubes division in Ulm, the phenomenon has been termed the DAP effect, from the initial letters for the German words for deformation of vertically aligned phases.

This new effect manifests itself as follows. In certain liquid crystal cell designs, with no voltage applied

across the cells electrodes the crystals' longitudinal axes will orient themselves in a direction nearly vertical to the electrode surfaces. This condition is called the vertically aligned phase. Now if an ac voltage of sufficiently high frequency is applied across the electrodes, the crystal axes will tilt.

The amount of tilt, or the angle of deformation from the original vertical position, is greatest for those crystals that are the farthest removed from the electrode surfaces.

This electro-elastic deformation effect, which shows up even with a relatively small applied voltage, is the key to obtaining the sharp display contrast. Liquid crystals of the nematic type exhibit optical characteristics similar to those of uni-axial crystals. So if a cell is placed between a pair of crossed polarizers and if the crystals in that cell are all vertically aligned, the cell will be

completely dark. But as the molecules are deformed under the influence of an applied voltage the cell becomes bright.

Optically, then, the cell behaves like an appropriately cut prism that is turned around its longitudinal axis. An even number of half-wavelengths will produce a bright surface in that prism, an odd number a dark surface.

Unusual curve. The lack of crosstalk stems from the sharply defined shape of the DAP-effect curve. This shape differs markedly from that for the dynamic scattering mode. Plotted as a function of contrast ratio versus cell voltage, the DAP effect will be zero up to a certain voltage, then climb to a specific value of contrast ratio, and remain at that value even with increasing voltage applied. The absence of crosstalk is a result of the jump from threshold voltage value immediately into satu-

Study in contrasts. AEG-Telefunken researcher Kurt Fahrenschon, who with Manfred Schiekkel discovered effect, checks out a prototype liquid crystal display.



ration. A typical curve for dynamic scattering is highly nonlinear. Scattering begins at around 4 volts, but it takes another 20 volts or so before saturation is reached.

To produce the DAP effect, Fahrnschon says, any of the common liquid crystals with negative dielectric anisotropic characteristics can be used. In their experiments, however, the two AEG-Telefunken researchers have used a mixture of two such materials, because combinations give a higher nematic temperature range than if each substance were used alone.

Purity. The main requirements for the DAP effect to occur in the mixture are that the materials have a high degree of purity and that the amount of water in the substance be as low as possible—typically less than 50 parts per million.

There are no stringent requirements as far as cell construction itself is concerned. Usual cell thicknesses of about 20 micrometers are just fine, Fahrnschon says. The electrodes, on the other hand, must be of a special type. As with most ordinary liquid crystal electrodes the material is tin oxide. But for the DAP effect to occur this material must have a specific crystalline structure, which is obtained by subjecting the tin oxide to heat treating.

For initiating the crystal deformation, the voltage applied to the electrodes must have a frequency of around 1 kilohertz. The voltage value required is from 4 to 6 volts at a current density of about 25 microamperes per square centimeter. This low voltage requirement is only a fifth of what is needed for dynamic scattering.

Great Britain

How to test 250,000 diodes, SCRS, etc. per week

To speed up testing of power control semiconductors, engineers at Mullard Ltd.'s Stockport manufacturing plant have built an automatic test machine intended to take on the plant's entire output of normal

zener diodes, rectifiers, thyristors and triacs.

Planned throughput is 200,000 to 250,000 devices per working week, figuring on an eight-hour day and allowing for four or five changes per day in the type of device going through the tester. Company finance men say its showing a 13% return on its \$200,000 cost so far, though its not yet working to capacity.

Apollo program. Mullard built its own machine because it could not buy outside one that would carry out all the necessary tests on all its production devices. Barry Slinger, engineering manager, says the machine was made possible by the introduction of programable power supplies that could be controlled by a small computer—a Digital Equipment Corp. PDP 8-L. It's called Apollo, and it took two and a half years to build.

Apollo carries out up to 24 tests on a device, shared out as required between an ambient test station and a hot test station. The programing allows up to 120 measurement bands to be distributed over these 24 tests. Some of these bands can be used for grading devices, which end up in selection bins at the far end of the machine.

Jig time. The only manual handling necessary is loading the test devices onto aluminium jigs on the conveyor feeding the machine. The jigs are all standard and each holds a plastic mount into which particular devices clip. Insulated fingers in the track, controlled by the computer program, index the jigs through the machine.

After the tests, a jig and its load pass a row of 36 fingers opposite 36 selection bins. As the jig passes, the fingers come out and push the devices into the appropriate bins. Finger and device are matched by the computer, which processes the results of the tests on a device, classifies it, and, because it keeps track of each device's travel, actuates the right finger at the right time.

In the ambient section of the machine, avalanche devices get a surge test of up to 150 kilowatts at the first test station. The second station, for

high speed diodes, applies a stored charge test.

However, most tests are carried out at the third station. For example, zener diodes get a first search test of 200 milliamps. If the resulting zener voltage is less than 5 volts, the device is graded as possible reverse polarity or short circuit, and it's destined for one of the reject bins. If the zener voltage is over 5 v, its graded according to the exact figure for further test at 0.5 ampere, 1 A or 2 A to establish which of 28 selection categories between 6 v and 82 v, plus one for over 82 v, it should go into.

Go/no-go. It then gets tests for slope resistance, forward voltage stability, and reverse leakage, at parameter values according to selection category. If it passes these it gets into one of the 29 category bins. If it doesn't, it gets into one of half dozen reject bins. The principle of the control programing is to avoid unnecessary tests by detecting rejects as early as possible and also placing devices in broad categories early on in the sequence.

There is a fourth station where hot tests can be carried out. The devices are heated by passing the jig over a hot plate. Because cold results and hot results have to be taken together to determine a pass or a reject, the cold results for each device are moved out of core onto disk until the hot results are available for matching. The mathematical routines are kept in the disk and transferred to core when needed.

Apollo is reprogramed following a device change by typing in the name of the device on a teletypewriter. It's also possible to punch in supplementary instructions. For instance, some device selection categories overlap and devices falling into two categories can be directed into the one for which there is most demand at the moment. The teletypewriter will also print out test results on-line as well as yields for any of the selection grades or test categories.

Checking. The machine automatically checks its software and hardware whenever data is transferred between disk and core. The machine

builders are developing ways in which Apollo can check itself against internal standards during the progress of every batch of devices, which Slinger thinks will eliminate any need for other checks.

Japan

Electroluminescent TV screen takes shape

Flat-screen electroluminescent television displays are coming to life at Matsushita Electric Industrial Co. Workers at the company's Wireless Research Laboratory are developing display panels driven by direct current and addressed with digital techniques.

The panels are extremely simple, being built on a 230-by-300-millimeter sheet of glass with 224 vertical transparent tin oxide stripe electrodes. The stripes, 1 mm wide with an edge-to-edge spacing of 0.2 mm, are photoetched. Electroluminescent powder with resin binder is spread over the electrodes and allowed to harden. The 224 horizontal aluminum stripe electrodes—with three quarters the horizontal stripes' width and spacing—are formed on top by vapor deposition. Then a nonhygroscopic sealing layer is applied to protect the panels from moisture.

Yellow-orange. After forming, by passing a direct current through them, the panels are capable of peak brightness of 250 to 300 foot lamberts with direct current excitation. Spectrum peaks at 5,850 angstroms to give a yellowish orange. Because individual picture elements of the panel are operated at a low duty cycle in this system, highlight brightness of TV pictures is only about 10 footlamberts—with contrast ratio of about 20 to one.

Although the structure of this panel is extremely simple it differs from the matrixes used for logic and other applications. No diodes are used at intersections to prevent current flow through sneak paths in parallel with selected crosspoints. Instead, the brightness of the



Action. Experimental flat-screen display shows off-the-air TV programs.

electroluminescent material used is very nonlinear with respect to the applied input voltage, which makes it possible to obtain high contrast even with parallel current paths through the matrix.

Split voltage. The nonlinearity of the matrix also makes it possible to use partial selection techniques to write picture information without suffering from excessive crosstalk. For example, the picture element addressed by applying half the total voltage to vertical and horizontal stripe electrodes will be 32 times as bright as other points along these electrodes if the exponent in the brightness function is five, even greater if the exponent is higher.

Because injection electroluminescent material responds to direct current, it is possible to use pulse width modulation of the video signals for controlling brightness, rather than the amplitude modulation used in an earlier Matsushita panel [*Electronics*, Mar. 17, 1969, p.114]. Pulse techniques make it possible to fabricate video circuits with digital circuits only and eliminate need for resolution-degrading delay lines or difficult-to-integrate linear amplifiers.

Brightness range. Basically the video signal for each television line is sampled by an analog-to-digital converter at 224 equally spaced time intervals. The brightness range of the video signal is divided into eight levels, and the results are stored in 224 memory registers as three-bit signals. Contents of the

memory registers are transferred to brightness control gates—which generate actual width-modulated pulses—and then to vertical electrode drive circuits, one horizontal line at a time.

Line selection. The horizontal stripes in the matrix are approximately equal to the number of active lines in one field of a TV picture. But to increase brightness, each horizontal line is selected for the duration of two horizontal lines, with turn-on of each horizontal line delayed by the duration of one horizontal line from the stripe above it.

Therefore, the picture displayed on elements of individual horizontal stripes overlaps each adjacent line during one horizontal line. Actually, the information displayed by picture elements on a given horizontal stripe is the average of the information in two succeeding horizontal lines of the video signal, but the result is a smooth, bright display.

In this panel, selection voltage is fed to the individual horizontal stripes only during the duration of two horizontal lines out of each field. Video signal pulses are fed to the vertical stripes essentially constantly, except when the portion of the picture being sampled is dark.

Partial selection. Thus, the duty cycle of the voltages fed to the vertical stripes is much higher than that fed to the horizontal stripes. This means that the voltage fed to the horizontal stripes can be higher than that fed to the vertical stripes. In this display two thirds of the exciting voltage is impressed on the horizontal stripes.

Airport ground radar spins at 500 rpm

An airport surface-equipment detection radar developed by Mitsubishi Electric Corp. will soon be installed at Japan's Chitose airport—the closest airport to the Winter Olympics site, Sapporo. It will aid air traffic controllers in straightening out on-the-ground traffic jams of airplanes carrying visitors to and from the Olympic Games despite all

the snow. In August, an earlier unit was installed at Osaka's international airport—Itami—where it is working satisfactorily.

Brighter. The most significant advance in the new radar is a 10-foot wide, 5-foot high antenna, which rotates at 500 revolutions per minute. Compared with the 40 rpm of an earlier Mitsubishi radar installed at Tokyo's international airport. The faster rate makes the image one to two orders of magnitude brighter, because the operators can view the screen fluorescence directly rather than the decayed afterimage as in slower radars.

The faster antenna speed provides continuity of the track of fast moving targets such as landing aircraft, which appear as a series of widely spaced dots on radar screens with antennas rotating at slower speeds. The new radar also clearly shows the motion of slowly moving objects like cars, whose motion is not readily apparent on older radars with slower antenna rotation.

For maximum resolution the new radar operates in K band at about 24,500 gigahertz. A hard tube modulator using a vhf transmitting tube gives a pulse repetition rate of 14,000 pulses per second with a pulse length of 20 nanoseconds.

Resolution. The antenna width, the high frequency, and the short pulse length give high enough resolution so that controllers can differentiate two-engined-planes, four-engined planes, people walking on the field, and vehicles driving on the

field. Even at a 2-nautical-mile range, the range resolution is better than 30 feet, and azimuth resolution is better than 50 feet.

Peak output of the radar's magnetron is 30 kilowatts. In the receiver, a Schottky-barrier diode used as mixer is followed by a low-noise transistor preamplifier, and an Impatt diode is used as the local oscillator. The Impatt diode gives noise levels comparable to that obtained with klystron oscillators used in earlier radars.

France

Motorola's semiconductor R&D goes European

American entrepreneurs have learned the hard way that such Yankee inventions as root beer, tail-finned automobiles and the electric can opener do not exactly take European markets by storm. Electronics firms have run into some of the same problems as they try to operate on a world scale with a product line designed basically by Americans for Americans.

Robert Heikes, European manager of Motorola Semiconductor division, is determined to steer his operations clear of such pitfalls. Motorola has passed its infancy, says Heikes, and now recognizes the whole world as a market.

Expatriation. To make sure that Motorola will have a substantial piece of this market, Heikes has launched a program to introduce MOS and automotive R&D in Motorola's European factories. Just two years ago this was only a dream, says Heikes. It will become a reality, he adds, as soon as the European and U.S. economies recover enough to justify the investment.

"If we only sell American products we will never be completely successful on the European market," Heikes says. "And if we depend on Phoenix to meet European needs we will have a long time to wait."

Motorola this year began moving toward European R&D by setting up

a small operation of just a few men at the firm's Toulouse plant, some 400 miles south of Paris. The 1,200-employee plant already is producing locally-designed bridges for automobile alternators in Europe. Heikes says the R&D facility could be expanded to about 50 persons within three or four years, assuming there is some economic progress in the meantime.

Centers. Motorola intends to create what Heikes calls "centers of competence" in Toulouse and in East Kilbride, Scotland, where the company's second European semiconductor plant is under construction. Other Motorola manufacturing plants abroad are in South Korea, Guadalajara, and Nogales.

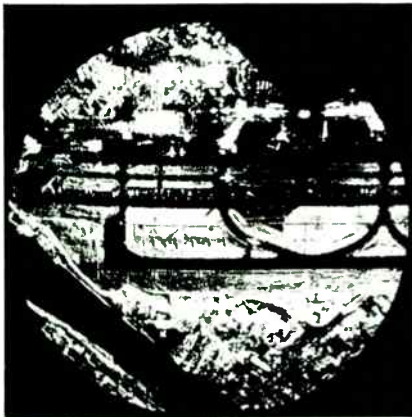
The Toulouse plant, the largest abroad, will become a center of competence for automotive electronics and also will be responsible for custom bipolar circuits for the European market. East Kilbride, under the Heikes plan, will become a center of competence in the memory area. The Toulouse and East Kilbride contribution to division R&D, says Heikes, could eventually exceed 50%.

"Europeans should welcome this change," Heikes says, "because it takes us further than simply having an American company hire local workers to manufacture and sell American technology."

Heikes sees a bright future in European automotive electronics. The day will come, he says, when cars will be equipped with radar anticollision systems. In the meantime all types of automotive electronics will use more and more semiconductors. European specifications, so different in temperatures and voltages from U.S. specs, will be cranked in as the European market expands.

Growth. Heikes likes to cite semiconductor/population ratios to dramatize the potential market that exists in Europe today. The value of semiconductors in the U.S. divided by the population works out to about \$6 per person today, he says. In Europe the value is \$1.50 per person. Thus Europe has growth potential worth \$4.50 per person before it draws even with the U.S.

Circling. Mitsubishi ground radar keeps track of surface traffic at Japanese airport.



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22 Chaussee de Wavre
Brussels 1040 Belgium
Tel. 13-65-03

Stockholm: Brian Bowes
Office 17, Kontor-Center AB Hagagarten 29,
113 47 Stockholm Tel. 24 72 00

European Special Project Manager: Oliver Ball
Tel. Hyde Park, 1451, London 34 Dover Street

Frankfurt/Main: Fritz Krusebecker
Liebigstrasse 27c
Phone 72 01 81

Tokyo: Masaru Wakeshima, McGraw-Hill
Publications Overseas Corporation,
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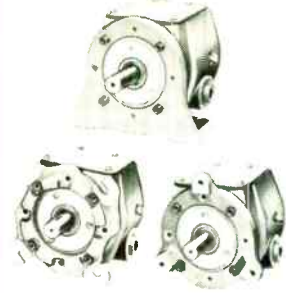
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Easy-grip bayonet-type knob—sturdy compression spring assures good contact

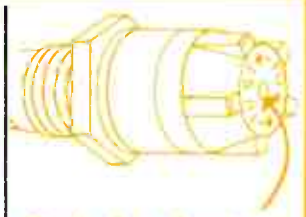


Knob grips fuse so that fuse is withdrawn when knob is removed

Made for installation in D-hole to prevent turning in panel



Terminals are mechanically secured in holder as well as soldered



Knob has break-out hole to allow use of test probe

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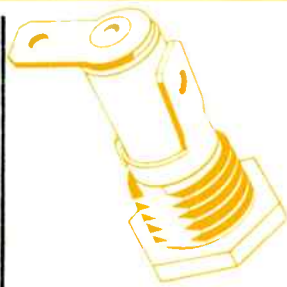
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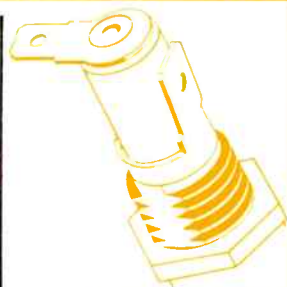
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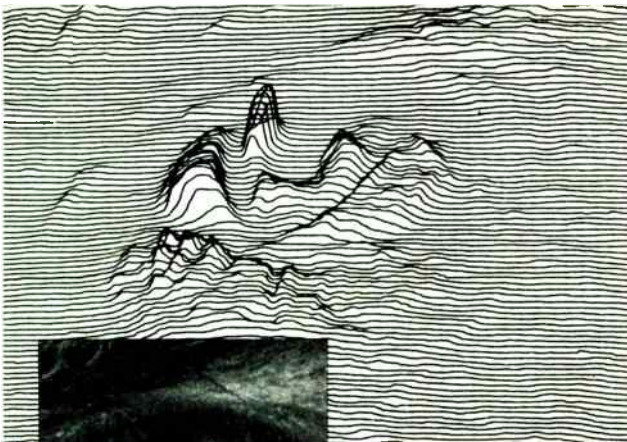
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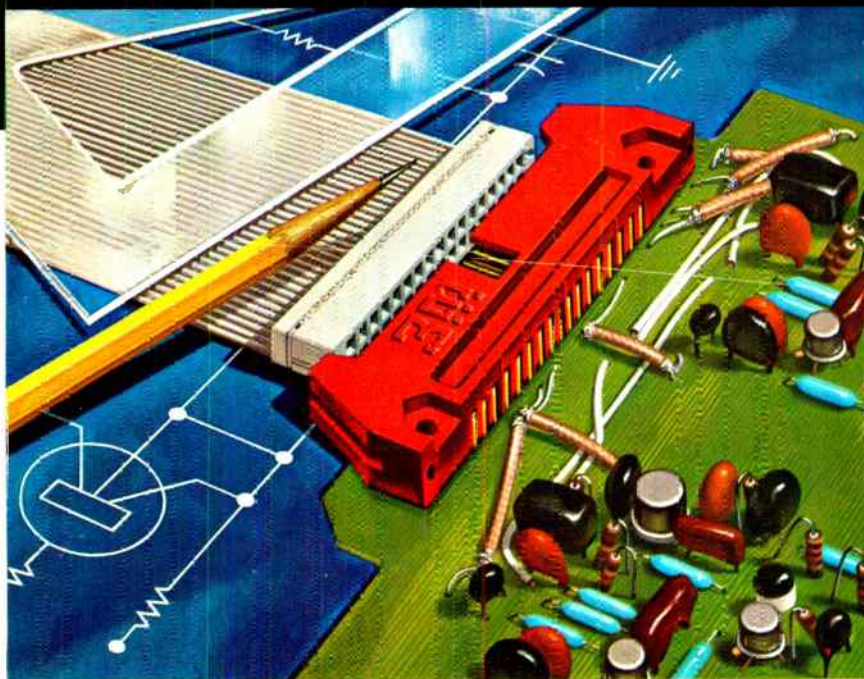
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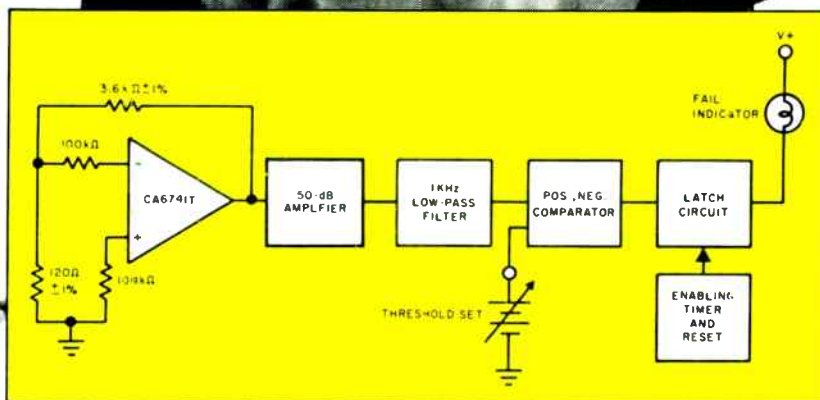
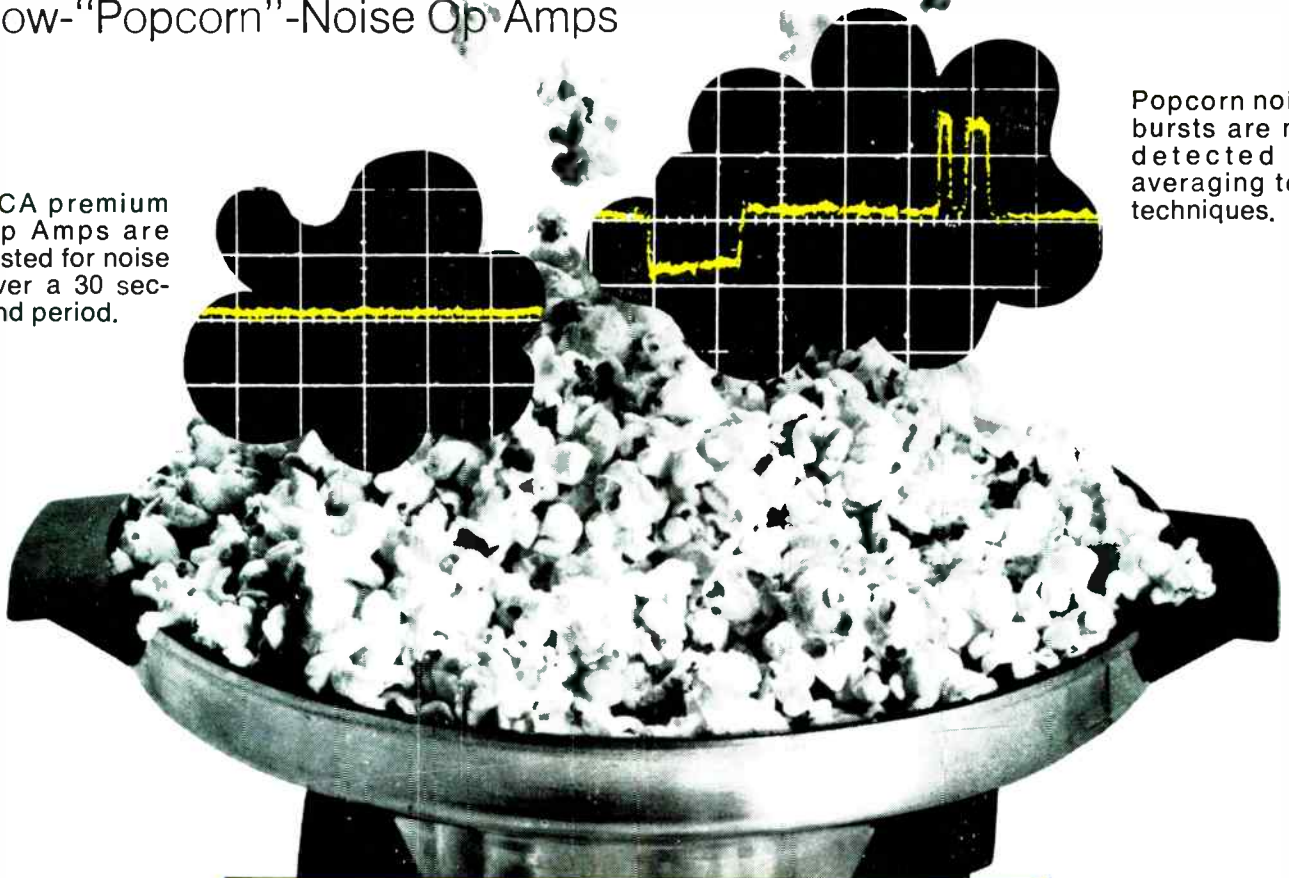
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