April 24, 1972

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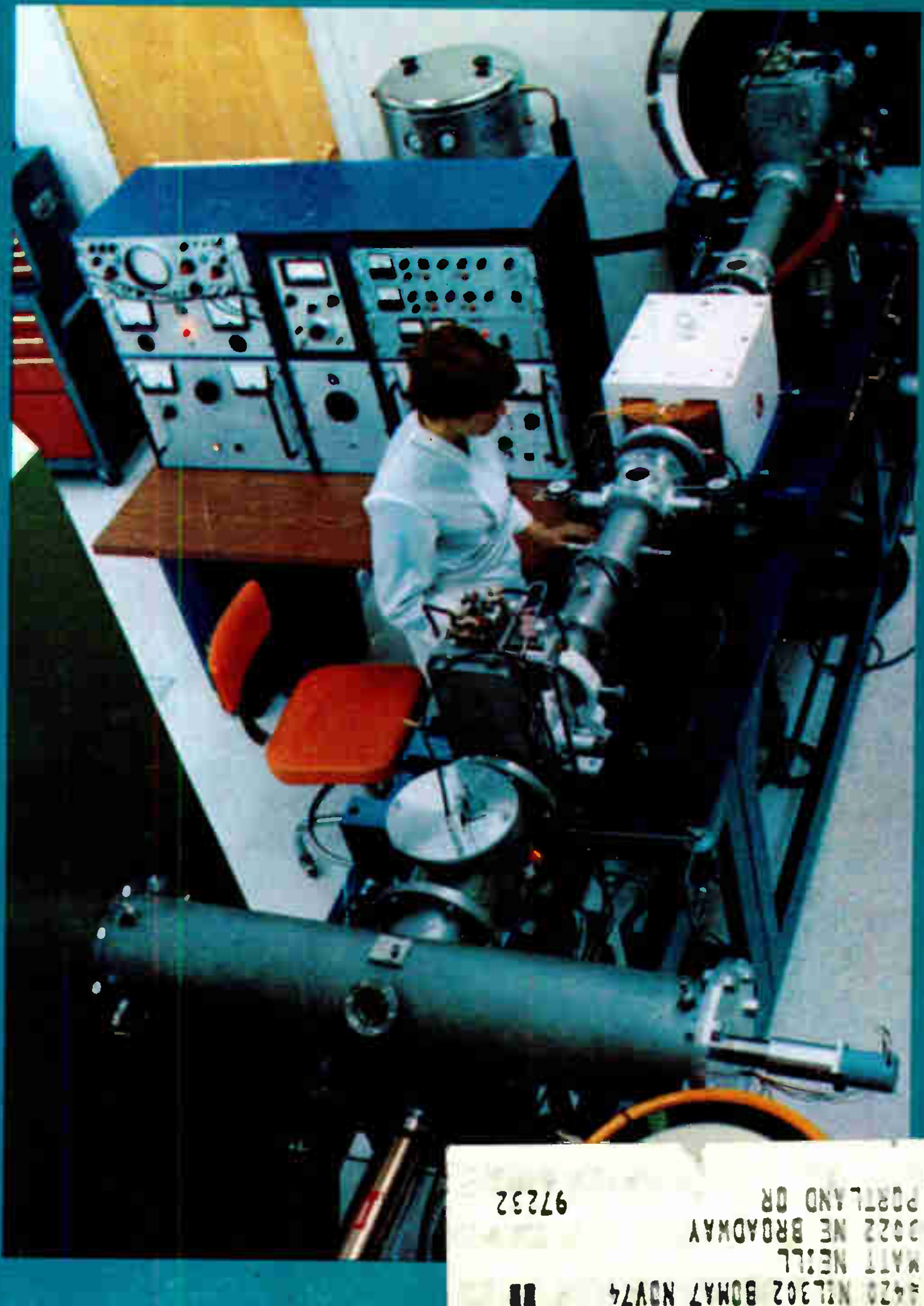

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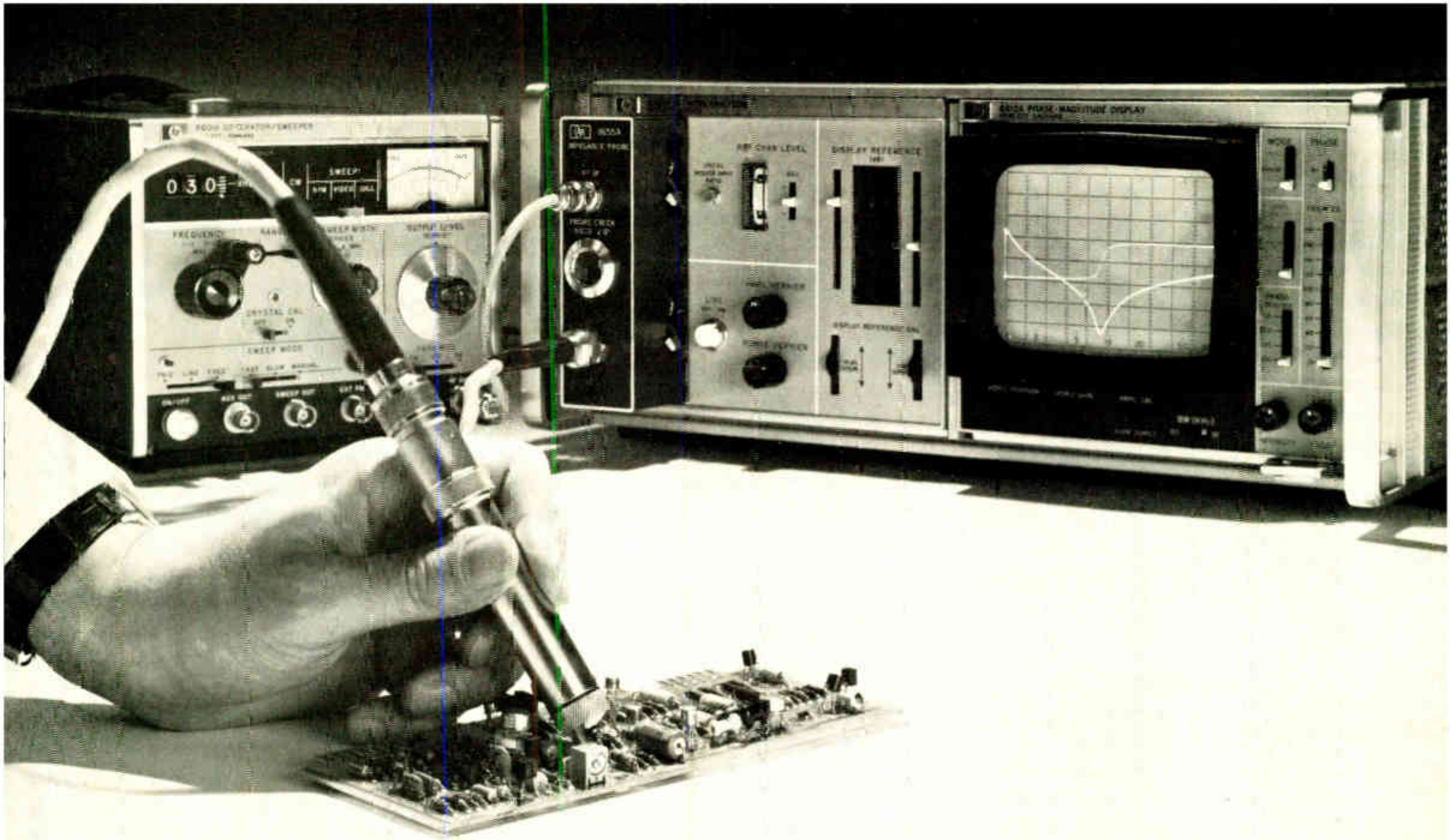

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Electronics

The International Magazine of Electronics Technology

April 24, 1972

Volume No. 45, Number 9

Highlights

New top brass polishes AT&T's image, 70
As the company's leadership changes hands, a reorganized chain of command—stressing service, relations with outside groups, and future planning—is Ma Bell's answer to mounting criticism of its position as a benevolent monopoly.

Frequency synthesizers tap new markets, 78
The price of frequency synthesizers is dropping as they take on applications—such as i-f component testing—where their high precision and ease of operation are useful but their costly high-resolution capabilities are not needed.

Ion implantation boosts MOS array output, 85
Depletion-mode devices can be made by simple fabrication processes. Ion implantation can add unique characteristics. Put together, the techniques are impacting memory and logic circuits by giving a 2-to-10-fold improvement in performance.

Compensating for changes in the speed of light, 91
In laser interferometry, variations in the speed of light, which is a constant only in a vacuum, can thwart precision measurements. Monitoring temperature, pressure, and humidity—and automatically correcting for changes—can cancel out the variations.

Custom design your own computer with chips, 112
Combining three standardized—hence mass-produced—chip elements and a fourth, customized, chip memory gives a low-cost minicomputer that the user can microprogram himself.

And in the next issue. . . .
Another look at CATV. . . . the rapid progress in n-channel technology. . . . what every engineer should know about patents.

The cover
What it takes to implant ions is a machine like this one, the Implanter I from Accelerators Inc. It's in operation at the Mostek Corp. See article on page 85.

Electronics

Publisher's letter

Instrumentation is in ferment. That's the word from Mike Riezenman, our editor covering the active field of instruments. Reflecting the fast pace of developments, for this issue alone Mike worked on two technical articles, reported and wrote on the rise of frequency synthesizers for the Probing the News section, wrote a new product preview, and covered a late-breaking story for the Electronics Review section.

"What impresses me is the wide variety of applications—from monitoring potentially dangerous electromagnetic radiation to the exotic world of laser interferometry that is tied together in this issue under the word 'instrumentation,'" says Mike.

For example, the automatic interferometer compensator detailed in the article on page 91 is really a miniature electronic weather station. It measures the microclimate in which the laser has to work, be it in a test lab or out on a machine shop floor. Since the speed of light is a constant only in a vacuum, knowing the exact temperature, pressure, and humidity of the air allows precise compensation to offset the variations they cause in the speed of light, and thus in the laser's wavelength.

And the solid state waveform display covered in the article on page 98 is in the vanguard of progress in another part of the instrumentation world—the visual presentation of measurements. This type of display, now being worked on at several European labs, may someday replace the cathode ray tube. "Although American companies think such displays will be a long time in coming," says Mike, "given the pace of progress in instrumentation they may be in for a surprise."

During the interviews that led to the report on AT&T's new top level organization (p. 70), the phone company's president, Robert D. Lilley, urged that executives appear more in public in "not-necessarily safe circumstances" in order to establish and strengthen communication with the public.

"Some businessmen can take on seemingly thankless and objectionable jobs in the community and establish valuable rapport," he commented. And he has done just that. In 1967, while he was president of New Jersey Bell, Lilley headed the Governor's Select Commission to Study Civil Disorder, particularly the events surrounding riots in Newark, N.J.—definitely a thankless job.

After six months of digging, Lilley reported to the governor, and he pulled no punches. The study bared widespread discrimination against Newark's blacks, and charged corruption in the city government. These disclosures brought the problems out into the open, leading to changes in hiring policy and, later, to a grand jury investigation that culminated in convictions.

To Consumer Editor Jerry Walker, who put together the article, Lilley may be the one who gets more AT&T executives to face the nation out in the open. On this point the new president remarked, "I've been immersed in the outside world. It's rough out there."

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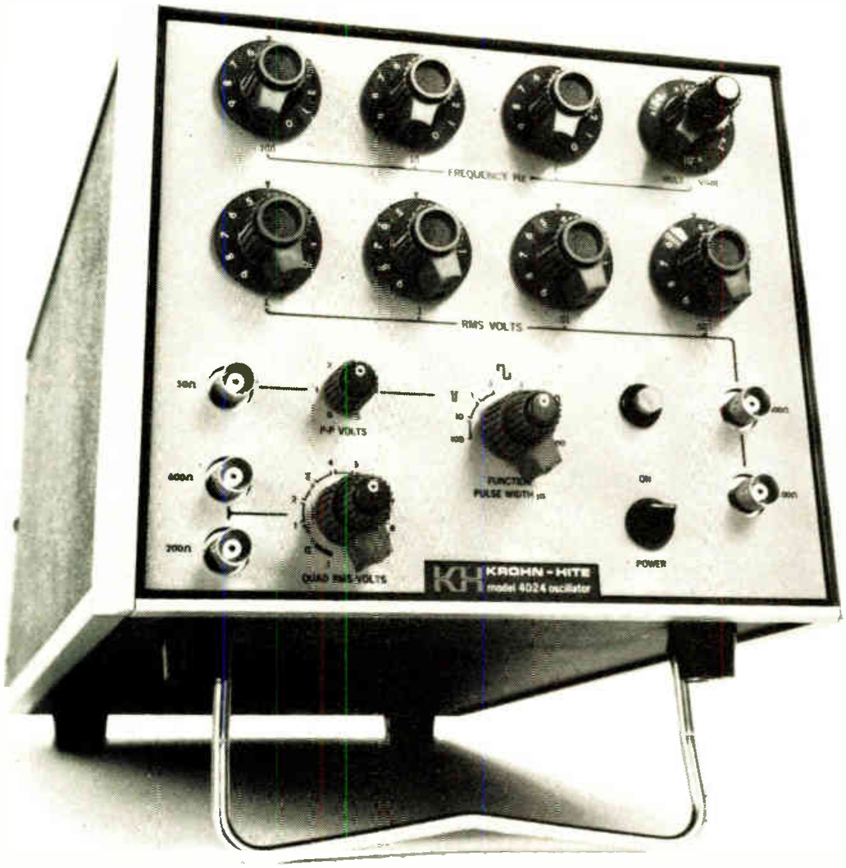

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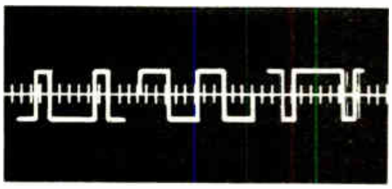
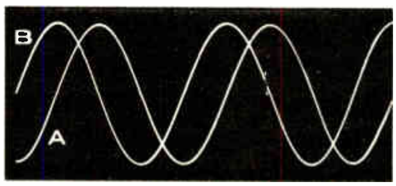


Square wave and pulse



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Readers comment

Diode costs challenged

To the editor: With reference to the Teledyne article by Dave Guzeman on diode switching matrices [Jan. 17, p.76], the first paragraph states, ". . . diode gates cost less than standard logic gates." The IN914 diodes have published prices of 14 cents each in 100 to 999 quantities, whereas a 7404 in the same quantities is listed at 57 cents each. With six gates per package, the integrated circuit is the more cost-effective.

In high volume, the difference is even more pronounced in favor of ICs; *i.e.*, the 7404 price is about 24 cents, or 4 cents a function, while the IN914 is about 6 cents. These are only the direct costs; obviously, the handling, testing, and insertion costs tilt the scale even more favorably toward the IC approach.

The practical designer would not use the IN914 if he were to use the diode-matrix approach. He'd use IN270s to maintain noise immunity. Furthermore, the sophisticated volume user (keyboards) would likely start off with a straight diode-transistor-logic or transistor-transistor-logic approach for breadboarding and then proceed to an MOS read-only memory for economy, space, and reliability.

It should be emphasized that noise immunity is not related to voltage alone, as is implied in the article. Rise and fall times, impedance, and energy content are equally important. Using standard techniques, we employ low-level logic in atmospheres of thousands of volts of noise with no effects.

Robert C. Foster
Rochester, N.Y.

■ *Mr. Guzeman replies: The IN914 is now available in volume for about 1½ cents, which shifts the advantage from ICs. Even after adding standard insertion costs in each of the diodes, they are still the cheaper devices.*

Mr. Foster apparently contradicts himself by saying that noise immunity is not related to voltage alone, but is tied into rise and fall times, impedance, and energy content. This is true; however it should be apparent that a noise source of several thousand volts that cannot supply current cannot be a problem. I am unimpressed by Mr. Foster's statement that he has used low-level logic in atmospheres of several thousand volts.

A logic circuit must dissipate power to offer power noise immunity. This forces the noise source to deliver current to the logic and pulls the high-voltage noise spike down to a level below the voltage threshold of the logic. MOS circuits, contrary to Mr. Foster's suggestion, do not dissipate power. Hence, it is doubtful that the user concerned with noise would switch to an MOS circuit that did not offer any power noise immunity.

Finally, Mr. Foster seems to have overlooked the fact that it is now possible to build systems with 3.5-volt guaranteed worst-case noise immunity with a power supply tolerance of ±1 V. One extra benefit is that use of this logic opens up other techniques such as diode switching matrices and second-level gating, not available to the low-level logic user.

Cal-Tex, not TI

To the Editor: In the Feb. 28 International Newsletter, the item concerning a Tokyo supermarket selling $87 and $129 calculators is correct. But it implies that Texas Instruments is supplying 12-digit single-MOS-chip calculators to Eiko Business Machine Co. and Crown Radio Corp. However, Cal-Tex Semiconductor Inc. is supplying the 12-digit one-chip calculator to Eiko.

Donald L. Brown
President
Cal-Tex Semiconductor Inc.
Santa Clara, Calif.

Scratch parylene

To the Editor: We appreciate your excellent coverage of the Access process in your Jan. 31 issue, but a slight problem has arisen from a miswording in the text.

The third paragraph contains the phrase, "including Union Carbide's parylene," as it lists materials which the Access process can remove. Union Carbide, among others, has found this comment interesting. Unfortunately, the Access process does not effectively decapsulate parylene.

Phoebe Williams
Amphenol SAMS division
Chatsworth, Calif.

40 years ago

From the pages of Electronics, April 1932

Like the poor, new tubes seem to be always with the radio industry. The approaching season is to be no exception for a number of new tubes is not only promised, or threatened, but some of them are on dealers' shelves—and as for the poor, the chances seem as good as ever.

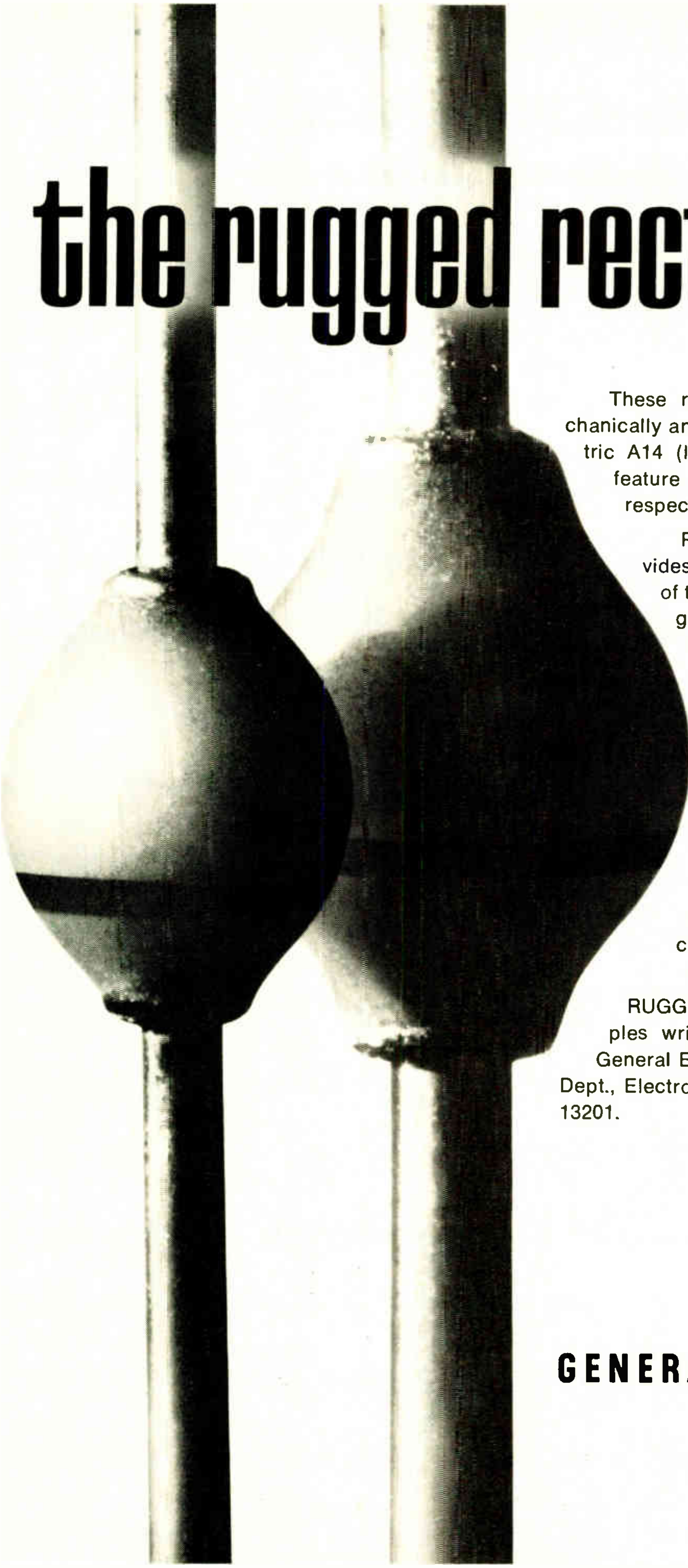
Class B amplification talk has crystallized suddenly with the announcement and introduction of a new tube (the 46) designed primarily for this purpose. It will deliver upwards of 10 watts, more or less undistorted, if anyone wants that much power. The attendant difficulties of poor regulation seem to be partially solved by the development and introduction of a new rectifier, a double-wave mercury-vapor tube (the 82) with low voltage drop.

On March 13 Professor Vladimir Karapetoff of the School of Electrical Engineering of Cornell University demonstrated before a University audience some new uses of the electric phonograph.

He played a Rachmaninoff prelude in which the phonograph took the place of the second piano, and also used a real piano in accompanying some vocal records. Some of the solos used were recorded on aluminum disks unaccompanied and specially made either by Professor Karapetoff or under his direction for use with a real piano. He also demonstrated a distant control by means of which he can regulate the pitch and the volume of a record while at the piano.

Scientists heard cosmic rays, silent messengers from the interstellar spaces, tick, during the annual meeting of the American Association for the Advancement of Science in New Orleans. The cosmic rays bombard the earth from every direction, but the heaviest shower comes from directly overhead. With his apparatus, Dr. Locher of the Rice Institute captured the cosmic rays in an electrified gas compartment. As the rays plunged through the gas, they set in motion electrical impulses which were translated into clicks by means of a loudspeaker.

the rugged rectifiers!



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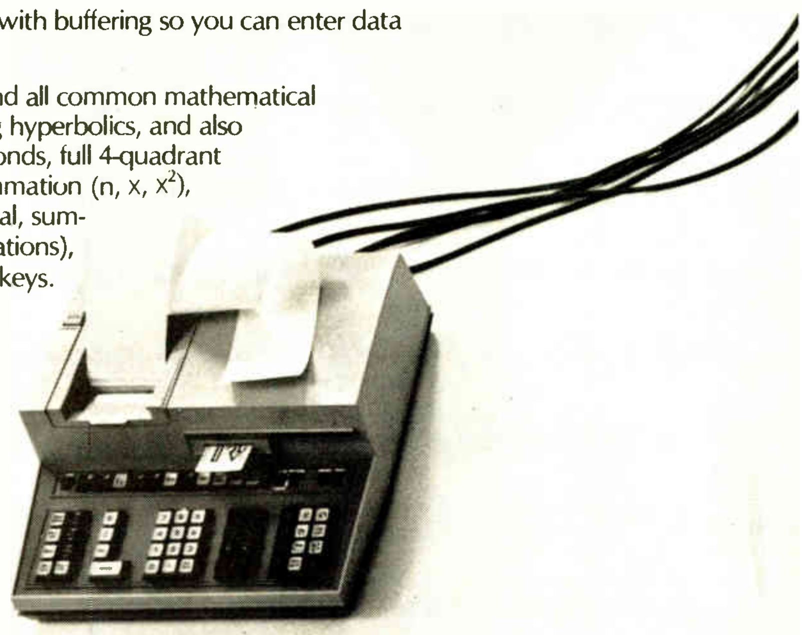

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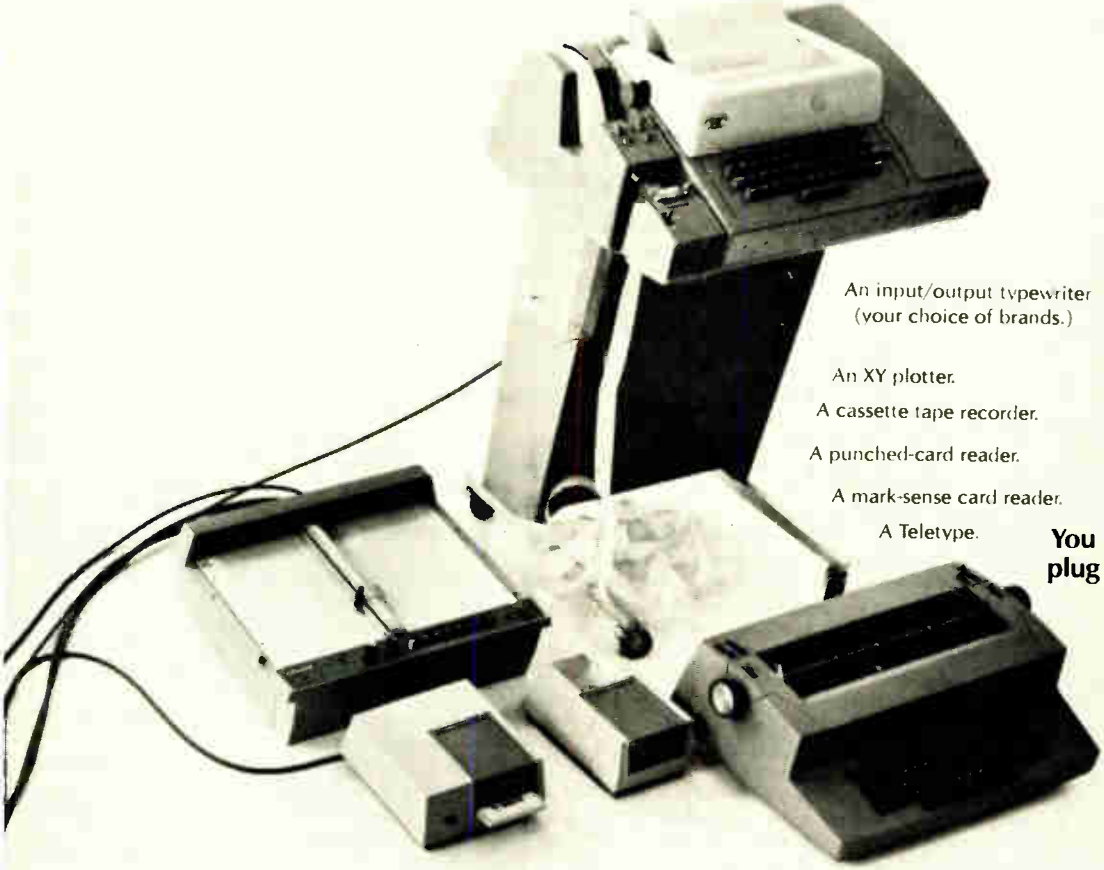

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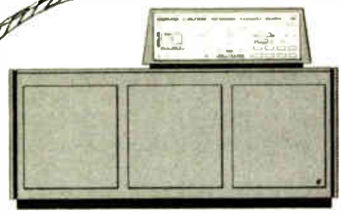

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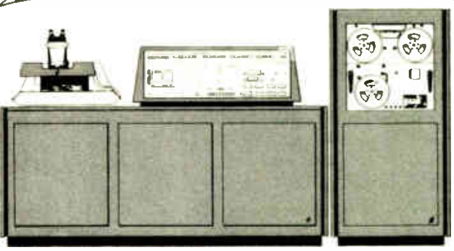

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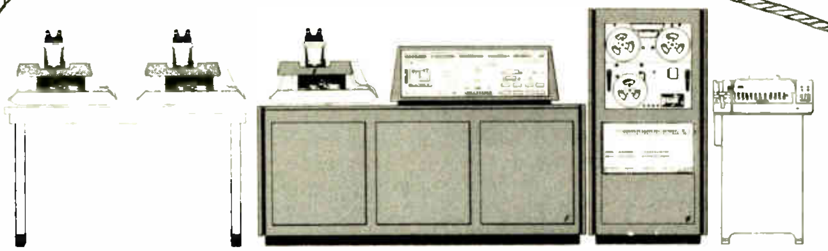
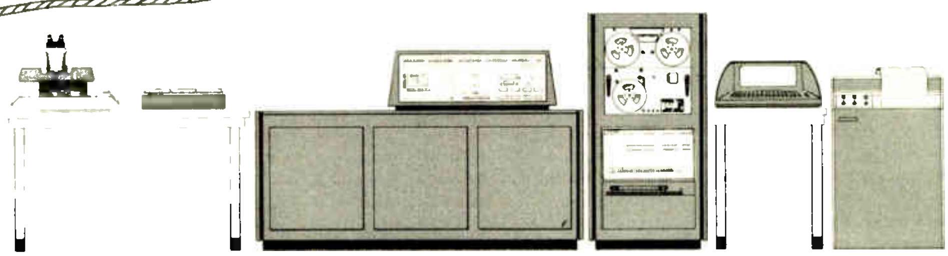
Ideal for engineering, pilot line or volume production testing of all LSI up to 48 pins with 40x1024 bit data channels per test head. The test head in the main frame may be used for device testing while the other head is simultaneously used for wafer probing. Comes read-to-go with paper tape reader, punch, and peripheral enclosure for an unbeatable performance/price ratio.



BRONCO BUSTER THREE-STATION SPARTAN 770 COMPUTER-AIDED PRODUCTION TEST SYSTEM . . . . only $120.9K
This is a real work horse combination that multiplexes three 24-pin, 20 data channel test heads each testing for both functional and DC parameters with different programs. Complete with 40x1024 bit memory, DEC PDP/11 Computer, tape reader and punch, TTY, peripheral enclosure and SPARTALK software for programming and test data logging.

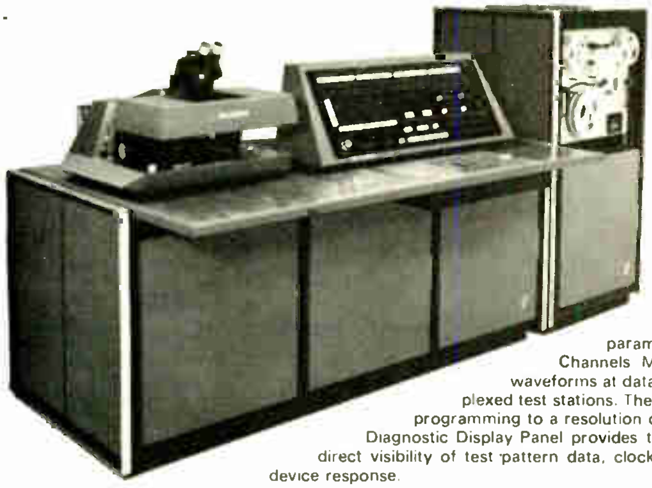


RANCH-MASTER TWO-STATION SPARTAN 770 COMPUTER-AIDED ENGINEERING CHARACTERIZATION TEST SYSTEM . . . . only $180.8K
This is truly a powerful combination that does just about everything you ask for in LSI testing up to 48 pins at nearly half the price of competitive systems. It includes such peripherals as the PDP 11 Computer, 1.2 million word disc, 300 line/minute printer, CRT terminal, tape reader and punch, and the SPARTALK software. Unlimited capability when it comes to data handling.

WATCH OUT... THIS BRAND IS HOT!

THE HI-PRICE LSI TESTING BIT!

SPARTAN 770



The SPARTAN 770 LSI Test System is a completely versatile and modular system lending itself to all applications of LSI testing of both MOS and Bipolar RAMs, ROMs, Shift Registers, and Logic in engineering, production, and quality inspection. The SPARTAN 770 is engineered and manufactured to the highest standards of quality and has an outstanding record of reliability and service-free performance in the field. The MODECON computer (Mode Sequence Controller) in the mainframe permits full automatic programming operation on either a stand-alone basis or with computer-aided capability utilizing the optional computer peripherals and SPARTALK software which provide for extended programming, data logging, and characterization. The standard SPARTAN 770 also features the high-speed Bipolar RAM memory and microprogrammer for the generation of an infinite number of complex test patterns required for any LSI device. Whether the system is used for wafer probe or automatic final test, the compact SPARTAN test head guarantees the measurement of both DC parameters and all Dynamic Functional parameters of LSI with up to 48 pins and up to 40 Input/Output Data Channels. Measurements are accurate to a resolution of 10 mv with clean waveforms at data rates up to 8 MHz and clock rates up to 20 MHz at all multiplexed test stations. The flexible clock and strobe system in the SPARTAN permits programming to a resolution of one nanosecond for each of six phases. The unique Diagnostic Display Panel provides the user with a "hands-on" analytical capability for direct visibility of test pattern data, clock timing, voltage levels, channel programs, and device response.

FROM THE FIELD-PROVEN SPARTAN 770 TEST SYSTEM, OUR WDC COWBOYS HAVE ROUNDED-UP A CORRAL OF LSI TESTER VALUES THAT'LL STEER THE COMPETITION TO THE NEAREST SALOON. WE'VE NOT ONLY ADDED BIPOLAR CAPABILITY, BUT HAVE MADE THE SPARTAN 770 SO MODULAR, THAT YOU CAN START OUT WITH OUR NEW "BIT-RIDER" AND LET IT GROW UNTIL IT RUNS THE WHOLE RANCH. BECAUSE OUR PRODUCTION IS STAMPEDING, WE CAN DELIVER MIGHTY FAST AT NEW, LOW PRICES. SO CALL OR WRITE FOR FREE LITERATURE OR C'MON DOWN FOR A REAL WESTERN DEMONSTRATION.

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Circle 13 on reader service card

People

NSF's Stever says science must be cost-effective

Science and technology would be used more to solve national problems if they were cheaper, asserts H. Guyford Stever, new director of the National Science Foundation. For example, the cost of computer systems will have to be reduced before they can contribute their great potential to education, he says.

"If we could get cost-effective computers in libraries, the whole electronics industry would benefit tremendously." While acknowledging that "the question is whether or not you can design a whole library

Stever: Science should give value for dollar.

with computers," Stever declares that "in pilot model experiments, the cost shoots up so much that people back off."

The same goes for computer-assisted instruction, Stever contends. "Instead of judging [CAI programs] on a cost basis, they're judged on the richness of the educational experience," he says. "That's a fair judgment, but CAI would go further if it were proven cost effective." NSF is instituting several experimental programs to ascertain if CAI can be made cost effective, the 55-year-old director says.

Instruments. NSF also must allocate money to upgrade scientific instruments, Stever states. "In the astronomy field, I have a strong feeling that we're not getting enough out of large-scale optical telescopes," he adds. "New image-enhancement equipment is needed," which means that "we support projects for optical telescope work and include money for equipment to achieve those goals."

Both problems are part of what he calls his "short-range challenge" of "getting scientific research and development turned around again and moving at a reasonable pace." Declaring that "the period of scientific affluence is over," he says, "the question comes to where does science relate" to a society beset with increasing external economic competition and internal social problems.

Although NSF's $700 million budget is a small slice of the $14 billion Federal R&D pie, Stever believes the foundation can lead by example in developing new programs. Science and technology have done a good job in solving some problems, he says, but "bridges to larger systems planning—such as in the urban area—have not been tackled. We've neglected to do all we can for the basics of life, the health area, clothing, and transportation." And one way is to become cost-effective, the scientist says.

Stever, formerly president of Carnegie-Mellon University, Pittsburgh, Pa., is no stranger to Washington. He has served as the Air Force's chief scientist, on the National Science Board, the advisory panel to the House Committee on Science and Astronautics, and on the President's Commission on the Patent System. Holder of a Ph.D. in physics from the California Institute of Technology, he gained national prominence in aeronautical engineering and space technology while at the Massachusetts Institute of Technology.

The tiger in NASA's tank

Rep. Olin E. Teague, the Texas Democrat who chairs the House Manned Space Flight subcommittee, will soon get another opportunity to demonstrate why his colleagues call him "Tiger." The issue before the 92nd Congress is the con-

(advertisement)

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

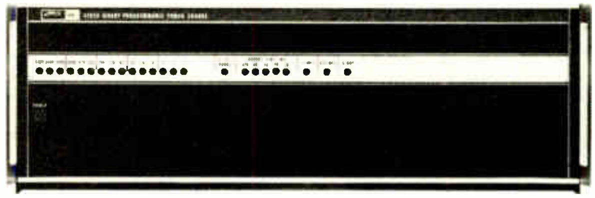
Have you ever needed just a little more current or voltage to test a new device? (Probably this slight extra capability is only needed for a very few tests.) With the 4200 Series Power-DAC, you can double, triple or quadruple your current or voltage capability by a simple parallel or series connection 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 μsec 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 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.



Model 4265A

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.

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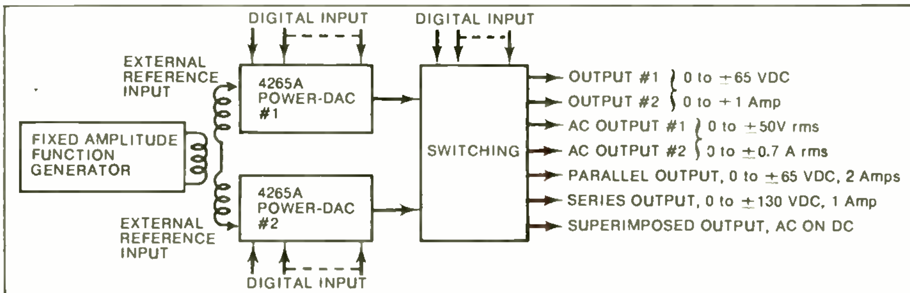

The 4200 Series POWER-DACs provide a wide range of automatic test system capability. With the equipment shown above, note the different types of output obtainable.

People

troversial $5.5 billion Space Shuttle, the vehicle with which NASA hopes to keep its manned program going beyond the final Apollo lunar mission next year. Teague, now sixty-ish, is an outspoken advocate of the shuttle program, and whether or not it makes it through the congressional maze in this election year will depend in good part on Teague's powers of persuasion.

Though Teague, like all consummate politicians, is well known for his affable, easygoing manner, it is his tenaciousness that shuttle opponents are likely to recollect best before the shuttle debate is over.

Opposition. Arrayed against Teague and his colleagues favoring the White House-blessed shuttle is an impressive array of scientists who see the program near the bottom of the list of national priorities. Where Teague supports the NASA view that the reusable shuttle will "remove the constraints imposed by an earlier level of technology" on spacecraft payloads and permit the civilian space program to "progress from adolescence to full maturity," opponents such as the physicist Ralph Lapp are arguing that shuttle payload cost projections now before the Congress are misleading.

Confident. Despite the formidable opposition to the shuttle and its heavy outlays for electronics, the Texas Tiger appears unworried about the prospects for the program. First elected to the House in 1946, Teague joined the Science and Astronautics Committee when it was formed in 1959, and quickly assumed an active role in the emerging space program. As subcommittee chairman he also oversees authorizations for Apollo, Skylab, and Space Station.

The extent of Teague's influence in the Congress is best described simply by noting his role as chairman of the Democratic Caucus, a title of no little significance that marks him as a politican's politician. Should the going get rough as the shuttle moves toward a vote this year, some observers suspect Teague may employ some of the leverage that post enjoys to round up sufficient votes.

What do you get when you cross a signal source with a calculator?

Automatic testing with HP's new 3330B AUTOMATIC SYNTHESIZER. In this one outstanding instrument, you get a flexible synthesizer, a top-performing sweep generator, and a precision level generator—all under digital control. Its built-in controller adds computer flexibility—you can forget about tying up an external computer for your automatic testing on the production line, and for the first time make this level of testing economically feasible in your lab.

For man-machine interfacing, 3330B's convenient swing-out keyboard, coupled with 9-digits of frequency and 4-digits of amplitude readout, gives you complete flexibility for setting up your test routines.

As a frequency synthesizer spectral purity is exceptional. Spurious is down 70 dB, and harmonics at least 40 dB below the carrier. Through its easy-to-use keyboard, you can, with 0.1 Hz resolution, set in any frequency between 0.1 Hz and 13 MHz, then automatically or manually increment (tune) that frequency by any amount. Each point has the synthesizer stability of $\pm$ 1 part in 10^8/day.

You can repeat the same automatic or manual sweeping operation with amplitude level. Its 100 dB range, 0.01 dB resolution and flatness of $\pm$ 0.05 dB make the 3330B a **precision level generator.**

Call on Model 3330B for your sweep generator needs, and you'll get performance levels of accuracy, linearity, and resolution never before available. That's because the internal serial microprocessor controls digital sweeping of synthesized frequencies or precise amplitudes. Through its keyboard and front-panel controls, you enter all sweep parameters—your 3330B takes it from there.

Systems Designers will find the standard 3330B fully programmable—ready for low-cost interfacing to other ASCII instruments and controllers, like marked card programmers, calculators, and computers.

Price? If you think about it, you would have bought a synthesizer, a sweeper, a marker generator, a counter, a programmable attenuator, and some computer time to come anywhere close to solving the same problems now done by the 3330B. At $6000 for a complete frequency lab, we think you'll agree that the price-performance ratio of the 3330B is great. (Model 3330A, priced at $5100, performs identically to the 3330B but has manual amplitude control and 13 dB range.)

For further information on the 3330A/B, contact your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

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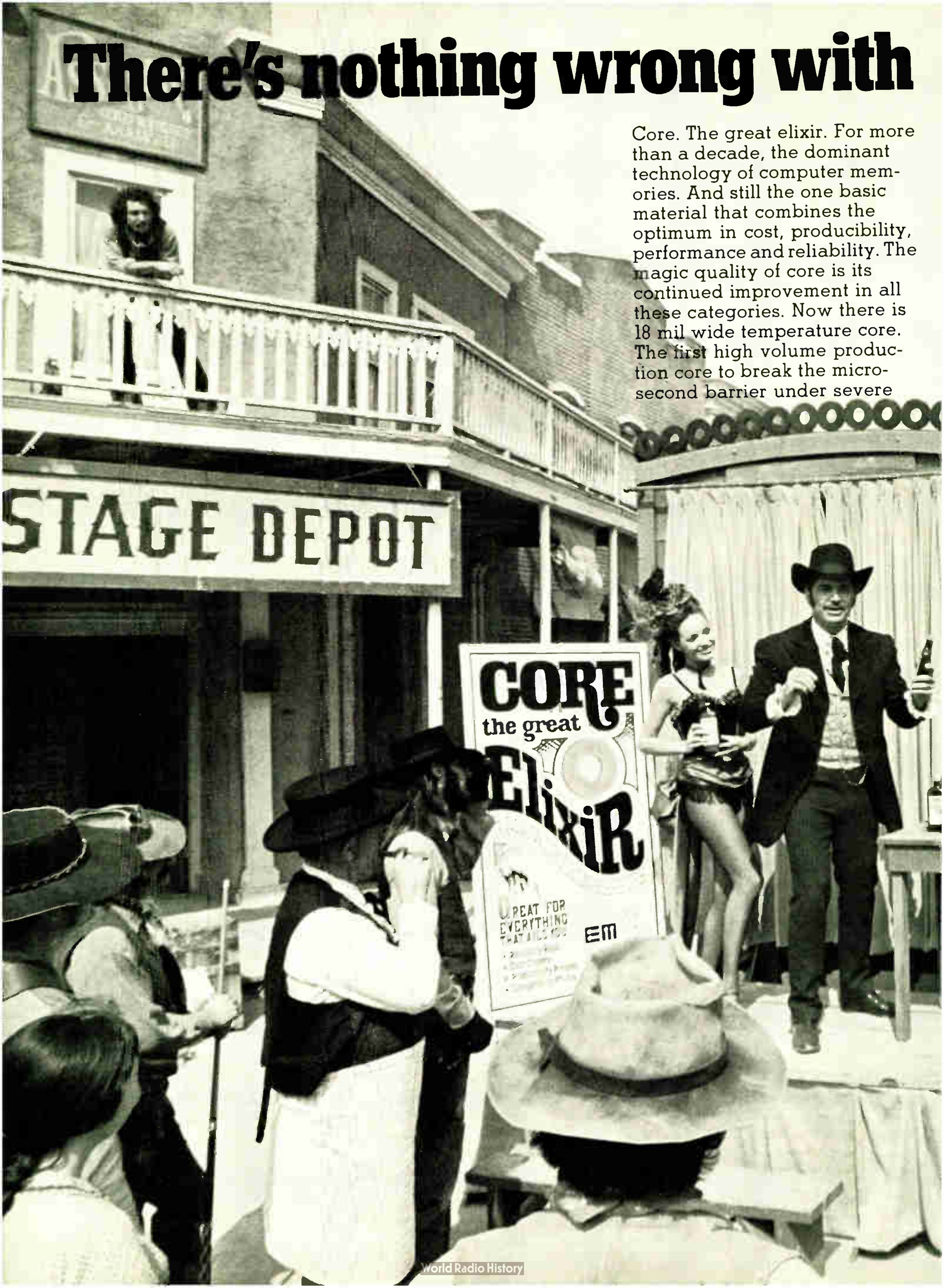
SIGNAL SOURCES

Circle 17 on reader service card

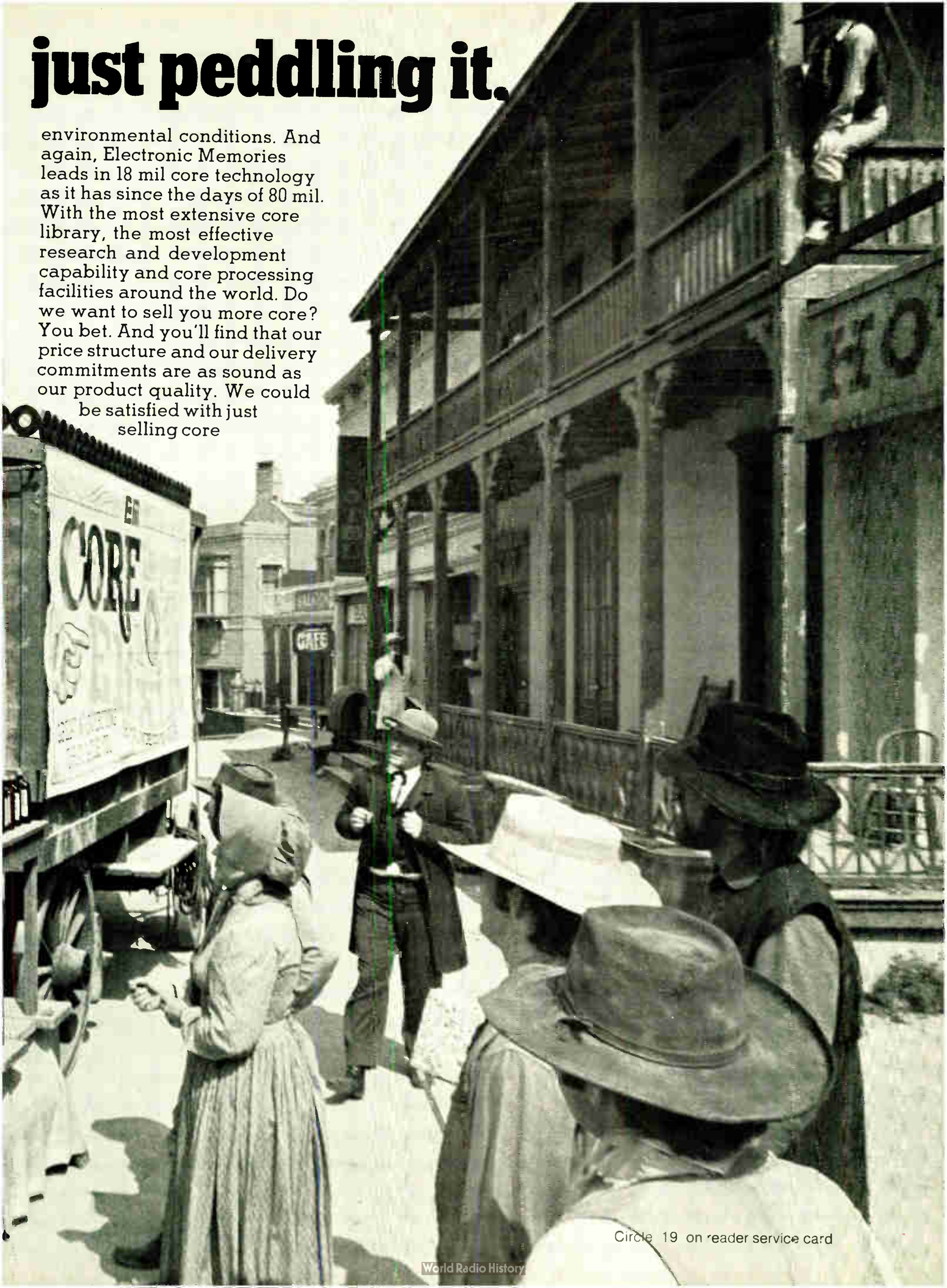
There's nothing wrong with

Core. The great elixir. For more than a decade, the dominant technology of computer memories. And still the one basic material that combines the optimum in cost, producibility, performance and reliability. The magic quality of core is its continued improvement in all these categories. Now there is 18 mil wide temperature core. The first high volume production core to break the microsecond barrier under severe



just peddling it.

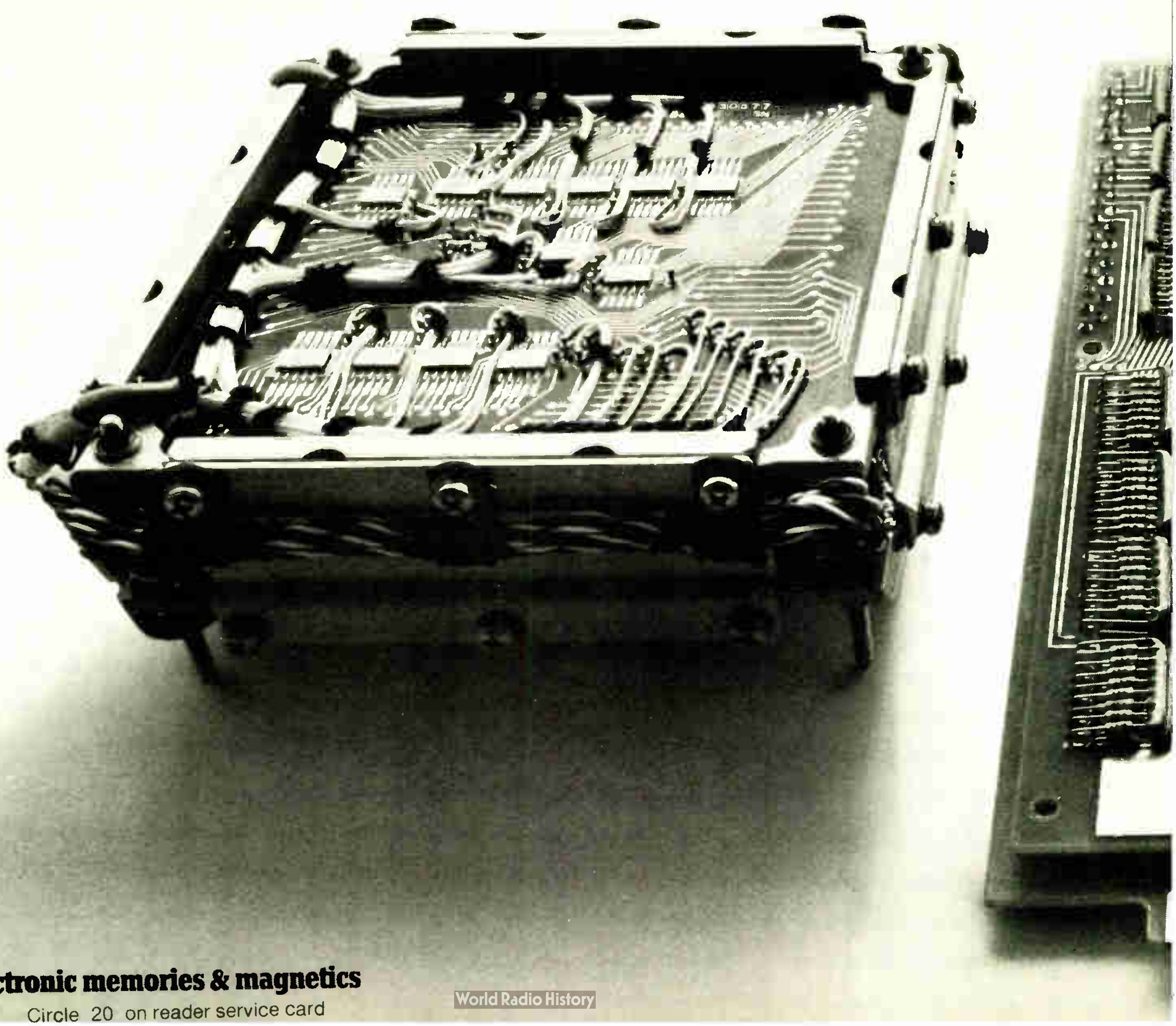
environmental conditions. And again, Electronic Memories leads in 18 mil core technology as it has since the days of 80 mil. With the most extensive core library, the most effective research and development capability and core processing facilities around the world. Do we want to sell you more core? You bet. And you'll find that our price structure and our delivery commitments are as sound as our product quality. We could be satisfied with just selling core



Circle 19 on reader service card

But when you take some

If you make the world's best 18 mil wide temperature core, you'd be foolish not to use it in your own products. And foolish we're not. So here are two new EM stacks based on 18 mil core technology, one for military applications, the other for commercial. *The M-18* is a militarized double-density stack that proves our accomplishments in 18 mil core and military packaging. With an operating temperature range of —55°C to 100°C, submicrosecond speed and a 16K word by 32 bit configuration, the M-18 meets all applicable severe environment specs of MIL-E-5400. Our exclusive finger contacts reduce the number of solder joints over conventional connections. Then there's the *EM2230*. A planar stack with our unusual "folded" design (similar to our successful 2220) and with a maximum capacity of 8K words by 18 bits. When everyone is looking for the most memory capacity per dollar, this stack has the potential

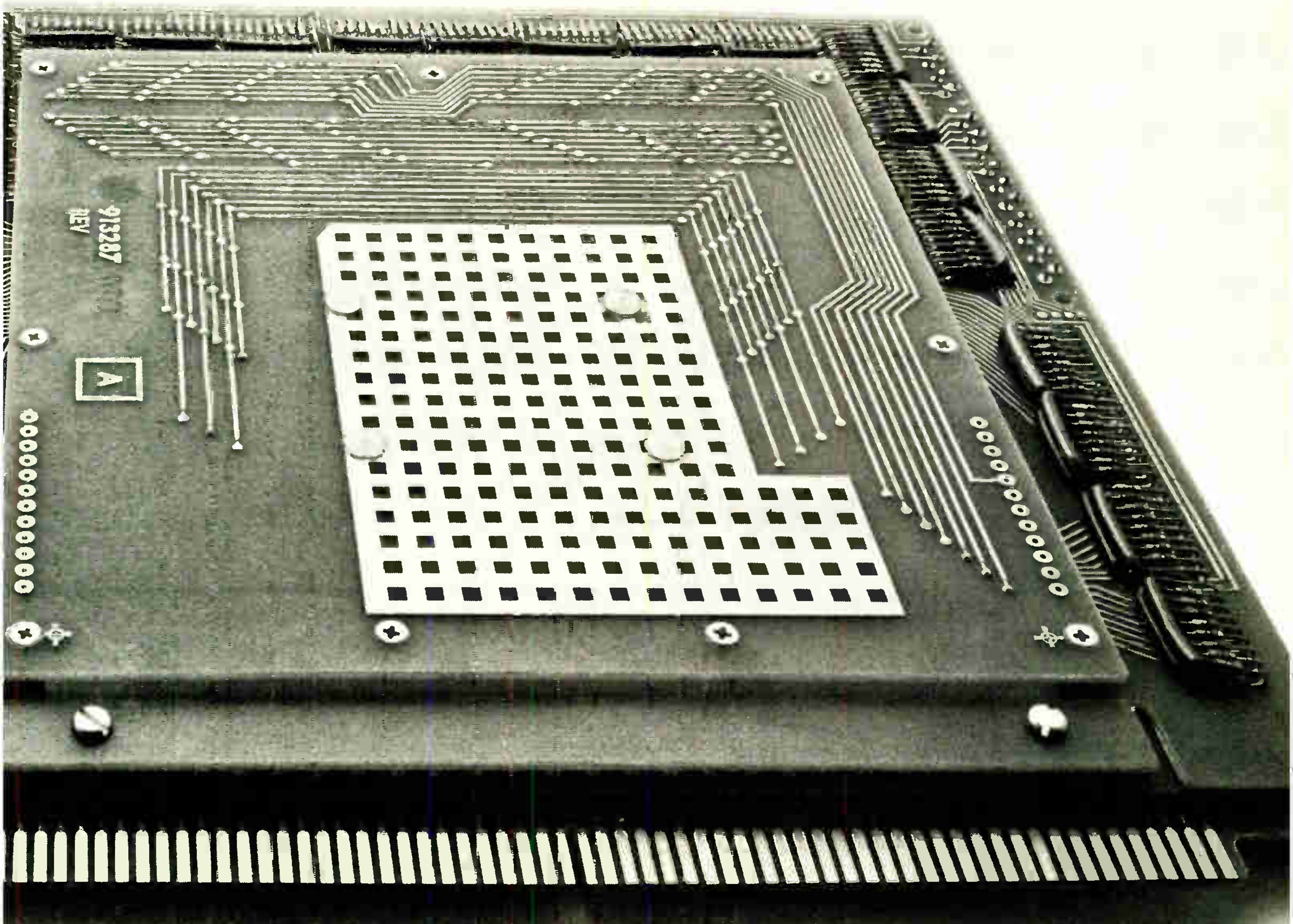


electronic memories & magnetics

Circle 20 on reader service card

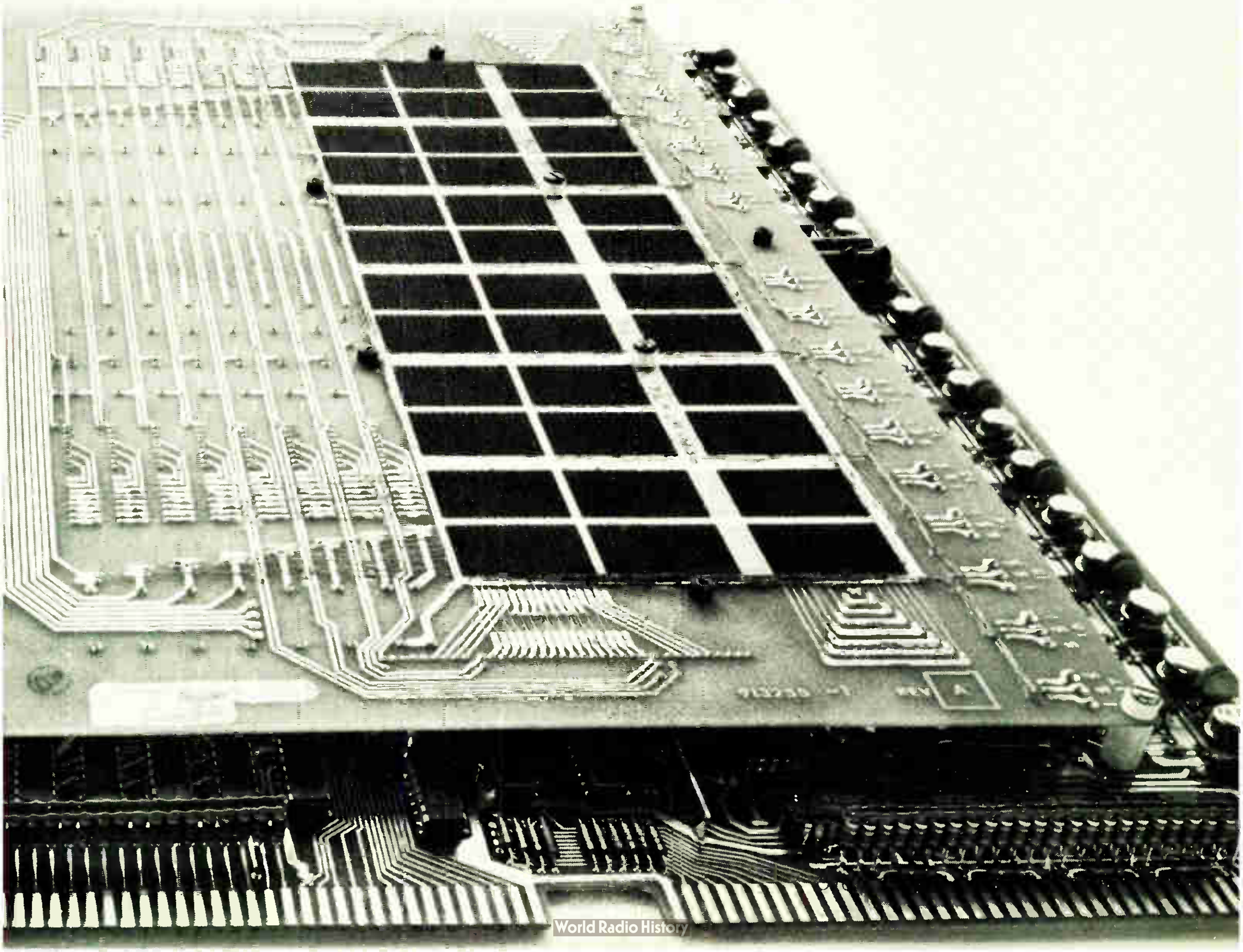
# of your own medicine

of giving you 16K in memory for less money and less space than you formerly needed for 12K. At 7½" x 8" (folded), it is small enough to fit all board sizes. Decode diodes are included and they're welded into clusters for easy assembling. By 1973, some of our competitors may be able to offer you competitive stacks. Meantime, we have taken our core technology and our stack technology and



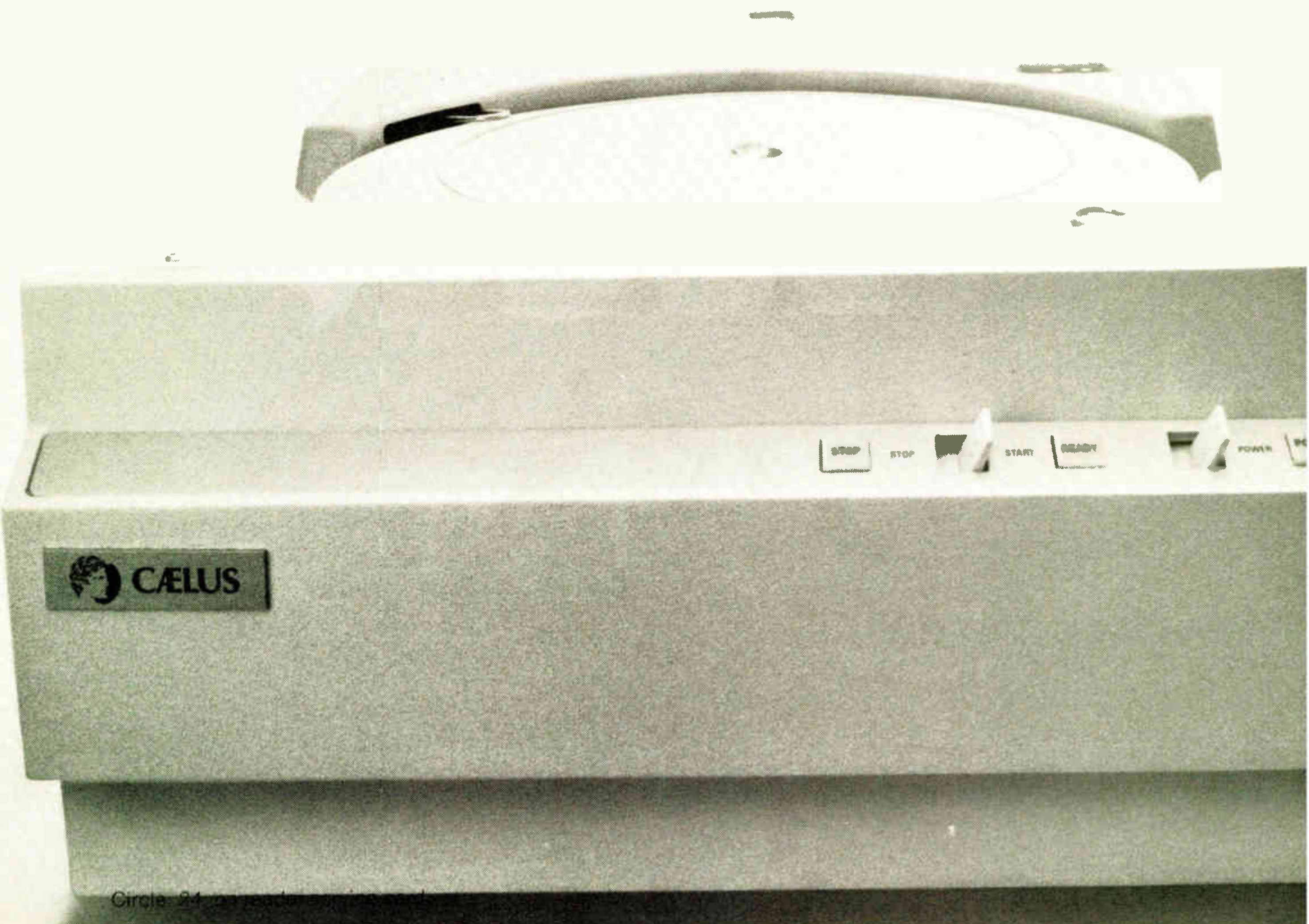
drive and sense circuitry. And it works off +5 V. only. As one example, our Micromemory 3000 features full cycle time of 650 nanoseconds and access time of 300 nanoseconds. Maximum capacity is 8,192 words by 18 bits per word or 16,384 by 9.

So far we've talked about new things that happen with core. But we're in the memory business. When your product interests encompass other media,



then you're ready for

That's why we've become the Memory Products Group of Electronic Memories & Magnetics Corp.: an integrated marketing force to serve you for all of EM's core memory products as well as Caelus disk drives and disk packs. Caelus. A name you know and trust as part of the EM family. Now an integral part of our multi-product offering to computer manufacturers. And here are two new stars in the Caelus line. First, the Caelus 303 disk file system: a big drive in a miniaturized package for small and medium size computers. Random access to 48 megabits in a package that's 8¾″ high. You can put four in a desk. There are two disks. One is fixed, and the other top loads just like the big systems or IBM Systems 3. Sixty milliseconds average access time. The Caelus 303 contains its own power supply and 0.3 micron air filtration system. And it can be configured to any OEM requirement. Finally, there's the new Caelus CMIII disk cartridge. Fully compatible with the IBM 5440, it provides 24 megabits of storage, 2200 bits per inch. Most important, it's ready to ship right now, and it comes with the trouble-free performance and service-



Circle 24

a family of memories.

in-depth that you've come to expect of any Caelus product. You say that's not enough? You say you want more? Tell you what we're gonna do: after you've read all eight, count 'em, eight pages of our important message, drop us a note and we'll send you a reward. Our own genuine old-time Memory Elixir poster (suitable for framing). The Sprightly Lass? We hope you already have one.

electronic memories & magnetics

Circle 25 on reader service card

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Meetings

National Telemetering Conf.: IEEE, Houston Shamrock Hilton Hotel, Houston, Texas, May 1-5.

Electrochemical Society Spring Meeting: Electrochem. Soc., Shamrock Hilton, Houston, Texas, May 5-12.

International Electronics Conf.: IEEE, AIP, OSA, APA, Queen Elizabeth Hotel, Montreal, Canada, May 7-11.

International Semiconductor Power Converter Conf.: IEEE, Lord Baltimore Hotel, Baltimore, Md., May 7-10.

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

Aerospace Electronics Conf.: IEEE; Sheraton Dayton Hotel, Dayton, Ohio, May 15-17.

Electronic Components Conference: Electronic Industries Assn., IEEE, Statler-Hilton Hotel, Washington, D.C., May 15-17.

International Microwave Symposium: IEEE, Arlington Park Towers Hotel, Chicago, May 22-25.

Power Sources Symposium: Army Electronics Command, Shelburne Hotel, Atlantic City, N.J., May 23-25.

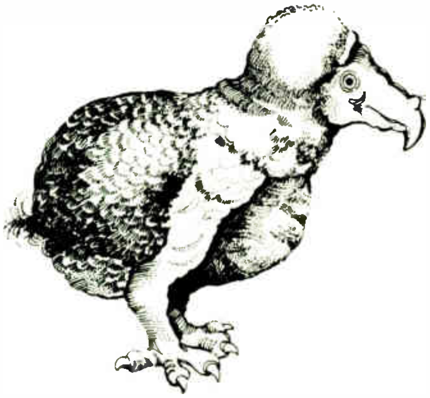
International Transportation Exposition/Congress of Transportation Conferences: FAA, SAE, IEEE, etc., Dulles Airport/Sheraton Park, Washington, May 27-June 4.

International Switching Symposium: IEEE, MIT, Cambridge, Mass., June 6-9.

Spring Conference on Broadcast & Television Receivers: IEEE, Marriott Motor Hotel, Chicago, Ill., June 12-13.

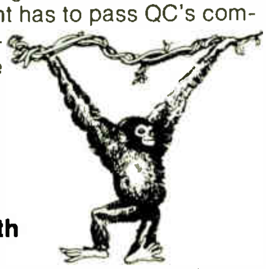
International Conference on Communications: IEEE, Marriott Motor Hotel, Philadelphia, Penna., June 19-21.

Evolution and the function generator



Lessons from the Dodo
IEC, in building its high-quality, low-cost Series 30 Function Generator, learned from the mistakes of others. (Yes, the industry has had its Dodos.) We knew that only a strong, highly reliable unit would survive, so we developed our compact, hard-working 0.3Hz-3Mhz Series 30 accordingly.

Performance and quality are built into the unit right from the beginning. Interstate Electronics Corporation's independent QC lab puts every Series 30 semiconductor through a rigorous performance test before production acceptance. Then, after Unit Testing, Calibration, Burn-In, and Stress Cycling, each instrument ticketed for shipment has to pass QC's computerized Assurance Test before it goes to our customer.



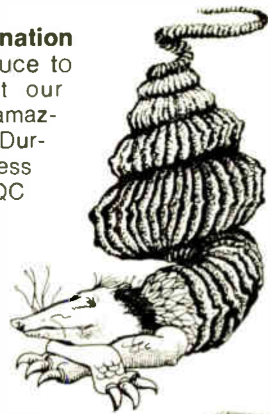
Monkeying with Ontogeny
The Unit Test is the first evaluation to identify and correct operative problems in the working instrument. Each of Series 30's versatile outputs, including variable Width Pulse, Sweep Sawtooth, Adjustable D-C Level, and Sine, Square, and Triangle waveforms are scrutinized for pure, consistent performance up to 20V p-p. In addition, our direct-reading Sweep Limit, 40-db Calibrated Attenuator, and other controls are handled for "feel" as well as accuracy.

During Calibration, Trigger, Gate, Burst, and Sweep Modes are given full play. By such critical inspections, we learn more about the instruments we make, and the product species as a whole is improved.

IEC actually over-calibrates to reach an exceptional quality of performance. While we spec a respectable 0.3% sine distortion, our generators typically achieve 0.18%.

Loss of the Sixth Toe
As part of the stress Cycle, we developed a "Shake 'n Bake" test that jolted and jarred Series 30 prototypes, then operated them in a 70°C. heat chamber. We still burn-in each Series 30 generator, but after extensive Unit Tests without a vibration failure, the "shake" cycle was declared obsolete.

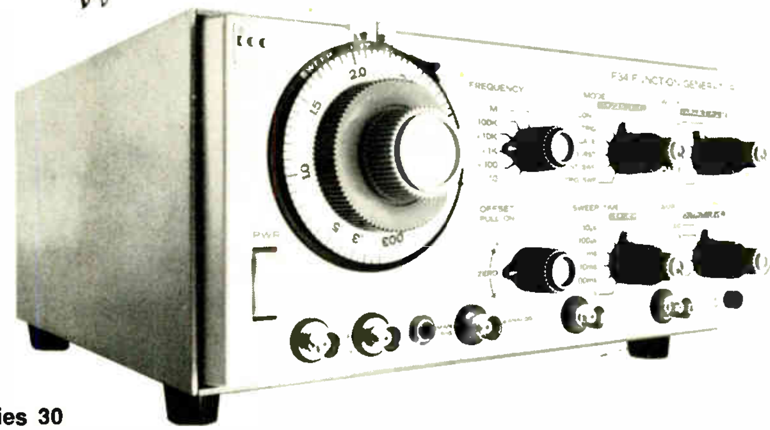
Mutation Elimination
We don't produce to MIL-SPECS, but our procedures are amazingly close to it. During four in-process inspections, a QC team checks everything from each solder joint to screw mounts, rejecting the slightest imperfections. We expect each Series 30 unit to evolve exactly as specified, with absolutely no mutations.



Survival of the Fittest
After calibration, the Series 30 generator undergoes a minimum 120-hour "mileage" test. We turn each instrument on and off at irregular intervals during this stress cycling to simulate real-world strain, and our exclusive Output Limit Indicator glows to confirm that the Generator is operating under stress.

Following this, all instruments are processed by a final automated lab system. At this point the Function Generator *must* continue to perform precisely, with an exacting degree of conformity and predictability. Only by surpassing the highest standards of the species does the Series 30 survive in the field, and enjoy the lowest return in the industry.

We're ready to back up our claims. Go ahead . . . call John Norburg, collect, at (714) 772-2811, and ask for a demo!



F34 . . . $495

5 Other Models available in Series 30 From $295 to $695

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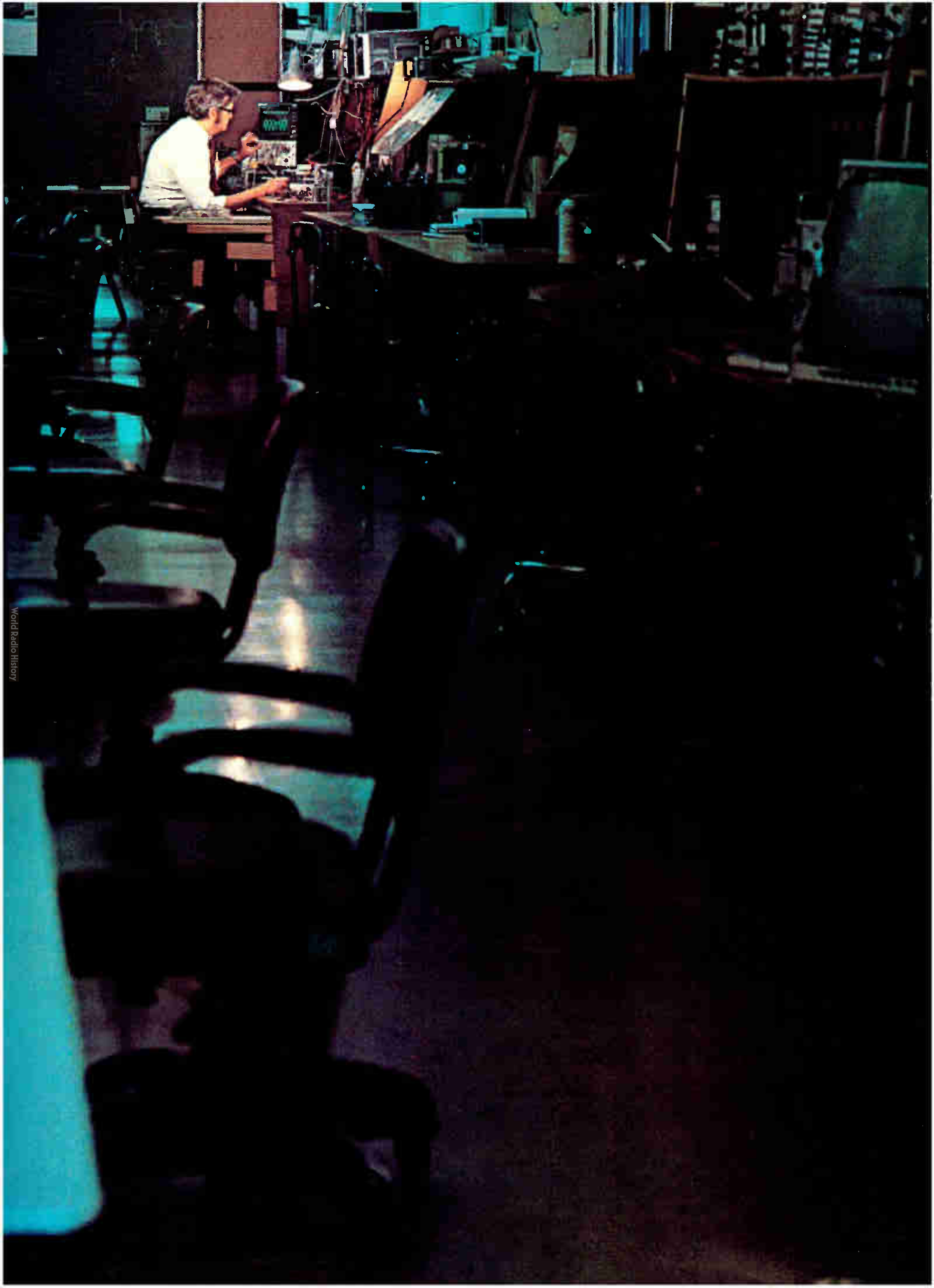
Circle 27 on reader service card

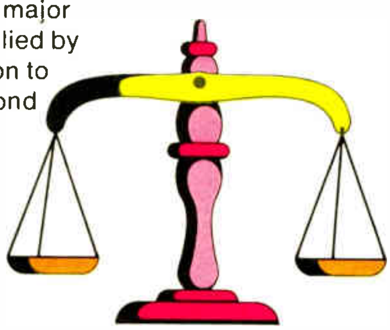


SPEED vs.

The one-nanosecond conundrum.

Schottky or ECL 10,000? How should you commit your engineers, your plant, your production, to get the faster logic that your next system will require?

It's a tough choice. Both major logic families volume-supplied by Signetics can be counted on to boost speed levels far beyond standard TTL. With each offering its own unique advantages, each with built-in drawbacks (sometimes more psychological than real).



PARAMETER	TYPICAL VALUES 74S/82S	TYPICAL VALUES ECL 10,000
Propagation Delay (per Gate)	3ns	2ns
Power Dissipation (per Gate)	20mW	25mW
Positive Volt. Supply (+V)	+5V	0V
Negative Volt. Supply (−V)	0V	−5.2V
Logic "1" Level	+2.7V	−.9V
Logic "0" Level	+0.5V	−1.8V
Output △V/△T	1V/ns	.25V/ns

Hands down, ECL 10,000 beats out Schottky 74/82 in performance—delivering the best high speed/low power trade-off yet. But the crucial question facing users: just how critical to your individual designs is that one extra nanosecond knocked off by ECL?

Unless you're into super scale or large scale computers, which have always utilized ECL's maximized performance, there's no pat answer to the question.

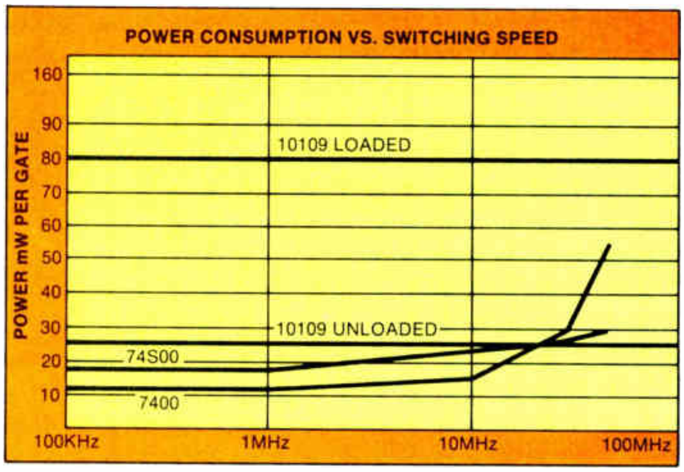
You have to balance where you've been, and where you're going, with a careful probing of both technologies.

For all practical purposes, 74/82 Schottky is third generation TTL enhanced to allow the designer to increase his system speed by replacing present TTL circuits with their Schottky equivalents. Signetics uses a 3 micron epitaxial film thickness to produce extremely small geometries. Combining small geometries with Schottky diode clamped transistors results in optimized T^2L performance plus remarkable high-density MSI capability. Since gold doping is no longer required, you get higher betas—making PNP transistors available for innovative circuit ideas. All Signetics 82S circuits use PNP transistors to reduce input loading, to insure that fan-out rules are not violated when upgrading existing systems.

Schottky TTL is compatible with standard TTL circuits, with logic rules familiar to the vast majority of engineers. That's the good news.

The bad news: wiring rules may become more stringent due to the sharper signal edges of Schottky TTL compared to standard T^2. Careful attention must be paid to PC board geometries and line terminations, as with 74H type circuits. And, of course, there is that one nanosecond difference in gate delay.

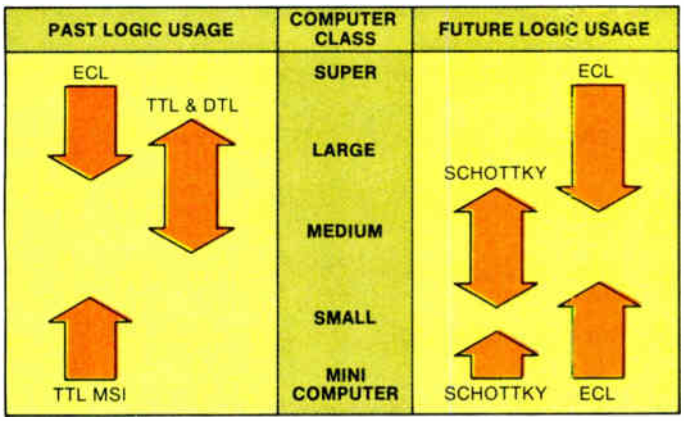
ECL 10,000 will drop propagation delay from 3 to 2ns per gate. With MSI frequently twice as fast. But it takes more than speed to make 10K so desirable.



SPEED

The constant current nature of ECL 10K is obvious. Properly loaded ECL gates show very flat power dissipation. This flat power curve means greater ease of power distribution. And the difference between loaded and unloaded curves offers termination freedom: this choice of resistor helps immensely in reducing internal dissipation to allow higher functional densities. ECL combines remarkable design/function flexibility with significant savings in gate and package count.

A fear of the unknown appears to be the key stumbling block to ECL. Probably the prime concern is the relative unfamiliarity with the NOR/OR logic. The system engineer or manufacturer often feels he has enough on his hands mastering the new usage techniques of 74/82 Schottky, where the basic logic is still TTL. Learning to cope with the sharp edge speeds of faster logic is one thing. Being forced to learn a whole new logic besides... that's often the last straw. Is one extra nanosecond worth it? Only you, the user, can tell.



Put yourself in this picture. Match usage to computer category. Match speed requirements to your own best interests, recognizing that the entire industry is trending toward ever-higher speeds. And before you commit to either Schottky TTL upgrading, or a switchover to ECL, consider both alternatives carefully.

74/82 Schottky. Or ECL 10,000. Signetics gives you both ways to go.

SCHOTTKY 82S MSI	
82S30/31/32	8-Input Digital Multiplexer
82S33/34	2-Input, 4-Bit Digital Multiplexer
82S41/42	Quad Exclusive-OR/Quad Exclusive-NOR
82S50/52	Binary-to-Octal/BCD-to-Decimal Decoder
82S62	9-Bit Parity Generator and Checker
82S66/67	2-Input, 4-Bit Digital Multiplexer
82S70/71*	4-Bit Shift Register
82S90/91*	Presettable Decade/Binary Counter
SCHOTTKY TTL 74S	
74S00	Quad 2-Input NAND Gate
74S03	Quad 2-Input NAND Gate (Open Collector)
74S04	Hex Inverter
74S05	Hex Inverter (Open Collector)
74S20	Dual 4-Input NAND Gate
74S22	Dual 4-Input NAND Gate (Open Collector)
74S112*	Dual J-K Edge-Triggered Flip-Flop
74S113*	Dual J-K Edge-Triggered Flip-Flop
74S114*	Dual J-K Edge-Triggered Flip-Flop
74S40*	Dual 4-Input NAND Buffer
74S140*	Dual 4-Input NAND Line Driver
ECL 10,000	
10101*	Quad 1-Input OR/NOR Gate
10102	Quad 2-Input NOR Gate
10105*	Triple 2, 3, 2-Input OR/NOR Gate
10106*	Triple 4, 3, 3-Input NOR Gate
10107	Triple 2-Input Exclusive OR/NOR Gate
10109	Dual, 4, 5-Input OR/NOR Gate
10110	Dual 3-Input 3-Output OR Gate
10111	Dual 3-Input 3-Output NOR Gate
10112	Dual 3-Input 1-OR/2-NOR Gate
10113*	Quad Exclusive -OR Gate/Comparator
10115*	Quad Differential Line Receiver
10116	Triple Differential OR/NOR Line Receiver
10117	Dual 2-wide 2, 3-Input OR-AND/OR-AND Invert Gate
10118	Dual 2-wide 3, 3-Input OR-AND Gate
10119	4-wide 4, 3, 3, 3-Input OR-AND Gate
10121*	4-wide 3, 3, 3, 3-Input OR-AND/OR-AND Invert Gate
10131*	Dual D-Type Master-Slave Flip-Flop
10161	1 of 8 Demultiplexer/Decoder (Low)
10162	1 of 8 Demultiplexer/Decoder (High)
10170*	9 + 2-Input Parity Circuit
10171*	Dual 1 of 4 Demultiplexer/Decoder (Low)
10172*	Dual 1 of 4 Demultiplexer (High)

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☐ Please rush us your technical booklet comparing Schottky and ECL 10,000 in detail.

☐ Send parts lists, pricing and data sheets on both lines.

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Circle 31 on reader service card

Electronics newsletter

AMI selling liquid crystal displays as standard wares

American Micro-systems Inc., Santa Clara, Calif., has entered the liquid crystal display business full bore. The firm has frozen its process and **is now turning out about 1,000 displays per month.** The output is expected to increase to 20,000 a month by September, when a new character printer is to be installed. The first standard products are a four-digit clock display with a.m. and p.m. indications, and a 3½-digit panel meter display with ac, dc, ohms, and polarity indications. The clock characters are 0.75 inch high, and the panel meter characters measure 0.6 in. high; **they are under $12 each in lots of 100.**

With the AMI process, either reflective or transmissive displays can be produced. Power supply requirements are 12 to 24 volts dc at 3 microamperes per square centimeter of active area. Operating temperature range is 10° to 90°C, and response time is about 40 milliseconds. **"We are with liquid crystals now where we were with MOS in 1967—we've built prototypes, have documented the process, and are going into production,"** says Warren Wheeler, president of the Micro-products division of AMI.

Data General making in-house peripheral

Data General Corp. is introducing its first in-house peripheral device—a fixed-head disk storage unit. **Previously, disks and other peripheral equipment available with Data General's Nova computers were made by other companies** and marketed by Data General as an original-equipment manufacturer. Like all fixed-head disks, the new unit will have a respectable access time and an unusually large capacity.

Motorola mapping rf, microwave push

Motorola Semiconductor, banking on increased civilian activity in the face of dwindling Government support for rf and microwave component work, **is preparing a large investment in that sector.** The big Phoenix, Ariz., components maker is about to bring out a line of hybrid amplifiers for the consumer and communications markets.

The first product, an rf amplifier for use as a line extender in cable television, will be announced in May or June. Other devices in Motorola's product plans include rf amplifiers and gain blocks for mobile radio, high-power modules in the 5-to-225-watt range, and hybrids operating in the 1.7-to-2.2-gigahertz range for microwave links.

Motorola's move completes the entry of the big three into the business. Fairchild announced a series of CATV hybrid amplifiers two years ago, retaining the line as it sold some of its microwave system capability. Texas Instruments has been building hybrid modules in England for mobile and airborne transmitters for about a year.

U.S. firms at Paris do good business

Even though 47 of them were permitted to pack into one U.S. Department of Commerce booth—to the resentment of Europeans—American firms at the Paris Components Show **took in $350,000 in firm orders.** Moreover, they report a forecast of $8.5 million in additional sales in Europe over the next 12 months, based on their Paris contacts. Eighteen of them signed up agents on the spot, and negotiations with 163 other agents are under way for representation in Europe.

The good business at the crowded American booth appears to be part of a trend. **Major exhibitors at the show report clear evidence of a turnaround on their European sales for the first quarter of this year.** Even the semiconductor makers are talking about a "ray of sunshine." Says Motorola's European field sales manager, Monroe Maller, "We have a fairly clear upturn, and we expect to see real momentum."

Use of package underside eased by du Pont paste

E.I. du Pont, which has been urging semiconductor manufacturers and users alike to put thick-film circuits on the undersides of LSI packages, has an easier way to do it. The chemicals giant has been pushing the technique as a way to cut the assembly costs of outboarded components, and now its Electronic Products division has come up with a **platinum metalization paste that won't oxidize in the thick-film firing furnace.** This means that the new thermal pulse-bonding machines can be used to bond a lead frame to metalization pads along the edge.

According to John C. Cox, packaging manager of the Wilmington, Del., division, it works this way: the thick film conductive and resistive patterns are screened and fired, discrete components are added, and the lead frame is bonded. This isn't possible when the lead frame is brazed **because of high temperatures required for the operation.**

H-P pulls out of SJCC, asks a single show

The Spring Joint Computer Conference is the latest large show to feel the chill from equipment manufacturers. The 1972 edition of the Spring Joint, starting May 15 in Atlantic City, has some conspicuous absentees. Not only are Digital Equipment Corp., Honeywell, and Burroughs (except for its components division), Interdata, and Varian joining IBM among the missing, **but Hewlett-Packard has pulled out.**

Says H-P's Russell Berg, manager of corporate marketing communications: "We no longer can absorb two computer conferences in one year." **H-P suggests "a single annual national computer conference complemented by several smaller shows."** Paul Rosenbaum, vice president of Memory Technology Inc. in Waltham, Mass., seconds the motion. "We go to the Fall Joint, but it's too expensive to go to two shows a year. Attendance is too diverse." GRI Computer Corp. of Newton, Mass., feels large trade shows are a "complete waste of money."

A DEC spokesman sums up: "We don't know if it's worth it."

ARPA net may go private in two years

Requests for proposals for a large shared computer network to service several Government agencies could go out to potential carriers within two years. The data service would absorb the Advanced Research Project Agency's national system, and might even be run by a carrier created specially for the task. **Discussions stress competitive industry involvement, with Government leasing its share;** the Federal Communications Commission has been contacted about new regulations for the precedent-setting network. Consolidation with computer nets of the General Services Administration and others is possible.

Meanwhile the problem of who is to run the ARPA net has still to be solved, but it looks as though the Defense Department agency may continue management until a private carrier takes over. Industry is keenly interested. Other agencies involved are the Office of Telecommunications Policy, the Office of Science and Technology, the National Bureau of Standards, and the National Science Foundation.

nuts

Their book, ironically symptomatic of minicomputer technology itself, was good as far as it went but didn't go far enough. Significantly absent was any reference to the only *really* new and different concept for systems computers in years: functional minicomputers using a universal bus system.

And that's a damned relevant topic to be leaving out!

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Circle 35 on reader service card

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Ion Implant Sparks Tidy Front-End Business

By NAT SNYDERMAN

NEW YORK — Ion implantation is gaining favor in semiconductor factories and is generating a tidy little business for a handful of equipment suppliers virtually unknown a few years ago.

Considered a laboratory maverick until recently, ion implanters have evolved into sophisticated front-end production equipment which may one day compete with diffusion in microcircuit processing, notably in MOS.

National Semiconductor, Intersil and American Micro-systems are among the major IC producers which have installed ion implanters. Fairchild, Mostek and Hewlett-Packard have units on order.

A solid endorsement of the ion bombarding art will soon be given by IBM which has placed orders for three machines — two for East Fishkill and one for Manassas, Va. — reported to be a prelude to a push in MOS circuits. Made by the Ortec division of EG&G, the units will be delivered in April.

Equipment manufacturers estimate the total cost of the three systems IBM will buy from Ortec at $250,000 to $300,000.

Ion implantation has b... technique for doping ser... — generally thin-films ... formly over each wafer ... ty from wafer to wafer ... process, in this technolo... ized, accelerated to hi... barded onto the surface ... they penetrate and then ...

Device engineers have ... permits them to dope ... fine adjustments of ...

Electronic News, 1/24/72

Ion-Implant Production Accelerating at Mostek

DALLAS (FNS) — Mostek Corp., here, has ion-implanted more than 100,000 wafers of MOS/LSI circuits during the past 15 months, according to Bob Palmer, vice-president of the firm's Worcester, Mass., processing operation.

All of the wafers were implanted with a single machine purchased from "Accelerators, Inc., Austin, Tex. Another machine is on order from the same firm.

The new unit will offer both higher ... currents, and will

Electronic News, 2/21/72

Technology

The HP-35 employs MOS/LSI circuits using ion-implant processes.

Hewlett-Packard thinks they are the largest presently in volume production. Each circuit is equivalent to 6,000 transistors — a total of 30,000 devices. They are made by Mostek especially for Hewlett-Packard (Dallas) and American Microsystems (Santa Clara, Calif.).

The HP-35 may well be one of the major developments of the current decade and the harbinger of things to come.

Electronic Buyers' News, 2/7/72

Hewlett-Packard Introduces Electronic Pocket Calculator

PALO ALTO, Calif. — Hewlett-Packard Co. said it has introduced a new electronic pocket calculator called the HP-35.

William R. Hewlett, president, compared the nine-ounce battery-powered calculator to a "fast, extremely accurate electronic slide rule, with a solid-state memory similar to those used in computers." The HP-35 is approximately three inches wide, six inches long and one inch high and will sell for $395, according to Mr. Hewlett.

Major Business Publication, 1/5/72

Ion implantation as a processing tool will be used in one way or another by all manufacturers within a few years. Equipment will be refined and become less costly as more suppliers move into this market. Because of its ability to adjust thresholds, make depletion devices, make CMOS devices, etc., it is too useful a tool to ignore. Circuits made by ion implantation will be cost-competitive with most other technologies and offer some perform-

EDN/EEE, 9/15/71

Ion-Implantation Moves Ahead

Ion implantation technology continues to advance. This was borne out at the recent International Electron Devices Meeting in Washington, D.C. where, of the twelve papers presented on the subject, nine described applications other than the most commonly known ones.

EDN/EEE, 12/15/71

Today ion implantation is big news.

Look what we started!

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Circle 36 on reader service card

Navy's new patrol frigates accent austerity

50-vessel purchase sought by 1980; to be 3,400 tons and cost $45 million each—half the price of DD-963 class

The Navy has awarded two design contracts for a new class of escort ships—patrol frigates—that are likely to spawn a demand for new shipboard electronics. However, Navy officials say these systems—like the ships—"will be as 'cheap and dirty' as we can make them."

The PF class is viewed in the Pentagon as the Navy's first major move to control rising ship construction costs while increasing fleet size to the extent it believes necessary to match Russian seapower in the decade ahead. The awards were for $3.2 million to Bath Iron Works, Bath, Maine and $1.8 million to Todd Shipyards Corp., Seattle, Wash.

Tight. As envisioned, the new patrol frigates will be "a very austere destroyer type in size and cost," says the Chief of Naval Operations, Adm. Elmo Zumwalt. He predicts that the PFs will displace 3,400 tons and cost $45 million each in 1973 dollars— roughly half that of 7,600-ton, $90 million DD-963 Spruance-class destroyers now being built by Litton Industries [*Electronics*, July 6, 1970, p. 102].

Some Navy line officers grumble privately that the PF concept of a single-screw ship using gas turbine propulsion and lacking any armor plate will reduce ship safety. "In some heads," mused one official, "I understand the PF is being called our new Kamikaze class."

Nevertheless, the Pentagon's decision not to go to a full-fledged twin-screw destroyer propulsion system is not regarded as handicapping the PF's maneuverability or reliability, in view of its light displacement. Moreover, the choices were viewed as necessary to keep the ship's production cost down to the $45 million range.

Adm. Zumwalt wants to get 50 patrol frigates into the fleet by about 1980 to "help fill the vacuum left by the fact that we must get rid of our World War II destroyers by that time" because they will be obsolete. Total cost of the effort could run to $2.5 billion, with construction split between three yards.

In addition to designers Bath and Todd, sources say that Litton is a likely choice for third if it can successfully perform on its DD-963 contract.

Protector. Designed to protect conventional shipping and amphibious forces rather than for high-speed carrier escort, the patrol frigate will carry antiair-warfare weapons, including the SPS-49 search radar, the MK-92 dual-channel fire control system, the Standard missile, one twin Ota Melara 35-millimeter gun, plus space for a weapon to shoot down subsonic cruise antiship missiles.

For surface warfare, the frigate will have an SPS-55 surface search radar, MK-92 fire-control system, a guided missile launcher, the Harpoon missile and the Lamps helicopter—which is also designed for antisubmarine warfare.

The ship's antisubmarine-warfare capability will be limited to the Lamps system, the SQQ-23 performance and information retrofit (PAIR) sonar, another classified sonar now in development called Tactlass, and two sets of torpedo tubes and launchers.

Adm. Zumwalt believes the PF "has the capability to deal with the subs, the airplanes and the surface-to-surface missile in as cheap a box as we can make."

The ship, as it is envisioned, will have no 5-inch guns capable of shore bombardment, no antisubmarine rockets, and will not have the Naval Tactical Data System. □

Government electronics

Aerosat program called a shambles

Industry officials fear that the proposed joint U.S.-European aeronautical services satellite program is in such disarray that launching may be years away for the navigation and communication satellite. Not only are the Americans and Europeans at loggerheads over how it should be built [*Electronics*, April 10, p. 57], but the White House Office of Telecommunications Policy, having quashed an Aerosat agreement between the FAA and the European Space Research Organization, now cannot get dissident Government agencies to agree on a U.S. position.

Further complicating things is industry concern that U.S. companies may be at a competitive disadvantage against foreign, government-backed firms, should any compromise agreement ever be reached.

"As I see it, the program is indefinitely delayed, perhaps years," says one electronics company source close to the program. "OTP went to Europe carrying the flag and came back with its banner torn," he says, referring to a recent OTP-led trip to try to smooth over differences. "I just don't see any reconciliation between the U.S. and European views," he observes, pointing up two major difficulties:

- **Ownership.** Agreeing on ownership of the program "is awkward at best," he says. "There might be a compromise, but the concept of joint ownership is unworkable."
- **50-50 sharing.** Europe wants 50% production sharing, but a U.S. idea is to spread Europe's 50% share over a number of nations reflective of ESRO's balance of payments, the source says. Calling the idea restrictive, he comments, "all of us are scared to death of the program. We keep our names in now for show."

A source in the communications industry says flatly, "Private business can't have a third party making decisions for it," referring to various proposed arrangements of Government-industry control and ownership. He further blasts the U.S. Government—particularly OTP—for not deputizing "one entity" to negotiate with ESRO, which "needs a designated body to deal with it." Also involved in Aerosat are the Departments of State and Transportation, the FAA and NASA, with the White House and Senate keeping a close watch.

Futile. Besides its difficulties in unifying the U.S. position, OTP is reportedly getting nowhere in trying to persuade ESRO that the telecommunications part of Aerosat should be privately owned. Both sides agree that air traffic control should be operated by participating governments, however. While the office has not objected to ESRO's sharing production, it does object to a negotiated guarantee of a fixed European percentage. Also, in regard to Europe's interest in sharing the system portion over the Pacific, where the U.S. dominates, OTP reportedly wants control of portions of the two-ocean system, based on actual use. This means that the two sides would share only the Atlantic system.

Another U.S.-Europe conflict is over the size of the system. OTP wants a simple system using off-the-shelf technology, whereas ESRO favors a larger system using newer technology. Industry speculates that ESRO prefers new technology because it couldn't compete with the U.S. in off-the-shelf hardware.

The consensus indicates that ESRO won't build its own Aerosat even though it talks about it. There will be pressure for compromise because too many parties have been working for an Aerosat, and increasing Atlantic air traffic will require a satellite by 1980. However, the U.S. position may remain hard because, as one Government source says, "If there isn't any compromise, there are few alternatives to the U.S. going it alone." □

Commercial electronics

Four-chip set from NRMEC for calculators, terminals, processors

Convinced that it can't go on developing new custom products for everyone, the North American Rockwell Microelectronics Co. has developed a set of MOS LSI chips that should fill the bill in most business machines, terminals, and process-control equipment. The four chips are organized like a modern, expandable databus minicomputer with more than 50 basic instructions.

Not a mini. NRMEC's William E. Wickes, product development marketing manager, says that the low-cost set can be used for calculators up to the most complex, credit terminals, electronic cash registers, point-of-sale terminals, billing machines, processor controllers, and more. But though it's organized like a minicomputer, and can do so much of the same work, Wickes won't call it that because it's typically an order of magnitude slower.

The basic chips are a four-bit central parallel processing unit, an input/output unit, and either a unique combination read-only and random-access memory or a separate RAM and ROM. The minimum set with CPU, RAM/ROM, and I/O chips can make a calculator or credit terminal. The maximum size, with 8,192 words of 8 bits each in ROM (eight chips), 4,096 words of 4 bits in RAM (16 chips), plus 16 I/O chips, can handle many microprocessor jobs. The large ROM is used because even small terminals can require 500 to 1,000 words. It was designed for the set, with small cell sizes that are optimum for the relatively low clock rate.

Wickes says that a major consideration in the set is its building-block approach, which gives maximum flexibility with minimum customizing charges. The CPU and RAM require no customizing, and the ROM is easily programed.

The I/O circuits are the only true custom parts, since they depend on the peripherals used. But even here, it may be possible to use one chip for more than one application. A single chip, for example, might interface to a keyboard, display, and numerous discrete switches and lamps.

The circuits are packaged in NRMEC's 42-pin cases for maximum versatility, and use a low-voltage nitride process for operation from a 17-volt (+5-V to -12-V) supply. The basic clock time is 200 kilohertz, but the parallel organization means that an addition is accomplished in only 20 microseconds, five times faster than other serially organized MOS parts, according to Wickes. Add/subtract time for two eight-digit numbers is 240 μs, multiplication time is 15 milliseconds, and divide time is 20 ms.

Cheaper. Wickes says that the set should offer a five-to-one improvement in cost over the same type of system with transistor-transistor logic, "but you wouldn't take the same approach in TTL." The chips would typically cost $10 each in 25,000 quantities, so four (CPU, ROM, RAM, I/O) might be $40. NRMEC sells only complete sets; Wickes says that, in general, about 10,000 sets a year would be about the minimum practical purchase for users. At that level the price is about $60 for the four chips. The parts will be available for prototyping this summer, with production starting this fall. Wickes won't identify users, but does say that the company has customers for a broad range of applications. "In fact," he says, "in the four months we've been talking to customers, we haven't seen an application the set couldn't handle." □

Military electronics

Norden to make British missile

With the Department of Defense leaning toward the purchase of operational weapons systems from foreign countries, rather than duplicating the development effort here, the Norden division of United Aircraft Corp., Norwalk, Conn., has obtained a license to build and sell the British-developed Rapier missile system in the U.S.

Rapier, a product of the Guided Weapons division of British Aircraft Corp., is an optically guided, ground-to-air defense system for warding off low-level attack. It is already being deployed, under production orders totaling $340 million, by the British Army and the Royal Air Force. And it is scheduled to be field-tested this spring by the U.S. Army.

The Rapier can be transported by truck or helicopter and fired by one man. It consists of a launcher containing a search radar, command transmitter, and facilities for launching four missiles; an optical tracker operated by the man; and a power generator.

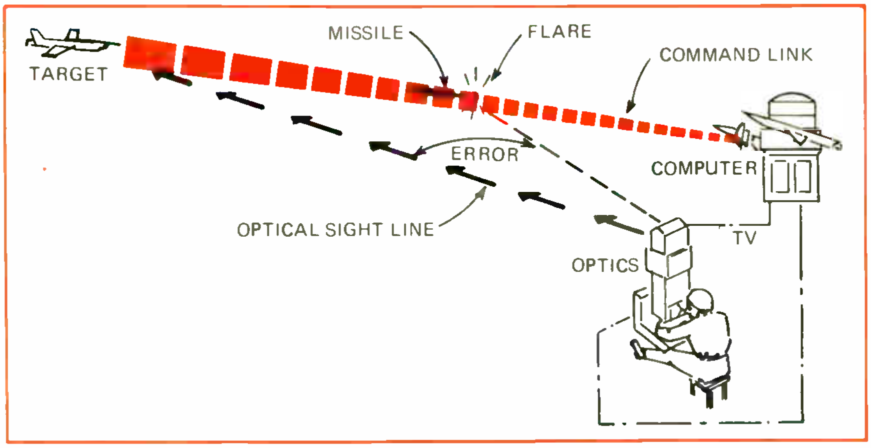
As the radar sweeps the sky around the missile site, it also slews the optical tracker and the missile launcher. Missile firing is controlled by the operator, who must first pick up an enemy aircraft in his optical viewer. When the missile is launched, the operator picks up both the missile and the target in the viewer and tracks them together via a communications link between the ground computer and the missile.

Radar on way. The British are also developing a special radar for Rapier, called Blindfire, which can do the job of the optical tracker so the system can be used at night and in bad weather. It is already undergoing firing tests and, once in the field, would plug into the launcher alongside the optical tracker.

If the Rapier system is bought by the U.S. Army, Norden plans to produce it completely in this country. With such made-in-USA production plans, DOD hopes to anticipate congressional criticism of reliance on foreign weapons [*Electronics*, March 27, p. 31]. Norden would be the over-all prime system contractor, probably subcontracting out everything but the radar, with which it has had ample experience. McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is already teamed with Norden to produce the Mach 2.6 missile itself.

Ground-to-air defense systems already in the hands of the U.S. Army include the shoulder-fired Redeye from General Dynamics and the Chaparral from Philco-Ford. Both are heat-seeking, infrared-guided missile systems, which may not be as suitable as an optically guided missile for launch against incoming aircraft which emit little heat. Other systems are GE's radar-guided projectile-firing Vulcan and Raytheon's radar-guided Hawk. □

Coming and going. British-developed Rapier has built-in IFF system, tracks aircraft optically. Computer determines when target is in range. Flare in missile tail helps visual tracking.



Memories

The talk of Tokyo: bubble technology

Bubble memory technology was the center of attention at the Intermag 70 conference in Tokyo. Spokesmen from several American firms, including Bell Laboratories, North American Rockwell, and Univac division of Sperry Rand Corp., claimed they were within a year or two of developing laboratory prototypes to replace disk-file memory.

On the materials side, both Allied Chemical and Monsanto hinted they may soon market epitaxial garnet wafers or chips. This would greatly ease the burden of bubble-memory device developers, who would no longer have to develop materials on their own.

Bell's J.A. Copeland asserts that the future of bubble technology depends on its use as disk-file memory replacement. Otherwise, all the specialized applications in the world won't be enough to make bubble devices commercially attractive.

Spokesmen from Bell said their schedule calls for development of a 16-megabit file memory of one-megabit modules by year's end.

Two types of memory chips are being developed. One of these, described by P.I. Bonyhard, is a field-access circuit, using T-bar or other geometry registers and logic. The other type, described by Copeland, is a current-access circuit, using a new propagation scheme having an ion-milled serrated groove in garnet with a superimposed single serpentine conductor.

North American Rockwell expects to have its memory prototype, somewhat smaller than Bell's, within a year. Univac, reported to be spending $800,000 annually on bubble research, will have its prototype "within one year after Bell," a company spokesman says.

Japanese developers of bubble devices include Nippon Electric Co., Hitachi Ltd., and Fujitsu Ltd.

The disk-file memory replacement that bubble people are working hardest to develop is three to four orders of magnitude slower than mainframe random-access memories. Thus, Univac is still strongly pushing development of its plated-wire memories, which G.A. Feede thinks will be used mainly in modules of 10 million bits with access times of 1 microsecond.

Some interpreters of bubble technology emphasize its logic capabilities, but most of its proponents say that bubble devices are most suitable for memory-oriented systems. However, the logic capabilities can greatly enhance the memory characteristics.

The conference heard a host of papers dealing with various aspects of bubble memory technique. In one, Copeland said Bell's ion-milled version eliminates Permalloy from the propagation circuit because in going from orthoferrites to garnet, with its smaller bubbles, the Permalloy elements became too small to produce.

H.H. Chang of IBM developed an "angel-fish" propagation circuit produced by sputter etching that uses no metal of any kind in the propagation circuit, and Nippon Electric described a bubble phenomenon that can be obtained with no metal or forming of the platelet surface. And Hitachi described an array of Permalloy elements on bubble material that can be used to rotate characters in character-recognition equipment. □

Medical electronics

Computer monitors women in labor

Fetal monitoring units have been around for some time, but while they are electronically sophisticated, they still must be watched constantly in the labor room. Now, however, a group of doctors at the University of Alabama at Birmingham is changing that. Working with

$20 million microwave network advocated to make Alaska pipeline safe

One of the many reasons environmentalists object to the controversial trans-Alaska pipeline is that the 48-inch-diameter pipe could be ruptured by earthquakes or by sagging in the permafrost. But Alyeska Pipeline Services Inc. is dickering with RCA Alaska Communications Inc. to build a $20 million microwave communications system that it says will safeguard the proposed $2.7 billion pipeline project from spilling oil into the ground.

The 6-gigahertz line-of-sight system, along with several backup radio modes, would continuously monitor and control 12 pumping stations—the red boxes on the map—along the tortuous terrain from the North Slope to Port Valdez. The route includes a variety of topography, ranging from the Arctic Plain in the north—at the Prudhoe Bay oil field—through uplands and mountains.

The computerized system would update pipeline conditions every 10 seconds, alert an engineer at the operations control center to any change in oil flow greater than 1%, and pinpoint the trouble so that he could turn off the oil flow. A uhf/vhf radio network would control block valves away from the pumping stations.

Should communications fail in two critical junctures of the pipeline, all 12 stations would stop.

"The design has to be compatible with the terrain and climate," says A.J. Baden, telecommunications engineering supervisor, yet "include all known factors of efficiency and safety." He notes that the suggested system is a "big application of existing techniques," whose "uniqueness is its redundancy and reliability."

The microwave system would use 26 relay repeaters, some built on towers, to withstand 150-knot winds and ice 3 inches thick, along the 789-mile pipeline.

In addition to leased common-carrier circuits on separate geographical routes as a microwave backup, the total communications system would include a dial telephone system with private automatic exchanges linking Valdez, Fairbanks, and the pumping stations; a mobile vhf two-way radio network; a high-frequency, single-sideband marine radio net; and a battery-powered uhf/vhf transmitter and receiver at each station, terminal, and maintenance depot along the route of the pipeline.

The microwave net would send sensing data and communications over four voice-grade channels to the control center, which would be equipped with dual operator control panels, cathode-ray tubes, and computers.

Automated Medical Data Inc., of Houston, they have strung together a Raytheon 703 computer, a fetal monitoring unit by Corometrics Medical Systems Inc., of North Haven, Conn., and a network of electrodes to provide almost instant indication of failure that can be monitored from a nurse's station. The electrodes are based on technology developed for NASA.

Available fetal monitoring units are used either internally or externally by means of highly sensitive transducers. They display data on strip-chart recorders and oscilloscopes. And they measure fetal heart rate, uterine activity pressure, and contraction rates.

Dr. Clark Hinkley says that the Alabama monitoring system uses amplifiers and filters with the electrodes for detection. Information is fed to the computer in analog format. The computer, utilizing pattern recognition programing, automatically checks each parameter of the labor progress. If an abnormality should develop, the computer sounds an alarm and prints a digital analysis within 10 seconds.

Dr. Hinkley says that since a failing fetus deteriorates rapidly, the most significant feature of the new system is the way it closes the gap between the first sign of abnormality and treatment. Hinkley says the alarm has sounded several times with "good correlation between the computer and diagnosis."

But there is a drawback—the system now operates on a one-to-one basis; only one patient can be hooked up to it. The next step is to move to a four-to-a-unit arrangement, which means time-sharing. □

Instrumentation

Radiation monitor measures wide band

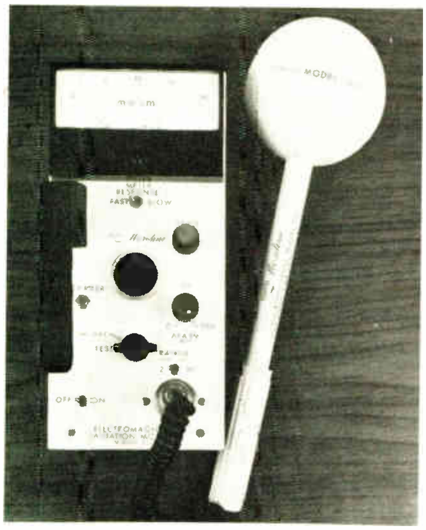
Enemy action is probably the biggest danger for a sailor on the deck of an aircraft carrier during general-quarters. But don't discount radiation from his own ship's radar and communications gear: it comes from so many sources at different frequencies that the bandwidth of the composite signal is enormous. What's more, the signals emanate from many directions. The problem has been just how to measure the total, and a Long Island, N.Y., firm has come up with a way to do it quickly.

While Navy officials claim to be confident that none of their personnel is being exposed to radiation exceeding currently acceptable limits, they also admit that they'd be much happier if they had an instrument that could accurately measure the total power density at a given point, regardless of the number, position, and frequency of the sources of the radiation. In fact, they are actively supporting the development of such an instrument by the National Bureau of Standards, Boulder, Colo.

Meanwhile, back on Long Island, the Narda Microwave Corp., Plainview, N.Y., seems to have at least a

Should one component fail, its twin would automatically take over. Teleprinters also would record principal data. Four automatic alarm methods—pressure deviation, flow deviation, flow-balance deviation, and line-volume balance—would be monitored by the computers. The microwave system also would carry information about the condition of the repeater stations and pumping stations to the control center and two master stations at Fairbanks and the first pump station at the northern end.

Baden indicated that negotiations with RCA, an Alaska common carrier, for the microwave net would probably be concluded during the summer. The Department of Interior is expected to approve the pipeline this summer, and barring suits by environmental groups, construction of Alyeska's system would begin in the spring of 1973. □



Getting it all. Thin-film thermocouples are key to Narda radiation monitor.

partial answer to the Navy's wish. By using an array of thin-film thermocouples as both the antenna and detector in new radiation monitor, the company has come up with a virtually isotropic instrument with a passband that extends from 300-megahertz to 18 gigahertz. Because the monitor uses thermocouples, rather than crystal detectors, it has a truly square-law response characteristic over its entire range, and it can add small signals to large ones without the errors normally caused by crystal nonlinearities. This is particularly important when the total radiation density at a point is made up of many small components. □

Consumer electronics

TI's liquid crystals set for digital watch

Texas Instruments has entered the growing electronic watch business with an eight-digit liquid crystal display, driven by bipolar chips. The all-solid-state movement will be assembled by Swiss maker Ebauches S.A. The movement, which has two 1.34-volt batteries and is 0.4 inch thick, is to be marketed later this year by Longines Watch Co., a partner of Ebauches.

Almost two years in development, the display shows hours, minutes, seconds, and the date—each set by one of four separate switches recessed into the rear of the watch. Numerals measure 0.2 in. for the hours and minutes, and 0.15 in. for the seconds and date.

Five years. Ebauches technical director Kurt Hubner states that the display will have at least five years of satisfactory performance, and passable usefulness for an uncertain period thereafter. A TI spokesmen in Dallas comments, "In order to serve the watch market, we have convinced ourselves and our customer through accelerated life testing that the displays' life will be suitable."

The display is attached to a 52-pin connector ring, that plugs into holes in a ceramic substrate. Here it is attached by split-tip welding or any of several bonding operations.

A surprise was Ebauches' decision to use bipolar chips when makers of other electronic watches are touting C/MOS. Says Hubner, "We're not married to bipolar. If the prices come down we can change; however, no one has proven to our satisfaction that C/MOS prices will come down lower than bipolar in the near future." TI indicates it's also building C/MOS watch circuits.

Despite the commitment to bipolar in the digital display watch, Ebauches is offering another electronic movement, also with a 32-kilohertz quartz crystal resonator, that has a standard face but contains a C/MOS circuit. This model is an outgrowth of the quartz watch that Ebauches helped develop with a Swiss consortium, the Center Electronique Horloger S.A., some years ago.

Power. The two bipolar chips in the digital model perform as an oscillator and divider and as a counter-decoder. A transformer steps up the 1.34-V battery power to 15 V to operate the display. On this point, TI says, "There was considerable innovation in arriving at the micropower bipolar designs and in the level of transmission required to drive the display."

Another liquid crystal display watch announced this month by Waltham Watch Co., division of So-

Bright time. Watch with TI liquid-crystal display promises five-year performance.

ciété des Garde-Temps S.A., has four digits and a colon mark, and was designed by Optel Corp., Princeton, N.J. This watch is to sell for less than $200 beginning in July.

The Longines watch will probably retail for about $300. According to Ebauches, the various electronic watches on the market now represent just 2% of world sales. □

Antennas

Process cuts cost of conical type

As the electronic surveillance business picks up, so does the need for broadband, omnidirectional antennas. But these small conical helix antennas are very expensive, because the tight tolerance involved makes it difficult to produce exact duplicates. That was the problem faced by Stanley Kaye, manufacturing research engineer at Lockheed Missiles & Space Co., Sunnyvale, Calif.

Previously, copper foil patterns were attached to epoxy cones. Pegs on the cone and holes in the foil took care of alignment. But because the foil was hand-cut, no two antennas were alike, and the cost for labor alone topped $75 apiece. Re-

Bell & Howell & The Do It Itself Transmitter

"Hey, I think I know a way for us to get into a new market." This from one of our new guys.
"How?" we ask.
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"We've never made transmitters."
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"Reliability?"
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"Why adjust? We'll calibrate at the factory. But for special requirements, we'll supply adjustment capability optional."
"What about shock and vibration problems?"
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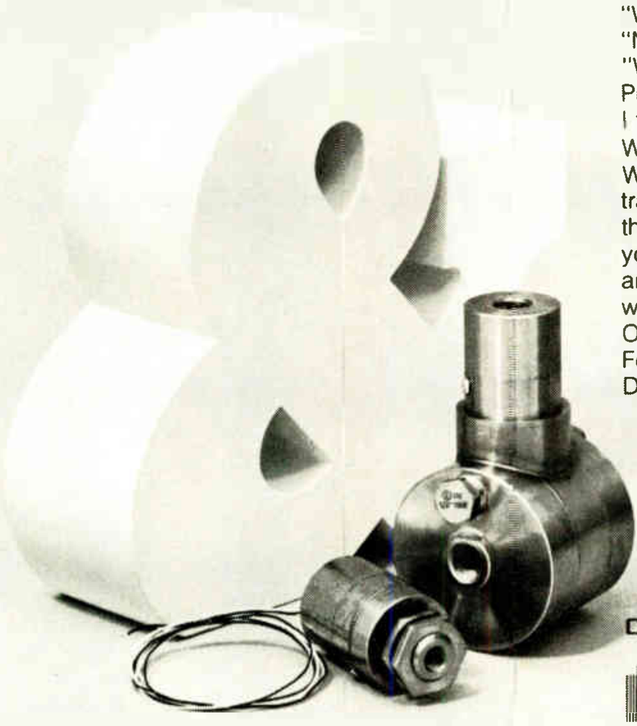

CEC/INSTRUMENTS DIVISION

BELL & HOWELL

Circle 43 on reader service card


New twist. Lockheed's Stanley Kaye displays his conical antenna that can be made for just $6—previously, labor alone was $75.

designing the manufacturing process, Kaye employed some fairly basic printed-circuit manufacturing techniques, and came up with an antenna that costs Lockheed only $6 per copy for labor. In addition, says Kaye, "we're getting better performance, and the results are repeatable." The VSWR, he says, is under 2 to 1 over the entire frequency range.

Kaye also says his antenna is superior because of the "better repetition and superior uniformity, especially with four arms or more, when the conductive traces become very minute." Based on rough data from one test, Kaye adds, "minimum front-to-back ratio is 25 dB, and the peak on axis is 1.0 dB actual ratio or crossband. At half the power beam width, peak variation across the band is ±5°. Gain tracking is within ±1.0 dB."

Converts to 2-d. The process resembles pc board fabrication. The desired pattern is fed into a computer, which then converts the three-dimensional spiral into a two-dimensional pattern and produces a coated tape. The tape is then fed to a Gerber plotter equipped with a diamond scriber. To increase the accuracy of the antenna pattern, the plotter cuts the spiral 10 times normal size on rubylith paper.

After the rubylith has been cut and peeled, an actual-size master is made, cut along one line, and rolled up to form a cone. This is placed over a 60-mil-thick epoxy cone that has been plated with 1 mil of copper and photo-sensitized. The cone is exposed to a carbon arc lamp and, after the pattern is removed, developed and etched.

The result is an antenna pattern that can be mass-produced to a tolerance of 2 mils—compared with ±6 mils with the hand method. And, says Kaye, "we can coat the cone with a water-soluble black dye that adheres to the exposed pattern. If the pattern is not perfect, we wash the cone in a solvent and start over; if it's okay, we simply wash the dye off and etch." □

Industrial electronics

Ultrasonic paging system pipes signals into every room of building

Radio-frequency paging devices work because their rf signals pass through walls and ceilings to fill the building space in which key personnel must be tracked down. On the other hand, pagers that depend on acoustic energy can't work, the conventional wisdom has it, because sound waves won't travel much beyond the confines of a single room.

But Robert Lester, president of Recognition Devices Inc., a small development company in New York City, says he's skirted the range limits simply by piping signals into every room and space in a building. Apparently the acoustic transmitter/receiver needed to do this is inexpensive enough.

The result is an ultrasonic selective paging system, called Trakatron, with several new features:

- It operates silently, without the usual pocket signal device to alert a person to telephone his office.
- It automatically dials the telephone nearest the person being paged.
- An operator's console can display the location of every person tied into the system. And if a person is unavailable, it shows that too.

The system consists of a transmitter-receiver in a central console, a sensor in each room, and pocket transponders carried by all persons that can be paged.

Pen-sized. The device a person carries in his pocket is only the size of an individual pen—one sixth the volume, Lester estimates, of conventional pocket paging devices. And he says that once in production—Lester is looking for manufacturers to license—the pen transponder device could cost as little as $25 each.

The transponder contains a piezoelectric transducer, an ultrasonic oscillator working at about 25 kilohertz, a receiver, a gate that switches the transducer between the receiver-amplifier and the oscillator, a decoder that gives each pen a unique 10-bit code, and a solid-state power switch. Power source is two 6-volt nickel cadmium batteries.

Sensors. Every room and hallway has an acoustic sensor—a cigarette-pack-sized device with separate transmitting and receiving transducers, an oscillator, receiver, and gates. These are wired, via existing 110-volt power lines or dedicated multiplexed wiring, to the central console, which can be near the main phone switchboard.

To locate a person, the operator at the central console sends that person's pulse code to all the room sensors. The sensors transmit it in about 0.1 second, then go into a listening mode for 2 seconds. When the individual's pen receiver identifies his transmitted code, the pen sends back its signal to the room sensor. The sensor then sends its address signal back to the console, which decodes it to obtain the room number and nearest phone.

This information can be displayed either on a small 2-by-5-inch cathode-ray tube or, in another configuration, on a large CRT that can display the names and locations of a host of key personnel. By including

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BV_{CEO} @ 100 ma	200V	250V	250V	300V	300V	350V	350V	400V	400V	450V	500V
V_{CE} (S) 0.4 h_{FE} 50 - 150	SDT520	SDT525	SDT530	SDT535	SDT540	SDT545	SDT500	SDT550	SDT560	SDT565	SDT570
V_{CE} (S) 0.5 h_{FE} 30 - 90	SDT521	SDT526	SDT531	SDT536	SDT541	SDT546	SDT501	SDT551	SDT561	SDT566	SDT571
V_{CE} (S) 0.6 h_{FE} 10 Min.	SDT522	SDT527	SDT532	SDT537	SDT542	SDT547	SDT502	SDT552	SDT562	SDT567	SDT572
V_{CE} (S) I_C/I_B	1.0 max. 5A/1A	1.0 max. 5A/1A	1.0 max. 4A/0.8A	1.0 max. 4A/0.8A	1.0 max. 4A/0.8A	1.0 max. 4A/0.8A	1.0 max. 4A/0.8A	1.0 max. 4A/0.8A	1.0 max. 3A/0.6A	1.0 max. 3A/0.6A	1.0 max. 3A/0.6A

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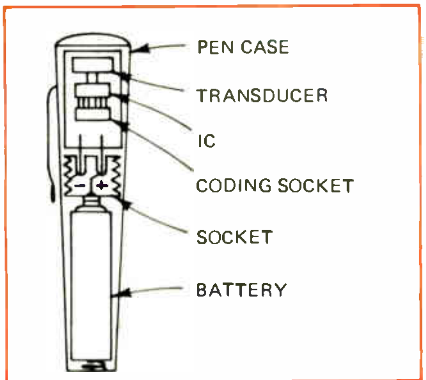


Pocketed. Pen-sized transponder is run by two 5-volt rechargeable NiCad batteries.

additional memory in the console, and making the proper connections to the switchboard, the system can also be made to dial the telephone nearest the person paged. □

Space electronics

Apollo 16 contains 2 new experiments

Although not generally billed as such, this month's Apollo 16 is essentially a repeat performance of last July's Apollo 15 mission. In keeping with NASA's avowed objective of flying all scientific experiments twice, there are only two new experiments in the lunar package; there are many minor changes, however, to insure that all systems go.

What's new is that astronauts John Young and Charles Duke will bring back from the lunar surface a film canister that should begin to answer some of the fundamental riddles of the universe. The far-ultraviolet camera/spectograph, to be set up in the shadow of the lunar module, is really a miniature astronomical laboratory—providing scientists with the first astronomical observations from the moon.

Young will point the 3-inch electronographic Schmidt camera at 11 targets during the mission; from these photos and spectra, astronomers hope to get a complete picture of the hydrogen content of galaxy clusters, star clouds like the Milky Way, various nubulae, solar wind, and the size and shape of the earth's geocorona, which is a cloud of atomic hydrogen that probably extends out about 10 earth radii.

When far-ultraviolet light hits the instrument's concave mirror, it is focused on a potassium bromide photocathode, which emits electrons in proportion to the amount of light sensed. These electrons are drawn by an electrostatic field—at 25,000-volt potential—through a cylindrical shell of Alnico magnets that focus the beam on the photographic film. The resulting spectra and photos should be 10 to 20 times more sensitive than a direct print.

The camera/spectograph will pick up light between 500 and 1,500 Angstroms, although researchers are principally interested in the characteristic atomic hydrogen band at 1,216 Å. In contrast, most wavelengths that are shorter than 3,000 Å don't make it through the earth's atmosphere. The 50-pound gold-coated camera—relatively heavy for lunar experiments—was designed and built at the Naval Research Lab for about $2 million.

The second new experiment consists of four panels of particle-detecting materials mounted on the outside of the lunar module's descent stage. They will measure charge, mass, and energy spectrum of heavy cosmic-ray and solar-wind particles. □

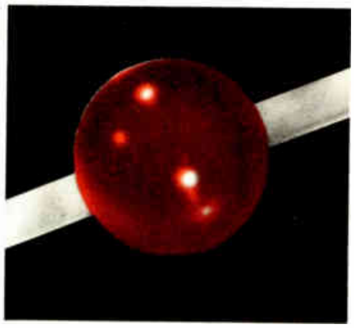
For the record

Boeing's B-1. The avionics award for the first three B-1 strategic bombers has gone to Boeing for $62.4 million. Boeing will integrate its packages into the first three prototypes being built by North American Rockwell. There were four others in the bidding. Boeing will use a computer by IBM, one of the losers.

Cheapie. The Air Force has awarded $39.1 million to the Northrop Corp. and $37.9 million to General Dynamics to build two competitive prototypes each of a new lightweight fighter (LWF) aircraft. The four planes are to be ready for a year of competitive testing at the end of 26 months. □

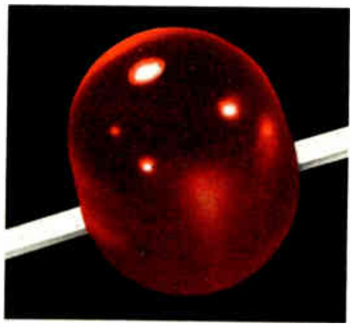
MLED50 Red LED Shows Big Performance
- 1 mcd luminous intensity
- PC-board mountable
- Wide viewing angle

CIRCLE NO. 73



MLED55 LED Turns Red from Any Angle
- 140° viewing angle
- New diffusing lens
- 600 μcd luminous intensity

CIRCLE NO. 74



MLED600 Mini-T* Gives High-Visibility Red
- 1,100 fL brightness
- Economical plastic
- Unique, molded lens

TRADEMARK MOTOROLA INC

CIRCLE NO. 75

MLED610 LED Offers High-Density Reliability
- Tiny, metal "pill" design
- 1,100 fL brightness
- Easy, PC-board mounting

CIRCLE NO. 76

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Everybody talks about optoelectronic capability but nobody documents anything about it.

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DOCUMENTATION #1:

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DOCUMENTATION #2:

Lower-cost, highly-available opto products are final-tested on fully-automated and computerized semiconductor test equipment. You get Motorola's traditional, fast factory turnaround on all your factory orders. Optomation again.

Plastic IR LEDs Do Invisible Things @ 9,000 Å
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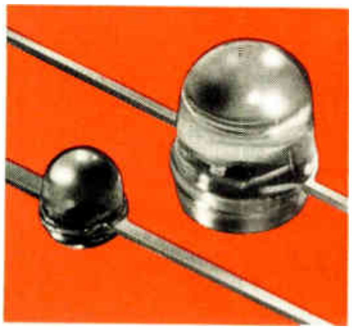
CIRCLE NO. 81



Metal IR LEDs Emit 9,000 Å, Small or Large
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- 150 to 650 μW output
- Hermetically-sealed

CIRCLE NO. 82

MRD500/510 PIN Photodiodes Respond In Nanoseconds
- 1 ns typical response
- Convex or flat lenses
- Sensitive through visible/near IR range

CIRCLE NO. 83

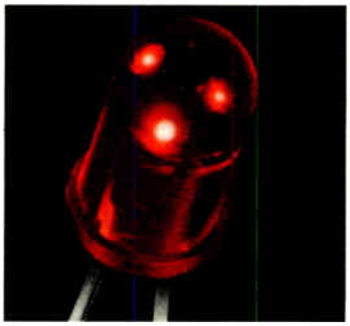
Plastic Photo Darlingtons Offer Economical Sensitivity
- 40-cent, 100-up prices
- typical sensitivities to 4 mA/mW/cm²
- Ideal for high-volume insertion

CIRCLE NO. 84

MLED630 Shines Out From TO-18 Package

- 120° field-of-view
- 1,100 red fL
- Panel indicator

CIRCLE NO. 77

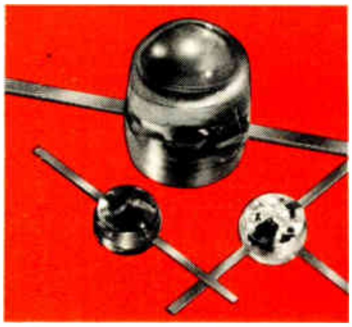


MLED650 Lights Up Panel Indicators

- Wide viewing angle
- Mounting hardware available
- 200 mil bright viewing surface

ADVANCE INFORMATION

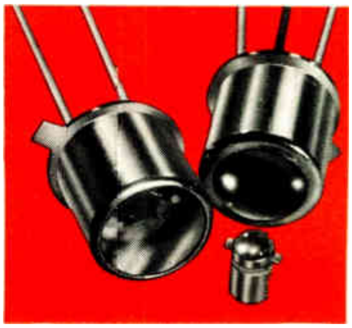
CIRCLE NO. 78



Plastic Photodetectors For All Arrangements

- High (MRD150) or moderate (MRD450) mounting densities
- Low-as-75¢, 100-up
- Sensitivities to 0.2 mA/mW/cm²

CIRCLE NO. 79



Metal Photodetectors Are Fast And Rugged

- TO-18 or "pill"-cased
- Microsecond switching
- Curved or flat lenses

CIRCLE NO. 80

Volumes Living Color

DOCUMENTATION #3:

Motorola's huge investment in in-house, III-V raw material facilities including crystal-pulling and epitaxial deposition will ensure unparalleled wafer supplies to satisfy any and all high-volume requirements. Motorola, the production house of the industry.

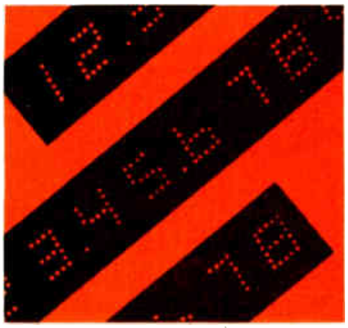
DOCUMENTATION #4:

The largest factory and distributor sales organization in the semiconductor industry — over 750 trained technical salesmen and engineers — in 96 U. S. and Canadian locations — is ready to serve your prototype or production needs. Right now.

For the latest word on optoelectronics in new-design considerations, write on your letterhead for "Opto Glossary" — a handy new designer's aid with opto terminology, a complete offering of LEDs, couplers, displays and photodetectors plus comprehensive cross-reference data. Box 20912, Phoenix, AZ 85036.

MOTOROLA OPTO

Let There Be Light

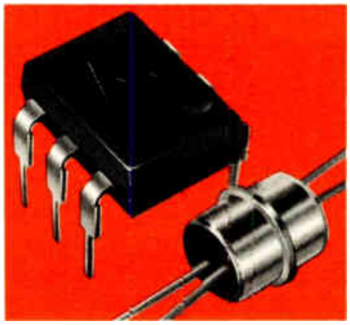


Custom Display Panels Count Up, Spell Out

- Available with or without decoder drivers
- Any combination of alpha or numeric digits
- Ultra-reliable 0.7" digits

ADVANCE INFORMATION

CIRCLE NO. 85



Opto Couplers Isolate Interfacing Perfectly

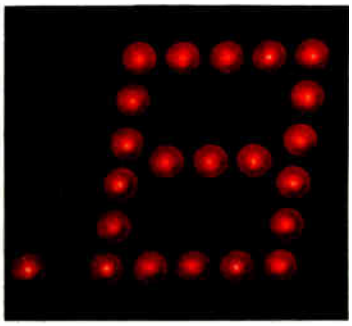
- 1,500 V dielectric isolation
- 60% transfer ratio — phototransistor
- Phototransistor or photodarlington

CIRCLE NO. 86

MOR10 Excellent Character For New Readout Role

- 0.120" character light
- Wide angle, single plane
- Straight or spread leads

CIRCLE NO. 87



MDP70 Displays 7/10" Readouts Through BCD Inputs

- Readable to 20 feet
- Compatible with T²L
- Easy insertion to connector

ADVANCE INFORMATION

CIRCLE NO. 88

The Kokomoans now give you Darlington Switching Power.

Use a Darlington in place of an ordinary transistor, and you'll realize an additional magnitude of gain plus increased switching power. Use a Delco silicon power Darlington (DTS-1010 or DTS-1020) and you'll also realize a gain in dependability.

Delco's Darlingtons are triple diffused mesa units housed in copper TO204MA cases and built for ruggedness. The design gives them high energy capability—the ability to handle surges of current and voltage simultaneously. They are ideal for switching inductive loads in circuits subject to transients or fault conditions.

Design a switching regulator circuit around a Delco Darlington or use it in any 60-100 volt application to reduce circuit size, weight, and cost. In addition, the Darlington space saving feature allows you more design flexibility. Unlike an ordinary transistor, it's only energy-limited, not beta-limited. You can exploit its full energy capability in your circuit.

Call your nearest Delco distributor. He has them in stock and he's got the data on high energy switching for small spaces.

For details on the switching regulator circuit, ask for Application Note 49.

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DIVISION OF GENERAL MOTORS CORPORATION.
KOKOMO, INDIANA

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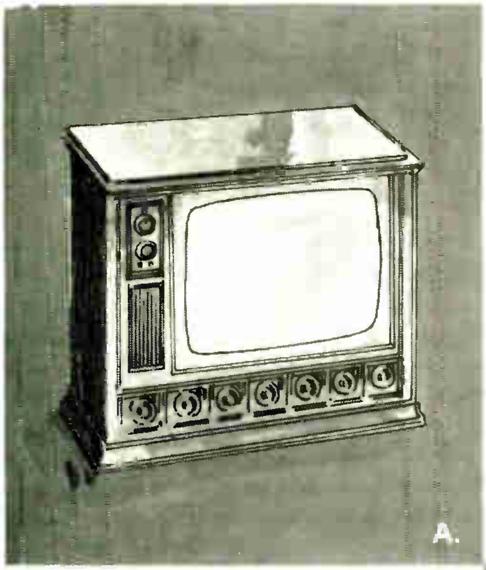
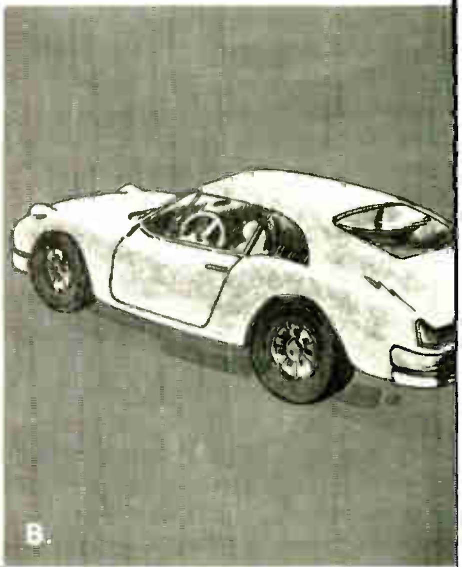
GM
MARK OF EXCELLENCE

Come to where



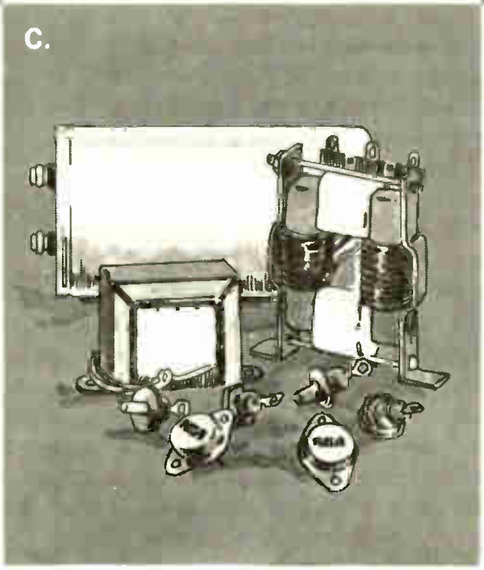
A

RCA 2N3440, 2N5804, 2N5838, and 2N6175 offer a high-voltage line-up for every high-voltage socket in color TV – video output, picture-tube driver, high-voltage regulator, class-A audio, horizontal driver, and vertical and horizontal deflection.



C.

RCA types 40850, 40851, 40852, 40853, and 40854 perform in off-line switching mode power supplies. Why not improve your system costs two ways: first, through RCA's exclusive thermal fatigue ratings to assure longer service life and, second, through competitive prices.



B.

RCA 2N5804, 2N5838, 2N6077, and 2N6249 are employed in inductive or capacitive discharge ignition systems or electronic carburetors. Device ruggedness is documented in RCA's second-breakdown data and the industry's only thermal fatigue ratings. If your specs don't require thermal fatigue ratings, you can't be sure you're protected.

Ratings within the basic families listed below vary from 200 to 400 volts. Custom selections with ratings above 400 volts are available.

Basic Family	Max. Ratings P_T (W)	I_C (A)	Pkg.	100-Unit Price (Each)
2N3440	10	1	TO-5	$0.65
2N5415*	10	–1	TO-5	0.90
2N6175	20	1	TO-5 (P)	0.59
2N3583	35	5	TO-66	0.96
2N6211*	35	–5	TO-66	2.70
2N6077	45	10	TO-66	1.80
2N5838	100	10	TO-3	1.98
2N5239	100	10	TO-3	2.16
2N5804	110	15	TO-3	3.30
2N6249	175	30	TO-3	6.00

*p-n-p types

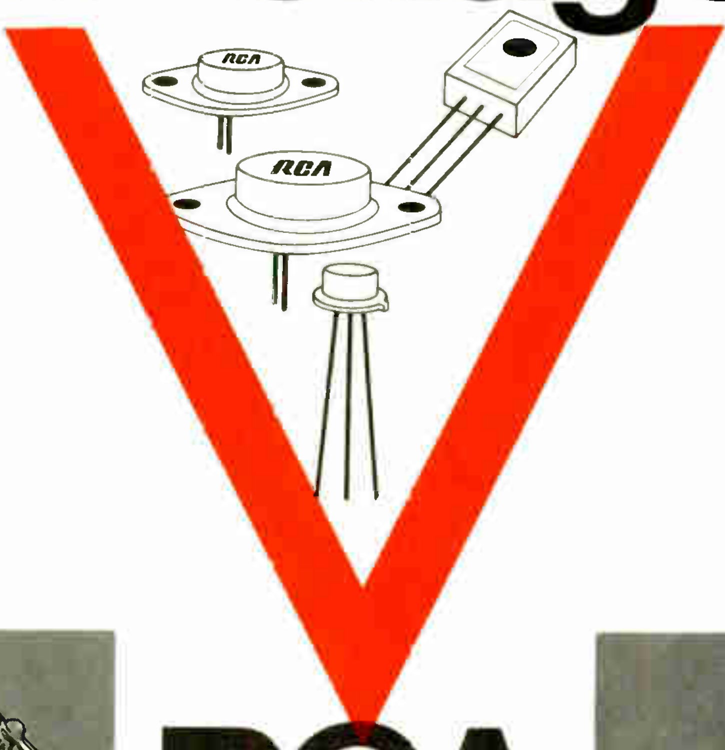
For more information on these and other RCA silicon power transistors, see your local RCA Representative or RCA Distributor. Or call Gene Van Wagner, Power Transistor Marketing Manager, at (201) 722-3200, ext. 3381. For technical data on specific types write: RCA Solid State Division, Section 70D-24 /UTL-28, Box 3200, Somerville, N.J. 08876. International: RCA, Sunbury-on-Thames, U.K., or P.O. Box 112, Hong Kong. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Quebec.

RCA Solid State

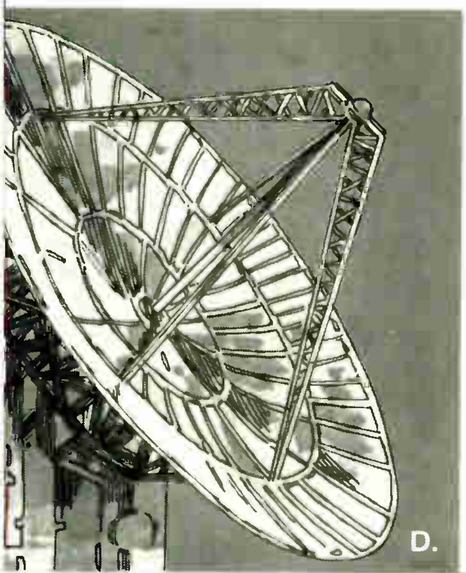
products that make products pay off

Circle 52 on reader service card

high voltage is...



RCA

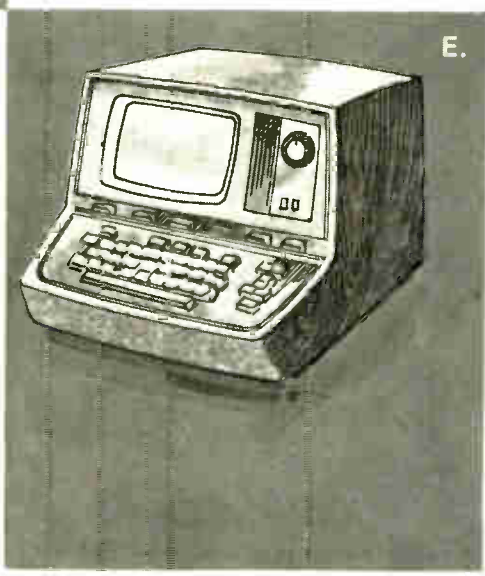


F.

RCA 2N5804, 2N5838, and 2N6249 are engaged in ultra-sonic transducer/driver and output applications where reliability is essential, based on forward-bias, second-breakdown-free operations and thermal-fatigue ratings.

D.

RCA 2N5415, 2N5838, and 2N6077 are utilized for high-reliability service in antenna PIN diode phase-shift drivers. For this — and other high-voltage military applications — check RCA's high-voltage devices from one of the lines of combined JAN, JAN TX and equivalent types.



E.

RCA's high-voltage p-n-p devices contribute to the broadest high-voltage line in the industry. From it, select 2N3440, 2N3583, 2N5415, and 2N6211 for electrostatic and magnetic deflection applications requiring high-voltage complementary device performance.

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It's a woman's right to change her mind.

SUE is as different from other minicomputers as women are from men. And for the same reason. It's the way she's built.

SUE is the System User Engineered minicomputer.

From the beginning, the first principle in her make up was flexibility. In that she's unmatched.

Look at her main frame. The wide bandwidth Infibus you see there has plugs for up to 24 cards. Memory cards. Logic cards. Arithmetic cards. Input/Output cards. Special interface cards. Even multiprocessors on a common Infibus. So there are literally hundreds of SUEs. What she can do depends on the number and combination of cards chosen for a particular application.

In short, whatever kind of minicomputer you want her to be, she is. And that's all you pay for. Exactly the minicomputer you need.

As your needs change, you can change SUE. Simply by changing cards. You can expand her memory to 32K. You can mix core and semiconductor memories, and memories of different speeds, in the same system. She'll give you a thruput of 80 million bits a second.

If you've got a system that's looking for a minicomputer, have we got a beauty for you.

Call SUE for her vital statistics. (213) 722-6810 or write: 6201 E. Randolph St., Los Angeles, California 90040

Lockheed Electronics
Data Products Division.
A Subsidiary of Lockheed Aircraft Corporation.

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Washington newsletter

Interest in laser propulsion of missiles . . .

Both the National Aeronautics and Space Administration and the Army are exploring the feasibility of rockets propelled by ground-based, high-energy lasers. The space agency's Lewis Research Center at Cleveland and the Army's Safeguard system office at Huntsville, Ala., premise their efforts on the idea that **an extremely high power laser aimed at the base of the rocket could vaporize the fuel to produce ion propulsion.** This concept was put forward more than a year ago by Arthur Kantrowitz, director of Avco Corp.'s Everett, Mass., Research Laboratory, who envisions **reducing launch costs from their present level of about $1,000 or more per pound to about two cents.**

. . . . prompts NASA, Army experiments

NASA may fund a laboratory experiment based on the conclusions of a Lewis Research Center team that examined the Avco-Everett laser propulsion theory. The initial experiment would probably use an infrared laser and a small-diameter rocket, and **cost about $70,000.**

NASA stresses it does not yet know if the exotic concept is practical or economical. Neither does the Army Safeguard office, whose Advanced Ballistic Missile Defense Agency is funding Avco-Everett for a feasibility study using high-efficiency metal vapor lasers.

GAO to publish F-14, Phoenix study next month . . .

The General Accounting Office is planning next month to release the results of its investigation into the Navy's F-14 jet fighter program. Agency sources say **it will strongly criticize not only the service and its prime contractor,** Grumman Aerospace Corp., Bethpage, N.Y., but also **cost overruns and performance problems with the F-14's principal weapon, the Hughes Aircraft AN/AWG-9 Phoenix missile.** However, these same sources add that the allegations by Sen. William Proxmire (D., Wis.) that the plane will be inferior in several respects to McDonnell Douglas' F-4J fighter, which costs a quarter as much, "are inaccurate" and "taken out of context" of the GAO investigation.

. . . but DOD still supports Grumman

The GAO disclosures are **not expected to alter Pentagon plans to restructure the F-14 contract** with Grumman later this year. [*Electronics,* April 10, p.57]. Increased pressure on the service and Congress to accept a new contract came from Grumman chairman E. C. Towl, who told the Senate Armed Services Committee that, **unless the contract is rewritten, the company "will close the doors, we'll have to,"** since the company's bank in New York has threatened to cut off its line of credit.

Addenda

Strong Defense Department influence on NASA's $5.5 billion space shuttle becomes obvious with the space agency's selection of Vandenberg AFB in California as an alternative shuttle launch and landing site to Cape Kennedy. Program insiders have long been aware that DOD virtually dictated the shuttle's payload requirements. . . . **The Federal Power Commission wants comments by May on its plan for the nation's growing energy crisis,** and hopes to proceed later this year with requests for proposals for a system that would centralize regulatory data and prepare studies on the effects of regulatory actions.

Navy ship programs come under congressional fire

Another congressional investigation of military procurement problems is about to bloom. And this time the Navy will be in the spotlight with the House Armed Services Committee's disclosure that it wants a close look at cost and performance of two of the service's big shipbuilding programs—the DD-963 Spruance class destroyers and the LHA amphibious assault ships. Both are under contract to Litton Industries Inc., Pascagoula, Miss., shipyards, a Gulf Coast facility touted by the company as one of the world's most automated.

Although the Secretary of the Navy and his Chief of Naval Operations, Adm. Elmo Zumwalt, have acknowledged unspecified cost and performance problems with both programs in published congressional testimony, the principal stimulus for the investigation by a committee normally friendly to the Pentagon is reputed to stem from classified investigations of the programs by the congressional economic watchdog, the General Accounting Office. GAO sources say the studies of the DD-963 and LHA—a highly automated vessel as big as a World War II carrier—were completed last month and are now going through final revisions in time for the House hearings.

All at sea

For the Navy, the hearings threaten to expose its ineffectiveness at evaluating cost estimates in an area in which it is supposed to be most expert—ship construction. For the Navy's contractors, the investigations could prove one more embarrassing example of a hungry industry anxious to promise performance at prices and under timetables they are not certain they can meet. For the defense industry generally, the hearings will do more than damage their credibility in the eyes of many taxpayers. The hearings are likely to expose the larger, more serious problems that rising defense budgets are not buying more defense, and, in some cases, are buying less.

"You are under a cloud," the Secretary of the Navy was warned by Rep. Robert F. Sikes not long ago. And the Florida Democrat, long known to be sympathetic to military problems, made it clear he was speaking of DOD in general, "not just the Navy." The fact that several other members of the Congress are also publicly expressing concern with the defense budget and what it is buying suggests that the issue will become a major one this election year.

What is of concern to the defense electronics industry is that the Navy is moving to control costs by stripping the capabilities of new systems to the bone. After conceding to Rep. Sikes and other committee critics that "we have been overly optimistic in the predictions we have made in the costs of weapons systems," the Navy Secretary said the service has now "to be brutal with our people in not putting everything that is good or desirable on that."

"A good example," he believes, is contained in the Navy's new class of austere escort ships, the Patrol Frigate. Design awards for the ship were recently made to Bath Iron Works Corp. and Todd Shipyards Corp. (see p.37). It is no secret that some senior Navy officers are unhappy with the concept of the PF as a vessel with a single engine shaft, a comparatively low top speed of 28.5 knots, a 4,500-mile range at 20 knots, and a limited electronics and weapons system. As the Navy Secretary put it: "There will be all kinds of temptations to get two screws on that, to change the power system, to get greater speeds. It is going to take some real, hardboiled supervision to see that that oh-so-desirable thing is not tacked on."

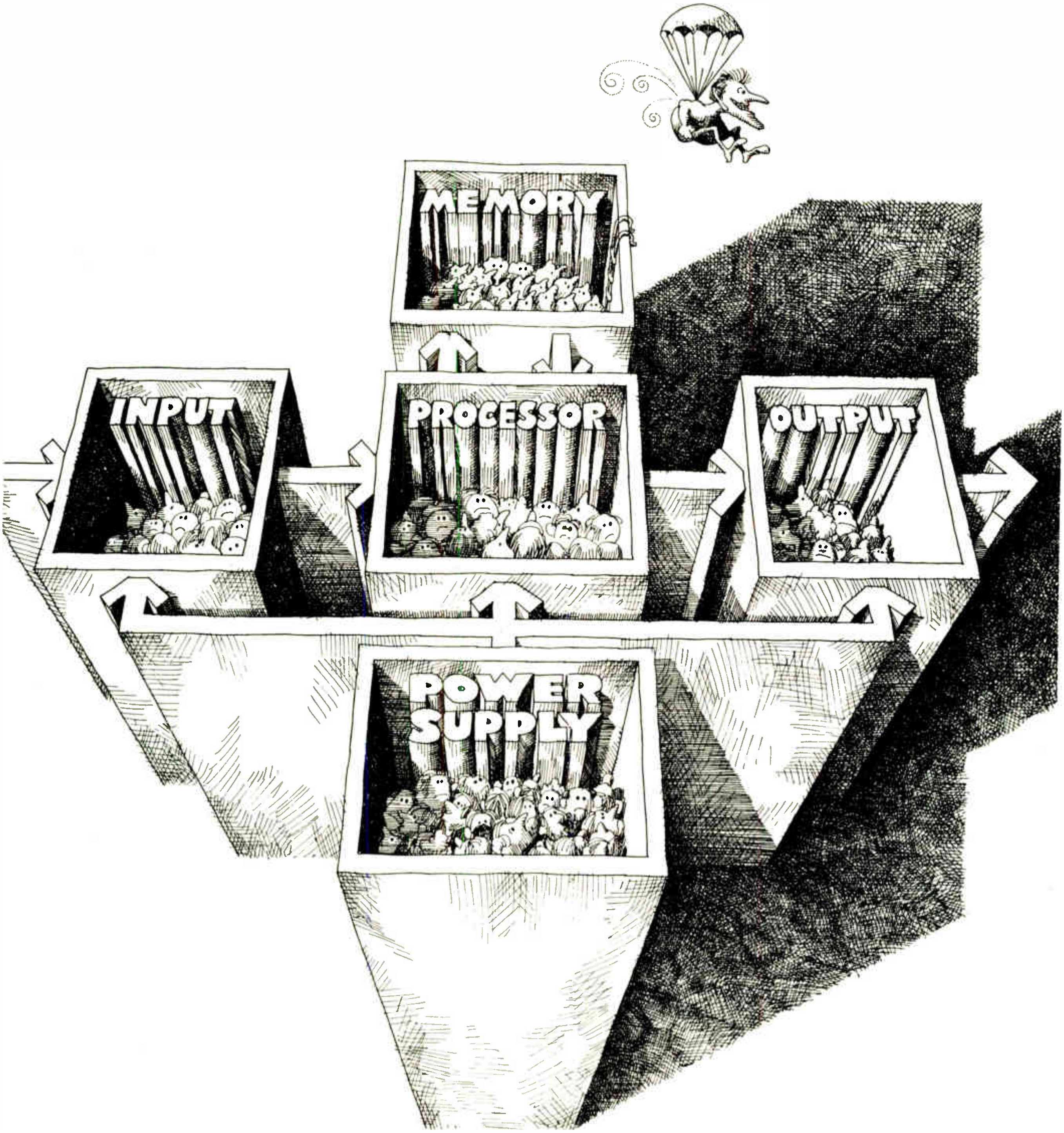
Is the Navy headed on the right course with its plans to generate what one officer dubs privately "a lot of little stripped ships"? Two defense electronics contractors' representatives in the capital express the views of many when they say no. They argue that the Navy is still trying to get "a little bit of everything" rather than make some major changes in its concept of a Navy of the future by staking its claim on fewer classes of ships.

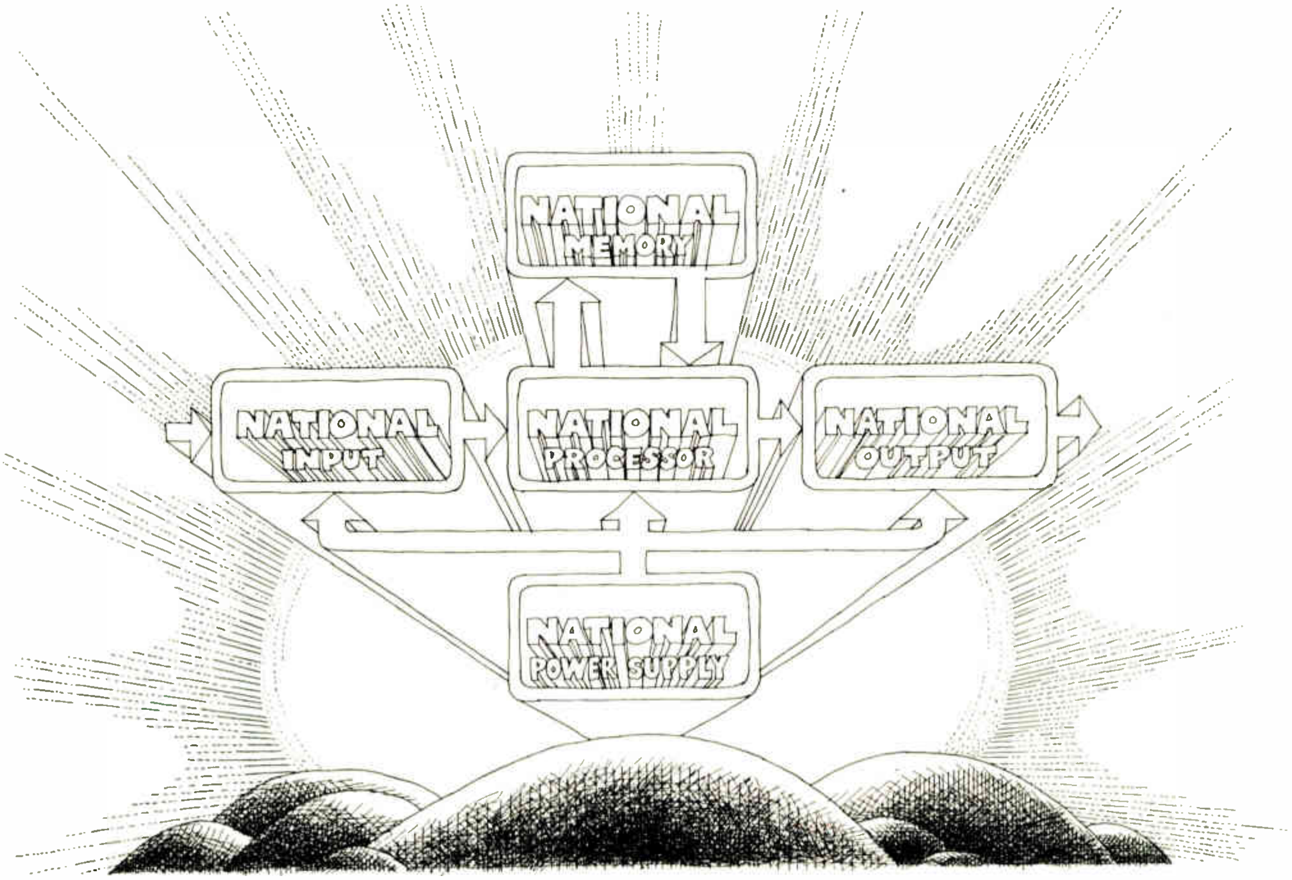
Is the carrier worth $1 billion?

One concept certain to get greater public visibility as 1972 becomes "the Navy's turn to sweat" in the investigative limelight on Capitol Hill is that of phasing out the aircraft carrier as the service's capital ship and giving that role to its missile-carrying nuclear submarines. With projected costs of the CVN-70, the third Nimitz-class carrier, now touching the billion-dollar level, that idea is making headway in Congress—much to the delight of the Air Force. The prospect of laying out a billion dollars for a single ship has boggled the minds of several members of Congress. And though it will take many such boggled minds to turn a tradition-bound Navy off on carriers, there are some industry veterans in Washington who see it as one way to let the Navy build a better fleet without compromising its technological options.

—Ray Connolly

HOW TO BEAT THE SYSTEM.





For the most part, until recently, system design consisted of linking together a string of components, with little or no regard toward the cost effectiveness of the system as a total integrated unit.

So, while pennies were being saved in one part of the system, dollars were being lost somewhere else.

Today, in order to be competitive, you've got to look beyond the cost of an individual component as to how it functions in relation to all other parts of the system.

Which is where we come in.

OUR COMMERCIAL

We make products to fit every part of the system. Input Interface. Processor. Memory. Power Supply. And Output Interface.

Products designed to perform a specific function. But always in the context of the system as a whole.

Products built so that the system you build doesn't end up costing an arm and a leg. Whether it's a computer system. Consumer system. Industrial system. Or military system.

On this page, we've taken the liberty of listing the types of products we make for each part of the system.

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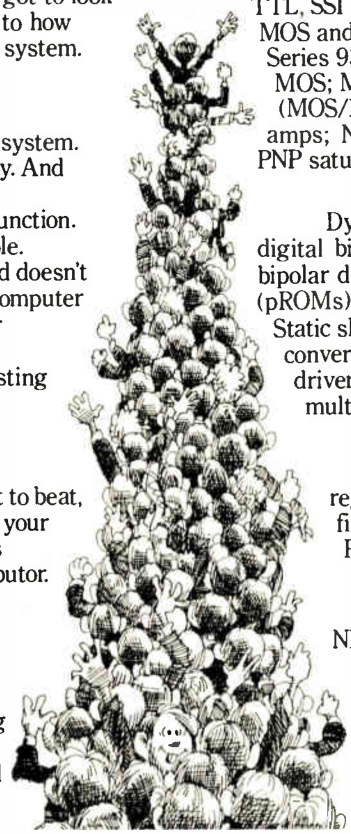
No matter what kind of system you've got to beat, there's a National Field Applications Engineer in your area who's ready, willing and able to help. For his name and number, ask your local National distributor. Or call us at (408) 732-5000.

INPUT INTERFACE CIRCUITS

Single or dual NPN low level amplifiers; Single or dual N-channel low noise amplifiers; Code converters; Table look-up devices; Analog switches, hybrid and monolithic; Operational amplifiers; Comparators and buffers, linear and digital; EIA line receivers; Digital line receivers; MOS transmitter/receivers; Bus line transceivers; VHF and UHF oscillators.



PROCESSOR CIRCUITS

Series 54/74 TTL, SSI and MSI; Series 54/74 Compatible Tri-State* (TSL) Logic, SSI and MSI; Series 54S/74S TTL, SSI and MSI; Series 54H/74H TTL, SSI and MSI; MOS and bipolar ROMs and RAMs; Series 10,000 ECL; Series 930 DTL, SSI; CMOS, Series 54C/74C; Custom MOS; Microprogrammable Arithmetic Processor (MOS/LSI); Linear communications circuits; RF/IF amps; N and P channel FET switches; NPN and PNP saturated switches.

MEMORY CIRCUITS

Dynamic RAMs, MOS; Static RAMs, MOS and digital bipolar; Read Only Memories (ROMs), MOS and bipolar digital; Programmable Read Only Memories (pROMs), MOS and bipolar digital; Dynamic shift registers; Static shift registers; Character generators; Code converters; NPN and PNP core memory drivers; Clock drivers; Sense amplifiers; Peripheral drivers; 54/74 multiplexers, comparators and control circuits.

POWER SUPPLY CIRCUITS

Voltage regulators, ± tracking; Voltage regulators, fixed positive; Voltage regulators, fixed negative; Operational amplifiers; NPN and PNP medium power amplifiers.

OUTPUT INTERFACE CIRCUITS

NPN and PNP general purpose amplifiers; NPN and PNP RF amplifiers; NPN high voltage video output amplifiers; Custom MOS; Operational amplifiers; Comparators/buffers; Peripheral drivers; Display drivers; Hybrid power amplifiers; Hybrid level shifters and digital drivers; Sample and hold hybrid circuits.

*Tri-State is a trademark of National Semiconductor Corporation.

FOR EXAMPLE:

MAIN FRAME COMPUTER

MEMORY
Sequential Access Memory
"Silicon Disc" MM5012, MM5013, MM5025 Series
MOS Random Access
MM1101 Series, MM1103, MM5260, *MM5262
Bipolar RAMs & Scratch Pad
DM7489, DM8599, DM74200, DM8551, DM8553
Memory Drivers & Sense Amps
MH0025, MH0026, LM75451, LM75452, LM75453, LM7520 Series, LM7534 Series

INPUT
Telecommunication Receiver
LM1489A EIA
Local Line Inputs
DM8820A
Bus Inputs
*LM130, *LM131 Series, DM8093, DM8094, *DM8095 Series

PROCESSOR
Microinstruction Decoders
DM74187, DM8597, *DM8596 ROM's
Arithmetic Logic Unit
DM7483 Fast Adder, DM74181 ALU, DM74182 Look-Ahead, DM8875 4-Bit Mult
Counters
DM8281, *DM8556
Random Logic
DM8093, DM7442, DM10,000 Series ECL, DM74S Series

OUTPUT
Display Drivers
LM350, LM75450 Series, DH0011 Series
Line Drivers
LM1488 EIA, DM8831, *LM131 Series

POWER SUPPLY
Voltage Regulators
LM100, LM104, LM105, LM109, LM723, LM376
Transistors
Process 12 & 67 Medium Power Transistors
Control Amplifiers
LH0052, LM108A, LM112, LM741

*To Be Announced

CARD READER

MEMORY
Rubber Band Accumulator (RAMs)
DM74200, MM1101, MM1103, MM5260, *MM5262
First In/First Out Memory (Static Regs)
MM5050, MM5051, MM5052, MM5053, MM5054, *MM5055, *MM5056, *MM5057
Memory Drivers
MH0025, MH0026

INPUT
(From Optical Data & Card Position Sensors)
Dark/Light Comparators
LM710, LM111, Process 52 & LH0042 FET Amps, Process 83 Dual J-FET Amplifiers

PROCESSOR
Memory Control
DM8281, DM7493, *DM8556, DM7483, DM74181
Card-Code Converters
To ASCII MM5230BO
To EBCDIC MM5230QW
Random Control Logic
DM7400 Series, Tri-State Logic
Bus Address Comparator
*DM8131

OUTPUT
Data Output Bus Drivers
*DM7438, DM7405
Transmitters/Receivers
DM7830, DM7831, DM7832
Bus Transceivers
*LM130 Thru LM136
Card Position Drive
DH0006, DH0008, DH0028, DH0034, Process 12 & 69 Drive Transistors

POWER SUPPLY
LM100, LM105, LM376, LM723, *LM140, LM109, LM104, Process 46 Medium Power Transistors

*To Be Announced

MODEM

INPUT
EIA Input From Terminal Equipment
LM1489A
Balanced Input From Data Access Arrangement (Telephone Lines)
LM301A, LM307

PROCESSOR
Bias Level Conditioner
LM301A, LM307, LM709
Active Notch Filter
LM373, LM374
Phase Locked Loop
LM565
Voltage Controlled Oscillator
LM567
Random Logic & Transistors
74 Series, Process 20 & 63 Medium Pwr Transistors

OUTPUT
600 Ω Balanced Output Driver
LM101, Process 12, 20, 63 & 67 Medium Pwr Transistors
Phase Locked Loop Control Voltage Transistor
LM711
EIA Line Driver
LM1488

POWER SUPPLY
LM300, LM304, LM305, LM309, *LM340, LM376, LM723, Process 12 & 67 Medium Pwr Transistors

*To Be Announced

AM/FM STEREO – PHONOGRAPH

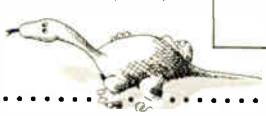
INPUT
AM Front End Oscillator Mixer
Process 46 Amplifier Transistor
FM Tuner
NF 506, LM1496, Process 43 & 44 Oscillator/Mixer Transistors
Record, Tape, & Microphone PreAmp
LM1303, LM381, LM382, Process 52 Low Noise Transistors

PROCESSOR
AM IF Strip
LM372, LM373
FM IF Strip
LM373, LM703, LM3075, LM2111, LM1351, LM2113, Process 47 IF Transistors
Buffer & Demultiplexer
LM1304, LM1305, LM1307, *LM1800, Process 27 Small Signal Transistors, Process 52 Audio FET Transistors
Tone Controls
LM381, Process 27 Transistors

OUTPUT
Left & Right Audio Power Amps
LM380, *LM383, *LM377, Process 12 & 67 Medium Pwr Transistors

POWER SUPPLY
*LM340, LM376, Process 12 & 67 Transistors

*To Be Announced



VIDEO DISPLAY SYSTEM

MEMORY
Static Buffer Registers
MM5050 Thru MM5057
Line Memory
MM5001, MM5006, MM5018, MM5054, MM5020, MM5021
Page Memory
MM5012, MM5013, *MM5017, MM5025 Series
Memory Drivers
MH0025, MH0026

INPUT
Keyboard Scanners (LSI)
MM5704 Serial, *MM5740 Parallel
(MSI)
DM74150 Series, DM8309, DM8312, DM8322, DM8123, DM8214
Line Input (Local)
DM8820A, DM8131, LM131 Series
(Remote)
DM8822, *DM1489

PROCESSOR
Formatting
DM8570, DM8590, *DM86L90
Character Generator ROMs
MM5240, MM5241, *DM8596, DM74187
Sync Generator
*MM5320
Memory Page/Line Control
DM8093, DM8094, DM8095 Series, DM8123, DM8322
Line Counter
DM7490, DM7492, DM7493, *DM8555

OUTPUT
Horizontal & Vertical Oscillator/Driver
Process 48 HV Video Output Transistors
Z Axis Driver
Process 48 HV Video Output Transistors
Deflection Drivers & Amps
LH0021, LH0041, Process 12, 14 & 67 Medium Power Transistors

POWER SUPPLY
LM300, LM304, LM305, LM309 Series, LM376, *LM340

*To Be Announced

COLOR TELEVISION

INPUT
UHF Tuner Oscillator
Process 43 & 47 Transistors
VHF Tuner Oscillator
Process 43, 44 & 47 Transistors
Automatic Fine Tuning
LM3064
IF Discriminators
Process 27 & 47 Transistors

PROCESSOR
Sound & Video IF's
LM3075, LM3065, LM2111, LM1351, Process 45 & 47 RF/IF Transistors
Video Processor
*LM1845, Process 27 & 63 Transistors
Luminance
Process 20 & 63 Transistors
Chrominance
LM3070/LM3071, LM3066, Process 27 & 71 Small Signal Transistors, Process 45 & 47 AGC/IF/RF Transistors
Chroma Demodulator
LM746, LM3067, Process 27, 71 & 47 Transistors

OUTPUT
Audio Amplifier
LM380, Process 12 & 67 Transistors
Video Output
Process 48 High Voltage Transistor
Vertical & Horizontal Output Drive
Process 12, 14 & 67 Medium Power Transistors

POWER SUPPLY
*LM340, LM376, Voltage Regulators, Process 12 & 67 Medium Power Transistors

*To Be Announced

NOTE: Detailed block diagrams are available for the systems shown, as well as the following systems: ECM Receiver, MOS/Bipolar Calculator, Credit Verifier, Telemetry, Process Controller, Printer and Digital Voltmeter.

Circle 59 on reader service card

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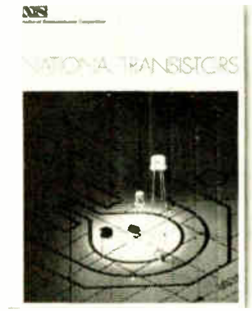

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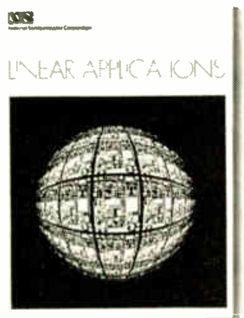

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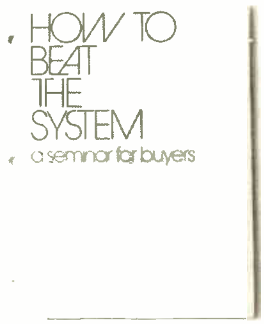

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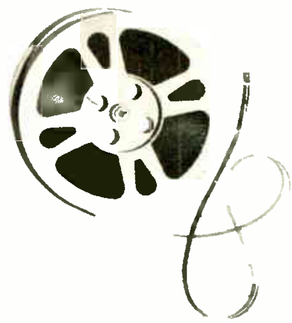

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National

Coils of thin film thermoelectric elements run West German nuclear pacemaker

For a cardiac patient with an implanted pacemaker, every heartbeat depends on a reliable battery. After three years of development work, researchers at Siemens AG have come through with a nuclear battery for pacemakers that offers high reliability even if one of its two voltage coils should fail.

On both sides of the Atlantic, medical electronics engineers are working to replace conventional electromechanical batteries with thermoelectric radionuclide types using the disintegration energy of radioactive materials. The big advantage of such atomic power packs is their long life—10 years or so, compared with about two years for conventional batteries. Long life, of course, means less frequent pacemaker implantation.

Isotope. In the Siemens battery, developed at the company's research labs at Erlangen, the primary energy source is plutonium 238, the same as in other nuclear batteries. Supplied by the German Society for Nuclear Research, it comes in 10-millimeter-diameter radiation-resistant capsules.

The plutonium 238 isotope, according to the experts, is a pure alpha emitter with good energy density characteristics and a half-life period of 86 years. Pure alpha emitters have the big advantage that their radiation is completely absorbed even by relatively thin metallic layers.

To produce an output of around 200 milliwatts—the power rating for which the Siemens battery is laid out—a thermal power of 100 mw is required. For that, 200 milligrams of Pu 238 are needed. The energy released during the radioactive decay of the plutonium causes the capsule to warm up to about 100°C. Thermoelements in the battery then convert this heat energy into electrical energy, with the temperature gradient between the capsule surface and the patient's body being used in this conversion.

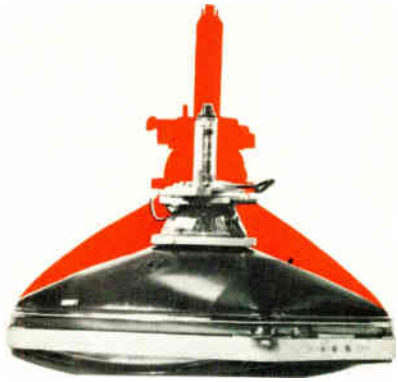
Deposits. In both design and arrangement of the thermoelements, the Siemens nuclear battery differs markedly from other nuclear batteries. In the new approach, the thermoelements are first vapor-deposited onto thin polyimide strips, with about 700 such elements continuously following each other in meandering fashion on a 3-foot-long strip. The element legs so produced consist of alternate p-type and n-type semiconductor material.

The strips are then tightly rolled into small coils, which are subsequently glued together with the plutonium capsule to form the thermoelectric-nuclear power pack. The front and the end faces of each coil are the hot and the cold sides of the system. One 200-element coil can deliver the required voltage for the pacemaker directly, without any voltage converters needed. By paralleling two coils, the battery reliability is increased so that, even if one coil should fail, enough energy remains to operate the pacemaker.

Japan

Sony pushes color tube to 114°

Sony Corp., which always tries to keep one up on its competition, says it is four degrees up this time. While other manufacturers are announcing new color sets with 110° wide-deflection-angle tubes, Sony has just announced its entry with a 114° tube. The tube has an 18-inch screen, but would be known as 17-V in the U.S.

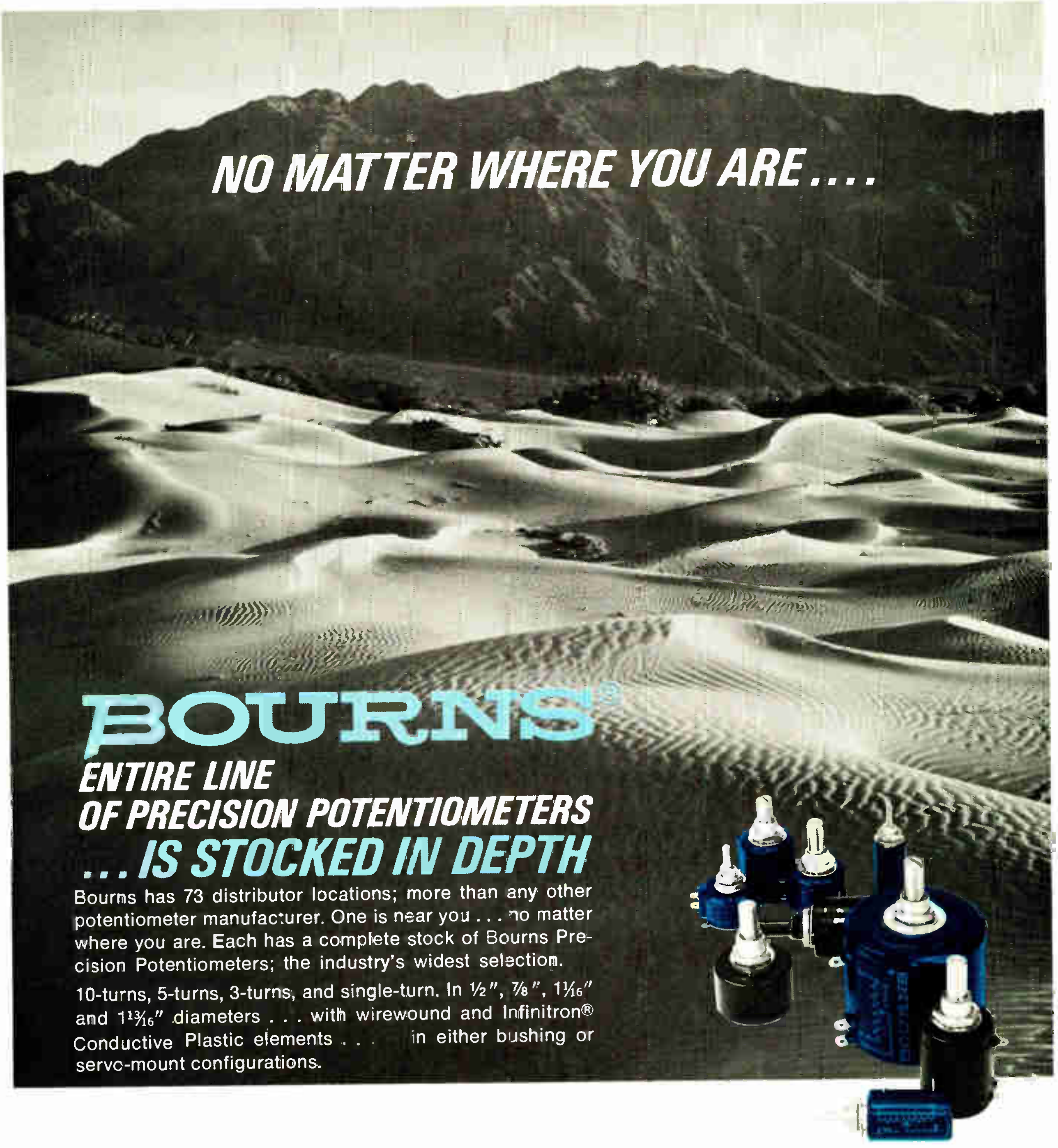


Smaller. Sony's 114° tube allows a set with two-thirds of previous set's volume.

Sony also came up with a second surprise. The set with the new tube will list in Japan for $444, almost 2% below the price of the 18-inch set it replaces. Other manufacturers have asked for higher prices for their sets with 110° tubes, and a number of manufacturers had been contemplating raising color-tube prices because of the increase in Japan's commodity tax.

But, what with the decision by Matsushita, which has at least 30% of the market, to hold the line on prices, and this decision by Sony, which has perhaps 15% of the market, to lower the price of its new set, it is probable that prices will not rise.

Pluses. Sony claims that development work shows it could produce tubes with deflection angles as large as 120°, but the 114° envelope was chosen because it is the most economical design. Company engineers say that, when the 114° tube is exposed to ultraviolet rays during fabrication, the shorter light-source-to-screen distance gives higher yield than for present 90° tubes. They further say that the in-line gun arrangement—together with the parallel-phosphor stripe design and the cylindrical face plate—eliminates the complex correction lens.



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MOS main memories appear in two Japanese computers

The semiconductor memory age has come to Japan with the announcements by Toshiba and Hitachi that they have started selling computers with MOS main memories. Toshiba's entry is a minicomputer that costs $6,330 with a standard 8-kilobyte memory and $9,600 with a 16-kilobyte memory. For the same capacity, it is both smaller and less expensive than the machine it replaces. The semiconductor memory has an 800-nanosecond cycle time. **Initially, the 1,024-bit chips will be imported, but Toshiba expects to switch over to its own LSI soon.**

The Hitachi entry is a small computer that comes with options for 24-, 32-, and 40-kilobyte memories. The smallest configuration rents for $1,585 a month, with the standard configuration renting for $3,000. Suitable for on-line real-time installations, it features a simplified approach to programing and a 4.9-megabyte file memory. **The MOS memory, which has a 900-nanosecond cycle time, is built from 1,024-bit chips that will be manufactured by Hitachi.**

Philips tries decentralization of R&D work

Philips Gloeilampenfabrieken long has followed a policy of setting up production centers outside Holland, while keeping most of the research and development and central marketing functions at its home base in Eindhoven. Now the company's Test and Measuring Instruments division plans to push decentralization even further. For starters, the division **will shift all its R&D and production efforts in pulse generators and counters to its Swedish subsidiary, keeping only the marketing function in Eindhoven.** The division's commercial director, Rien van Dijk, expects the move will tighten up operations. **If the scheme works, Philips eventually will move other instrument R&D groups out of Eindhoven, where the company is holding the line on its workforce.**

SAAB announces 370/155 rival

Taking a page from the marketing book of its giant competitors, SAAB-Scania has presented details of a new generation computer over a year and a half before the first unit will be delivered. **SAAB says its D23—which will have semiconductor internal memory—is comparable to the IBM 370/155, but will sell at a lower price.** Right now, the D23 is being weighed against the 155 by Swedish officials, who are deciding on purchasing two new computers for military administrative purposes. The state computer purchasing agency had some months ago **recommended the IBM machine over the predecessor SAAB D22, but SAAB brought out its D23 as a new contender for the contract.**

According to SAAB officials, **the D23 will enable the Swedish maker to remain competitive—at least in the Scandinavian market—for the most part of this decade.** The D23 has a capacity of 786,432 bytes in the central processing unit. The cpu reads or writes eight bytes in storage in a 400-nanosecond period, giving a storage cycle time of 50 nanoseconds per byte.

Japanese, Germans in computer peripheral talks

German-Japanese cooperation in computer peripherals might well be the outcome of exploratory talks being held between Siemens, Hitachi and Fujitsu. Each would probably take out licenses from the others to build peripherals that would fill out its own systems lineup. That's what

Siemens and Fujitsu have been practicing for years in industrial equipment. Moreover, a Siemens official does not exclude the possibility that **either or both of the Japanese companies might eventually join the recently negotiated computer accord between Siemens and France's Compagnie Internationale de l'Informatique,** a tie-up to which Philips Gloeilampenfabrieken is expected to become the third partner [*Electronics*, Feb. 14, Electronics Newsletter]. But such a link is not a near-term prospect, says Siemens, scotching rumors that a European-Japanese computer grouping is imminent.

Germans land solar cell contract for Canadian bird

AEG-Telefunken, a big name in satellite subsystems, **has won a $2 million contract for supplying flexible, large-area solar generators for a 1975 Canadian domestic communications satellite.** Awarded by the European Space Research Organization, the contract calls for the development and production by early 1974 of one prototype solar generator and two flight versions. At 1 kilowatt, the unit will generate five times more power than Europe's Symphonie satellite and two times more than Intelsat 4. **Power is produced by very thin solar cells welded side by side and attached to two special plastic-foil sheets about 4.25 feet wide and more than 20 feet long.** During launch the sheets are folded accordion-style and stashed away along two opposite sides of the satellite body.

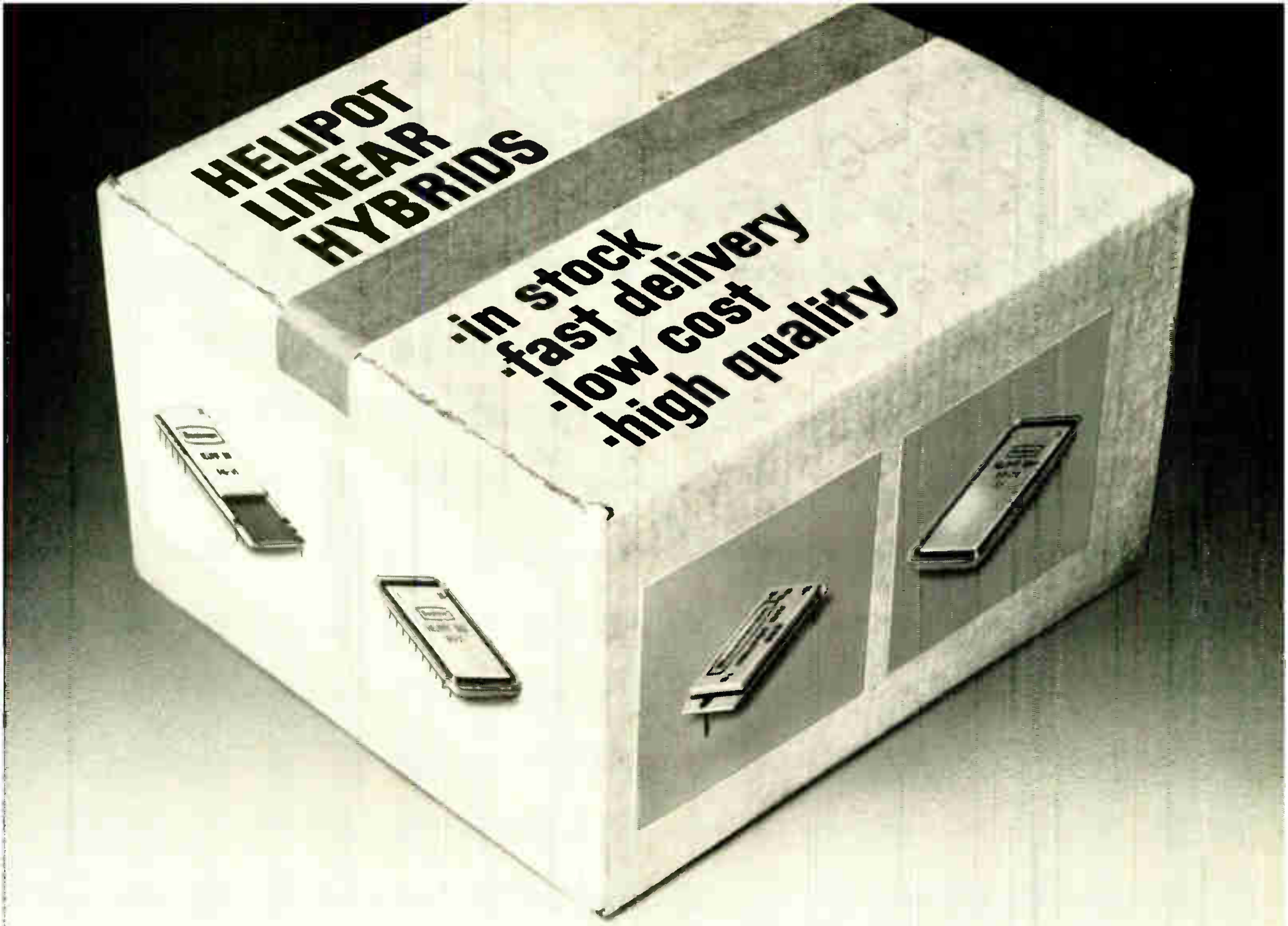
Pye pushes its phase-ranging location system

Pye Telecommunications Ltd. is about to start selling the phase-ranging vehicle location system on which it has been working with Mullard Ltd. [*Electronics*, Electronics International, June 21, 1971]. Pye men say tests in central London show that they have reduced the fundamental problem of phase ranging—the discrepancy between the vehicle's real position and the location indicated on the display that stems from multipath propagation of the radio signal by reflection from buildings. **Pye has achieved an 80% probability that the error will be less than a quarter-mile, and a 95% probability that it will be less than a half-mile.** Outside dense high-rise districts, the error performance improves considerably.

The system uses a vehicle's ordinary mobile radio installation. Pye puts the cost of equipping a 500-vehicle fleet from scratch at approximately double the cost of providing radio-telephone facilities only. The company will provide any display required but **favors a printed map, which is viewed through an angled half-silvered mirror onto which symbols are projected from a cathode ray tube.** One big advantage is the case with which the map can be changed.

Addenda

Representatives of Britain's General Electric Co. Ltd., Plessey Co., Pye Ltd., and International Computers Ltd. are in **a British delegation visiting China to try to open up trade links.** The first three companies reckon the best sales bets will probably be in the communications field. . . . British Aircraft Corp. has signed up the Norden division of United Aircraft Corp. **to make and sell BAC's Rapier low-level air defense missile, if the U.S. Army decides to buy Rapier** [*Electronics*, March 27, p. 32]. Norden would subcontract responsibility for production to McDonnell Douglas Astronautics Corp.



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815 (Binary)	10K	None	±1952 ppm −55°C to +125°C	815	6.95
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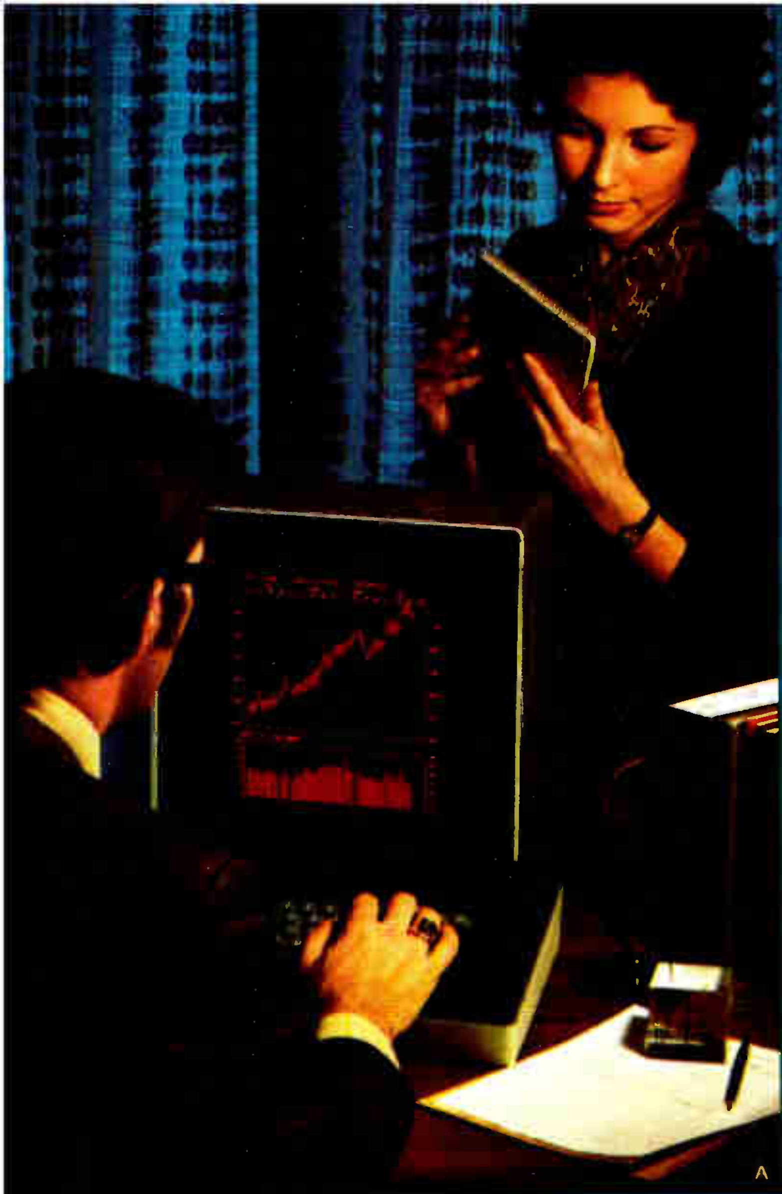

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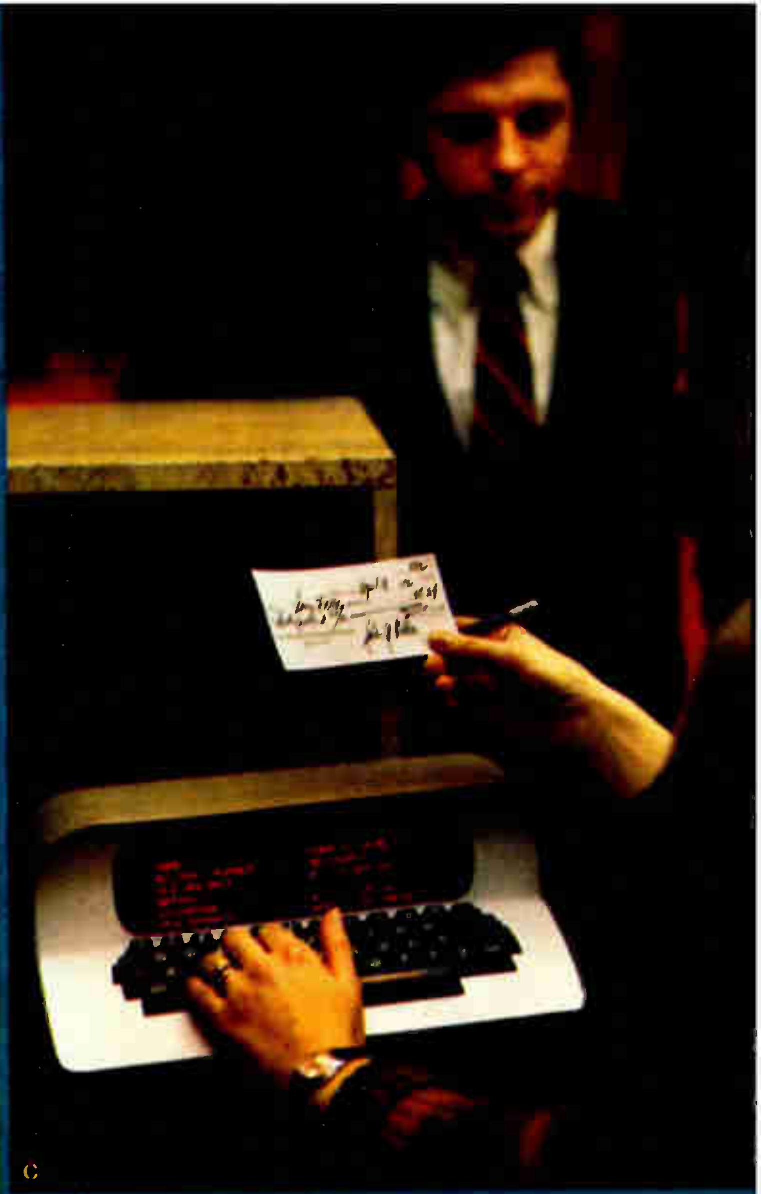

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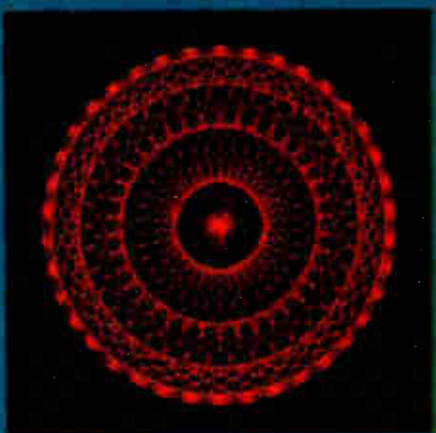

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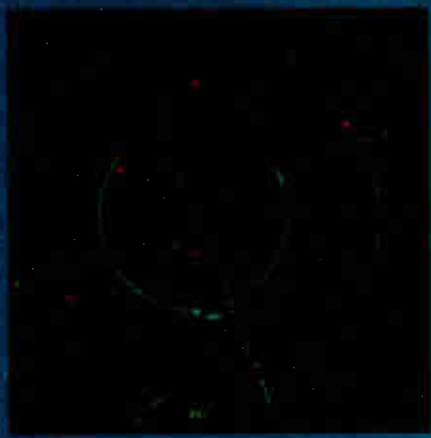

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A. Digivue 512-50 Display/Memory Unit. An 8½" x 8½" square panel of 512 x 512 lines at 50 lines per inch resolution.

B. Digivue 256-50 Display/Memory Unit. A 5½" x 10¼" panel of 256 x 512 lines at 50 lines per inch resolution.

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AT&T switches executives

Determined to brighten Ma Bell's tarnished image, the new top management is focusing on service, relations with outside groups, and the future

by Gerald M. Walker, Consumer Editor

With the public, the regulators, the Congress, and competitors increasingly contesting AT&T's benevolent monopoly, the communications colossus has installed a new chairman of the board and restructured its headquarters organization. At the peak of the executive pyramid is John D. deButts, who became chairman of the board this month after 36 years in the Bell System.

Two other officials stepped up a slot with the recent mandatory retirement of H.I. Romnes, who was president, as well as board chairman. These duties have been split, and the staff has been reconstituted into three functional areas to replace the previous division of these responsibilities among a row of vice presidents.

The business of service. Chairman deButts explains the concept: "We think we have established an organization that realizes the importance of the key elements reporting directly to the chairman. Our business is service—communications service of all kinds. That's the only thing we have to sell, so it has to have top-line attention."

To tighten controls and thereby counter public criticism, corporate responsibilities have been divided into sectors of internal and external operations and long-range planning, with the heads of the three sectors reporting to chairman deButts.

Mr. "Inside" is William Lindholm, vice chairman, with responsibility for all Bell System operations. Lindholm heads the Long Lines organization and coordinates operation of Bell Laboratories, Western Electric Co., and the telephone operating companies.

Mr. "Outside" is Robert D. Lilley, the president, who directs AT&T's relations with the Federal Communications Commission, other regulatory agencies, and financial institutions, as well as relations with employees and the public.

Mr. "Future" is Cornelius W. Owens, who continues as executive vice president, with responsibility for corporate planning, organizational studies, and business research.

All four officials have been presidents of telephone operating companies; therefore, although the organizational chart may be new, the men are hewing to the traditional Bell principle that profits depend on service. But all four are determined to polish the public image that has been tarnished by years of criticism of traditional policies.

Problems tackled. Chief among these headaches are the questions of how closely Ma Bell should be allowed to work with the FCC, whether or not the company should be allowed to retain its subsidiary Western Electric Co., and, of course, the rate structure. To deButts, the 56-year-old former president of Illinois Bell, whose first job was as traffic department trainee, the vital concern is financial.

Knowing that AT&T must raise $4 billion a year for growth and maintenance, the chairman points out that customary means of acquiring capital must be augmented by income gained through strict cost regulation, new cost-cutting technologies, and repricing of present services. For example, he says, it is possible that in areas where Bell competes for microwave transmission rights, national averaging of prices may be replaced by setting of regional rates for telephone calls.

To Lindholm, 57, a former president of Chesapeake & Potomac Telephone Co., who entered Bell as a service representative in 1936, a crucial task will be maintaining a balance between the amount of service offered and the work force necessary to provide that level of service. If the work force is cut too far, service will suffer; if the service commitment is over-extended, a costly increase in personnel will be needed to implement it.

President Lilley, who had been responsible for personnel and public relations, now has the added burden of dealing with finances and regulatory agencies. The objective is to concentrate all "outside" activities under one manager. He brings to this job a viewpoint completely different from that of most utility executives concerning communications with the regulators and the public.

Ma Bell's relations. Contrary to criticism that AT&T has been too cozy with the regulators, Lilley contends that the public would benefit from closer relations. "It seems to me," he says, "that a complete standoff and [maintaining] a distance from [Government] regulators would not help anybody—including the public—because these people are overseeing very complicated enterprises. And I'm not sure they can do it effectively unless they talk frequently with the industries. I don't mean in some underhanded way. I think in a perfectly aboveboard way, we can just tell a regulatory body what we are up against.

"Now, we don't think they understand it. Regulators get thick reports and go through hearings that last

Top telephoners. The three new men heading AT&T are all former operating company presidents and are service-oriented. John D. deButts (left) is the new chairman. Robert D. Lilley (center) is in charge of outside relations, and William Lindholm heads internal operations.

for days, and it's mind-boggling to try to understand. They [the regulators] should get somebody who has a profound knowledge and talk to him for a couple of hours," says Lilley.

On communication with the public, Lilley comments, "The big task for us today is believability." Observing that telephone executives seem to appear in public only when there's a crisis, he adds, "You can't do much if you're always firing your rifle over your shoulder in retreat. It's an embarrassing way to look good, so we ought to appear more often before the public to discuss our problems without staging these appearances."

Labs to help. This sense of improving the image is apparent in Lindholm's goals, too—through service. In the last few years, critical service problems have developed in New York City, Miami, Denver, and Boston—and to a lesser degree, in Atlanta and Baltimore. Lindholm says these problems are headed toward solution, but he is convinced that their complexity demands help from researchers in frontline projects. Accordingly, Bell Labs is reassigning 200 technicians this year to concentrate on day-to-day company operating problems.

One team of Bell Labs researchers has helped to unravel the complex overload situation plaguing New York City, and another group has begun a study to develop an inexpensive means of servicing secluded rural areas, where conventional methods have been too costly.

New technology is also expected to reduce operating costs. Lindholm predicts that electronic switching systems (ESS) for central offices will cut maintenance costs substantially. About 500 ESS offices are now in service, and two a week are being added to the system. By 1975, ESS offices are to be cut over at the rate of one a day, Lindholm says.

Another planned cost-cutter—data-under-voice—is to be field-tested this year in New Jersey, and is expected to be in service by 1974. This technique employs segments of microwave bands not used for voice transmission to be used for data transmission. For every working radio channel in a microwave system, Bell plans a digital stream of 1.5 million to 25 million bits per second.

One possible solution to telephone traffic handling in the 1980s is millimeter waveguide transmission, but field tests of the technique, which has been designed to provide a capacity of 250,000 two-way voice circuits, probably won't begin until toward the end of the 1970s, says Lindholm.

Going Western. The route from Bell Labs to the operating companies historically has been through Western Electric, and AT&T considers its links to both these subsidiaries inviolate. Not so, say some critics in the FCC, Congress, and competitive companies, who have proposed that AT&T divest itself of Western Electric.

The proposal to spin off the manufacturing facility brings all three new top executives to the defense of the present corporate relationship. Says deButts, "I am absolutely convinced that any spinoff of Western Electric would be detrimental— not only to the customer, but to investors.

"Everything that is installed—regardless of when, has to have replacement parts. By having the close association between the operating companies, Bell Labs, and Western Electric, we get quicker response to public needs. We get better response, and we get cheaper response. All of these things would be lost if Western were to be spun off, and the cost of service would go up considerably."

Lindholm, who is responsible for coordinating Western Electric's production, contends that outside suppliers cannot meet prices. "By any measurement we have been able to devise, and this has been proven over and over in state rate hearings, Western's prices are lower than prices for similar products on the outside. They always have been and they still are."

Western Electric's role is close to Lilley because he spent 28 years in the company, rising from metallurgical engineer to group vice president. "I know firsthand that quality is paramount. The ability of Bell Labs to work closely with a telephone company on an intricate design in its early stages—without a lot of lawyers shoving contracts under my nose and telling the engineer not to go too far—meant a great deal to me. True cost reductions mean true price reductions, because Western passes its savings down to the telephone company when it reduces its costs. This is something you can do more easily in a closed system than with outside equipment suppliers that are out to maximize profits."

Lasting impact sought. Each of the top executives enters his new job with service problems uppermost in his mind, and each would like to leave with improved service as his major contribution to the Bell System.

"I would like to leave the job with the public completely satisfied with the quality of the service being rendered," deButts muses. "I would like to leave a company that is completely solid financially, not only from a capital structure, but also from the earnings levels and trends point of view." He adds, "I'd like to leave an organizational structure that's patterned to current and future needs of the business."

"I was born into the public utility business in a little town in the Ozarks where my father was in the electric power company," says Lindholm. "He had a service concept that I learned from him. I want to leave this business in the best possible condition, as far as service is concerned."

Perhaps Lilley, the oldest of the three, summarizes the thinking of AT&T's top brass when he suggests, "I hope I'm lucky enough so that it will be said when I leave, 'This guy saw things before they happened and devised what should be done so the company kept a step ahead.' " □

The enormous house of Ma Bell

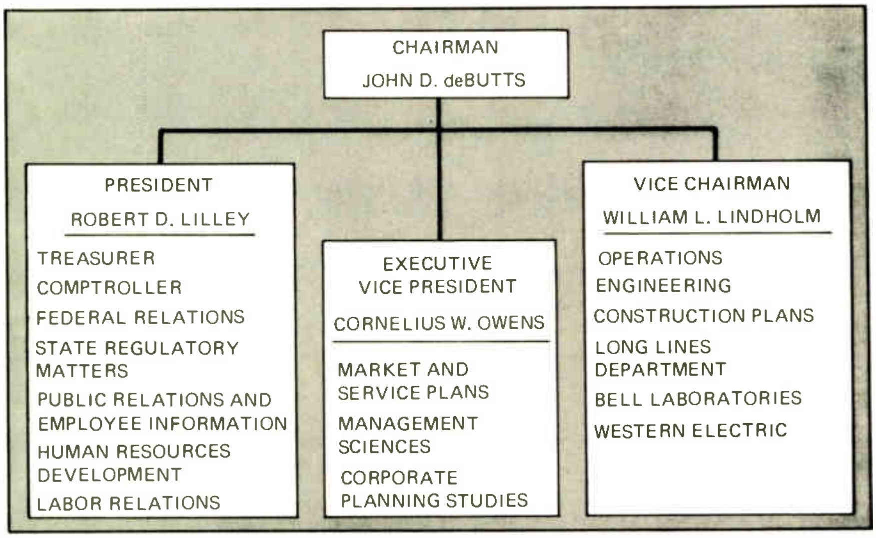
By nearly any way of measuring a corporation's bigness, American Telephone & Telegraph Co. is a world leader. At the end of 1971, the communications giant reported more than a million employees and in excess of 3 million stockholders—more than any other company. Total corporate assets were listed at $57.6 billion—again placing the company well ahead of all others in the world.

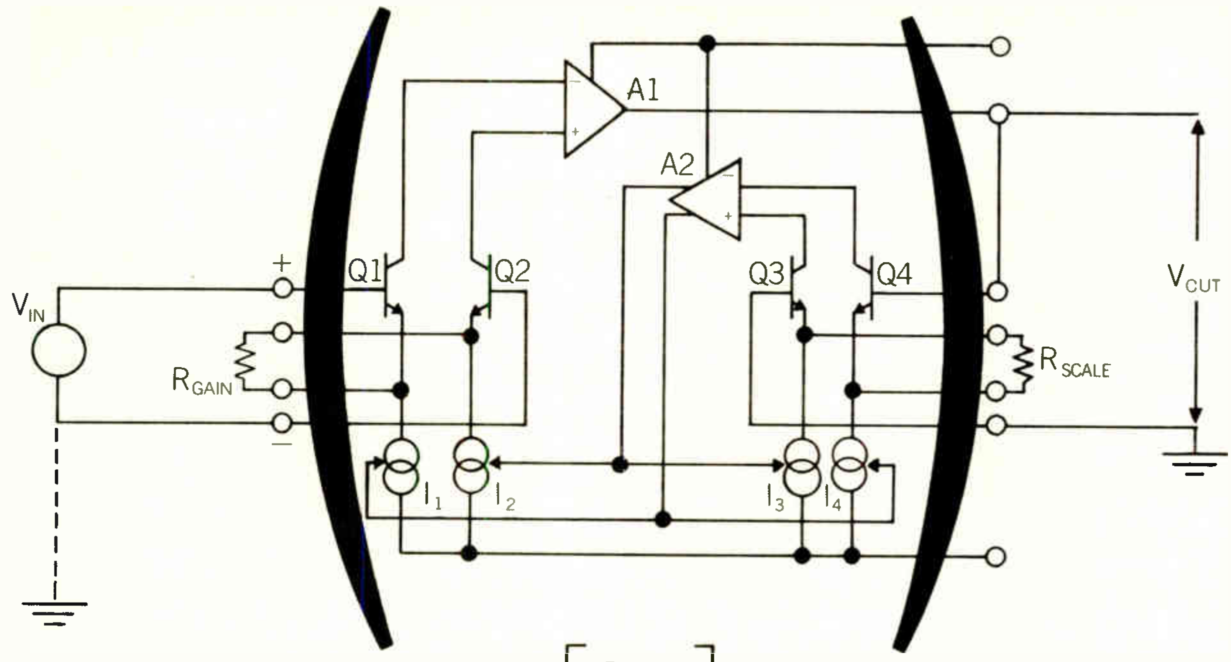
AT&T's 1971 revenues—slightly less than $19 billion—rank third largest in the world, behind those of General Motors at $28.3 billion and Standard Oil of New Jersey at $20.3 billion. By comparison, last year's sales by IBM were $8.3 billion. ITT grossed $7.3 billion in 1971, while RCA reported a total income of $3.54 billion in its latest annual report.

The 1971 construction budget for AT&T was $7.6 billion, the company's largest ever. And $5.1 billion of these expenditures went to meet growth requirements, according to the company. To help finance this expansion budget, external financing requirements will run in the order of $4 billion annually for the next several years.

The prime source of income for AT&T is derived from the services of its 24 operating companies which control about 85% of the 120 million telephones installed within the contiguous United States.

Supporting these operating companies are Western Electric Co., the Bell System's manufacturing arm; Bell Laboratories, its research and development facility; AT&T Long Lines, which trunks the operating companies into a single nationwide system; and corporate headquarters at 195 Broadway in New York City.





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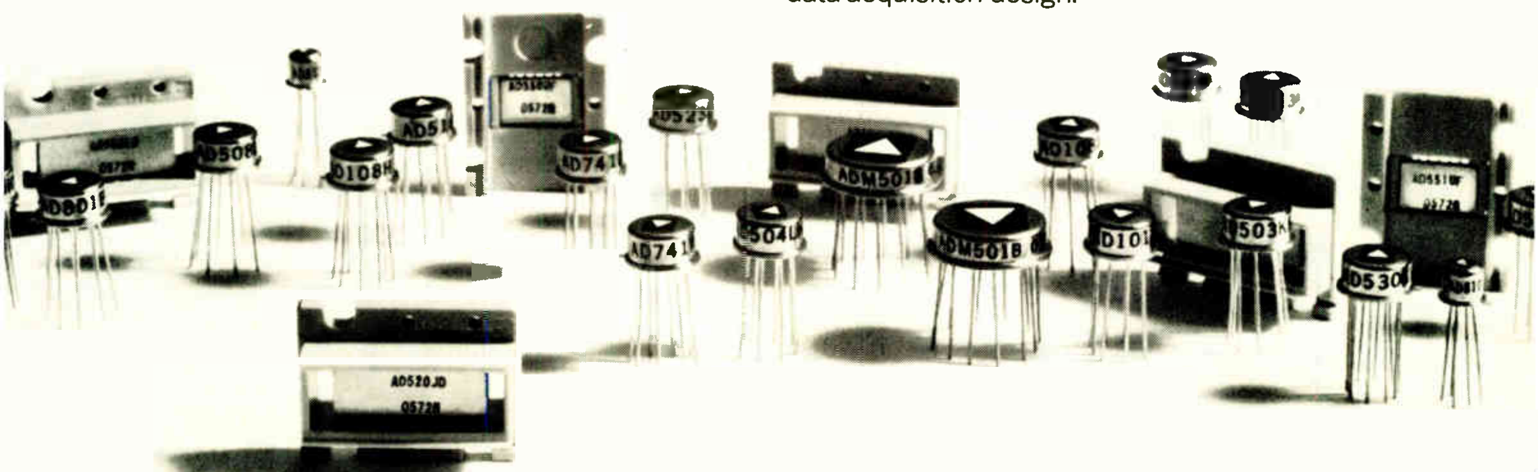


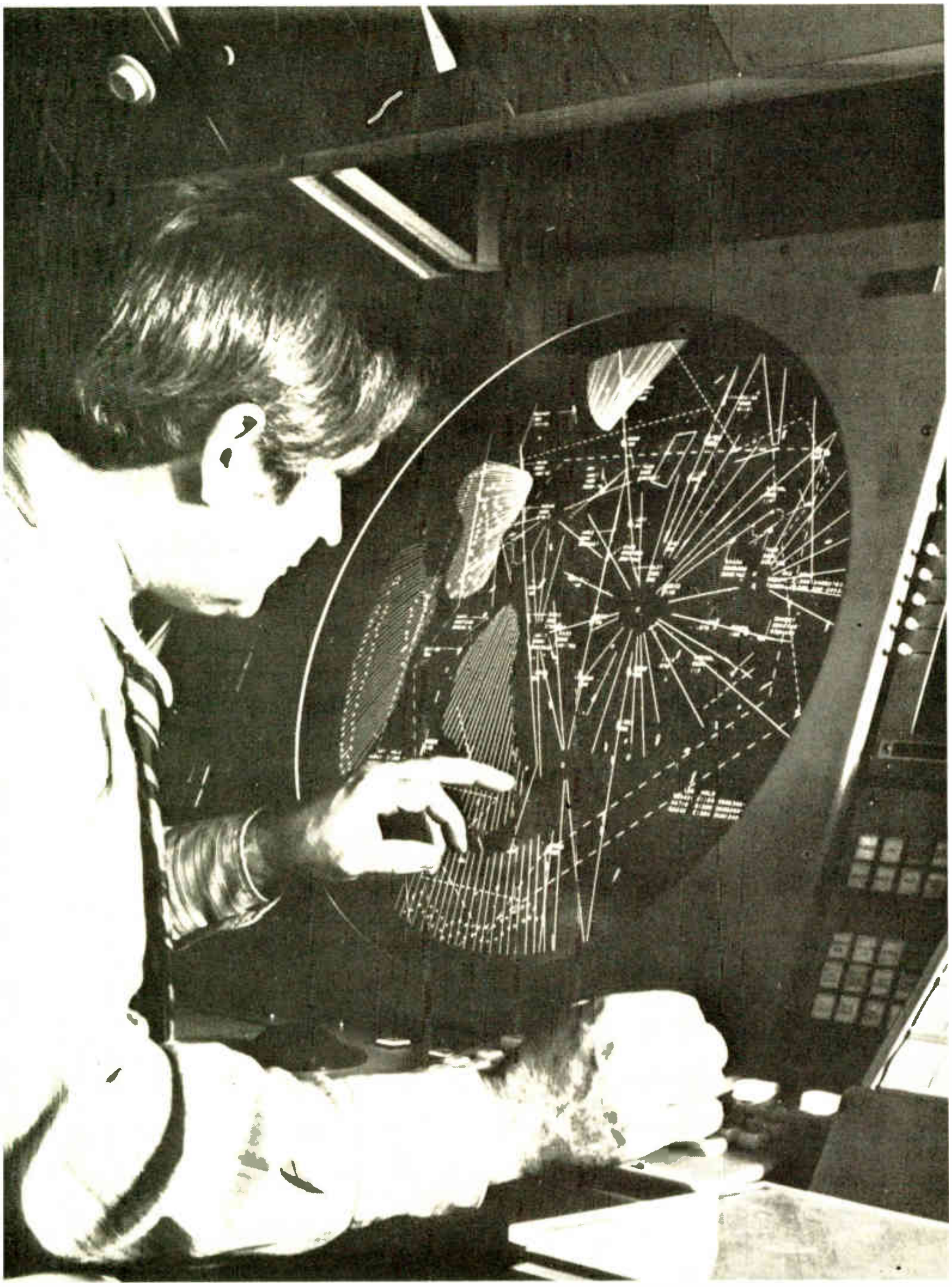
Circle 73 on reader service card

Government electronics

Air traffic: en route to automation

With computer-run display gear due at its New York control center next month, the FAA's delayed $600 million en route system is nearing takeoff

William F. Arnold, Aerospace Editor



The mammoth attempt by the Federal Aviation Administration to automate its en route traffic control centers, although some two and half years behind original schedules, appears to be finally on course.

The New York control center, one of five super-centers spotted on the most congested routes, will receive next month its new computer-run equipment as the FAA finally begins installing the capstone of its $600-million project. Simply called the "display channel complex (DCC)," the high-capacity hardware is a combination of an IBM 9020E computer and specially designed Raytheon radar display consoles.

With this gear, the FAA expects its controllers to cope successfully with the takeoff in aircraft traffic expected up to the early 1980s. And that's a big job. Last year, the Chicago super-center handled 1.66 million flights, and traffic is expected to soar to 3.8 million flights within a decade. New York handled 1.4 million planes last year and is expected to process 1.77 million by 1978. The Washington, Cleveland, and Fort Worth centers will have to meet the demands of similar growth, according to the FAA.

Since the load will only be smaller in scale at the other 15 en route centers, the FAA, faced with the inevitable bogging down of its present semiautomated system, is building the first stage of an all encompassing national airspace system. In doing so, it is creating one of the world's biggest networks, in terms of the number of on-line in-

New view. Plan view displays automatically will give controllers weather, flight number, and altitude data to better direct traffic.

teractive systems, according to Robert E. Lee, FAA's terminal system branch chief.

As planned, each of the 20 en route centers will not only be able to communicate automatically in real time with each other, but also with military bases, radar sites, FAA flight service centers, and airline operations centers. Each en route center will also interface with 60 airports now being equipped with automated radar terminal systems (ARTS), another large FAA program.

The DCC-equipped super centers will provide continuous digitized information to 120 radar scopes, called plan view displays (PVD). Together with a central computer complex, the DCC equipment at peak load will process 7,200 bits of data per second from each of six radar sites at each center. And the exchanges between other points will include weather, flight plan, radar tracking and control data.

Operational when? The 20 en route centers are slated to have their new equipment by the end of this year, with all centers operating by early 1974. Initially, all centers will have flight data processing, including automatic data update. It takes about a year to set up the computer hardware, debug the programs and train controllers.

Today, controllers have to transfer a great deal of information by phone and use "shrimp boats"—small word blocks with flight tags on them—to track flights manually with each sweep of the radar. But with all systems go, the PVDs will display alphanumeric altitude and flight number tags with each radar blip, and this information will be handed off automatically to other centers.

The need for the DCC equipment arose when the FAA discovered several years ago that it had underestimated the traffic demand in the five largest en route centers. Originally, all 20 centers, were to have the same type of equipment: a central computer complex of either an IBM 9020A or the larger 9020D—both hybrid 360/60s—teamed with a Raytheon computer display channel designed to drive 60 Raytheon PVD radar consoles.

For greater capacity in the five largest centers, the DCC uses an IBM 9020E computer—a hybrid 360/65—in place of the smaller Raytheon processor to further refine the data from the 9020D in the central computer complex.

Multi-symbol scopes. To meet FAA's exacting specifications, Raytheon combined existing display techniques to come up with a new design, according to John Stearns, display project engineer at the Raytheon Equipment division, Waltham, Mass. Each PVD has to show up to 45 track targets, with alphanumeric tags, 400 other alphanumeric letter symbols, 300 map and other lines from 4 to 5 inches in length, plus 1,250 radar dots or trails—all refreshed 55 times a second, he says.

The FAA also wanted the PVD console displays to have even overall brightness, precise generation of characters, and sharp definition, says Stearns. To do this, Raytheon uses a digital vector generator with digital medium-scale integration logic, which makes it easy to control beam angles on the scope.

Raytheon will deliver 345 of the 20-inch PVDs to the five big control centers and the FAA field centers, at Atlantic City and Oklahoma City—at a cost of $14.7 million. It is delivering 750 to the other 15 centers for $117 million, including computers and input and output controls. Each DCC costs about $8 million, of which $6 million is for the IBM computer.

Programing the hardware also has been a tremendous task, says FAA air traffic control specialists Will A. Larson and Nick M. Craddock. Each center will need about 350,000 words of program logic. But, even though the FAA has developed a national standard program, the adaptation of any one center's program to local conditions will cause it to grow to more than 600,000 words. Then to insulate each center from being swamped with unneeded data, each central computer will be programed to refuse data from another center until it needs it. Thus, if Los Angeles reports that a New York-bound flight will be late, each center along the way will not acknowledge the fact until the flight approaches its territory.

Will the system FAA is building be able to handle the actual traffic when the 1980s arrive? The agency believes so—one reason being that it has built a 20% error margin into its traffic projection, says Robert P. Pringle, en route branch chief. Also, the FAA could put more 9020Es into the centers to handle more traffic or develop new techniques to do the job. As for the continuing growth of air travel, "there just doesn't seem to be an end to it," Pringle says. "One wonders whether the amount of concrete that could be laid for runways might be the limit." □

Why the delay?

Installation of the automated en route air traffic control system slipped from its original schedule by about two and a half years because the FAA—and just about everyone else involved in the system—underestimated the complexity of the job. Clashes between the agency and contractors occurred when the delays cropped up, and the whole issue is still a touchy subject for all concerned. But Washington observers conclude that contractors bit off a little more than they could chew in promising to meet the FAA's specifications within the given time frame. And this misplaced optimism was complicated by the number of times the FAA changed its mind.

IBM reportedly has had software problems. But Raytheon had the worst run-in with the FAA. Raytheon signed a contract in January 1967 to deliver the first computer display complexes in 18 months. It took twice that long. Raytheon finally delivered its first system in January 1971. In the meantime, the company had to both resolve technical problems and placate the FAA, which threatened to cancel the contract.

The agency even went so far as to fund Sanders Associates, Nashua, N.H., for parallel development of the super center displays [*Electronics*, March 2, p.78, and May 25, 1970, p.34]. Meanwhile, Raytheon's contract grew from an original $44.8 million to $117 million, due to modifications, expansion of systems, and more buys of equipment. And now, there are rumors that the total system cost, including construction, will exceed the current figure of $600 million.

Companies

NRMEC finds a winning system

By its early adoption of a systems approach to MOS LSI, NRMEC turned its aerospace experience to commercial advantage

by Paul Franson, Los Angeles bureau manager

A subsystem or even a complete system on a chip is increasingly the trend these days in the semiconductor business. But five years ago, when officials at what is now North American Rockwell Microelectronics Co. (NRMEC), Anaheim, Calif., disdained standard parts and subscribed to the systems approach, many other semiconductor manufacturers waited for them to fall flat on their faces. By now, NRMEC has turned its aerospace systems orientation into one of the biggest success stories in MOS LSI.

"It took two additional factors to make our systems approach profitable," points out NRMEC's president, R.S. (Sam) Carlson. "One, we invested in market research that identified the most profitable areas. Two, we exercised strong discipline to stay on target and not get sidetracked by new, unresearched [market] possibilities."

That discipline and the commitment to systems sales brought NRMEC a claimed 22% to 25% of the world's MOS calculator chip sales. And NRMEC appears to have taken the lead in over-all MOS sales, with last year's total topping $28 million. That's a rise from 1970's $12 million and just $800,000 in 1969.

When the beginnings of NRMEC first appeared in mid-1967 as part of the Autonetics division of North American Aviation, few in the semiconductor industry expected the group to do more than develop parts for Autonetics use. Myriad failures had marked attempts by other aerospace firms trying to diversify into the commercial marketplace. Then came the announcement in early 1969 of the initial contract from Japan's Hayakawa Electric, now renamed Sharp Corp., followed in mid-1970 by another Sharp award for more than $30 million in calculator chip sets.

Disbelief. The reaction in the semiconductor industry was one of incredulity. Most observers openly questioned the company's ability to deliver. Since then, NRMEC has whipped its production startup problems, met its initial Sharp commitments, and captured a flock of other custom MOS LSI orders as well. It now supplies MOS chips to major U.S. calculator manufacturers (Monroe, Victor, Singer-Friden), to Japan's Sharp Corp., and to five European companies, including Sumlock Anita (which reportedly has 60% of the UK market), Lagomarsino in Italy which markets under the Totalia label, and N.V. Philips in Bremen, Germany.

In June it will start shipping complete low-cost calculators to a number of customers—including Sears Roebuck [Electronics, March 27, p. 26]. Initial contracts are for 195,000 units that will retail for about $100. (Other semiconductor companies, notably Texas Instruments, are reportedly working on calculators to be sold similarly). The NRMEC machines use a single MOS chip, and will be the first mass-production item with liquid crystal displays.

Part of the company's success is probably due to its relative independence of the rest of North American Rockwell's electronics group. It was 1969 when it was spun out of the Autonetics division into a new company under Carlson. "We're a division, but I've never seen such a hands-off attitude at a big company. We feel that we've earned the right to be different," says NRMEC marketing vice president Charles V. Kovac. "For example, we have a 17-page operating manual—the rest of the company has a fat book."

This independence has come with the backing of the former Rockwell side of North American Rockwell. "Watching a military electronics house struggle to find a place in the commercial area has been a very difficult and trying experience," says North American Rockwell president Robert Anderson, "but I can't think of any other aerospace company that has succeeded in moving into the commercial area as NRMEC has. They've taken a technology and built a business with it."

In MOS technology, NRMEC is rather conservative. It sticks to high-threshold p-MOS, though other processes are highly touted in the industry. In this, it resembles the other large MOS producers, American Micro-systems Inc., Texas Instruments, and General Instrument Corp. NRMEC is working with other processes in the laboratory.

Another sign of this conservatism is relatively small chips to get high yields. "It takes an act of Congress around here to approve a chip over 180 mils square," Kovac says.

In any case, most of the products NRMEC supplies don't require highest performance. Kovac says that a telephone touchtone generator, produced for three telephone companies, is one of the few devices for which 5-volt operation is required.

Outside MOS, however, NRMEC is more daring. A production line of liquid crystals is in operation for the Sears calculators. The displays, which won't be available separately for a few months, are transmissive digits that work only over the 5° to

40°C range, but NRMEC feels that few would use inexpensive calculators at other temperatures. Nonetheless, the NR Electronics group's research and technology division, to which NRMEC contracts out much of its research and development, is working on extending the range.

In addition NRMEC's very-high-speed (10-nanosecond) 5,000-diode silicon-on-sapphire arrays, which recently entered production after a long period in a preproduction state, are being augmented by the development of more conventional MOS on SOS.

Wash your mouth out. One expression not used at NRMEC is "standard product," although some parts designed by NRMEC are called "general" and are available to customers without the additional design cost required for custom designs. Aside from the systems orientation of the management, Kovac makes two good points why NRMEC isn't going after this market. In 1971, he says, standard parts accounted for only $6 million out of $92 million in addressable MOS sales—yet the prices of standards have been dropping 30% to 40% per chip every year while the prices of customs have been going down 20% a year, even though circuit density is increasing.

Nevertheless, there is considerably commonality in many of the chips that NRMEC sells to different customers, and the "general" products include three sets that cover the range of calculator and mini-processor-type applications all the way from a simple teaching machine selling for less than $50 retail to computer-like systems. The simplest chips, developed for consumer calculators, can be tailored to many different functions by just changing one metal mask that programs a 4,096-bit read-only memory. The simplest applications for chips require no numeric display, the most complex have twelve digits.

The next step up in chip set complexity, according to Kovac, is a set of two for display calculators or three for printer calculators. For $10,000 to $15,000, these can be tailored to provide a device in the $150 to $550 retail price range.

A third level of complexity is typified by a new parallel-processor system that can be used in virtually any other type of calculator or in simple computer equipment (see p.38). It includes a one-chip central processor unit, a one-chip, 8,192-bit, read-only memory, and an input/output chip. (The ROM and RAM can be combined on one chip.)

Yet another type of opportunity lies ahead—producing the equipment that uses the parts. The calculators to be shipped to Sears this June are only a beginning. Nonelectronic product categories offer special promise, and Kovac feels that the next big area of penetration is business machines.

The company won't go after such new product development unless the retail price of the present product can be cut in half. For instance, a stand-alone electromechanical cash register now costs about $1,500, but Kovac thinks that an electronic version might sell for only $700. Still, though the company is known to be working with National Cash Register in Dayton, Ohio, officials won't comment any further.

Other business machines in development include point-of-sale terminals, billing machines, precision scales, and credit card and tag readers. Data communications equipment is also in the works, with a recently announced 4,800-bits-per-second modem leading the way. Automobile products are another area of great interest, and NRMEC is working on fuel-injection systems with a U.S. company. Appliance controls will be along, too, but not for a few years. □

Calculating moves. Sam Carlson (left), NRMEC president, confers with Charles Kovac, vice president. Both pushed the systems approach.

Instruments

Synthesizers gain popularity

Stable frequency sources improve market position through lower-cost circuits and uses that don't need expensive high-resolution capability

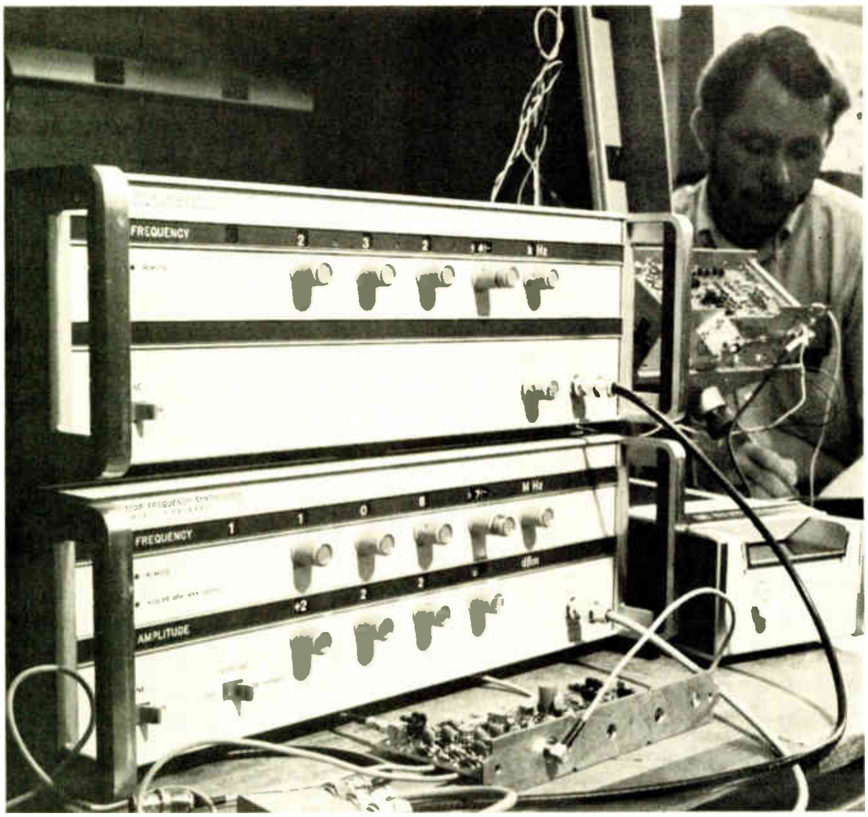
by Michael J. Riezenman, Instrumentation Editor

Frequency synthesizers are becoming popular in the commercial world. Once restricted to a few exotic applications in research laboratories and military communications systems, these super-stable frequency sources are beginning to appear in many areas once regarded as the domain of either the laboratory signal generator or the crystal-controlled oscillator.

Growing at a healthy 10% to 15% annually, the synthesizer market today is about $20 to 25 million a year. The use of synthesizers however, is growing much faster than these figures indicate. The reason is that unit prices are dropping from well above $10,000 a few years back, to under $2,000 for at least one low-resolution model today.

In fact, the key to their surge in popularity is the significant reduction in costs. Not only has the use of medium-scale and large-scale integration cut manufacturing costs, but synthesizers are also finding applications in areas that require their high accuracy and stability, but not high resolution. With frequency synthesizers, high accuracy is inherent, even in the cheaper models; it's high resolution—especially at high frequencies—that costs money.

Low cost. Low resolution keeps the cost of the Hewlett-Packard 3320A (top) under $2,000. The 3320B at $2,450, allows the user to set the levelled output with four-digit accuracy.

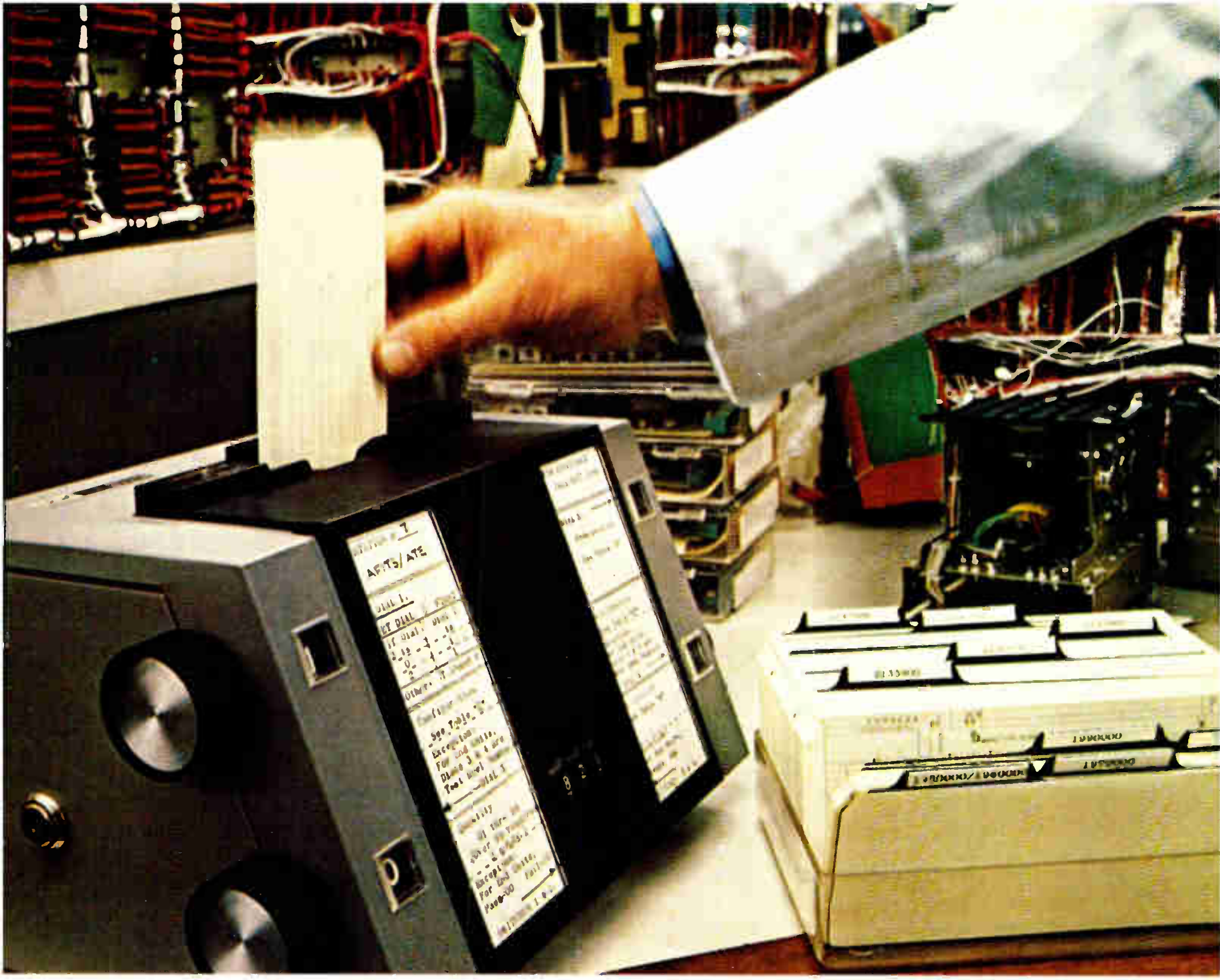


The single biggest application of frequency synthesizers is telecommunications, according to Bill Parzybok, product marketing manager at Hewlett-Packard's Loveland, Colo., division. But they are also widely used in educational and research equipment and as on-line local oscillators in frequency-agile radars, multi-channel receivers, and various communications products.

Like a crystal-controlled oscillator, a frequency synthesizer derives its accuracy from a stable frequency standard, such as a quartz crystal. However, the synthesizer is not limited to a single output frequency. By performing a series of arithmetic operations on the signal from the stable source, the synthesizer can achieve any desired output frequency within its range.

On the air. Although companies like Collins Radio Co., Dallas, have been making special-purpose synthesizers for use in communications systems for over two decades, the price in the past has been high, and the units were limited to such applications as military and aerospace communications. Now, however, costs are coming down and the firm is actively pursuing custom development, principally of communications synthesizers for systems companies that do not have that in-house capability.

Where it formerly was cheaper to use a bank of crystals for a multichannel transceiver, the synthesizer now is the way to go when a substantial number of frequencies must be generated. To get a feel for the



IBM System/7 installed at Bendix to speed production reporting.

Until recently, production control reporting at a Bendix Corporation plant at Teterboro, N.J. was a 4-day process. It took that long to ascertain the status of some 10,000 electronic subassemblies moving through the shop.

Now, with the use of an IBM System/7 computer, a complete report on all of the previous day's activities is ready at the start of each working day. This simplifies and streamlines the flow of materials and the assignment of job priorities.

The plant, part of the Navigation and Control Division of Bendix, produces components used in the PB-100 Flight Guidance System which Bendix manufactures for the McDonnell Douglas DC-10 aircraft.

All changes in location and status of the subassemblies are entered at fourteen IBM 2796 Data Entry Units on the shop floor. The units are controlled by the System/7, which edits the data input for accuracy. The data is then transmitted to an IBM System/370 Model 155 at a nearby Bendix plant, which updates production records and compares actual performance with planned schedules. Items not following schedules are singled out for immediate attention and corrective action.

Full information on the System/7 is available through your IBM representative or local office. Or write IBM Data Processing Division, Department 807-E, 1133 Westchester Ave., White Plains, N.Y. 10604.

IBM

Circle 79 on reader service card

price of a modern special-purpose communications synthesizer, the units used in Comsat's Spade system [*Electronics* Feb. 28, p.102] cost only $500 each.

Low resolution. Pointing out the need for high-accuracy low-resolution synthesizers, Parzybok says that it only takes a resolution of three digits to set the 10.7-megahertz frequency needed to check out the i-f stages of an fm receiver. But the unseen digits to the right of the decimal point must be all zeroes.

With what may be slight exaggeration, David P. Friedley, product marketing manager at the General Radio Co. High-Frequency Equipment division, Bolton, Mass., says, "Stability is free. We can make a $100 synthesizer as good as a $10,000 machine." Friedley goes on to explain that the difference in price is largely determined by resolution. Of course, spectral purity, output levelling, switching speed, and sweep capability are also important factors.

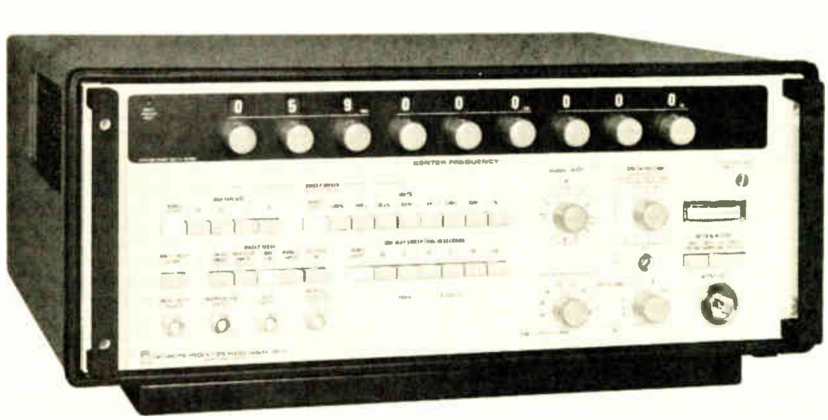
An excellent illustration is the price difference between Hewlett-Packard's 3330A synthesizer at $5,100 and the company's 3320A at $1,900. Both go up to 13 MHz, but the 3330A maintains a resolution of 0.1 Hz over the entire range—that's up to nine digits—while the lower-priced instrument has only three frequency-setting digits plus a 10-turn two-digit vernier.

At General Radio, price is reduced by eliminating unnecessary frills. "Rather than building in all the features, we offer them as options," says William B. Reich, a GR product promotion specialist. Reich foresees a trend toward stripped-down synthesizers because of their increased use as system components. "When people use them in systems, they don't need a lot of things like knobs on the front panel," he says, therefore, GR offers a model without knobs. In some applications, several synthesizers are driven by a single reference oscillator, so, says Reich "we offer a model without an oscillator."

At John Fluke Manufacturing Co., Seattle, Wash., where most synthesizer sales are to the OEM communications market, custom modifications—often to reduce costs—are the rule. Product supervisor Henri Pichal points out that Fluke's 6160A synthesizer normally sells for $5,000. A recent purchaser, however, was able to save $800 per unit because he did not need the full resolution and noise performance of the standard unit.

Where next? Prices will continue to fall at least for a while, making frequency synthesizers practical for even more applications. Louis Pollack, manager of the RF Transmission Laboratory of Comsat Labs in Clarksburg, Md., says he saw a Heathkit fm tuner at the IEEE show with a built-in rudimentary frequency synthesizer. "It may become a trend," he said. □

Versatile. In addition to serving as a stable frequency source, this General Radio synthesizer also acts as a precision sweeper. The $8,950 instrument covers 1 Hz to 160 MHz.



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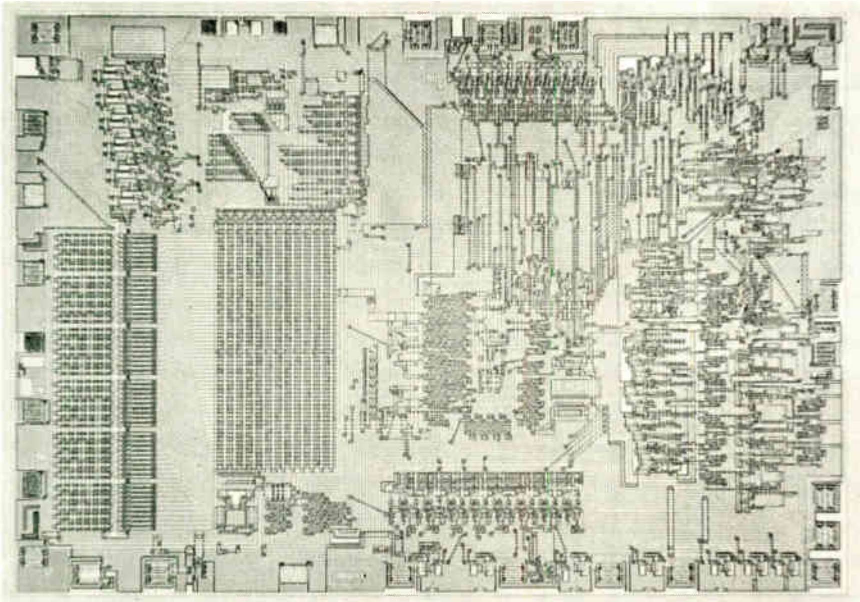
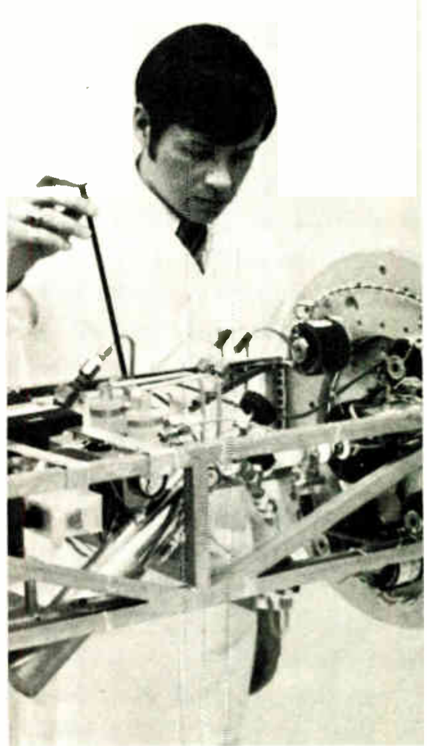


Ion implanter (below) produces both enhancement and depletion MOS devices on high-density chip for pocket calculator.



Implanted depletion loads boost MOS array performance

Ion-implanted depletion-load circuits are giving 2-to-10-fold improvement in output when used with enhancement-mode devices; alternative to C/MOS can operate with logic power as low as 9 microwatts per gate at 200 kHz

by Bob Crawford, *Mostek Corp., Carrollton, Texas*

☐ Combining the simple fabrication processes of depletion-mode devices with unique characteristics that can be achieved by ion implantation is impacting metal oxide silicon memory and logic circuits. Ion-implanted depletion-mode transistors can increase MOS array performance by a factor of 10, as well as provide smaller size and lower threshold characteristics.

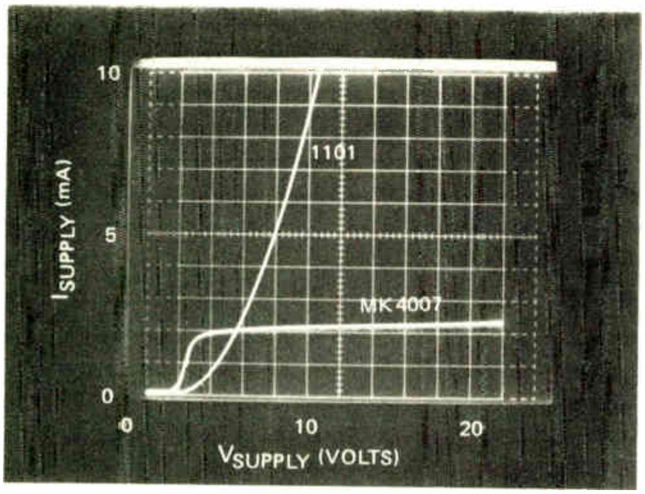
The technique enables MOS circuits to be built with performance impossible 12 months ago—requiring lower power per gate, allowing better tolerance to power-supply variations, and providing faster speeds than are possible with conventional enhancement-mode devices.

Depletion-mode devices are not new, but combining depletion-mode and enhancement-mode devices in an integrated array provides several desirable circuit characteristics. And yet, the technique uses basically the same process as the industry standard—p-channel metal-gate fabrication. Only a slight modification—an implantation step—is necessary to change some of the high-voltage enhancement transistors in an array to low-voltage depletion devices.

Comparisons

Three examples, covering a wide spectrum of applications, indicate the strength of depletion-mode devices: custom random-logic chips, static random-access memory, and standard off-the-shelf logic circuits.

Applications of p-MOS depletion technology to custom random logic chips is illustrated in the Hewlett-Packard Co. battery-operated electronic pocket calculator [*Electronics*, Jan. 17, p.31]. This tiny calculator is really a sophisticated microprocessor. Preference was given to p-MOS depletion technology because it could meet the system requirements of low power at the system clock rate of 200 kilohertz, could confine the system to five MOS chips (three basic types), with the arithmetic chip containing 3,600 transistors, and could provide immunity to battery voltage variation—exceeding significantly the specification of ±16.6% fluctuation. The



1. Out of bounds. Current varies wildly in the matrix (256 flip-flops) of a 1101-type memory, while the MK 4007, using depletion-mode devices, draws approximately 2 mA independently of supply voltage.

sum of the five chips typically required only 90 milliwatts.

All of these specifications apply to structured repetitive circuits, as well as random logic. This can be seen from a comparison of Mostek's MK 4997, a 256 × 1 static RAM, to the industry standard 1101. Voltage variation permitted for the 4007 is ±30%, compared to ±5% for two common enhancement-mode 1101 parts. Power dissipation for the 4007 is 370 mW, at the ±30% voltage variation limit, compared to 700 mW and 625 mW, respectively, at the 1101's ±5% voltage fluctuation limit. The low power operation is due in part by the constant-current character of depletion loads.

Figure 1 shows the supply current in the standby mode as a function of the supply voltage for the 4007 and the competitive 1101 part. Once pinch-off is reached and the current saturates in the depletion-mode part, there is little change, whereas the enhancement current varies widely with voltage.

An outstanding feature of the depletion part is its ability to keep the output sink-current specification within reasonable bounds. The 4007, with a depletion-load transistor-transistor-logic buffer output, is specified at 3.2 milliamperes to 7 mA over a wide range of supply voltages. On the other hand, the 1101, which uses enhancement loads, exhibits an extremely loose current spread, spaced at 2 mA to 13 mA at the restricted ±5% supply range.

With depletion-mode devices, p-MOS circuits operating from TTL-compatible 5-V supplies are also possible because the characteristics of depletion transistors pull the output all the way to the supply voltage. Because of depletion loads, a circuit of this type, the MK 5002 counter/display decoder, can have both random logic and repetitive logic together in a standard product that operates from a single +5-V supply. The supply voltage may range from 4.5 to 20 V. At a typical 10 mW for total chip power, the MK 5002 shows the low-power possibilities of depletion-load MOS.

Performance data of depletion-load circuits with comparable MOS enhancement circuits are shown in the table and accompanying chart, which plots the operating speed and power-per-gate of the circuits in the table. From the data, it becomes apparent just how much higher performance can be realized from depletion mode arrays than from enhancement arrays. An improvement of 2 to 10 in the speed/power figure-of-merit is clearly at hand.

Depletion-load devices provide faster switching than linear resistors, while preserving the many advantages of MOS active loads. Whether fabricated by p-channel, n-channel, or some other means, depletion-load elements will probably eventually dominate the world of static MOS arrays.

The difference

As opposed to an enhancement MOS transistor, a depletion device is initially "on," i. e., it has appreciable device current at zero gate voltage. The transfer curve of Fig. 2, a plot of output current vs input voltage, illustrates this point. In the enhancement instance, no current flows with zero gate-to-source voltage V_{GS}; in fact, a voltage greater than threshold (−2 V typical) must be applied to initiate conduction.

Just the opposite is the case for the depletion-mode transistor. At zero V_{GS}, appreciable drain current flows. This current is designated I_{DSS}. A voltage V_P, more positive than pinch-off (+5 V typical) must be applied to stop conduction.

Although the current states are different, the characteristics of a depletion device are nevertheless exactly the same as an enhancement device: both obey the same basic square-law current equation.

I_D enhancement $= K(W/L)(V_{GS} - V_T)^2$

I_D depletion $= K(W/L)(V_{GS} + V_P)^2$

W and L are the width and length of the gates, respectively, K is device gain constant, V_P is the pinch-off voltage, and V_T is the threshold voltage of an enhancement device. These equations show that a depletion device is really an enhancement transistor with its threshold shifted from negative to positive. There is no real difference between V_P and V_T—starting at O V, they are simply approached from different directions.

A depletion load looks like a constant-current source at the power supply and like a non-linear resistor at the output terminal. A typical MOS inverter with a depletion-load device and an enhancement driver device is shown in Fig. 3a.

From the power supply, looking into the drain terminal, the circuit has the desired constant-current characteristic. Assume for a moment that the driver transistor is turned on hard so that the gate and the source of the load transistor are held at ground or substrate potential. Under this condition, the typical drain characteristic is shown in the photograph of Fig. 3b. As soon as the drain-to-source voltage (the voltage across the load transistor) reaches pinch-off, the device saturates, current is limited, and the device operates in the constant-current mode. The slight slope of the $I_D - V_{DS}$ curve is caused by channel shortening, or the channel-modulation effect. Thus, the power supply sees a constant-current loading, once the load transistor has reached pinch-off.

The situation changes when looking up into the source terminal of the load transistor, i. e., treating the

Depletion devices are easy to implant

Significantly, the simplicity of ion implantation is one of its major attractions. Low-threshold depletion-mode devices are implanted merely by modifying slightly the standard threshold-voltage process. Implantation—with its accompanying improvement in array performance—may be applied to other MOS technologies, including n-channel, C/MOS, and self-aligned gate.

The figure shows how implantation is applied to standard silicon planar processing. First, p+ source, drain, and tunnel regions are defined by mask I as shown in (a). A diffusion and oxidation cycle forms the thick oxide at 16,000 angstroms over the field region (b). Mask II (c) delineates gate and contact regions. A second oxidation provides 1,200 angstroms of clean gate oxide.

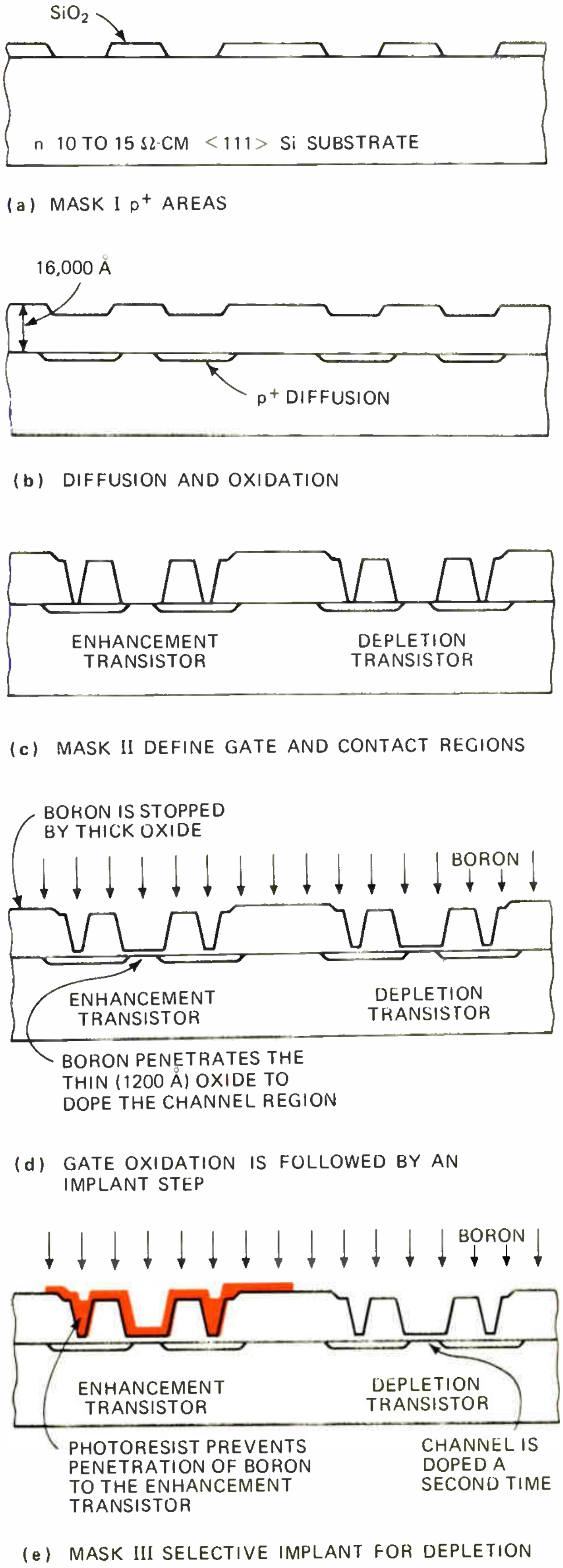
At this point, the decision is made whether to make the chip a high- or low-threshold part. For a high-threshold device, the implantation steps will be omitted, and the chip will be routed directly to contact and metal. A low V_T device will, however, be subjected to the first implant step, as shown in (d). No masking or chemical process steps are involved—only a quick trip through the implanter at a rate of 144 wafers per hour per system. The process at this stage is inherently self-masking, and only the channels themselves are implanted. Energy of the implanted particles is selected so that the boron particles do not penetrate the thick oxide and alter the characteristics of the field region. This leaves the field with a high turn-on voltage.

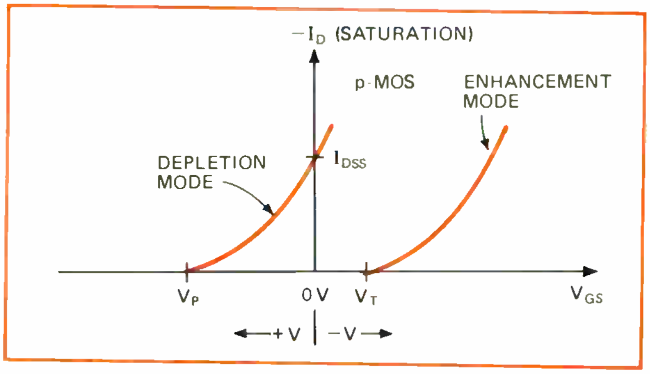
Depletion-mode transistors may now be included at the special masking and implant step of (e). Photoresist is then used to mask selectively the enhancement transistors against the additional dose of boron required for the depletion devices. This masking step is not critical because, again, the self-masking feature of the thick-oxide process is employed. All that is required is removing the masking resist in the area surrounding the depletion-gate region. The normal thick silicon oxide adjacent to the depletion device prevents doping of unwanted areas.

From this point, the processing is straightforward, including standard contact and metalization operations.

IMPLANTED LOW-THRESHOLD DEPLETION DEVICE PARAMETERS

Process	
Substrate material	n-Type, <111> ρ = 10 to 15 Ω-cm
Junction depth	0.09 mils (nominal)
Oxide thickness	
Field	⩾ 15,000 Å
Gate	1200 Å (nominal)
Electrical parameters	
Threshold voltage	
Device	−1.7 V extrapolated (nominal)
Field	⩾ −30 V @ 1 μA
Pinch-off voltage	+5.0 V extrapolated (nominal)
p region sheet resistivity	70 Ω/□ (nominal)
pn junction breakdown	⩾ −60 V @ 1 μA
Gate rupture voltage	⩾ ± 100 V @ 1 μA
Capacitance	
Gate oxide	0.2 pF/mil² (max)
Field oxide	0.018 pF/mil² (max)
Conduction constant ($\mu = \epsilon_{ox}/t_{ox} \approx 5.4$)	μA/V² (nominal)





2. Shifted characteristic. Transfer curves show the similarity between the two types of devices. At zero gate-to-source voltage, the enhancement-mode device is turned off and is nonconducting, while the depletion-mode device shows appreciable current.

device as a load resistor element for the driver transistor. In this case, the presence of the substrate has a degrading effect on the characteristics of the depletion-load element from a current source to a non-linear resistor.

In any MOS device, the current through the transistor is controlled by the gate-to-source voltage. In a depletion (normally "on") device, with its front gate connected to its source so that the gate-to-source voltage always equals zero, the current may be expected to be independent of the voltage across the device when it is in saturation.

But this is not the case here because for an integrated structure, the substrate acts as a separate, or back-gate. Consequently, as the source output (V_{out}) moves up and down, the source-to-back-gate voltage V_{BG} is modulated.

The problem is that the modulated back-gate voltage causes a change in the pinch-off voltage V_P, shown in the equation

$$V_P = V_P(O) - \Delta V_P$$

where $\Delta V_P = BE[(2\phi_F + 1V_{BG})^{1/2} - (2\phi_F)^{1/2}]$
BE = body effect constant
ϕ_F = Fermi level
$V_{BG} = V_{out}$ = back-gate bias
$V_P(O)$ = pinch-off voltage with V_{BG} = O

Now, as V_{out} moves closer to V_{DD}, the source-to-substrate voltage V_{BG} increases, causing a reduction in the pinch-off voltage. And since $I_D = K(W/L)V_P^2$, the MOS device current is also reduced. This means that, as the MOS load pulls the output toward V_{DD}, the current level is reduced, and the load line degrades from the ideal case. The load-line curves shown in Fig. 4 illustrate this degradation. However, these curves show that, even with the back-gate effect, the depletion device is better than a linear resistor and is far superior to enhancement loads.

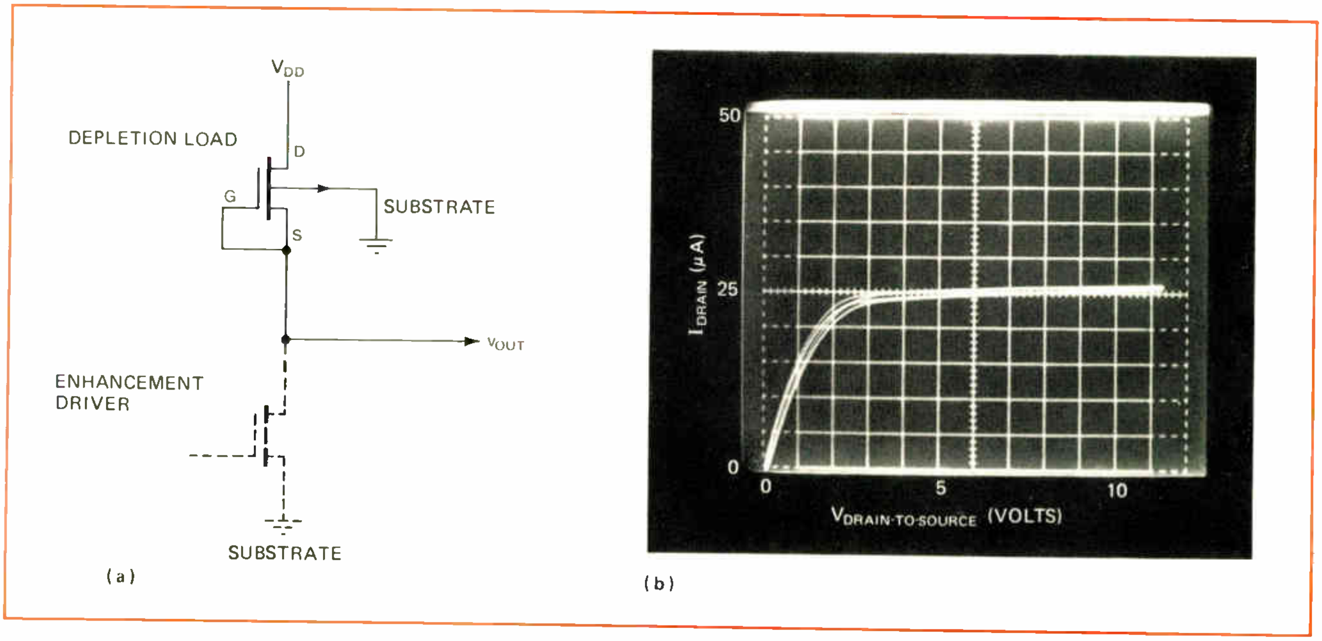
Circuit advantages

By far the largest implementation of depletion-mode devices is in the load-resistor area, where the characteristics of depletion loads approach the ideal situation for static logic gates. Typical circuits and β ratios of a depletion-mode device used as a load element in a simple inverter circuit are shown, along with a standard enhancement inverter in Fig. 5. The major difference in operation between the two loads is that the gate of the depletion device is connected to its own source, while the gate of the enhancement load must be connected to a voltage more negative than V_{DD}.

A depletion load can swing the output to the full supply voltage because at zero gate-to-source voltage, the device remains on. In contrast, the enhancement load requires a separate V_{GG} supply to enable the load to swing all the way to V_{DD}. In addition to its advantage in internal circuitry, this feature is especially useful in clock-generator circuits and for output buffers.

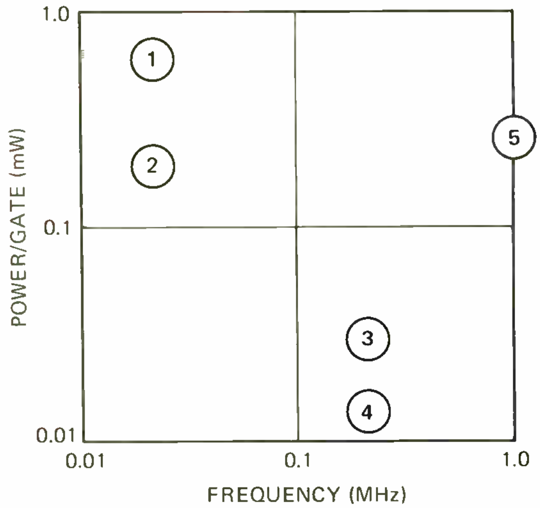
Depletion-load devices are also insensitive to power-supply voltage variations because the constant-current

3. Constant-current source. The depletion-mode transistor provides a constant-current source for the driver, but unfortunately acts like a non-linear resistor. At the depletion-drain load terminal, a perfect constant-current characteristic (b) results, once the device saturates.



COMPARING PERFORMANCE				
Circuit [1]	Power (typical) mW	Number of gates	Operating speed [2] (kHz)	Power/Gate (μW)
(1) Single-chip calculator: high V_T, p-channel enhancement load	430	660	20	650
(2) Single-chip calculator: low V_T, p-channel enhancement load	120	660	20	182
(3) MK5002 Counter/Display – Standard product: low V_T, p-channel depletion load	10	330	250	30
(4) H-P random logic chip: low V_T, p-channel depletion load	2.5	163	200	15.3
(5) MK4007 (1101 type RAM): low V_T, p-channel depletion load	170	612	1,000	280

[1] These five circuits are in production.
[2] All five circuits are static, i.e., capable of operating down to dc.



character of this type of load maintains a fixed current through the driver device, independently of the supply voltage, assuming that the supply is above pinch-off. Thus, as V_{DD} increases from –5 to –10 V, the current does not change (assuming that V_P = 5 V) so that the driver transistor is not even aware of the voltage fluctuation.

Just the opposite is true of the enhancement load device. As either V_{GG} or V_{DD} is increased, the load current is increased correspondingly, which, in turn, degrades the "on" level across the driver transistor. Because of this, only a limited amount of supply variation can be tolerated.

This constant-current effect of the depletion-mode device minimizes chip power requirements, which is most important in battery-operated systems and makes depletion-mode technology ideal for this application. Because the depletion-mode device maintains constant current, its power increases linearly, rather than roughly as the square (or greater) of the supply voltage demand for an enhancement inverter.

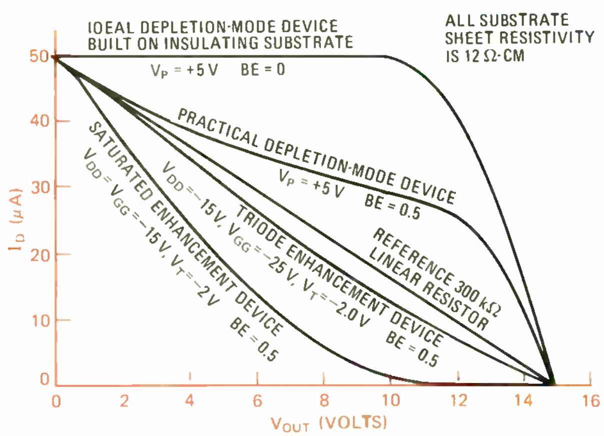
Small packages

In addition to consuming less power, significantly smaller logic gates can be used if depletion-, instead of enhancement-mode, devices are used as MOS loads. This is because the β ratio, which is a geometry factor relating to size, is much less.

The smaller β_R of the smaller depletion inverter is due to the (effective) lower gate drive on that load element. The drive or turn-on voltage for a depletion transistor is only V_P, while the effective drive for an enhancement load is the gate voltage less the threshold, which can be significant.

The size advantage may be realized either in a reduced load size or smaller driver area. For example, using the voltage levels given for the configuration in Fig. 5, the ratio of enhancement-to-depletion load currents is a factor of 5. A factor of 10 is easily reached when the enhancement load is operated in saturation at higher

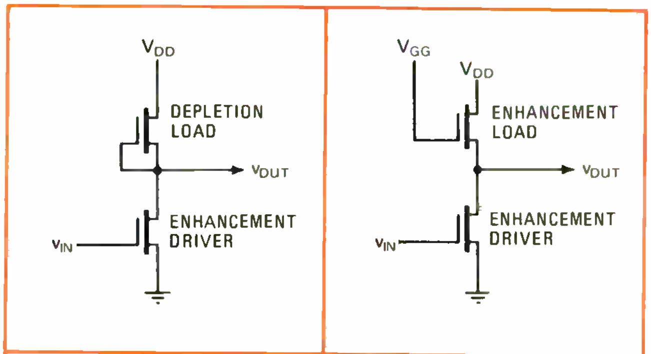
4. Not so flat. The back-gate bias effect is responsible for degrading the constant-current character of an ideal depletion-load device. Depletion loads perform better than linear resistors and are far superior to enhancement devices.



voltages. For these voltage conditions, the depletion load channel length can be five times shorter than an enhancement load for the same current level. Or, if the same length is used, then the width of the driver used with the depletion-mode load can be reduced by a factor of 5.

The low β_R offers a particular advantage in the construction of complex gates. Because the driver devices can be made narrower, the transistors can be arranged in series more easily to form complex logical functions (see Fig. 6). The advantages over equivalent gates are fewer stage delays, fewer transistors, fewer load resistors for less power demand, and smaller chip area.

These gates were used in a circuit with a 5-V V_{DD} supply and a system clock rate of 200 kHz. Significantly, the series devices were small—only 0.4-mil wide—and the typical gate power was as low as 9 μW at a 50% duty cycle.



	DEPLETION LOAD	ENHANCEMENT LOAD
β_R	4	20

$V_{DD} = -5$ V, $V_{GG} = -17$ V, $V_P = +5$ V, $V_T = -2$ V

5. Better performance. The enchancement load needs a separate V_{GG} supply to enable the logic-gate output to swing all the way to V_{DD}, whereas the depletion load allows the output to swing the full supply voltage. And the depletion load's constant-current characteristic buffers the driver transistor from any voltage fluctuations. Typical beta ratios for both types are shown.

In general, a speed/power figure-of-merit is so dependent on external bias conditions relative to device parameters that it is difficult to pin down the amount of increase in the performance of depletion loads over enhancement loads. However, it is in the range of 2 to 10.

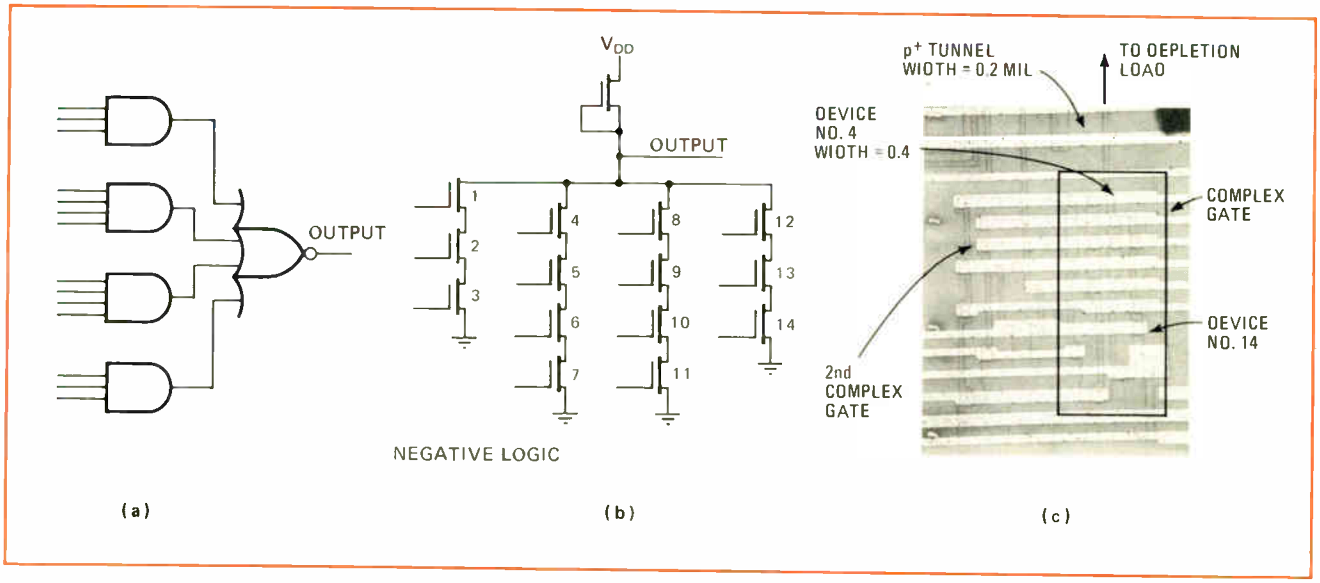
The average stems basically from the shape of the load line characteristic shown in Fig. 4. For the same static current level (50μA at 0 V) the depletion-mode device can supply more transient current to charge capacitance than can an enhancement device or a linear resistor. Moreover, the smaller driver transistors associated with the depletion logic gate (because of lower β_R) tend to reduce the over-all circuit capacitance, which results in an increase in speed.

Applying depletion devices

The low power requirement is particularly attractive to depletion techniques. Advocates of complementary MOS circuits will argue that they can achieve lower operating power for a given circuit. This may be true, but in many applications, such as portable communications systems and battery-operated calculators, peripheral electronic circuits may dissipate significantly more power than the MOS chips. In such situations, battery performance would not be improved appreciably, even if the MOS power demand were zero; therefore microwatt circuits would be of no advantage. In contrast, the significantly lower processing costs and higher functional densities of simple p-MOS depletion-mode circuits offer a much more cost-effective system.

Indeed, depletion-mode devices offer an attractive alternative to low-power complementary arrays. Complex circuits using this technology are already in production. Soon, complex LSI arrays consuming less than 1 mW of power will be available. □

6. Dense logic. Depletion loads enable logic designers to increase functional density, to eliminate transistors, and to reduce the number of gate delays. The logic diagram (a) is shown implemented with MOS transistors and a single depletion-load transistor (b). The photomicrograph of the gate (c) is arranged exactly the same as the gate schematic, with transistors 4 and 14 shown for reference.



Measuring the variable speed of light improves laser distance measurement

In laser interferometry, you can't take comfort in the constancy of the speed of light, because it changes with air temperature, pressure, and humidity; but the variations can be measured and compensated for automatically

by Jonathan D. Garman and John J. Corcoran, *Hewlett-Packard Co., Palo Alto, Calif.*

☐ Everyone knows that the speed of light is a universal constant. Scientists have been refining their estimates of it for over a hundred years, till today its value is known to a part in ten million. It's known, too, that light travels at the speed limit of the universe and that this is axiomatic to relativity and much of modern physics. All of which lends an aura of finality and irrefutability to the concept, and makes it easy to overlook the fact that the speed of light is a constant only in a vacuum.

In laser applications, such as interferometer systems, it's important to remember that the speed of light is *not* constant in air, and in fact varies with air temperature, air pressure, and humidity. If it is not carefully monitored, the accuracy with which a laser interferometer system can measure distance will be severely degraded.

Since it is difficult to measure the speed of light directly, it makes more sense to measure the atmospheric parameters—temperature, pressure, and humidity—and factor them into the calculation. In other words, the best place for a photon speedometer to start from is an electronic weather station. This approach also makes it easy to compensate automatically for errors caused by the thermal expansion of the object being measured.

Laser interferometers measure changes in distance by means of a technique developed by Michelson in the last century. A light source is split into two beams and directed to a fixed and a movable mirror (Fig. 1). The reflected beams recombine at the splitter, where they interfere and form a dark or light spot—a "fringe"—depending on the relative phase of the two waves. If both mirrors are stationary, the fringe pattern at the beam splitter (interferometer) will not change. But when the movable reflector traverses one half wavelength, one full cycle of fringe brightness occurs at the interferometer. This can be detected by a photodiode, and the resultant pulse stored in a counter.

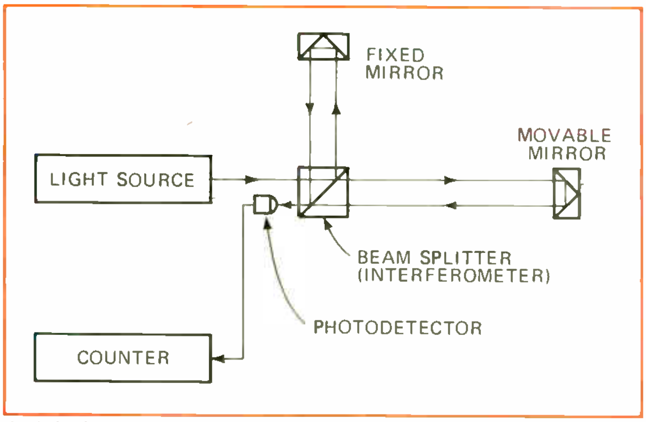
Counting half wavelengths

The number of pulses stored in the counter at any time represents the number of half wavelengths of motion the reflector has moved from some arbitrary reference point where the counter contents were set to zero. To convert this raw fringe count into useful form, it must be multiplied by the length of one half wave. Consequently, the length standard of a laser interferometer is the wavelength of the laser light in the air.

A laser is a frequency standard—not a wavelength standard. It emits light of a constant and well-known frequency. Since the product of wavelength and frequency for any electromagnetic radiation equals the propagation velocity of the wave, variations in the speed of light produce proportional changes in a laser's wavelength. Measurement of the speed of light, therefore, determines the laser wavelength also.

A typical stabilized laser has a frequency stability of about one part in 10^7. To make full use of the measurement accuracy this implies, it would be necessary to continuously measure the speed of light (and thus the laser wavelength) to the same part-in-10^7 accuracy. But in a field instrument measuring the speed of light directly with this degree of refinement is impractical. The most carefully controlled laboratory experiments have only recently reached such a level of accuracy.

Consequently, in designing an automatic compensator for laser interferometry, it is advisable to use the indirect approach and measure the index of refraction of the air (the ratio of the speed of light in a vacuum to its speed in air). This approach takes advantage of the rela-



1. Interferometer principles. Each half wavelength of motion of the movable mirror produces a full cycle of fringe brightness when it is reflected back to the photodetector.

tive ease of finding the precise index of refraction for air, and makes use of the already well-known vacuum speed of light.

An empirical formula is available for expressing the refractive index of air in terms of air pressure, air temperature, and partial pressure of water vapor in the air.[1] For typical indoor atmospheric conditions, the refractive index is around 1.0003, or a variation of three parts in 10^4 from the vacuum value. For a wide range of environments, this value can be expected to change about one part in 10^4. The empirical formula allows this range to be split into a thousand parts, so that the refractive index can be determined to a part in 10^7. The net result is that an instrument with roughly 0.1% accuracy and suitable environmental sensors can determine refractive index (and thus laser wavelength) over a wide range of conditions to a part in 10^7. This four-orders-of-magnitude reduction in accuracy requirements makes the indirect approach very attractive.

Computing the wavelength

A reduced form of the formula for refractive index, which holds for dry air and wavelengths near 6,328 angstroms (the wavelength of a helium-neon laser), is

$$N = 1 + (104.79 \times 10^{-6})P/T \quad (1)$$

where N is the refractive index, P is the air pressure in millimeters of mercury, and T is the air temperature in degrees Kelvin. The formula merely states that the refractive index is a linear function of the ratio of air pressure to air temperature. More simply, refractive index is a linear function of air density.

The speed of light (and thus the laser wavelength) is proportional to the inverse of the refractive index. Since the refractive index is only slightly different from 1, the inverse can be found by subtraction rather than division. Within a part in 10^7, Equation 1 becomes:

$$1/N = 1 - (104.79 \times 10^{-6})P/T \quad (2)$$

As air density increases, therefore, the speed of light decreases, agreeing with intuition. For example, with P = 760 mm and T = 300° K, 1/N = 0.9997345, which is the ratio of air wavelength to vacuum wavelength for the stated conditions.

Some laser interferometers—such as the Hewlett-Packard model 5525B—contain a calculator which uses 1/N directly to compute distance,[2] which is given by the product of fringe count, vacuum wavelength, and inverse refractive index. Since the three most significant 9s in 1/N do not change for any reasonable environment, they are hard-wired into the calculator. Only the last four digits, which resolve the wavelength to a part in 10^7, need be supplied by the electronic compensator.

Several techniques are availabl for solving the equation for 1/N electronically. In designing a compensator for the 5525B, the constraints were that the selected pressure sensor (aneroid capsule) and the temperature sensor (thermistors) are inherently analog while the output to the interferometer system had to be digital. The linear designer's approach might be to use an analog divider to form the ratio of P and T, an operational amplifier to perform the difference operation, and an a-d converter to produce the final result. The digital designer's approach might be to a-d convert P and T individually, then perform the division and subtraction operations using a small arithmetic unit. But both these techniques have disadvantages—for example, there is imprecision in the former and complexity in the latter.

Another, perhaps less obvious, approach was adopted. A flexible, precise, dual-ramp integration technique was used to perform the division, subtraction and a-d conversion operations all in a single step (see panel, "How the dual-ramp integrator works").

Equation 2 only holds for dry air. If water vapor is present the refractive index is changed and a correction must be made to 1/N. The correction required is directly proportional to the partial pressure of water vapor in the air. In this compensator, direct measurements are made of humidity and air temperature. Water vapor pressure is then derived from these two quantities in a second cycle of the dual-ramp integrator, and the appropriate correction to 1/N is simultaneously made.

Practical limitations

Wavelength errors of a part in 10^7 are introduced by quite small errors in the measurement of the important environmental parameters. Air temperature, for example, must be known to 0.1°C to achieve this level of accuracy. But temperature measurements at different points in the same room often differ by as much as several degrees, and it is unrealistic to expect the same temperature to occur everywhere along the beam's path.

Uncertainty in the measurement of air temperature can easily therefore introduce a wavelength uncertainty of several parts in 10^7. An error in measuring air pressure of just 0.01 in. of Hg produces a wavelength error of a part in 10^7. Yet a mercury barometer must be very carefully maintained to achieve this accuracy, and only the best aneroid barometers approach it.

If long vertical distance measurements are undertaken, another problem enters—air pressure drops about 0.01 in. of Hg for each 10-foot increase in altitude. Humidity (or water vapor pressure) has a smaller effect—a part in 10^7 wave-length error results from roughly a 5% error in determining relative humidity at normal room temperatures. But the accurate measurement of humidity also presents some problems.

Because of these effects, it is perhaps impractical to expect wavelength determination accuracy of much bet-

How the dual-ramp integrator works

The heart of the automatic compensator is a dual-ramp integrator—a precision a-d converter with built-in computational capability. The integrator finds the ratio of the two analog signals required by the wavelength formula. It multiplies the expansion coefficient by the material temperature to correct for material expansion. And it converts individual analog sensor readings for display as digital quantities.

The dual-ramp integrator uses current switches, an integrator, a comparator, and a timer (Fig. A). The comparator threshold is V_c at the integrator output. Two currents, I_1 and I_2, are switched into the integrator during each conversion cycle. The first current, I_1, is turned on to start the cycle, and the time interval, T_1, begins when the integrator output crosses the comparator threshold. At the end of T_1, current I_1 is switched off, and at this point,

$$V_{peak} = V_c + I_1T_1/C$$

I_2 (of polarity opposite to I_1) is now switched into the integrator, and the time required to return the integrator to the comparator threshold—T_2—is measured. Another expression for V_{peak} can then be written:

$$V_{peak} = V_c + I_2T_2/C$$

Setting these two expressions equal leads to

$$I_1T_1 = I_2T_2, \text{ or}$$

$$T_2 = (I_1/I_2)T_1$$

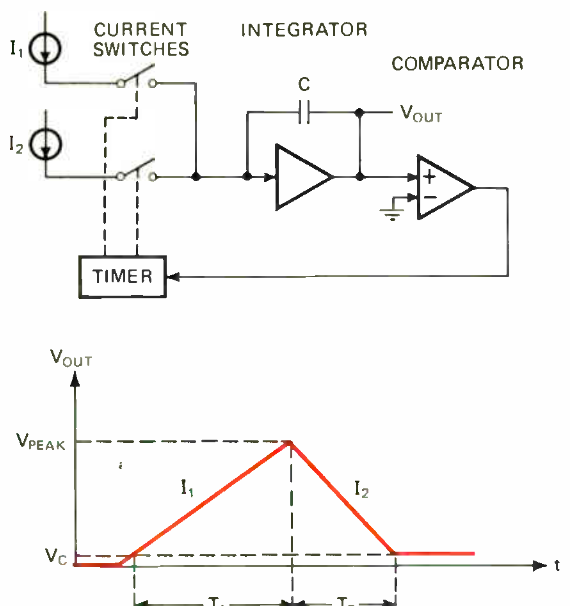
Important features of this technique are

- V_c cancels out, so comparator drifts do not degrade the conversion accuracy.
- If I_1 and I_2 are linearly derived from the same reference voltage, then any drift in that voltage will cancel out.
- If T_1 and T_2 are measured from the same oscillator, then any drift in the frequency of the oscillator will cancel.
- T_2 is proportional to I_1/I_2, permitting a dc ratio measurement to be made if T_1 is a constant. This is used to form the ratio of P to T in the wavelength computation.
- T_2 is also proportional to I_1 and T_1, enabling a multiplication (analog current times digitally derived time) to be made if I_2 is a constant. This is the mode used to correct for thermal expansion. The coefficient of expansion (entered on thumbwheels) sets the time interval T_1 directly, and a current proportional to material temperature (which is zero at 20° C) is switched in as I_1.
- If T_1 and I_2 are constant, the dual ramp cycle becomes a straight a-d conversion of the unknown current I_1. Individual sensor readings are converted in this manner.

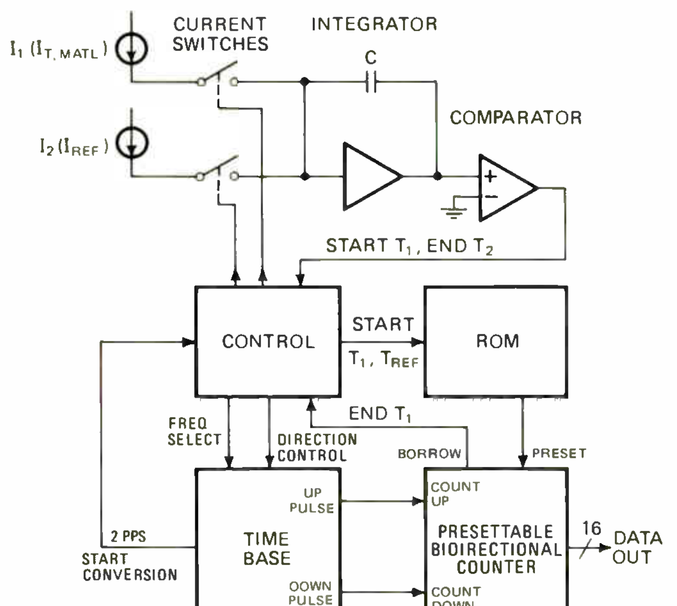
As an example of the operation of the dual ramp integrator, suppose it is desired to display material temperature in degrees centigrade. A number representing the desired time interval T_1 is read from a small read-only memory and preset into a counter (see Fig. B, which is a simplified block diagram of the 5510A automatic compensator). Then the material temperature current is turned on, and when the integrator output crosses the comparator threshold, down-count pulses are routed to the counter. When the counter reaches zero, T_1 is complete, and the material temperature current is turned off.

The reference material temperature number (20.0° C, where the material temperature current is zero) is then read from the ROM and preset into the counter. A fixed current (with the proper sign to return the integrator to zero) is now switched on to begin T_2, and simultaneously a pulse train is routed into the appropriate (up or down) counter input. When the integrator output again crosses the comparator threshold, the counter contains the digital representation of the temperature since the reference number has been changed up or down by an amount proportional to the difference between the actual and the reference temperature.

When multiple terms must be converted separately and then summed, as in the computation of the total compensation factor, the first term is converted normally, and at the end of T_2 the result from the counter is stored in a scratchpad register. For subsequent terms, the scratchpad contents are preset into the counter just before the beginning of T_2, then stored again in the scratchpad at the end of T_2. When all terms have been completed and summed, the scratchpad contents are read into an output buffer register, and conversion is complete.



(a)



(b)

2. Compensation. Errors produced by thermal and other factors are corrected by 5510A automatic compensator. The probes have magnetic bases for easy attachment near the measurement path.

ter than a part per million, except under laboratory conditions. Still other sources of measurement error in laser interferometry can degrade the over-all accuracy to several parts per million, unless corrections are made for them. Two of the most important of these other error sources are the thermal expansion of the object being measured and what is referred to as "deadpath error."

Compensating for thermal expansion

All common materials expand as their temperature is increased. Although this expansion may not seem to change the size of an object significantly, it becomes very visible when a precision yardstick like an interferometer is performing the measurement. If a steel part is measured at two different temperatures, say 70° F and 72° F, two values differing by 13 ppm will be obtained. This is another way of saying that the coefficient of expansion of steel is 6.5 ppm/°F. This 13-ppm difference means there is a significant ambiguity about the "true" size of the part. To remove this ambiguity, a reference temperature must be established. The size of a part is therefore defined as the measured size when the part is at the reference temperature. Metrologists and others have set the reference temperature at 68° F (20° C).

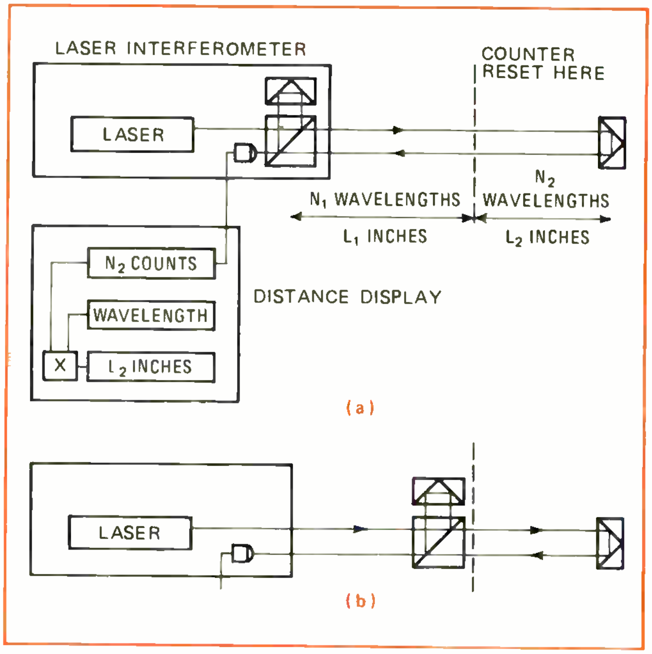
Since all measurements of distance cannot be performed in temperature-controlled rooms at 68° F, some provision must be made for correcting measurements made on parts at other temperatures. For laser interferometer distance measurements, the simplest way is to vary the wavelength digits supplied to the interferometer calculator in such a way as just to compensate for the expansion of the part. The distance display of the interferometer then is forced to show the size the part would be at 68° F (the "true" size of the part) instead of the actually measured, expanded size.

The compensator under discussion corrects for thermal expansion in precisely this fashion. A surface-temperature sensor is supplied with each instrument, and thumbwheel switches on the front panel provide for entry of the coefficient of expansion of the material being measured (Fig. 2). The compensator finds the difference between the temperature of the part and 68° F, a result which is multiplied by the coefficient of expansion to get the expansion in ppm. The four digits representing the wavelength are then decremented by the amount of the expansion. This forces a smaller-than-actual distance display, the size the part would be at 68° F. The multiplication and subtraction operations necessary are again performed by the dual-ramp integrator, a single cycle being sufficient to correct the wavelength digits for thermal expansion.

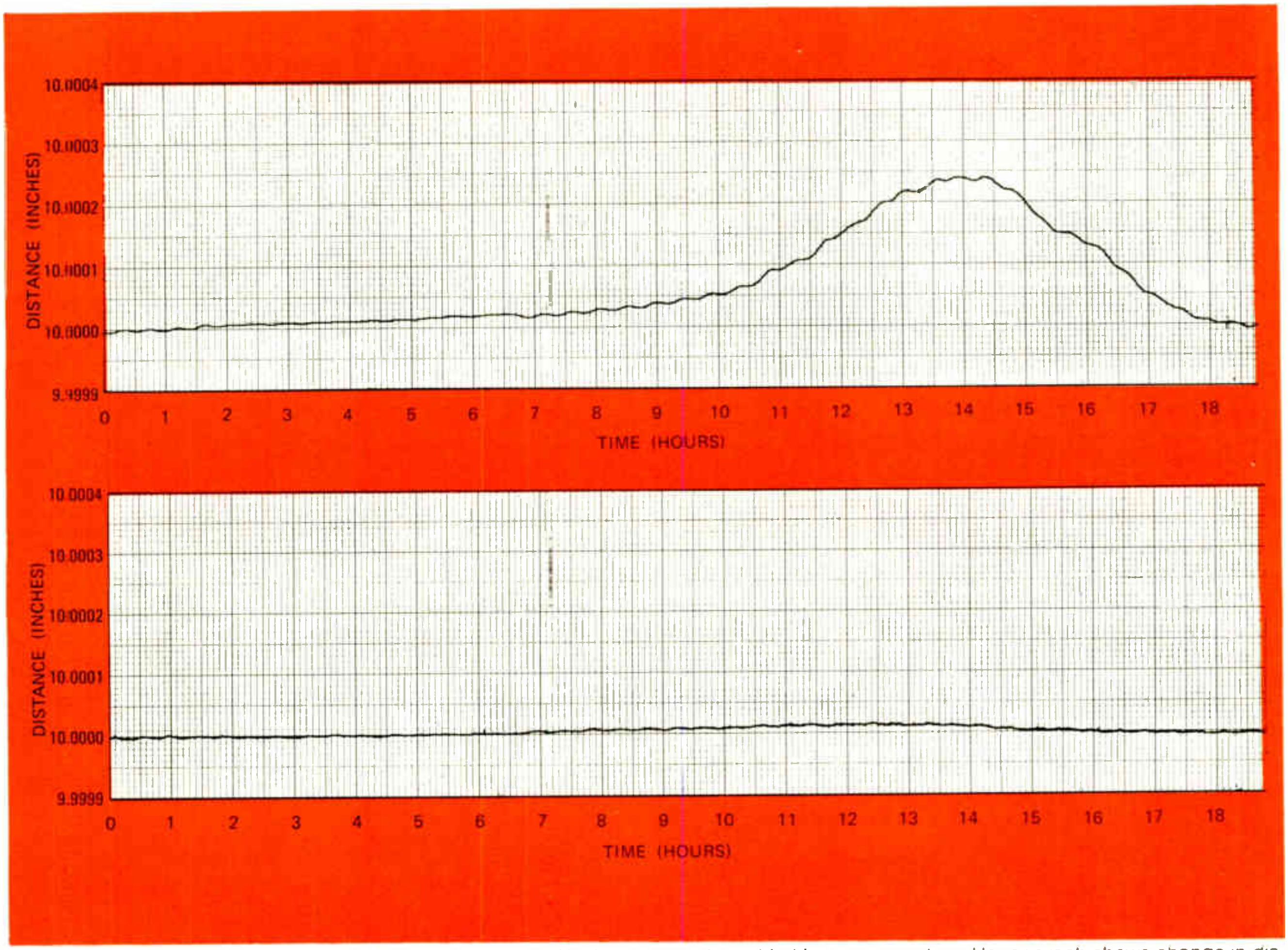
When large parts are being measured, thermal homogeneity cannot be assured. For such situations, the compensator has provision for averaging up to three strategically placed temperature sensors. This consideration is particularly important in the laser calibration of large machine tools.

Reducing deadpath error

The other common source of error in interferometer measurements is referred to as "deadpath" or uncompensated path length error. This type of error can arise when environmental conditions change during a measurement. Assume the measurement shown schematically in Fig. 3a is being made. Let L_1 be the distance from the interferometer to the reference point of the measurement (the point where the counter is set to zero), and let N_1 be the number of wavelengths of light constituting this length. Similarly, let L_2 be the distance



3. Deadpath errors. Significant errors can occur when distance L_1 from interferometer to reset point of counter is large compared with measured distance, L_2 (a). Because its optics are very close to reset point, remote interferometer (b) almost completely eliminates deadpath and the need to compensate for it.



4. It works! Typical before-and-after readings illustrate stability improvement provided by compensation. Upper graph shows change in distance reading without compensation. Lower graph, which was produced at the same time, shows the benefits that arise from including automatic compensation for both wavelength and expansion of material.

being measured and N_2 the corresponding number of wavelengths (the number of pulses stored in the counter). Now assume that the environment changes and the wavelength decreases by 10 ppm.

This will increase the number of wavelengths required to represent the fixed distance ($L_1 + L_2$). The interferometer will detect the increased number of wavelengths as fringe motion, just as if the target reflector had been moved. However, the number of fringes added will be proportional to the total fringe distance ($N_1 + N_2$), not to the number of fringes in the measured path N_2.

If automatic compensation is being used, it will decrease the wavelength standard by 10 ppm, which will compensate for the 10-ppm addition to N_2, but not for the extra fringe counts due to N_1. In short, the change in wavelength scale factor has been tracked, but a zero shift has occurred of magnitude $N_1 \times 10^{-5}$ fringes. Such a shift can cause a significant error when short measurements are being performed.

Previous attempts to compensate automatically for this effect have required the user to estimate the deadpath distance L_1 and enter it on thumbwheel switches. When wavelength changes occurred, the assumed zero shift was computed and then corrected for.

Another type of deadpath zero shift can be caused by the thermal expansion of the material upon which the interferometer and reflector are placed. Its correction requires entry of a coeffecient of expansion. These "open-loop" attempts at correcting for deadpath error are inconvenient, unsatisfying and often ineffective. In the compensator described here, therefore, the need for thumbwheels has been eliminated by a separate device, the Hewlett-Packard 10565A remote interferometer.[3] This small optical element moves the interferometer optics from the laser head to a point as close as desired to the zero point of the measurement (Fig. 3b). As a result, L_1 is minimized, and the possibility of serious deadpath error is eliminated.

The effectiveness of the automatic compensator is illustrated in Fig. 4. The large hump in the uncompensated trace was caused by a temperature change of approximately 2.5° C, which induced both a wavelength change and expansion of the steel surface upon which the measurement was performed. The stabilized trace was made using compensation for both the wavelength change and the expansion of the steel bench. □

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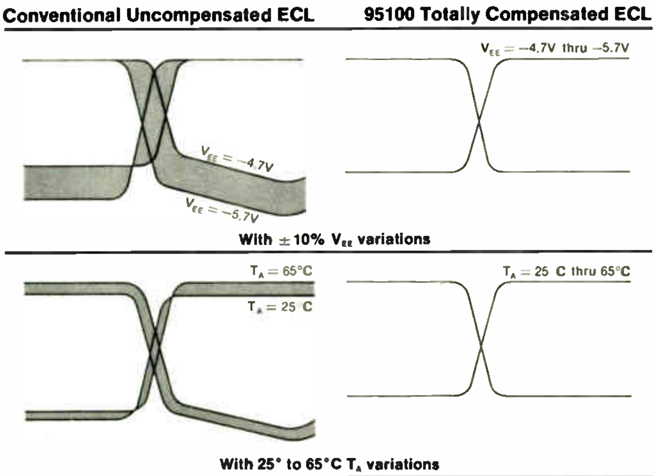
Noise Margin Comparison

V_{IN} and V_{OUT} transfer characteristics



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95108	Quad 1 i/p OR/NOR Gate	,,
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Solid-state waveform displays demand special drive circuitry

The analog signals now displayed as waveforms on CRTs will need conversion into digital form once solid-state arrays of discrete light elements take over; a matrix drive is being developed for the job

by Joachim Kuhlmann, *AEG-Telefunken Semiconductor Division, Heilbronn, West Germany*

☐ Matrixes of solid-state light elements—whether light-emitting diodes, gas-discharge devices, or liquid crystals—are likely to replace the cathode-ray tube in many display systems. But if these arrays are to be capable of displaying waveforms, special circuitry will also have to be developed that will convert analog input signals into a digital form suitable for driving a large array of sources.

A waveform display presents a different problem from an alphanumeric display. The latter generally needs only a spot drive, which addresses all appropriate light spots simultaneously. The former, however, needs a matrix drive—one that will light up a series of spots across the array by addressing one unique row-and-column intersection after another.

In addition to the supply voltage, a display that is to replace a CRT needs two inputs through which the X and Y coordinate information can be fed in analog form. This arrangement is analogous to a CRT's deflection-plate drive, and must be digitized in a manner appropriate for addressing discrete rows and columns. This means that the drive circuitry must be a form of analog-to-digital converter.

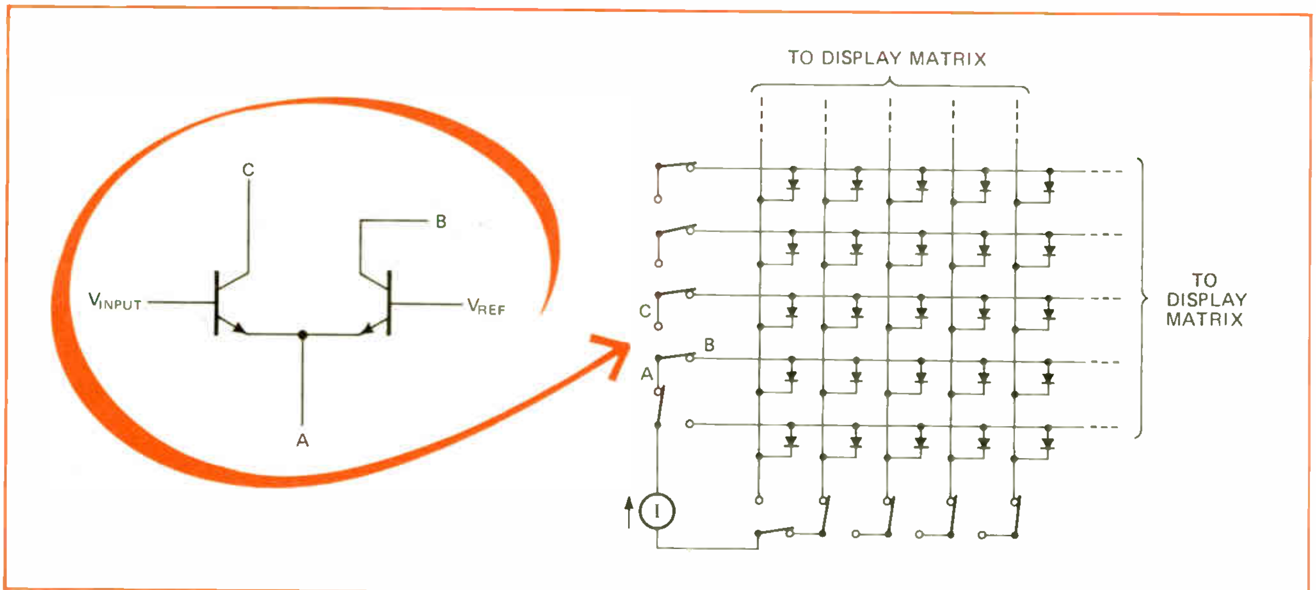
General requirements for such a converter are:

- The resolution accuracy in the X- and Y- directions should be within 1% of the full deflection range, or about that now available with the CRT. This resolution is achieved in a 100-by-100 element matrix.
- The switching time from one point to another should be within the nanosecond range. With a 10-ns switching time, for example, a deflection time of about 1 microsecond per scan is attainable for a 100-by-100 element matrix.
- All digital values must be available in decoded form. Thus, the circuit design becomes more economical when the a-d converter furnishes output signals in simple coded form.
- The circuit should lend itself to integrated circuit techniques, and should consume as little power as possible so that the display and the drive circuitry can be designed as one unit.

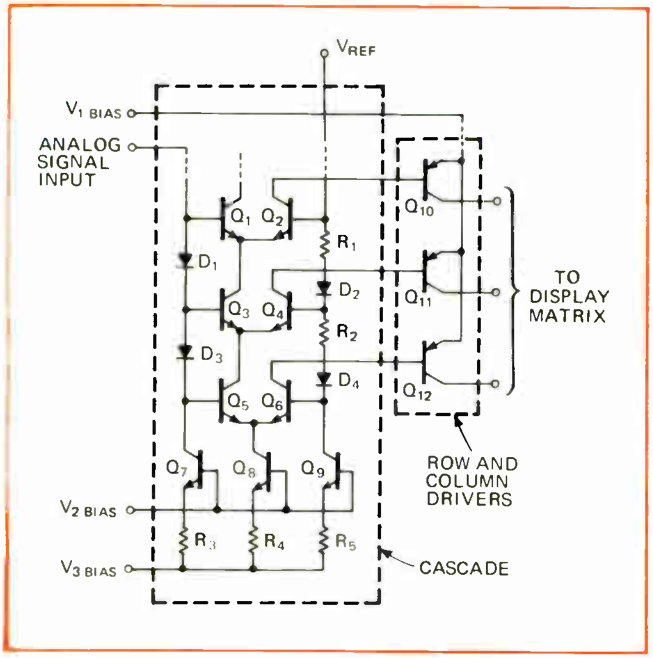
Cascades of switches solve problem

With these design goals, a drive system has been designed and breadboarded, using discrete components, plus incandescent lamps as the matrix elements.

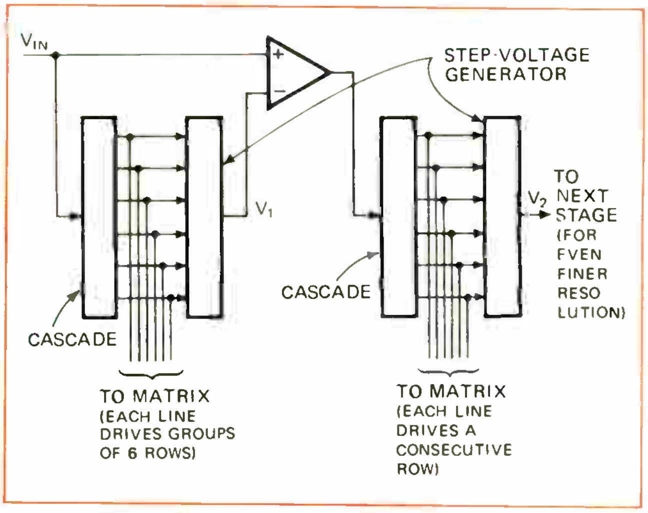
The drive circuitry for the diode matrix (Fig. 1) consists of a current source and cascade arrangements of



1. Display needs. In this display drive circuit, only one matrix element is addressed at a time. Difference amplifiers compare input signal to reference values to determine which row and column should be connected to complete the drive circuit.



2. Cascade. More than 10 comparators can be incorporated into one driver cascade. Resistors place correct voltages on the reference side of the comparator. Diodes protect against transistor overload and stabilize the cascade against temperature changes.



3. Enhancement. Improved resolution is obtained by adding cascades in the arrangement shown. If one cascade is capable of N discrete row or column drive outputs, m cascades provide N^m outputs.

single-pole, double-throw switches. Voltage comparators actuate these switches so that the rows (or columns) remain connected to the cascade as long as the input voltage does not exceed a reference voltage assigned to that row (or column). When the input voltage does exceed that value, switching from row (or column) to the cascade occurs, so that the matrix drive current is applied to only one row and column at any instant.

Design of the comparators is detailed in Fig. 2. Transistors Q_1 through Q_6 are connected on one side to a voltage divider (R_1, R_2, D_2, D_4) that produces the unique threshold voltage for each comparator, and on the other side to a diode-voltage divider (D_1, D_3) which applies the input voltage to the circuit. Diodes in the input divider prevent the transistors from being overdriven. Diodes in the reference-voltage divider equalize the voltage drop in the input voltage divider, making the circuit fully temperature-compensated. Because the transistors are never saturated, switching times below 10 nanoseconds are achieved.

Comparators per cascade limited

The number of discrete voltage levels over which the drive circuit operates is determined by several factors. The threshold voltage range in which the current is completely switched from one collector to the other is about 200 millivolts. With a safety factor, the threshold of adjacent difference amplifiers must be separated by about 0.5 volt. The maximum difference voltage at the amplifier is limited by a base-emitter reverse voltage breakdown of about 6 V. A single cascade can therefore furnish up to about 10 discrete threshold values, spaced about 0.5 V apart.

To improve the circuit's resolution, the difference-amplifier cascades are arranged as shown in Fig. 3. The first cascade resolves the input signal into N discrete levels, where N is the number of stages in the cascade. Then a difference amplifier, a step-voltage generator, and a second cascade are employed to subdivide each of these levels into N additional levels.

The heart of this arrangement is the difference amplifier. It subtracts the step-voltage output of the first cascade, V_1, from the input signal, V_{in}, and amplifies the result. The voltage thus obtained is applied to the second cascade to produce N discrete voltage increments for each value produced by the first cascade.

In this way, two cascades, each having N different threshold values, can produce N^2 different digital outputs.

One problem is the requirement that the threshold value of the first cascade must be well defined and constant. This problem is solved by feeding the output of the step-voltage generator in the second stage to the reference voltage bias line of the first stage (Fig. 4a). The waveforms of Fig. 4b result. For this example, the input voltage at the first cascade is a linearly rising function. The reference voltages at the difference amplifiers are staircase functions. Corresponding drive current lines to the matrix are also shown.

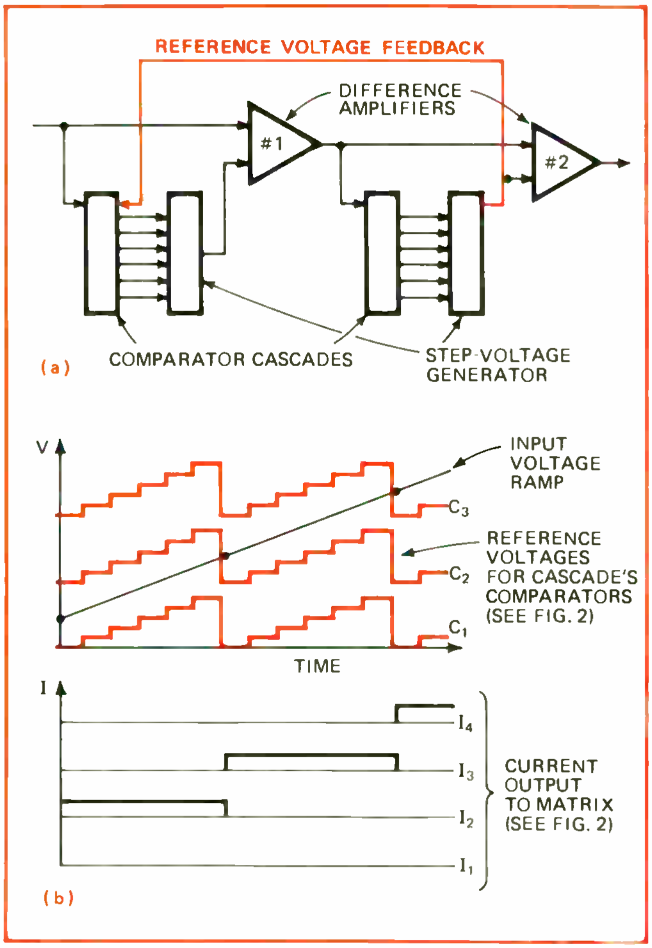
The waveforms in the diagram are based on a six-stage cascade. When the input signal exceeds the range of the sixth stage, the step voltage jumps back to its lowest value.

The reference voltages at the first cascade are therefore far below its input voltage, and the cascades all advance by another value. In this way, accurate switching of the second cascade is obtained, and the threshold values are always separated from the input voltage by a large enough tolerance.

As more cascades are added to increase resolution, similar feedback loops are added.

Prototype uses 1,296 lamps

Circuits to test the above technique have been assembled with discrete components on printed-circuit cards. The experimental display is made up of a 36-by-36-element array of small incandescent lamps, each placed in series with a diode for decoupling individual rows and



4. Controlled threshold. Stable switching threshold is obtained by adding feedback from the second cascade to the reference-voltage input of the first one. This arrangement ensures that the first cascade will advance on step precisely when the second one reaches the end of its range and resets to zero.

columns during operation. The 1,296 lamps are arranged in a matrix measuring about 10 centimeters on each side, and simulate the individual light spots of future solid-state displays. Photos of the breadboard system display (Fig. 5) show typical curves obtained.

With discrete-component circuitry, a switching speed—the time it takes to switch from one light spot to another—is typically 10 nanoseconds.

Frequency response for the display system is related to the switching speed, and also depends on the number of light spots that are switched on the display. To discern, for example, a one-period sine wave on the 36-by-36 element experimental display, about 50 spots must light up. With a 10-ns point-to-point switching time, it takes 500 ns to produce the entire wave on the display. The frequency response is thus 2 megahertz. When the same switching speed is used for a 100-spot one-period sine wave, the frequency response is 1 MHz. Response is thus inversely proportional to the number of spots that make up the curve.

The power consumption in the breadboard is 1 watt per cascade, and four cascades are required. If the same circuitry were implemented with integrated circuits, the power level could be reduced by some 20% to 30% without significantly reducing the switching speed. □

Solid-state display elements

The most promising candidates for solid-state light source elements in display arrays include:

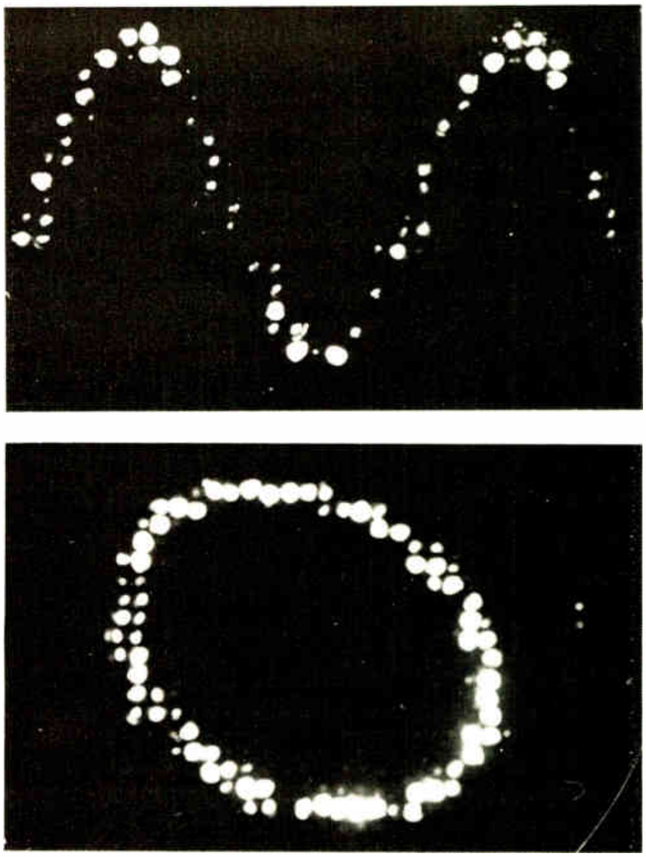
- Nonjunction light-emitting material as, for example, zinc sulfide.
- Light-emitting diodes, such as those made with gallium arsenide and gallium arsenide phosphide.
- Gas-discharge devices on a planar surface.
- Liquid crystals.

The large surface area required by a zinc-sulfide or liquid-crystal element limits its use to big displays. Gas-discharge cells are best suited for displays of medium size, while GaAs and GaAsP diodes will find greatest use in small displays with high resolutions.

ZnS and gas-discharge light sources need an operating voltage of about 200 volts (alternating current for ZnS), liquid crystals require from 5 to 50 V, and GaAs diodes need only about 2 V.

Drive power demand is lowest for liquid crystals. But input power requirements for all solid-state sources must be assessed in terms of their luminescence, duty cycles used, and the switching times required.

Switching times for GaAs diodes are in the nanosecond range. For ZnS and gas-discharge cells, microsecond switching is typical. Liquid crystals take from a few milliseconds up to one second to switch, slowing down as the temperature falls.



5. Waveforms displayed. Discrete components make up an experimental display driver to light a 36-by-36-element array of incandescent lamps. While resolution can be greatly improved by building larger arrays with smaller elemental areas, sine-wave and Lissajous patterns prove the technique. Display shown is nearly actual size.

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by Mahendra J. Shah
University of Wisconsin, Madison, Wis.

High-voltage regulation usually calls for high-voltage transistors. But, by absorbing the bulk of the output voltage with a zener diode, only relatively low-voltage devices are needed. The circuit illustrated regulates 250 volts with a 90-V transistor; however, the same concept can be applied to regulating voltages in the kilovolt range.

Transistor Q_1 operates as a shunt regulator, monitoring the output voltage, e_o, across the load. Without zener diode D_1, Q_1 would be subjected to nearly all the output voltage. But D_1 absorbs a good part of this voltage because it is in series with the collector of Q_1. This allows Q_1 to operate at the difference voltage between e_o and the voltage across the zener.

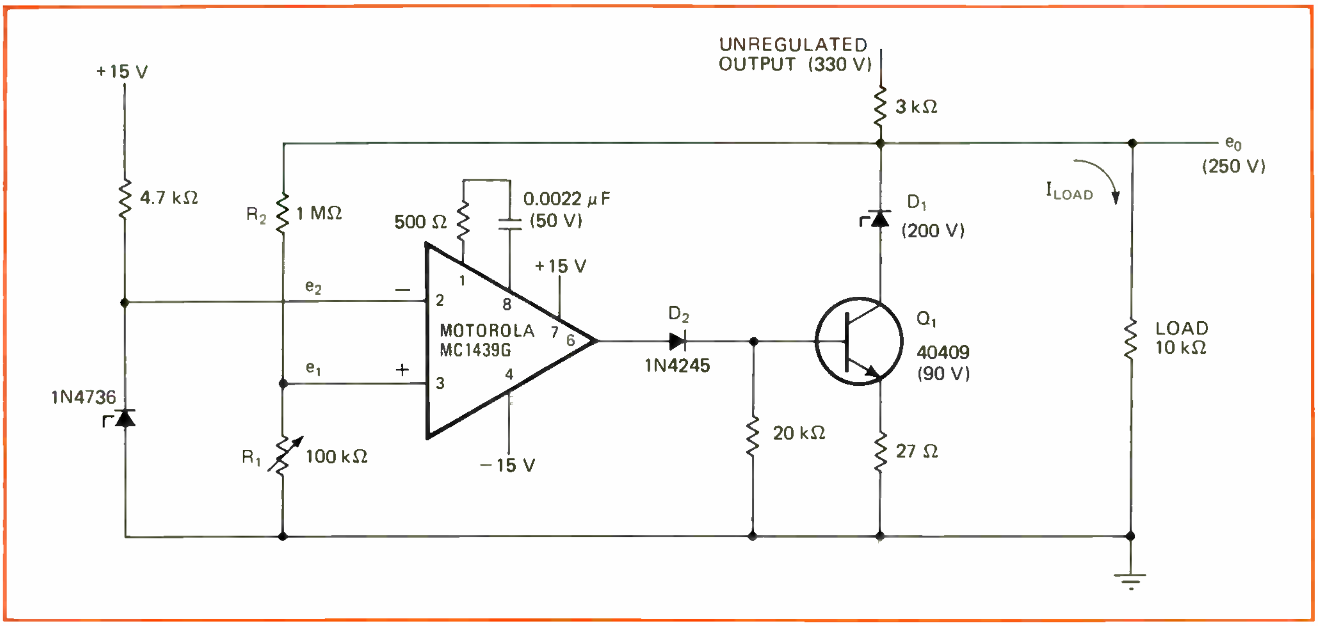
The output voltage is divided by resistors R_1 and R_2 and applied to the non-inverting input of an operational amplifier, which functions as a comparator. The op amp compares e_1 with e_2, and maintains output voltage e_o so that $e_1 = e_2$. Regulated output is a function of the comparator's inverting input voltage, e_2, and the resistors of the voltage divider:

$$e_o = e_2(1 + R_2/R_1)$$

Another diode, D_2, protects Q_1's base-emitter junction from reverse breakdown. During normal operation, D_1 is forward-biased, allowing Q_1 to receive base drive for proper regulation.

For the component values shown, voltage regulation from no load to full load (25 milliamperes) is less than 0.04%. Unregulated voltage is 330 V, and the voltage across Q_1's collector-emitter junction is approximately 40 V. □

Putting a zener to work. Zener diode D_1 handles most of 250-volt regulated output, permitting a mere 90-V transistor to be used. Transistor Q_1 acts as conventional shunt regulator for load resistance. Op-amp comparator maintains output voltage to keep its inputs e_1 and e_2 equal, thereby providing proper base drive for Q_1. Regulated output voltage is: $e_o = e_2(1 + R_2/R_1)$. Unregulated output of 330 V is also available.



Op amps multiply RC time constants

by Quentin Bristow
Geological Survey of Canada, Ottawa, Ont., Canada

Unusually long time constants can be generated with considerable accuracy by combining readily available low-value resistors and capacitors with a couple of general-purpose operational amplifiers. Besides being physically smaller than their higher-value counterparts, low-value components offer tighter value tolerances and do not have leakage or polarity problems. Furthermore, when high-value resistors are used, field-effect-transistor-input op amps must be employed. They are more expensive than general-purpose op amps and do not provide as good input offset and temperature drift specifications.

A number of instrumentation applications require time constants in the order of seconds or minutes. Circuit (a), for instance, can be used to stretch one-shot output pulses, or as a low-pass insertion filter for monitoring slowly changing meteorological, oceanographic, or other geoscientific phenomena where low-frequency noise is undesirable. This network can multiply a basic RC time constant by a factor as large as 10,000. (For example, a 100-second time constant can be realized with R = 100 kilohms and C = 0.1 microfarad.)

When V_i is a step input, output voltages E_1 and E_2 rise exponentially to final values $-V_i$ and $+V_i$, respectively, with a time constant (taken at 63% of the final level) of $(N+2)RC$.

$$E_2 = -E_1 = V_i[1 - \exp(-t/(N+2)RC)]$$

The actual values of resistors R_1 and R_2 are not critical because the time constant is determined by ratio N and the values chosen for R and C. The components indicated provide a time constant of 50 seconds.

The drift and noise of either output referred to the original input V_i will be the same as that obtained when amplifier A_1 is operated at a closed-loop gain of $N+1$, modified of course, by the filtering effect of the time constant generated. After capacitor C is removed, the circuit can be seen to be an op amp (A_1) connected for a closed-loop gain of $N+1$, since amplifier A_2 is simply a unity-gain inverter.

The offset null trimmer permits the E_1 output to be set initially to zero for a zero input. Generally, the trimmer can be omitted for values of N less than 50. To avoid a tedious time lag in circuit output response when making this adjustment, one end of the capacitor should be disconnected temporarily.

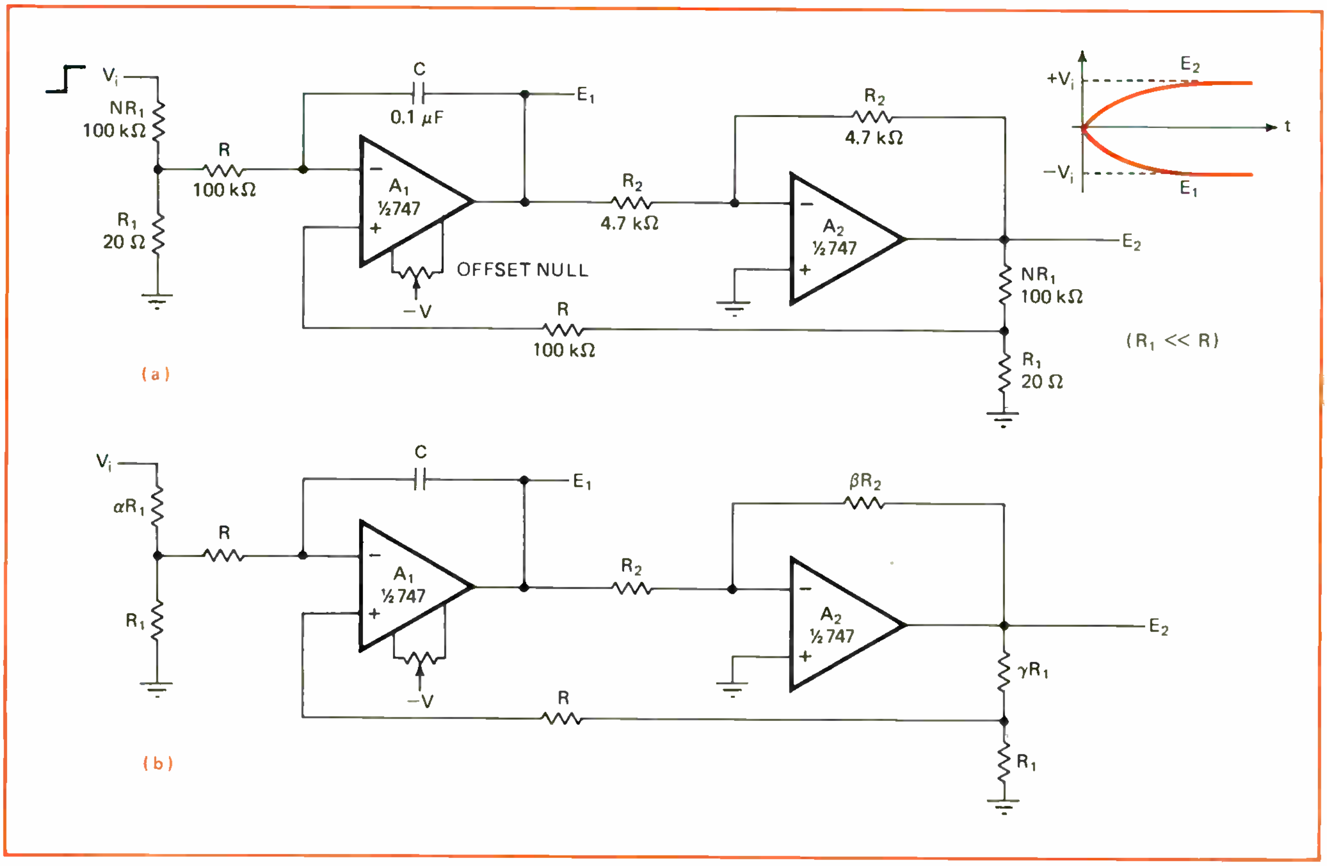
Gains other than plus or minus unity can be obtained at outputs E_1 and E_2 by making the input attenuation and feedback ratios unequal; they are both $1/(N+1)$ for circuit (a). Also, the inverting gain of amplifier A_2 can be other than unity. As shown in circuit (b), input attenuation can be controlled by ratio α, feedback by ratio γ, and inverting gain by ratio β. The two outputs become:

$$E_1 = -V_i(\gamma+1)[1 - \exp(-t\beta/(\beta+\gamma+1)RC)]/(\alpha+1)\beta$$

$$E_2 = V_i(\gamma+1)[1 - \exp(-t\beta/(\beta+\gamma+1)RC)]/(\alpha+1)$$

In applications where desired drift and noise specifications cannot be met by a 747-type op amp, amplifier A_1 can be stabilized with a temperature-controlled differential preamplifier, such as Fairchild's μA727B. This integrated circuit has an on-chip proportional temperature regulator, affording tight control of chip temperature at about 100°C. The 727-plus-747 combination provides excellent dc stability at high closed-loop gains and can be treated circuitwise as a single op amp. If a preamplifier is added, the null offset trimmer is no longer effective. □

Extending RC time constants. Low-value resistors and capacitors and two op amps can generate time constants that are several minutes long. Output voltages E_1 and E_2 exponentially approach level of step input V_i. Time constant, which is 50 seconds for circuit (a), primarily depends on R, C, and ratio N. For circuit (b), there are three controlling ratios: α for input attenuation, γ for feedback, and β for gain.



One-shot/flip-flop pairs detect frequency bands

by Edward E. Pearson
Opelousas, La.

A retriggerable monostable multivibrator and a type D flip-flop can form a simple reliable frequency comparator that senses if an input frequency is greater than or less than a predetermined reference. Connecting additional comparators in parallel, together with AND logic, permits the detection of input frequencies that fall within selected bands.

Both the one-shot and the flip-flop are wired for positive edge triggering. Each input pulse causes the monostable's output to go high for the period of its preset timing interval. The flip-flop is triggered simultaneously, but its output is determined by the state of its D input at the time of trigger threshold.

If the period of the input frequency is shorter than the preset timing of the monostable, a constant high level will be present at the D input, forcing the flip-flop's Q output to remain high. If the input frequency period becomes greater than that of the monostable, the D input will go low prior to the next incoming trigger. The flip-flop's Q output then goes low and remains low until the input period becomes shorter than that of the monostable.

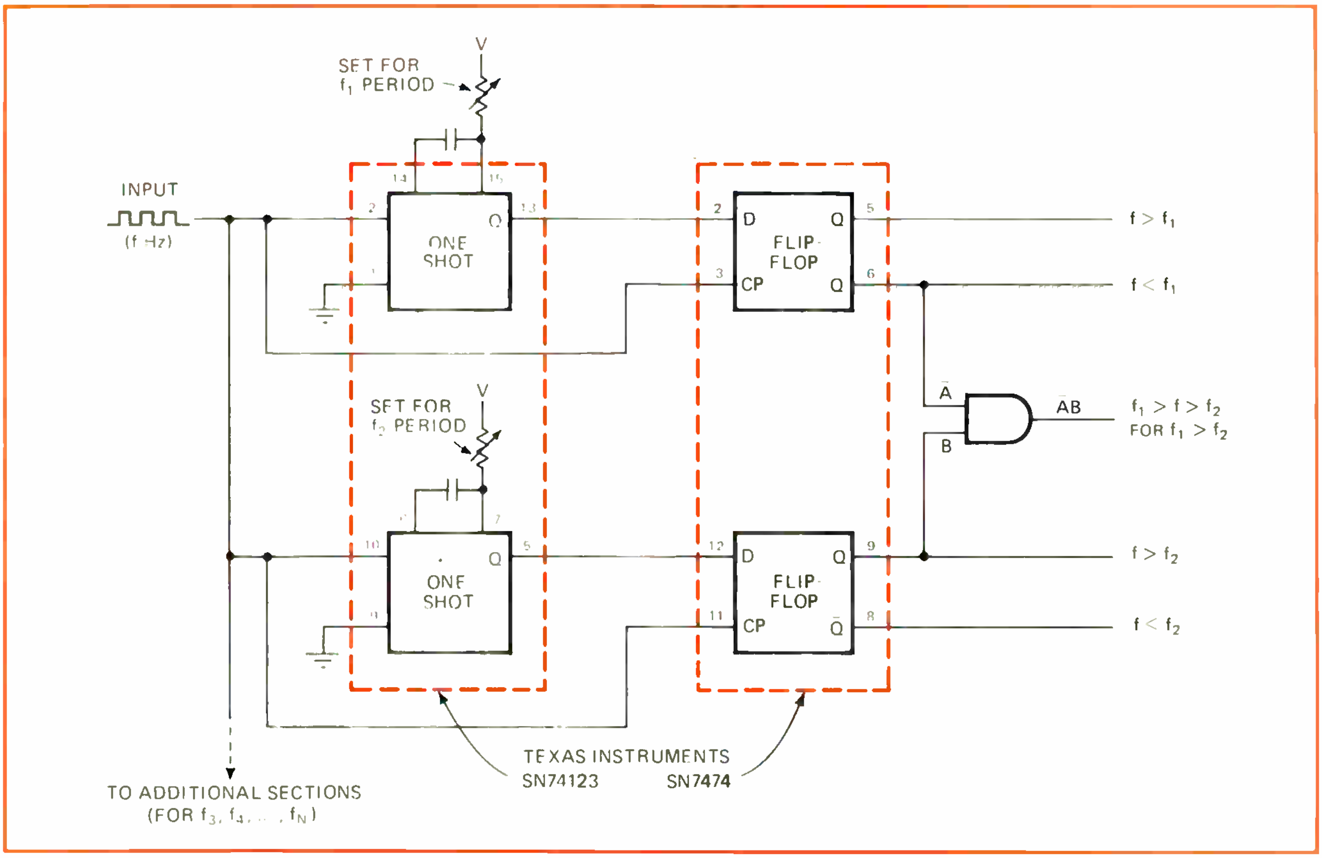
To determine whether an input frequency (f) falls between two known frequencies, f_1 and f_2, two one-shot/flip-flop combinations are required, as shown. The top pair of devices detects an input greater or less than f_1, while the bottom pair detects an input greater or less than f_2. The AND gate provides a high output when the input frequency lies inside the preset band (less than f_1 or greater than f_2, if f_1 is greater than f_2). This detection scheme can be expanded to include any desired number of segments within the operating passband.

The frequency band detector also has an inherent memory function that could be particularly useful in control applications. When the input signal terminates, for example, with a tone burst, no trigger is available to the flip-flops, and all outputs remain static until the input signal returns.

Although the detector responds only to the period of the input signal and does not require the input to maintain a specific duty cycle, input pulses must have a rapid rise time. All trigger thresholds must be reached within an interval that is appreciably less than the monostable's propagation delay time. Circuit speed is limited only by the setup and hold performance of the components being used. □

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

Sensing frequency. Retriggerable one-shot and flip flop compare frequency of input to preset reference frequency. To form frequency-band detector, two frequency comparators and AND gate are needed. Depending on period of input pulse train, each one-shot output is high or low. Each flip flop triggers to level seen by its D input prior to trigger threshold. AND gate output goes high when f falls between f_1 and f_2.



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Active resonators save steps in designing active filters

Resonator model allows active filter sections to be treated as common components, side-stepping design details that bog down analysis; the model employs a simulated inductance that remains inherently lossless

by Randy Brandt, *Integrated Electronics Inc., Los Gatos, Calif.*

☐ Active filters make possible the realization of inexpensive high-Q networks at low frequencies. Passive filters, on the other hand, tend to become costly, lossy, and unwieldy in physical size when large inductances are required. Since active filters simulate inductance, extremely large values can be realized while holding down filter cost, losses, and size. Furthermore, the ever-decreasing price of today's monolithic operational amplifier, the heart of any active filter, is constantly improving the attractiveness of building an active, rather than passive, filter.

However, because of the proliferation of active filter analysis techniques, only a core of full-time design specialists can differentiate between the merits of various approaches and select the optimum solution. The occasional filter designer finds it easier to build a passive circuit, despite the advantages of the active approach.

But a basic building block, called the active resonator, allows even the occasional filter designer to handle an active filter as an ordinary circuit component. This active resonator model is common to all active filter sections. It consists of a tuned RLC circuit for resonance and an op amp for the necessary gain and isolation.

Modeling the active resonator

An active filter section, regardless of how many amplifiers it contains, is the fundamental repetitive portion of a complete active filter. Generally, the active filter section can perform as a filter itself or be cascaded to realize higher-order filter functions. The term "active resonator" is simply another label for active filter section. With varying degrees of difficulty, any active filter can be reduced to active resonator form.

Because of its utility and simplicity, a sound choice for demonstrating how to form an active resonator model is the popular biquad active filter. This filter is particularly noted for its insensitivity to variations in component values. When it has three amplifiers, as shown in Fig. 1(a), the biquad filter provides both low-pass and bandpass outputs. By adding a fourth summing amplifier, the circuit can supply a high-pass, all-pass, or notch output.[1]

The network's transfer function between its bandpass output, $(V_o)_{BP}$, and its low-pass output, $(V_o)_{LP}$, is that of a non-inverting integrator:

$$(V_o)_{LP}/(V_o)_{BP} = 1/sR'C'$$

where s is the Laplace variable. Feedback current is:

$$i_f = (V_o)_{LP}/R_f = (V_o)_{BP}/sR'R_fC'$$

Solving for the equivalent impedance of the loop with these two equations gives:

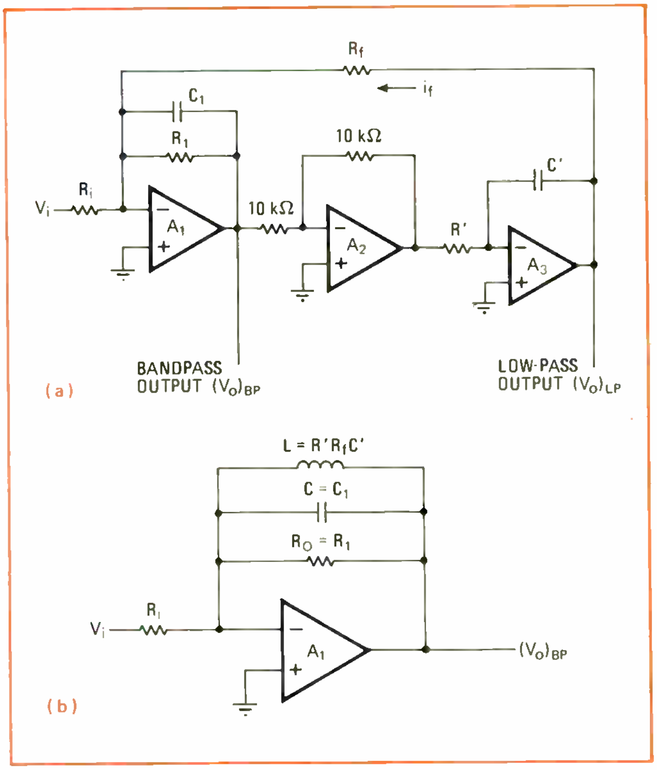
$$Z_L = (V_o)_{BP}/i_f = sR'R_fC'$$

showing Z_L to be inductive in nature. Therefore, amplifiers A_2 and A_3, and feedback resistor R_f can be replAced with the equivalent inductance:

$$L = R'R_fC' \qquad (1)$$

connected in a negative feedback loop around amplifer A_1. Now the general form of the active resonator can be drawn as depicted in Fig. 1(b).

Identifying equivalent inductance L is the key to deriving the active resonator model. Once L is defined in terms of existing components in an active filter section,



1. Resonator model. Biquad filter section (a) can be reduced to active resonator model (b) by replacing amplifiers A_2 and A_3 with equivalent inductance L. This simulates L with non-inverting integrator in negative feedback loop, but other techniques can be used. Very high but lossless inductances can be realized. Single-amplifier resonator can be treated as complete filter section.

the active resonator model can be used to represent that particular active filter section.

Since L is known for the three-amplifier biquad network, it can be handled as a single-amplifier circuit. This reduces analysis complexity and allows the designer to concentrate on his over-all filter requirements without being unduly concerned with the details of each filter section.

For the biquad filter, inductance L may be simulated in several ways by using different non-inverting integrators in a negative feedback loop around an operational amplifier.[2] Of course, any other technique for simulating a stable inductance is also suitable for the biquad network or whatever filter section is being modeled as an active resonator.

Because L is simulated, its inductance can be very large and yet remain absolutely lossless if ideal amplifiers are used. Although ideal operational amplifiers are fictitious, practical op amps can approach the ideal so that inductance L stays virtually pure (lossless). This is true whenever resistance into the summing junction is an order of magnitude less than the amplifier open-loop input impedance, and when the gain of the feedback loop is high enough to prevent open-loop rolloff from affecting desired Q.

Therefore, assuming that loop gain and amplifier input impedance are sufficiently large, the only lossy element in the network is the parallel resistor, R_Q. It can be regarded as the Q-setting resistor, even though the product of R_QC really determines the 3-decibel bandwidth, and both the R_QC and the LC products establish the Q of the active resonator.

Matching the transfer function

The transfer function of the resonator's tuned circuit must be identical to that of its passive counterpart. For the entire resonator of Fig. 1(b):

$$V_o/V_i = s/R_iC(s^2 + s/R_QC + 1/LC)$$

Analyzing this function in the complex s-plane yields the graph of Fig. 2(a). The location of the complex-conjugate pair of poles is determined by the roots of the denominator, while the positions of two transmission zeros (roots of the numerator) are fixed at frequencies of zero and infinity.

This means that the logarithmic magnitude response has a bandpass characteristic with a shape as illustrated in Fig. 2(b). The slope of each curve in the vicinity of resonant frequency f_o is a function of Q. The slope away from resonance is eventually 6 dB per octave because of the zeros that are located at zero and infinity.

The transfer function of a passive parallel RLC network can be written as:

$$G(s) = hs/(s^2 + \Delta\omega s + \omega_o^2)$$

where h is the attenuation factor of the network, and $\Delta\omega = \omega_o/Q$. Comparing the coefficients of G(s) to the coefficients of V_o/V_i for the active resonator yields:

$$\omega_o = 1/(LC)^{1/2} \qquad (2)$$

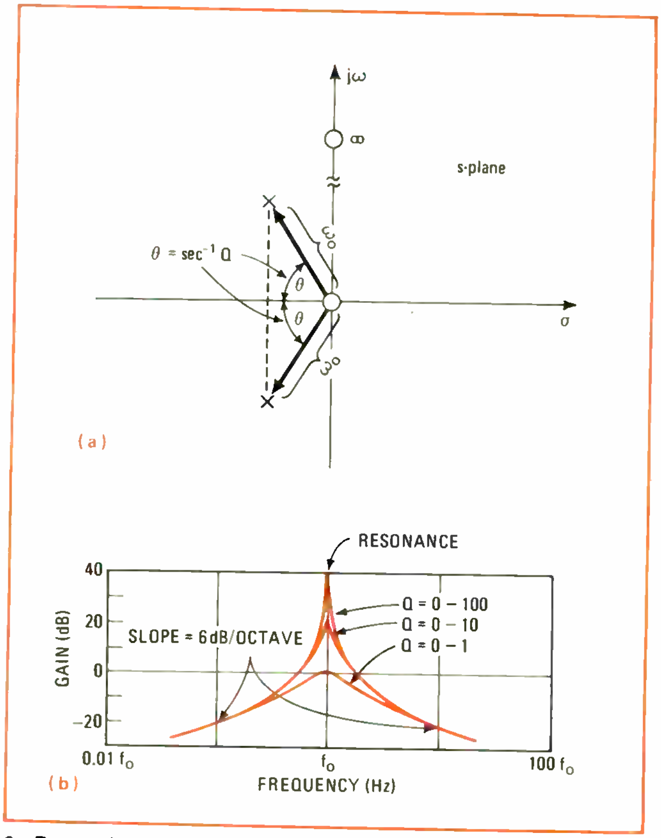
and:

$$\Delta\omega = 1/R_QC \text{ or } Q = \omega_oR_QC \qquad (3)$$

and:

$$h = 1/R_iC$$

The magnitude response of G(s) reaches a maximum at $\omega = \omega_o$, and the 3-dB bandwidth is determined by the



2. Resonator response. Characteristic behavior of active resonator is identical to that of tuned RLC circuit. Pole-zero plot (a) illustrates bandpass nature of resonator transfer function—there are two complex-conjugate poles and two zeros. Magnitude of pole vector is fixed by radian center frequency ω_o, while vector direction is function of Q. Slope of resonator magnitude response (b) depends on Q near resonance and then becomes a constant value.

$\Delta\omega$ coefficient of s in the denominator. At $\omega = \omega_o$, response magnitude becomes:

$$A(\omega_o) = h/\Delta\omega$$

For the active resonator, the response magnitude at ω_o is found by substituting $h = 1/R_iC$ and $\Delta\omega = 1/R_QC$ in this last equation. Then:

$$A(\omega_o) = R_Q/R_i \qquad (4)$$

Since the impedance, at resonance, of a parallel tuned LC network with lossless inductors is infinite, the closed-loop gain of the active resonator at resonance is simply equal to a resistance ratio. The active resonator, then, has all the properties of a parallel RLC network and can be described in familiar terms once inductance L is identified.

Designing with the resonator

The placement of poles and zeros in the complex-frequency plane fully defines the shape of a filter's response. Furthermore, the locations of these poles and zeros are determined strictly by the Q and ω_o of the transfer function. And since Q and ω_o are known for the active resonator, complete active filter networks can now be designed.

In general, filter design with either active or passive sections is a matter of obtaining the best curve fit over a band of frequencies for a given set of specifications. The designer usually begins by searching through tables or

Bandpass transformations

The appropriate low-pass approximation function for transforming to a second-order bandpass function has a single pair of complex-conjugate poles in the left-hand s-plane. To transform fourth-order functions, the transformation equations for the second-order functions are used twice.

Transforming each low-pass complex-conjugate pole (a) into its bandpass equivalent requires six parameters: the over-all Q of the bandpass filter at its center frequency (Q_c), the bandpass center frequency (f_o), and the real and imaginary parts of the two low-pass poles.

Since the vectors drawn from the origin to the poles in (a) are defined in terms of Q and f_o, it is convenient to write the transforms with Q and f_o as dependent variables. As shown in (b), the low-pass complex-conjugate pole pair transforms into the bandpass plane as two pairs of complex-conjugate poles and two pairs of zeros.

The bandpass pole Qs are identical, and the center frequencies are geometrically symmetrical about the center frequency of the over-all filter. The zero pairs are located at $\omega = 0$ and $\omega = \infty$, thereby establishing the bandpass character. Further, for each pair of complex-conjugate poles and each pair of zeros, there is a filter section with Q and f_o given by the Q and f_o of the transformed pole pair.

The bandpass Q transformation for a low-pass complex-conjugate pole pair can be written as:

$$Q_p = \left[\frac{4 + ry + (r^2y^2 + 8ry - 16y + 16)^{1/2}}{8y}\right]^{1/2}$$

Here, y is defined as:

$y = (Re/Q_c)^2$

where Re is the real part of the low-pass pole pair, and Q_c is the cutoff-frequency Q. And r is defined as:

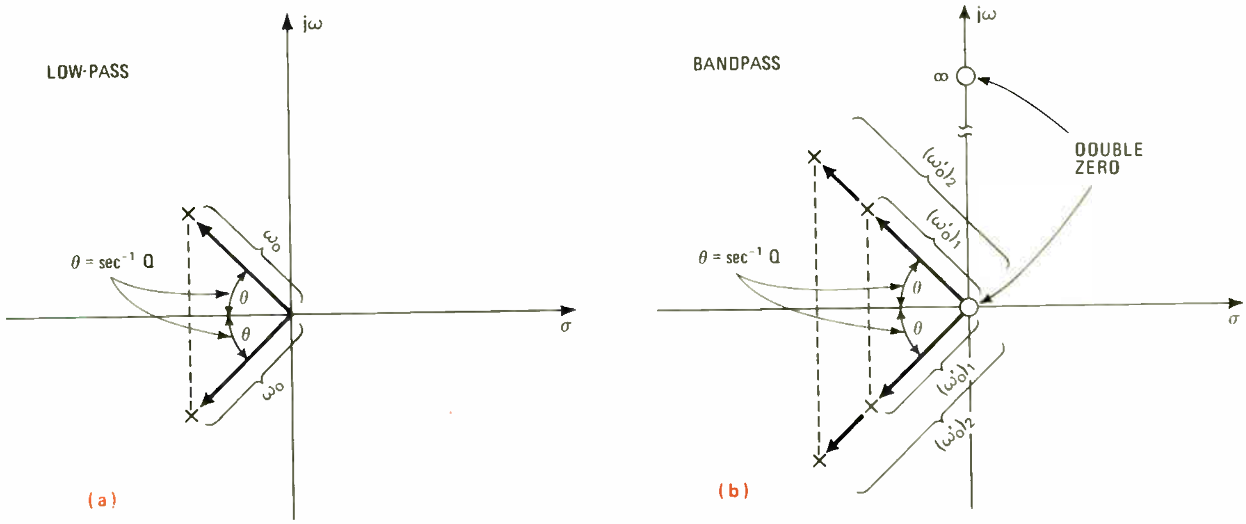
$r = 1 + (Im/Re)^2$

where Im is the imaginary part of the low-pass pole pair. The f_o transformation is:

$(f_o')_1 = [Q_p y^{1/2} + (Q_p^2 y - 1)^{1/2}] f_o$

$(f_o')_2 = f_o / [Q_p y^{1/2} + (Q_p^2 y - 1)^{1/2}]$

where $(f_o')_1$ and $(f_o')_2$ are the resonant frequencies of the bandpass filter sections, and f_o is the resonant frequency of the low-pass filter.



by using a computer program to find the mathematical function that most closely approximates his requirements. In doing so, he may select any one or a combination of such well-known functions as Butterworth, Chebyshev, or Bessel.

Once the function or functions are chosen, the designer decides on the order of the filter, based on characteristics such as shape, minimum stopband attenuation, maximum passband ripple, group delay, and phase response. The order of a filter function fixes the number of sections needed for a given response. And the coefficients of the filter's characteristic equation determine how each section is to be tuned for Q and f_o.

As an example, a typical fourth-order bandpass filter—the type frequently used in low-speed telephone data communications systems—illustrates designing with the active resonator. Suppose the specifications are: a center frequency (f_o) of 2,125 hertz, an over-all passband gain [$A(\omega_o)$] of 200 (46 dB), a 3-dB bandwidth (Δf_3) of 400 Hz, a minimum stopband attenuation (A_{min}) of 60 dB at a lower cutoff frequency (f_L) of 1,270 Hz, a maximum passband ripple (A_{max}) of 0.1 dB, and geometrical symmetry.

First, the filter type and function order that best fit the specifications must be found. To do this, the bandwidth at -60 dB (Δf_{60}) is computed from the upper (f_U) and lower (f_L) frequencies about geometric mean f_o:

$f_U = f_o^2/f_L = (2.125)^2/1.270 = 3.560$ Hz

Then, for this case:

$\Delta f_{60} = f_U - f_L = 3.560 - 1.270 = 2.290$ Hz

And the center-frequency Q (Q_c) of the entire filter is:

$Q_c = f_o/\Delta f_3 = 2.125/400 = 5.32$

Shape factor Ω_s is determined next:

$\Omega_s = \Delta f_{60}/\Delta f_3 = 2.290/400 = 5.13$

The design step that follows often involves the transformation of a normalized filter function into the proper filtering plane. After transforming and denormalizing this function, the designer can tune each resonator to a particular Q and cutoff frequency. Tables of transfer functions are usually written for low-pass functions so that realizing other filter types requires transforming the low-pass function into the desired function.

Using the computed value of Ω_s, and specified values of A_{min} and A_{max}, and published filter data[3] shows that a fourth-order Chebyshev filter will satisfy the example's skirt, bandwidth, and ripple requirements. The normalized coefficients of the low-pass Chebyshev function are found in a table of low-pass Chebyshev polynominals.[4] For a ripple of 0.1 dB and an order of four, the filter's characteristic equation is given as:

$$D(s) = (s^2+0.458s+1.153)(s^2+1.616s+0.789)$$

Solving for the roots of D(s) yields:

$$s_{A1,A2} = -0.229 \pm 1.05j, \; s_{B1,B2} = -0.808 \pm 0.369j$$

These low-pass roots contain two complex-conjugate pole pairs, which transform (see panel, "Bandpass transformations") into bandpass equivalents of four complex-conjugate pole pairs and eight zeros. Since there are four pairs of poles, four active resonators are needed to attain the requirements.

Finding resonator components

From the low-pass-to-bandpass transform equations in the panel, the values of Q and f_o can be computed for each resonator in the bandpass filter. Low-pass roots s_{A1} and s_{A2} characterize the first two resonators:

$Q_1 = 23.3, (f_o)_1 = 2{,}350$ Hz
$Q_2 = 23.3, (f_o)_2 = 1{,}925$ Hz

while s_{B1} and s_{B2} characterize the last two resonators:

$Q_3 = 6.6, (f_o)_3 = 2{,}135$ Hz
$Q_4 = 6.6, (f_o)_4 = 2{,}120$ Hz

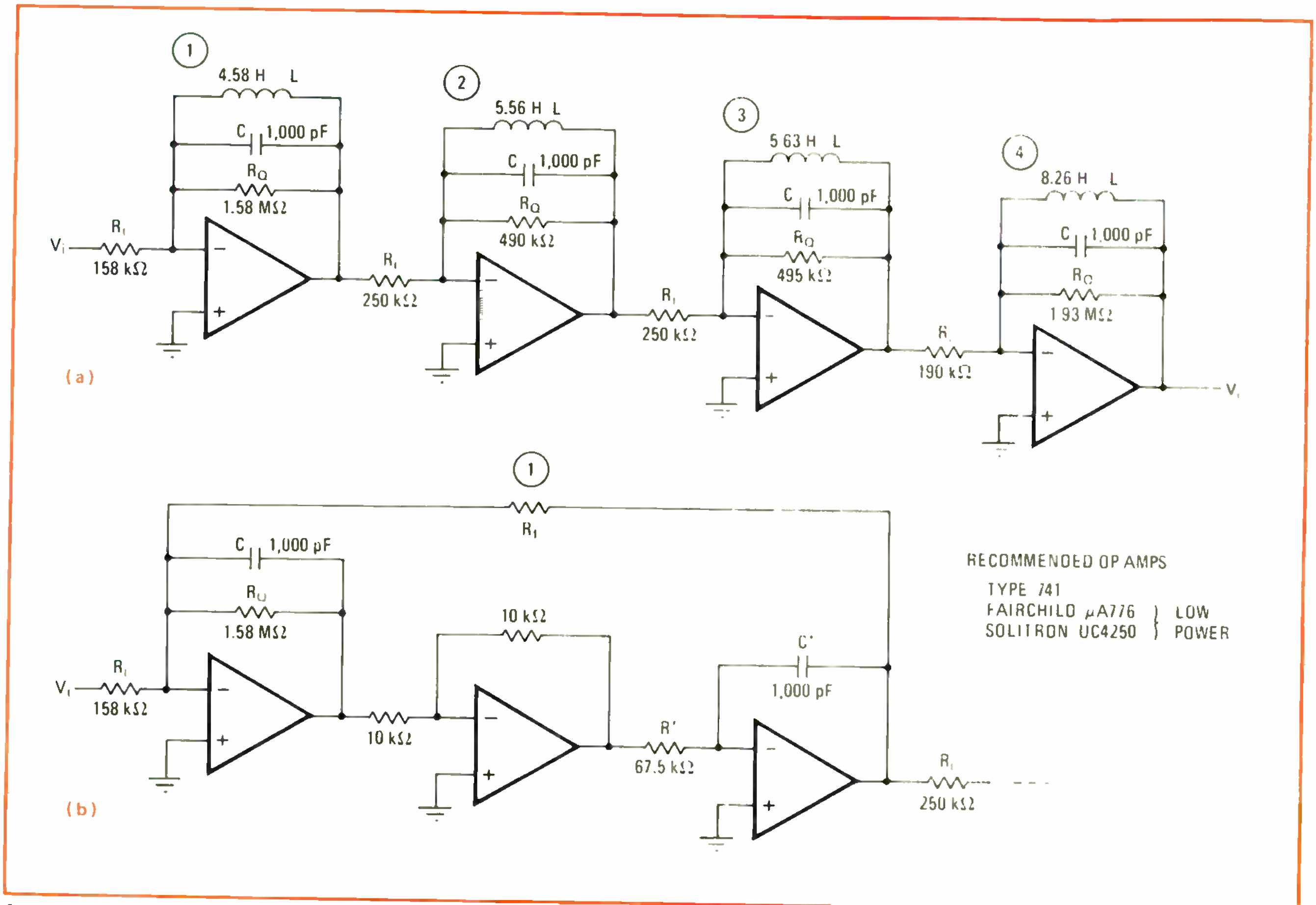
Off-the-shelf resonators

Packaged active resonators, available as standard product lines from more than a dozen companies, can almost reduce active filter design to a matter of resistor selection. Some manufacturers refer to their lines of active resonators as universal active filters, but the circuit function is the same.

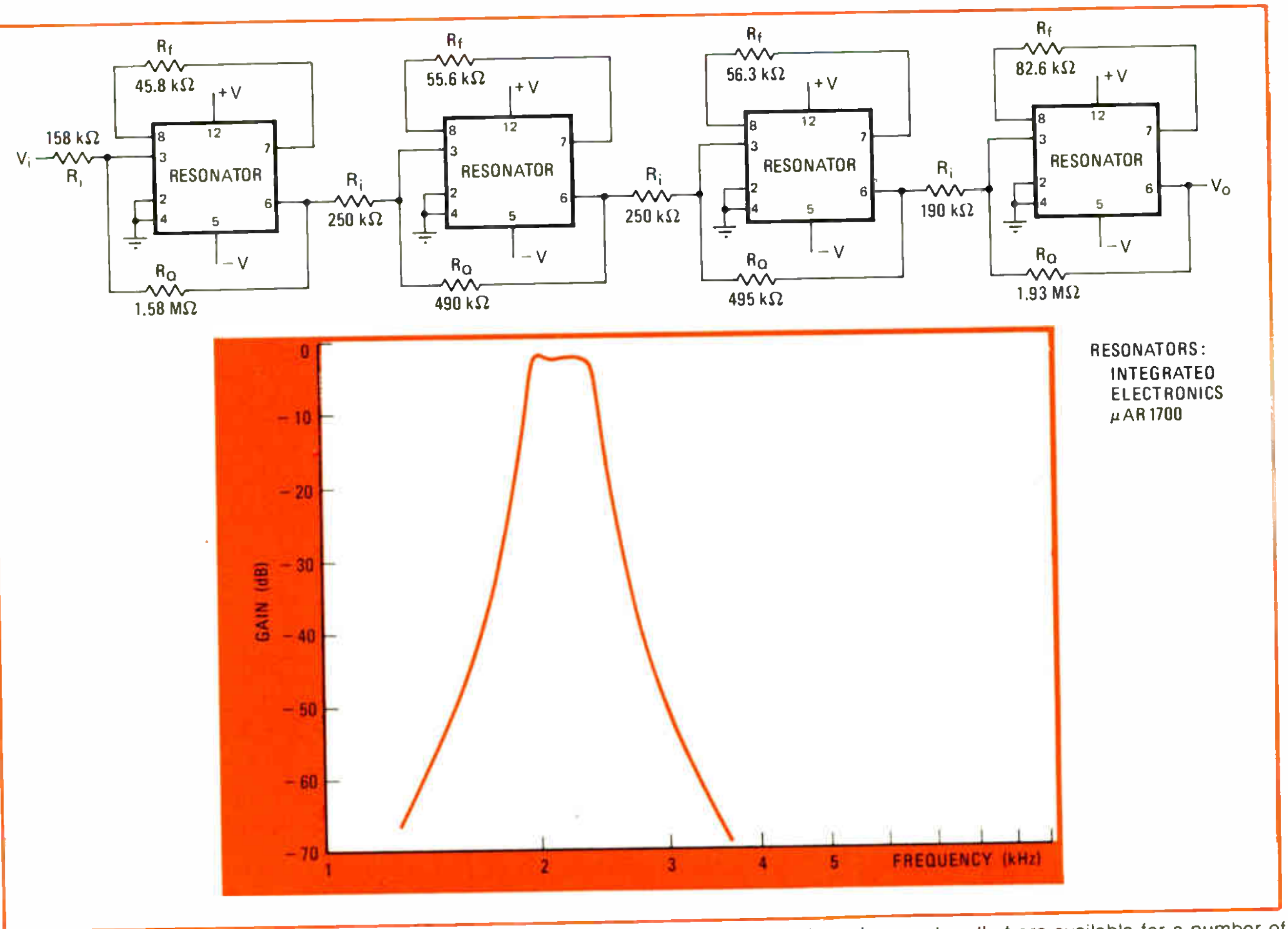
The larger suppliers include Beckman Instruments Inc., Fullerton, Calif.; Datel Systems Inc., Canton, Mass.; Kinetic Technology Inc., Santa Clara, Calif.; Optical Electronics Inc., Tucson, Ariz.; and TRW Semiconductor division, Lawndale, Calif.

A standard family of hybrid microcircuit active resonators also is offered by Integrated Electronics Inc., principally for use in audio and subaudio applications. In large quantities, they range in price from about $5 to $8.

Figure 3(a) shows the bandpass filter configuration using the active resonator representation. It should be remembered that the resonator model employs an equivalent inductance requiring practical simulation and that each resonator section actually consists of three amplifiers and associated circuitry, as noted in Fig. 3(b) for the input resonator. Once the components for the resonators are known, those required to complete each



3. From model to design. Fourth-order bandpass filter (a) is represented by four cascaded resonators. Each resonator, with its simulated inductance, actually requires three amplifiers (b), making 12 op amps necessary for entire filter. Component values can be found once Q and f_o are known for each resonator. Capacitor values are assigned for computation convenience. R_Q principally determines Q of resonator.



4. Ready-made resonators. Active filter design is considerably simplified by using packaged resonators that are available for a number of filtering functions. Those in this diagram are biquad networks connected to realize bandpass filter of Fig. 3. Only three components must be added to each package—R_i for gain adjustment, R_Q to fix resonator Q, and R_f to set resonant frequency.

filter section can be found.

To keep the analysis simple (neglecting the input impedance of practical operational amplifiers), a convenient value is chosen for capacitor C. Generally, C should vary between 800 and 1,000 picofarads for resistor values to remain reasonable. By letting C = 1,000 pF and computing the radian center frequency ($\omega_0 = 2\pi f_0$) for each resonator, L can be found from Eq. 2:

$$L = 1/\omega_0^2 C$$

The value of resistor R_Q is determined with Eq. 3:

$$R_Q = Q/\omega_0 C$$

Since there are four resonators and the over-all required gain is 200, then each resonator must provide a gain of 50. Eq. 4 becomes:

$$A(\omega_0) = R_Q/R_i = 50$$

which can be solved for input resistor R_i:

$$R_i = R_Q/50$$

After the component values for the four resonators are computed, the other components needed to simulate inductance L can be found. Again, the value of 1,000 pF is chosen for capacitor C′ to simplify the calculations. Feedback resistor R_f is set equal to resistor R′:

$$R_f = R' = R$$

so that Eq. 1 can be used to find R:

$$R = (L/C')^{1/2}$$

Active resonators, however, are available as standard products from several manufacturers, as noted in the panel, "Off-the-shelf resonators." These packaged circuits often reduce the final design step to choosing resistor values, once Q and f_0 are known.

For instance, the μAR 1700 resonator from Integrated Electronics is a biquad network that can be used for the resonator sections in the fourth-order bandpass filter design example. Components C, L, R_Q, and R_i are computed as before; of these, only R_Q are R_i are required for the actual filter implementation, as indicated in Fig. 4. None of these component values differ from those already calculated.

Next, the "internal" resonator parts are found. In addition to setting C′ = 1,000 pF, R′ is assigned a value of 100 kilohms for convenience, and then R_f is computed from Eq. 1:

$$R_f = L/R'C'$$

The resulting values of R_f are noted in the figure. When the μAR 1700 resonator is used to build an active filter, R_Q effectively sets resonator Q, and R_f effectively sets resonator f_0. The magnitude response of the fourth-order bandpass filter is also illustrated. □

REFERENCES:
1. J. Tow, "Step-by-Step Active Filter Design," IEEE Spectrum, December 1969, pp. 64-68.
2. L. C. Thomas, "The Biquad: Part I—Some Practical Design Considerations," IEEE Transactions on Circuit Theory, Vol. CT-18, No. 3, May 1971, pp. 350-357.
3. A. Zverev, Handbook of Filter Synthesis, John Wiley & Sons, 1961.
4. R. P. Sallen, E. L. Key, "A Practical Method of Designing RC Active Filters," M. I. T. Lincoln Laboratory, Tech. Report No. 50, May 6, 1954.

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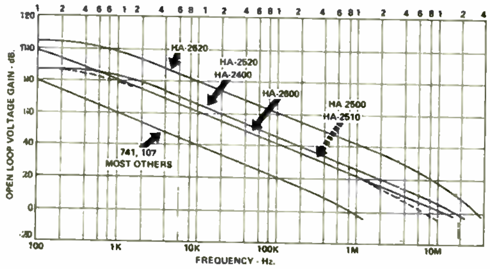

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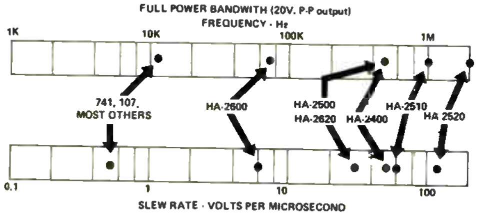

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Circle 111 on reader service card

Standard parts and custom design merge in four-chip processor kit

Processors of various degrees of complexity can be designed from three standardized chip elements and a fourth, a read-only memory, customized to each user's specific purpose by his own microprogram

by F. Faggin and M. E. Hoff, *Intel Corp., Santa Clara, Calif.*

☐ A vast new array of applications has opened up with the advent of low-cost minicomputers that the user can microprogram himself for any number of repetitive functions. These applications range from control of computer peripheral devices to hospital patient monitors to gaming machines.

Such widespread use of microprogramed minicomputers is made possible by large-scale integration that brings the cost about two orders of magnitude below the cost of the most inexpensive conventional minicomputer. One such computer, the Intel MCS-4, is composed of only four kinds of LSI chips. Three of these chip modules—a read/write memory, a processor, and a shift register—are standardized designs. The fourth module, a read-only memory, is programed to the user's specifications.

Among the potential applications for these microprogramed machines are, generically speaking, office equipment, process control, and instrumentation. More specific examples abound in these and other categories: billing machines and point-of-sale terminals, numerically controlled machines and traffic control, spectrum analyzers, navigational receivers, hospital patient monitors, intelligent terminals, and others.

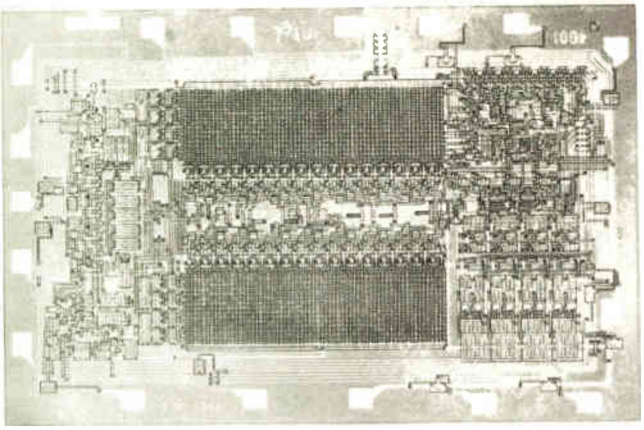
The MCS-4 consists of the 4001 read-only memory (ROM), which also contains a four-bit input/output section, or port; the 4002 read/write memory (RWM), which includes both main storage and status memory, and a four-bit output port; the 4004 four-bit central processing unit (CPU); and the 4003 shift register (SR) for extending output functions—actually a medium-scale circuit because it holds only 10 bits and is on a relatively small chip. Input lines can be expanded with standard MSI multiplexers.

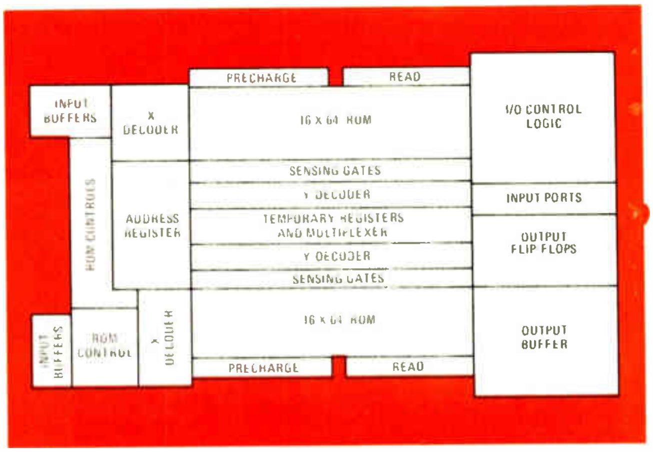
Unexceptional chip size

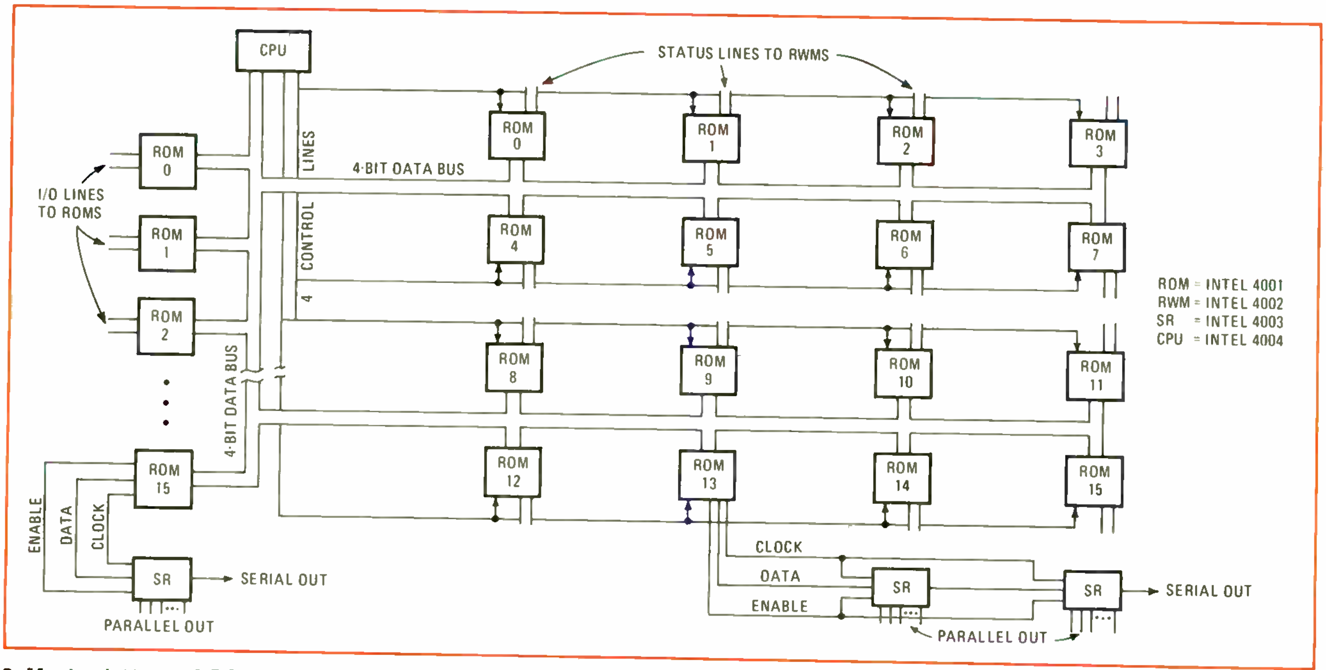
All employ p-channel silicon-gate MOS circuitry and have conventional measurements typical of today's smaller LSI circuits—53 by 85 mils for the shift register and roughly 110 by 150 mils for the other three. Circuit density is quite high; each chip holds more than these measurements imply. The standard LSI circuits—the RWM, the SR, and the CPU—are produced in high volume, and the only specialized part of the design—the ROM—uses the already proven economy of mask programing. Because the customer can maintain the mask patterns for his ROMs as proprietary, he still has the advantages of a custom design, without the high cost that usually accompanies custom designs.

The I/O port of the ROM contains latches that store data being transferred from the computer's data bus to the outside world—that is, the remainder of the system in which the computer is used. Should such external equipment require more than the number of output

1. Read-only memory. This array of 256 eight-bit words can be used from one to 16 times in a computer made from the 4-chip microcomputer set MCS-4. Chip also contains multiplexing and demultiplexing circuits to permit it to transmit and receive words through the processor's data bus, four bits at a time, and buffers for transferring data from the bus to the outside world.







2. Maximal. Up to 16 ROMs and 16 RWMs can be attached to one processor in the new chip set. Input and output are also handled through these chips; output can be expanded beyond four bits in parallel through shift registers.

lines provided by the ROMs and RWMs, the SR makes more lines available, as described below.

The status memory portion of the 4002 RWM is really only an extension of the main memory, differing from the latter primarily in its means of access. It is useful for storing labels, exponents, signs, and other control information associated with the data stored in the main memory.

A typical computer configuration uses one CPU, together with several RWMs and ROMs, and perhaps a few SRs. These configurations are flexible, economical, and easy to design.

Flexibility comes from easy program changes, ease of changing capacity, small size, and low power dissipation. A short design cycle is possible because the system is controlled by a microprogram, which is inherently easier to design and implement than either random logic or custom LSI circuits.

The system is economical to manufacture because all the chips come in standard 16-pin dual in-line packages that lend themselves to automatic insertion and enable the customer to implement rather complex functions with relatively few chips. Furthermore, because three of the four chips are standardized, the customer is not faced with a development charge for them, while mask charges for a new ROM are far less than development charges for custom LSI chips. Furthermore, even these mask changes can be saved, particularly during prototype development, by using electrically alterable ROMs.

Minimum system

The smallest possible system would require one CPU and one ROM. The latter, which contains 256 words of eight bits each, as shown in Fig. 1, would hold programs and subroutines for the CPU, and perhaps some fixed data. The maximum amount of ROM that can be directly addressed is 16 chips or 4,096 bytes (see Fig. 2). While these 4,096 bytes require a 12-bit binary address, the ROM communicates with the CPU over a four-bit-wide data path. Therefore the ROM contains, in addition to the usual decoding circuits, a demultiplexer to permit the address to come in three four-bit chunks and a multiplexer to divide the output word into two more four-bit chunks.

The CPU delivers the three address chunks in three cycles. The first two of these select one byte in each ROM chip, while the third selects one chip out of all the ROMs, which delivers its byte to the data bus. Following these three address cycles are two more cycles during which the CPU accepts the eight bits from the ROM—four during each cycle.

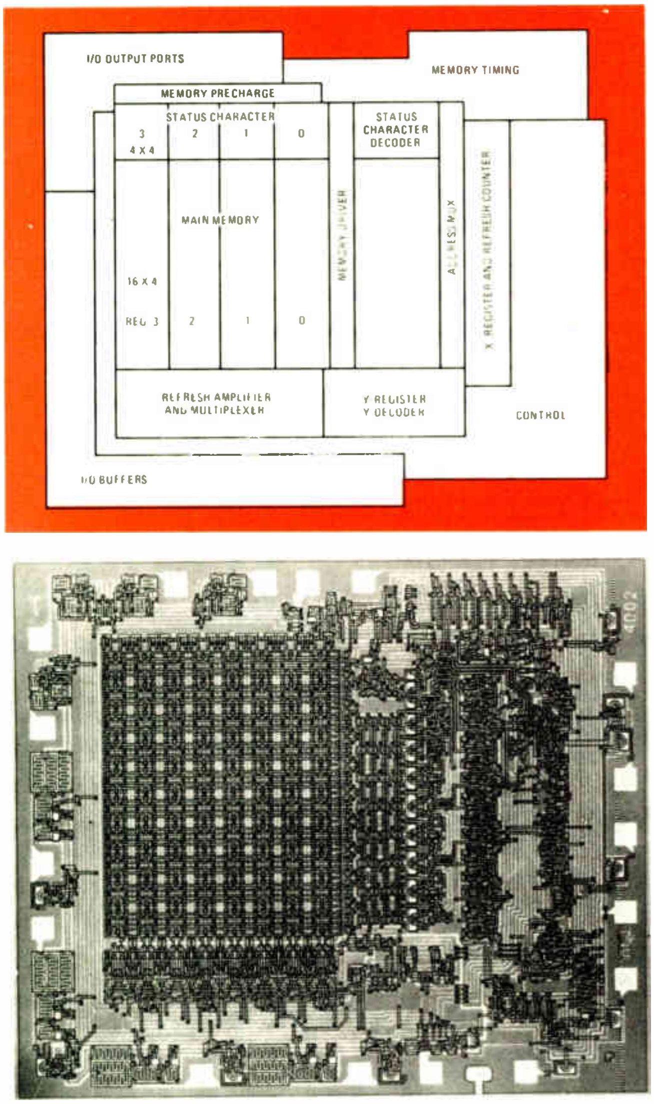
The ROM chip itself contains the logic circuitry required to keep track of which data transfer is in process at any time, so that it can react to each one in the proper way.

Read/write memory

Each RWM (Fig. 3) contains 80 characters of four bits each, organized as four 20-character registers. In each register, 16 characters are part of the main storage, and the other four characters belong to the status memory previously mentioned. Therefore, the 16 chips in the largest memory configuration contain 64 registers, or 1,024 characters of main storage and 256 characters of status memory.

The CPU controls both the RWM and the ROM chips through six control lines. One of the six synchronizes the clocks of all chips to that of the CPU. The other five, called command lines, control the chip addressing and the input/output function. These six control lines permit the single family of chips to be used in a wide variety of system configurations, suitable for many applications.

If more than the 16 ROMs and 16 RWMs are needed for a particular application, external interface circuits and bank switching techniques similar to those used in



3. Read-write memory. Four 16-character data registers and four 4-character status registers appear in the rectangular array at left center in this photo. Remainder of chip holds control and timing circuits, and output buffers similar to those in the ROM.

some minicomputers permit the necessary number of additional memory chips of either type to be connected.

The SR, a 10-bit static shift register into which data is loaded serially, has output lines that are accessible in parallel. Logic included on the chip disables the output lines until all desired data has been shifted into it from a ROM or RWM.

The CPU is a small but complete processor (Fig. 4) capable of executing 45 different instructions in a basic instruction cycle of 10.67 microseconds. It is built around a four-bit adder, and has a set of 16 four-bit scratchpad registers. Internally, the CPU is strictly binary; but for applications using decimal arithmetic, the binary result of adding two binary-coded decimal digits can be returned to BCD by a special instruction.

Of particular interest is the set of four 12-bit address registers that permit as many as three levels of subroutine nesting. During the execution of a program, when a jump to a subroutine is encountered, the instruction address register contains the address of the next instruction to be performed after the subroutine is executed.

Bigger and better

Intel's new microcomputer set, as described in the accompanying article by Ted Hoff and Federico Faggin, is actually only one of several microcomputers now appearing on the scene. Recently, Intel also announced its 8008 microcomputer, an eight-bit CPU on one 125-by-170-mil chip [*Electronics*, March 13, p.143]. Like the 4004, the 8008 requires external memory and interface chips to make a full computer, which, in turn, would be only one part of a larger system in most applications. However, it does have an internal scratchpad memory of seven words, plus an instruction counter to use with the external memory.

"But the eight-bit chip doesn't make the four-bit obsolete," insists Hoff. "For example, the 4004 is more economical; a functioning computer can be made with it and only one additional memory chip." But the minimum system using the 8008, he says, would require 15 or 20 packages and would be a correspondingly more powerful system.

Similarly, National Semiconductor Corp. has a seven-chip bit-serial processor that it calls MAPS, for microprogramable arithmetic processor system [*Electronics*, April 10, p.121]. The chip set comprises an arithmetic unit, a set of registers, a timing circuit, two ROMs, a keyboard interface, and a static data monitor; the last is used with the interface for large keyboards, in somewhat the same way as Intel's second application example [p. 116]. **—W.B.R.**

Its contents must be temporarily stored to permit the main program to resume following the subroutine. In the 4004 CPU, the subroutine may itself branch to a second subroutine, and that one to a third; three of the four address registers store three address words for this nesting process, while the fourth holds the address of the current instruction.

Extended capability

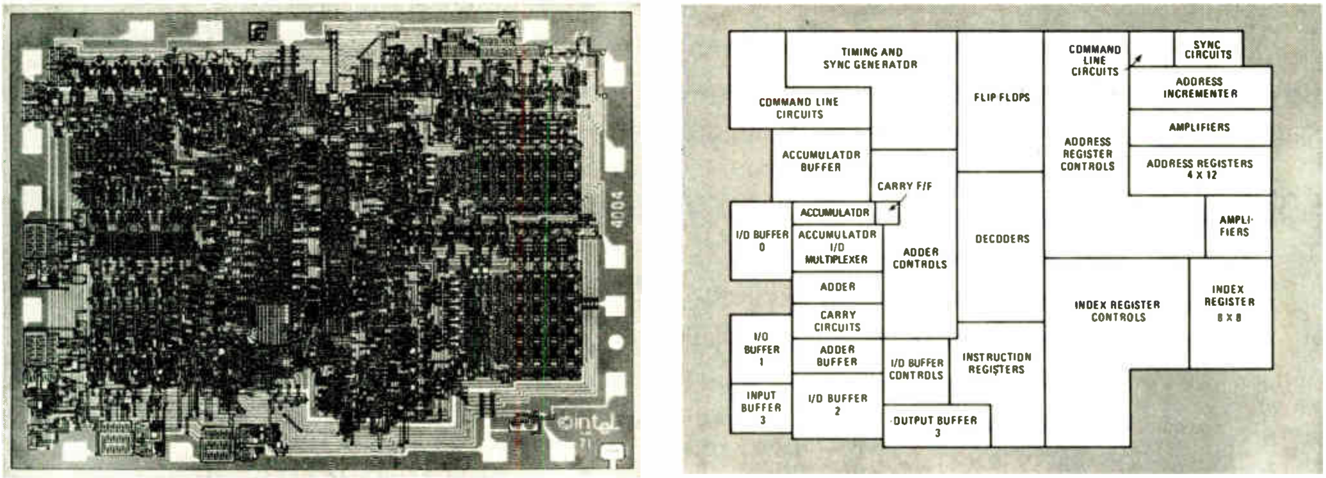
For a complex system, requiring more extensive processing capability, multiple processors can be used. In such a system with two central processing units, one CPU could be dedicated to control functions and the other to arithmetic functions. They could communicate with each other through the I/O ports, or they could share a common memory through a minimum of external circuitry.

Each 10.67-μs instruction cycle is divided into eight machine cycles of 1.33 μs each, as shown in Fig. 5. During the first three of these, an address is sent out to the ROM. Data from the ROM is returned to the CPU during the next two cycles and is processed during the last three. Some instructions require an additional 10.67-μs cycle to fetch eight more bits from the ROM.

The individual machine cycles are driven by a two-phase clock running at 750 kHz.

Steps in design

All four LSI chips may operate with a single −15 volt supply voltage with respect to ground; or they may be made compatible with transistor-transistor logic by operating them between −10 volts and +5 volts.



4. Processor. Heart of the four-chip set, this central processing unit is a small but complete general-purpose computer that can execute 45 instructions. The four-bit adder, its central component, is at left center, as key diagram shows. Address registers at right are important features. Processor works exclusively in binary, but has a special instruction that translates a pure binary sum to decimal form. Four white lines around left, bottom, and right are bus interconnecting major sections on chip.

For a particular application, designing a system around the MCS-4 is quite simple. There are essentially seven steps:

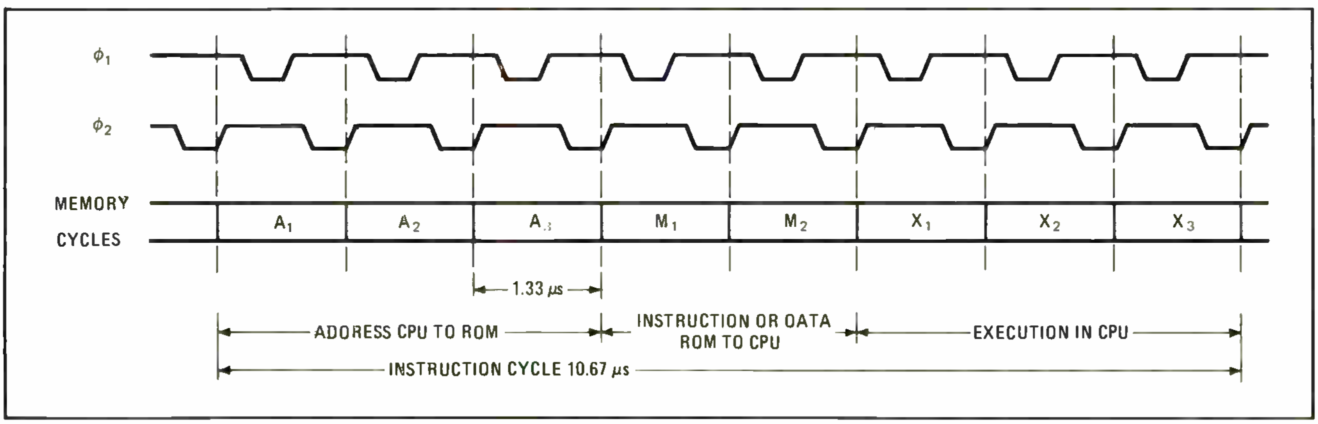
- Define the input/output requirements in terms of the peripheral equipment that will be needed.
- Define the amount of storage needed, and from that determine the number of RWM chips.
- Define the amount of control and/or program, and thus the amount of read-only storage needed; this determines the number of ROM chips. (This step may involve an iterative procedure.)
- Specify shift registers as needed to increase the capacity of output lines.
- Write the program.
- Build a prototype system, implement the program and controls in electrically programable ROMs, and get the bugs out.
- Submit the program for manufacturing mask-programed ROMs for volume production.

In defining the input/output requirements, the first step in the design sequence, a number of software/hardware alternatives are available. For example, if the system includes a keyboard, it will interface with the computer's data bus through either a ROM or a RWM. This interface may be capable of eliminating bounce from the key depressions, encoding the data, and rejecting the results of a multiple key depression; or all these functions may be implemented in software and executed in the CPU.

Keyboard design

An approach that uses little hardware and a moderate amount of software, shown in Fig. 6, places each key at the intersection of one input line of a ROM port and one output line of another ROM or RWM port. The program continually scans the keyboard by sequentially placing a single binary 1 on each output line; if any key has been depressed, that 1 reappears on the corresponding input line. The particular combination of output and input lines establishes the key's identity, and may be translated by a code conversion routine in the CPU into a command or character in conventional ASCII or other code. By requiring an encoded character to appear on several successive scan cycles, the CPU obtains key debouncing. With other suitable programs the CPU can detect multiple keying or key rollover.

5. Eight-in-one. Instruction cycle of 10.67 microseconds comprises eight 1.33-μs machine cycles in 4004 CPU. First two cycles transmit address of desired word in ROM, third selects one of up to 16 ROMs. Then the addressed word returns to the CPU in two cycles; instruction is executed in remaining three cycles, plus another full eight if needed. Clock frequency is 750 kHz.

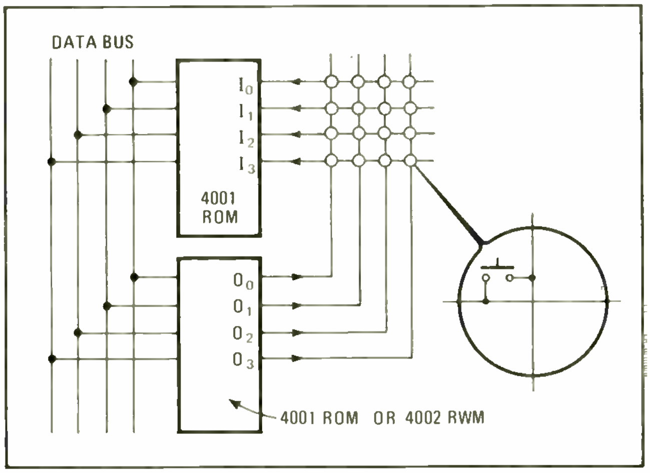


A larger keyboard may be more conveniently scanned by the 4003 SR, as shown in Fig. 7. Here only two output port lines are used. One of the lines is programed to provide a clock pulse for the shift register, and the other supplies data. A single binary 1 is loaded into one end of the register and shifted along it; the parallel outputs effectively scan the large keyboard, and appear at the input port just as with the previous example.

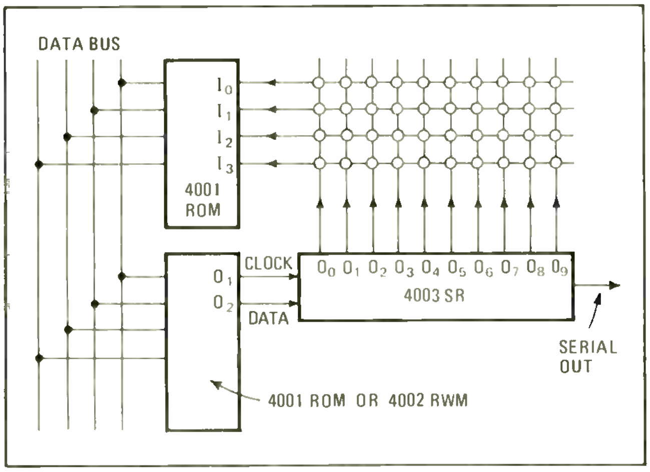
A third design that uses the most hardware and very little software, shown in Fig. 8, requires an external diode encoder and debouncing circuits. In this arrangement the key depressions are read directly into the computer without any scanning.

The amount of read-write storage depends on the number of characters to be stored at one time and the number of bits that are to be stored in read/write storage as opposed to ROM.

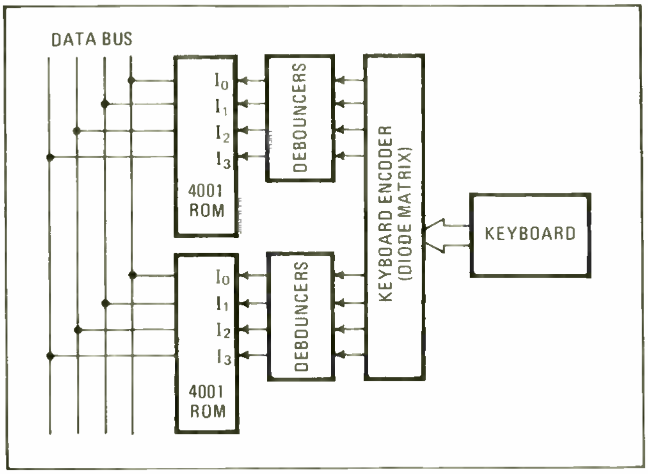
For example, if a particular computer is to work with 16-digit numbers and may have to store 10 such numbers at any one time, these numbers will occupy the main-storage registers in three RWM packages, leaving two spare registers in one of the packages. These three packages also contain status memory with a capacity of 48 characters or 144 bits.



6. Keyboard interface. For data entry to system, the MCS-4 scans all columns on keyboard; signal reappearing on a row input shows that a key has been depressed, and timing of signal relative to scan identifies the key. Program then encodes the signal, and also eliminates bounce and multiple keying.



7. More hardware, less software. For larger keyboards, the 4003 shift register extends the scan while simplifying its operation.



8. Still more hardware. Direct approach requires external encoding and debouncing, and works with minimum support from program.

Calculating ROM needs

In most applications using the MCS-4 chip family, normal programs are stored in the ROM. However, when the user desires to load programs at execution time, it is open to him to program the MCS-4 to operate in interpretive mode.

In this mode, the program in the ROM fetches "data" from RWM and interprets it as new instructions for the CPU, jumping as required to subroutines kept in the ROM. Interpretive mode programs may also run with pseudo-instructions kept in ROM; such programs often use ROM more efficiently than conventionally written programs. In either case, the designer planning to use interpretive mode must allow space for the programs when defining his memory requirements.

Determining the amount of read-only storage is a good deal more difficult. It depends on the system complexity and sophistication. The ability to make an educated guess early in the design process largely depends on experience.

With the number of ROM and RWM chips established, another look at I/O requirements may be in order if the number of I/O lines provided by these packages is substantially different from that assumed in the first step of the design process. But if the I/O layout is firm, the number of lines can be increased if necessary through the use of SRs.

After development of the program that the computer will execute, the next step is to simulate the program before committing it to mask tooling for the production of ROMs. The suggested approach is to use programable ROMs, instead of the 4001, at the prototype stage. When all the bugs are out of the system in the simulation, the truth tables for the program can provide the data for mass-produced mask-programed ROMs.

The MCS-4 is just a beginning. More complex CPUs are being designed [see "Bigger and better," p. 114], and will be common before long. Some of them will be faster, and some of them will be extremely flexible, thanks to the use of programable ROMs. □

A simple way of measuring high-frequency transistor gain

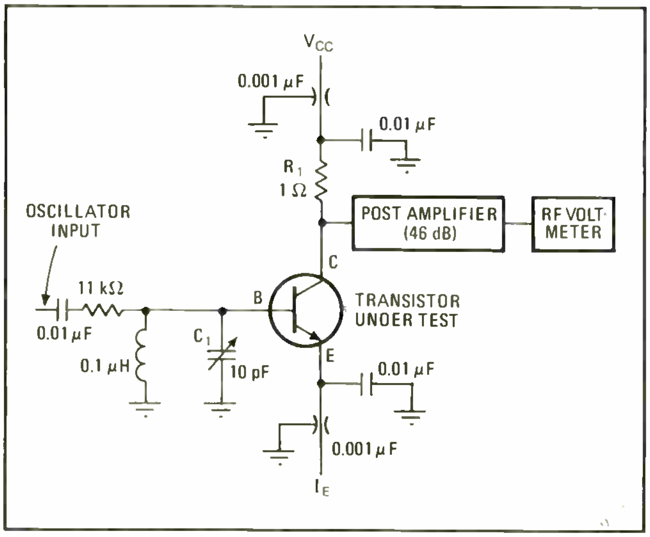
by Glen Coers
Texas Instruments, Dallas, Texas

Accurately measuring transistor high-frequency gain requires the collector-to-emitter voltage to remain constant—and in some test setups this is difficult to accomplish. Using a tuned transmission line makes life much easier, since it lets dynamic collector current be measured without any change in V_{CE}. The test method, useful up to several hundred megahertz, gives consistent results and requires no critical collector bypassing.

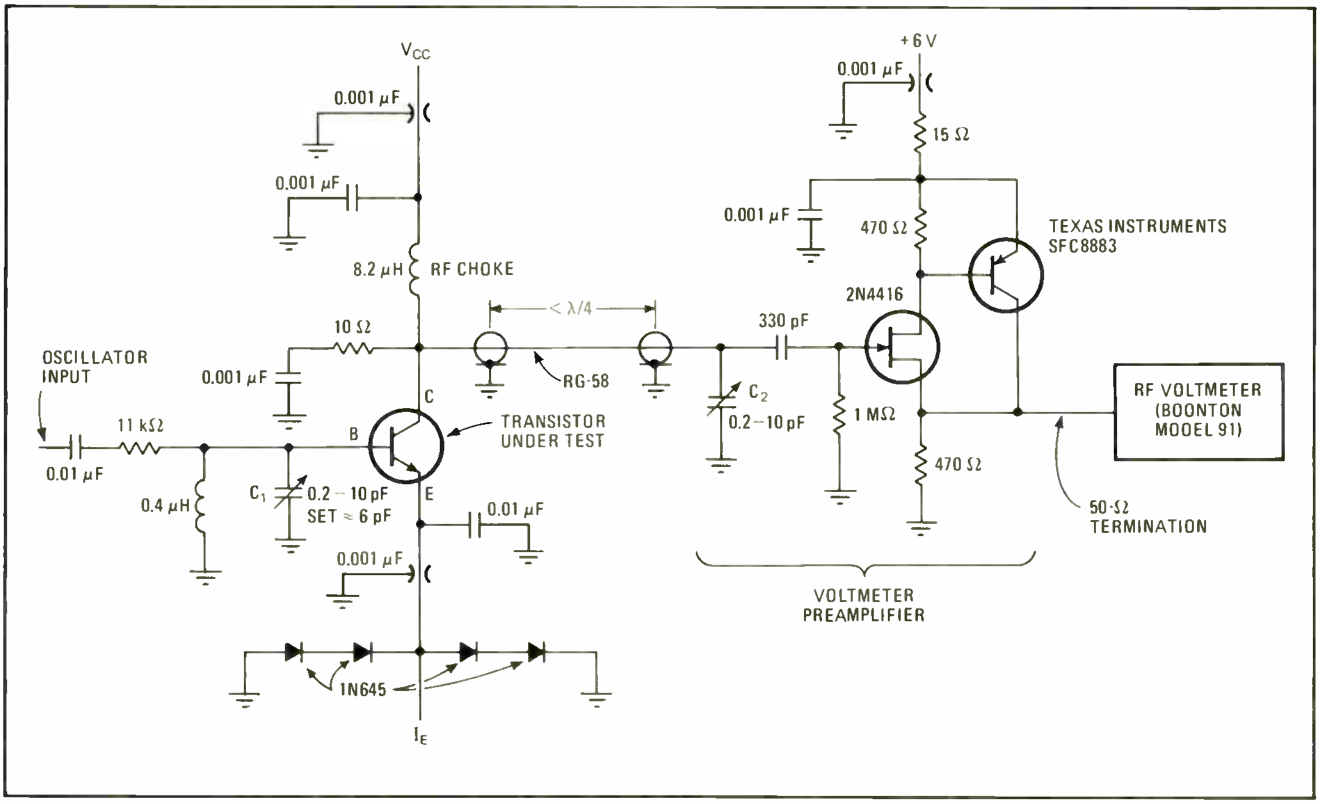
Usually, the value of h_{fe} is obtained by reading the rf voltage developed across a small sampling resistor (R_1) of about 1 to 3 ohms as shown in Fig. 1. Since this voltage can be as low as 10 microvolts, an amplifier providing a gain of about 50 decibels is generally required. Also, noise voltage must be minimized because the amplitude of the desired signal is extremely small. The rf base current is multiplied by the transistor's gain, which becomes proportional to the rf voltmeter reading.

This method, although straightforward and easy to implement, has some problems. Perhaps the worst is the need to bypass the sampling resistor at high frequencies, since the impedance of the bypass capacitor may be several ohms, sufficient to cause a large error.

A better approach, which also reduces the problems caused by ground loops and stray capacitances, uses a one-quarter-wavelength transmission line (Fig. 2). A section of coaxial cable, slightly less than λ/4, is tuned by C_2, so that the collector of the transistor under test looks like a short circuit and V_{CE} remains constant. The tuned line also steps up the voltage, eliminating the



1. Measuring h_{fe} with sampling resistor requires extra amplification.



2. Tuned transmission line uses a foreshortened quarter-wavelength line to simulate good short-circuit condition at transistor collector.

TUNED-LINE CHARACTERISTIC AT 100 MHz

Resonant frequency: f_o = 100 MHz
Cable velocity propagation constant: $v_p = 0.66$ for type RG 58 cable
Cable attenuation: dB loss = 5.2 dB/100 ft for RG-58
Cable characteristic impedance: Z_o = 52 ohms for RG 58
Wavelength: $\lambda = 300\ v_p/f_o$ = 1.98 meters
Line length: $\ell = \lambda/4$ = 0.495 m
Line attenuation constant: α = 0.378 (dB loss/ft) = 0.0197
Line phase constant: $\beta = 2\pi f_o/3(10^8)\ v_p$ = 3.18
Line impedance: $Z_l = Z_o/\alpha\ell$ = 5.33 kilohms
Line Q: $Q = \beta/2\alpha$ = 80.5
Impedance at collector: $Z_s = Z_o^2/Z_l$ = 0.511 ohms
Line voltage transformation ratio: $V_r/V_s = (Z_l/Z_s)^{1/2}$ = 102

need for a high-gain amplifier.

At low frequencies, however, there are limitations. The cable has to be very long, and the impedance at the transistor's collector becomes prohibitively large.

To calculate line resonant impedance and Q, at least three cable parameters must be considered. These are: characteristic impedance, Z_o, velocity factor, v_p, and line attenuation, which is usually specified in decibels per 100 feet. At 100 MHz, type RG-58 coaxial cable is described by: Z_o = 52 ohms, v_p = 0.66, and attenuation = 5.2 dB/100 ft. Wavelength at 100 MHz:

$\lambda = 300v_p/f_o$ = 1.98 meters

A measurement of the tuned line at 100 MHz will yield an impedance of 0.511 ohms at the generator end. Even at higher frequencies, good short-circuit conditions can be obtained because the low impedance at the collector is transformed to a higher value, resulting in a higher voltage at the open end. The small voltage across the 0.511-ohm resistance is stepped up by a ratio of 102. The voltage at the open (meter) end of the transmission line is typically 1 mV, a significant improvement in signal-to-noise performance over the sampling resistor method.

FREQUENCY (MHz)	LINE LENGTH (INCHES)
50	39.4
100	19.7
200	9.8
400	4.9

A voltmeter preamplifier assures that the open end of the line is terminated by a high impedance. A bootstrap source-follower is used to minimize loading of the resonant circuit. Because of the small amount of capacitance at the input of the source-follower, the transmission line should be physically less than a quarter of a wavelength long when resonated with C_2.

The test procedure is straightforward. A 68-kilohm resistor is inserted between the transistor's base and collector socket pins, and C_1 is adjusted for a peak reading on the voltmeter. Then the resistor is removed. Next, a 0.01-microfarad capacitor is placed between the base and collector pins, and the oscillator input level adjusted for a voltmeter reading of 1 mV. The capacitor is removed, and the transistor to be tested inserted in the socket. The collector-emitter voltage (V_{CE}) and emitter current (I_E) are adjusted to the desired operating conditions, and h_{fe} can be read directly from the voltmeter (a meter reading of 5 mV corresponds to an h_{fe} of 5).

To reduce ground loops, the shield of the transmission line should be connected as closely as possible to the transistor's emitter. Any general-purpose signal generator can be used, as long as it can deliver 0.5 Vrms into a 50-ohm load.

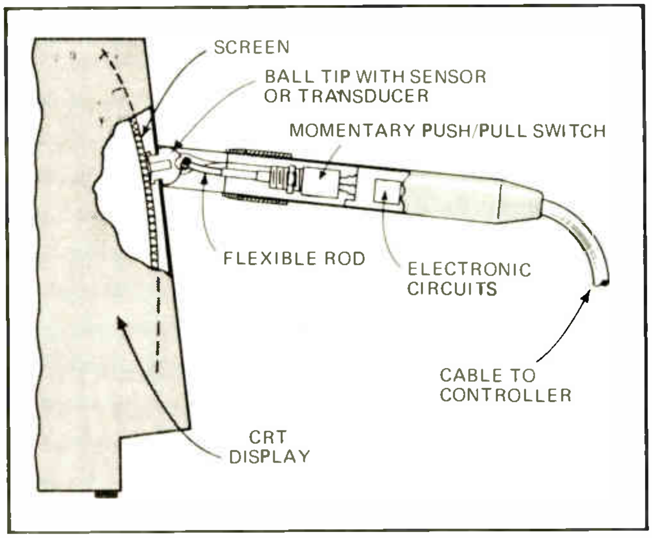
Self-orienting probe tip eases light pen use with CRTs

by E. V. Butera
IBM Corp., San Jose, Calif.

Accurate positioning of a conventional light pen to operate a cathode-ray tube display is inconvenient and soon becomes tiresome. The probe must be held nearly perpendicular to the surface of the CRT to establish accurate coordinates for each point being probed, or in some cases to respond to the CRT scan at all. This difficulty is compounded by the convex surfaces of many CRT screens.

However, a simple probe with a self-orienting tip capable of moving in any of three dimensions can help solve this problem. The tip has a ball mounting that swivels to position itself flat against the CRT screen. This always maintains the sensor or transducer in the perpendicular position, even when the probe itself may be far from perpendicular. The tip can be made slightly concave to match the convex surface of the screen.

Some probes contain photocells or other transducers in their tips. Outputs are electrical signals transmitted via wire or coaxial cable to controllers. Other probes simply transmit the light from the phosphor directly along optical fibers to photocells in the controllers. Any



Versatile probe holds transducer or sensor perpendicular to CRT.

of these tips can be used in the self-orienting probe.

On the back of the ball mounting is a rectangular recess, which matches a self-centering flexible switch rod. This rectangular mate keeps the tip from rotating and thereby twisting, fouling, or breaking the wires or other connections between the tip and the body of the probe. As the ball mounting swivels, the rod flexes; when the tip is lifted from the screen, the rod's self-centering property centers the tip. The rod also actuates a switch that signals the probe's contact with the screen. □

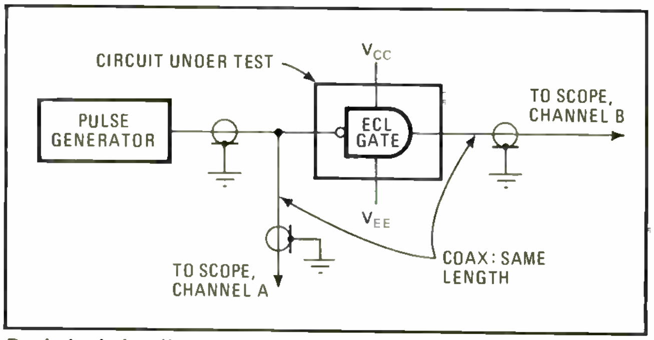
How not to destroy beam leads in testing IC chips

by Allen Y. Chen
Univac Data Processing division, Roseville, Minn.

Checking the dynamic performance of high-speed beam-lead integrated circuit chips cannot be done very efficiently with conventional chip-probing heads. The standard heads do not maintain the rf integrity that accurate testing of these circuits requires, unless the beams of the IC chip are bonded to large metal paths on a ceramic substrate—a process that usually destroys the beams before the chip can be reused.

A test fixture using a modified lead-bonding machine, however, will perform dynamic testing of beam-lead chips without any lead destruction. The accuracy is as good as if the chip were fully packaged. Moreover, the fixture can be used for static testing of all beam-lead ICs and, in addition, to insert a chip temporarily into a working system and hold it there to check performance.

Essentially the only modification needed is to replace the standard bonding head with an insulated head. During testing, this holds the chip's beams firmly against the metal pattern of a substrate. The pattern can be made part of the signal transmission-line system or fabricated separately, with a length of less than ⅛ inch to minimize transmission-line distortion. Since the beams of the chip are in pressure-contact with the metal pattern, signals to the chip and/or from it pass through a controlled-impedance transmission-line system. In the basic test circuit, an internal scope-channel resistor (50 ohms) terminates the circuit output to eliminate ringing and assure accurate results.

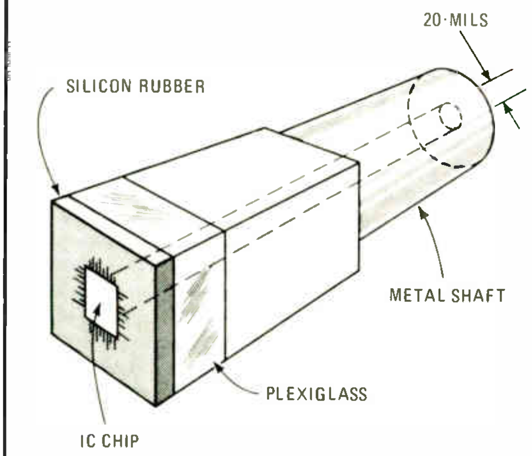


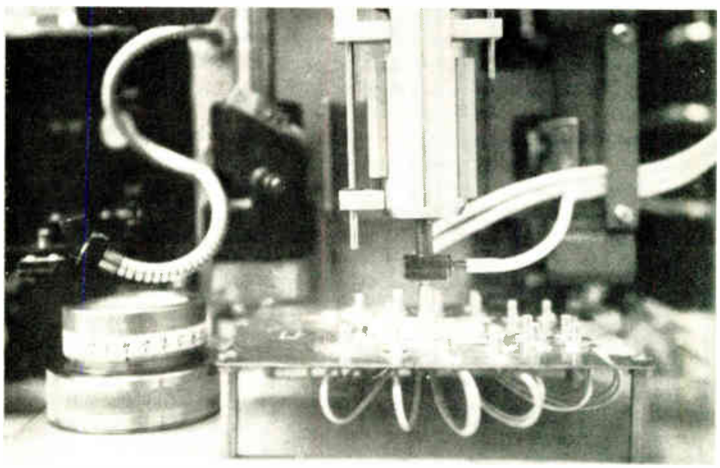
Basic test circuit uses rf techniques to check dynamic parameters.

Although the probing head was made of Plexiglas with a silicone rubber end to hold the chip, other materials can be used. A tunnel with a diameter of 20 mils is drilled through the head to serve as part of a vacuum system for picking up and holding the chip. (The tunnel opening at the silicone rubber end must be the exact size of the chip.) A metal shaft is then attached to the probing head for fixing the assembly to the bonder. This shaft also has a 20-mil-diameter tunnel that aligns with the opening in the probing head.

Thermal environmental testing can be accomplished by drilling a hole in the metal pattern of the substrate where the chip sits and putting a nozzle underneath the hole. An external temperature-controlled gas may then be fed through this nozzle to establish whatever environmental condition is wanted over the chip area. □

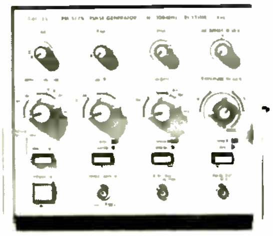
Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original and unpublished design, applications, and measurement ideas.





Modified probing head uses a vacuum system for picking up and holding the chip's beams firmly against the metal substrate pattern.

Add a Philips 1ns pulse generator



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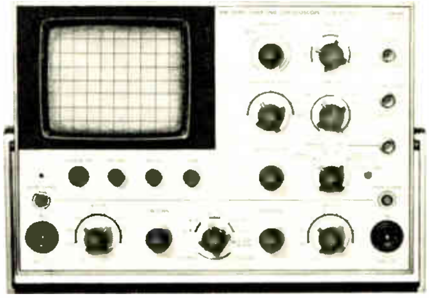

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Engineer's newsletter

Filters cut CRT reflections

Tired of cocking your head to get the exact angle to view a display so that overhead fluorescents don't wash it out? Since such specular reflections can be tremendously annoying, some display manufacturers have found it worthwhile to invest in inert coatings such as magnesium fluoride to eliminate reflections. **Now one company says it can reduce coating costs to 20% of the magnesium fluoride costs.** Panelgraphic Corp., West Caldwell, N. J., says it can supply antireflective filters that cut specular reflections to less than 1%, and these filters can be tinted to provide maximum contrast for the CRT, gas-discharge tube, LED, or whatever's behind them. For a large CRT, cost would be about $10; a filter for a digital panel meter might run 25 or 35 cents.

Wall charts are worth watching

For a bare spot on your wall or for privacy in a glass cubicle, wall charts are handy—and can display useful information, as well. Ballantine Labs Inc., P.O. Box 97, Boonton, N. J. 07005, has a new one that gives such data as **time-frequency domain conversions, universal resonance curves, and peak-average-rms conversions.** Federal Scientific Corp., 615 W. 131st St., New York, N. Y. 10018, will send you one that shows how 10 waveforms (five repetitive waveshapes and five random signals) look **in terms of time, auto-correlation, frequency spectrum, probability density, and cumulative distribution.**

Philco-Ford offers used satellite

In the market for a one-of-a-kind used Ford? Philco-Ford Western Development Labs, Palo Alto, has a late 1970 model for sale for about $600,000. **It's a qualification model of a military X-band (7.9 to 8.1 gigahertz) communications satellite** similar to the Skynet I. Developed under Air Force contract, the qual model ended up as Philco-Ford's property. However, you'll have to come up with about $4 to $5 million to put it into orbit with a Thor-Delta booster.

Hot market: bulk memories

If your management is looking for a future market area, suggest they let you look at computer bulk memories. "If anyone comes up with a workable bulk memory with the following characteristics, the computer world will be his," says Doug Powell, Motorola Semiconductor manager of computer industry marketing. Powell's specs are random-access capability, minimum capacity of 7 million bytes, cost of 1 cent per 3,000 bits, and access time of 150 to 350 microseconds. His top candidates are bubble domains and optical memories.

Addenda

It's over-all cost that counts: Wire-wrapping contract costs often aren't as low as they should be, says Karl Magnussen, engineering specialist at Raytheon's Waltham, Mass., facility, because designers squeeze cost out of the sockets and **end up with pin location and straightness tolerances that don't allow automatic wire-wrapping** . . . When is it worthwhile to try to beat out an electromechanical system with electronics? Based on its experience in electronic calculators, North American Rockwell Microelectronics Co.'s criterion is **if you can't give equivalent performance at less than half the ultimate user's price, forget it.**

Plastic tailored to consumer safety

Thermoplastic polyester with flame-extinguishing property is aimed at electronic components in home, office equipment

by Stephen E. Scrupski, Packaging & Production Editor

For molded parts in electronic applications, thermoplastic polyesters have been coming on strong. They are easily moldable, and they have good surface lubricity, dimensional stability, and resistance to heat and solvents. They also have excellent electrical properties, and they cost less than many of the plastics previously used.

The latest in this family of materials is also highly flame-resistant. Made by General Electric Co., it is called Valox 310-SEO—the SEO indicating that it is self-extinguishing and that it meets the Group O standards of Underwriters Laboratories.

The material is the first self-extinguishing thermoplastic polyester that is not glass-reinforced—and this, says GE, means better ductility and moldability. It's also lower in cost than most: 85 cents per pound in large quantities versus 95 cents for the reinforced SEO-grade material. The 310-SEO has essentially the same electrical and mechanical properties as earlier GE Valox plastics, according to Morton Kramer, manager of R&D for polyesters.

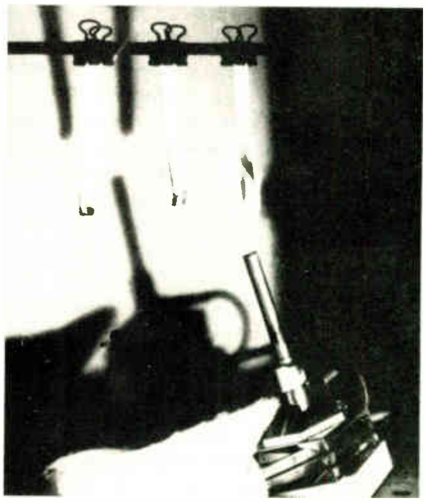
Compared with other SEO-rated materials, such as polypropylene and nylon, GE's 310-SEO has higher heat resistance than the polypropylene and much lower water absorption characteristics than nylon. GE says that no significant changes are necessary in today's molding equipment to use the new material. It also has the impact strength of such materials as Acetal, commonly used for molded gears but not rated as self-extinguishing. The ductility of the 310 will make it useful in such items as flame-resistant cable clamps.

GE is aiming Valox 310-SEO at applications in consumer electronics, including coil bobbins, tuner mechanisms, and connectors for television sets, as well as in home appliances, office machines, and other commercial equipment where flame resistance is required.

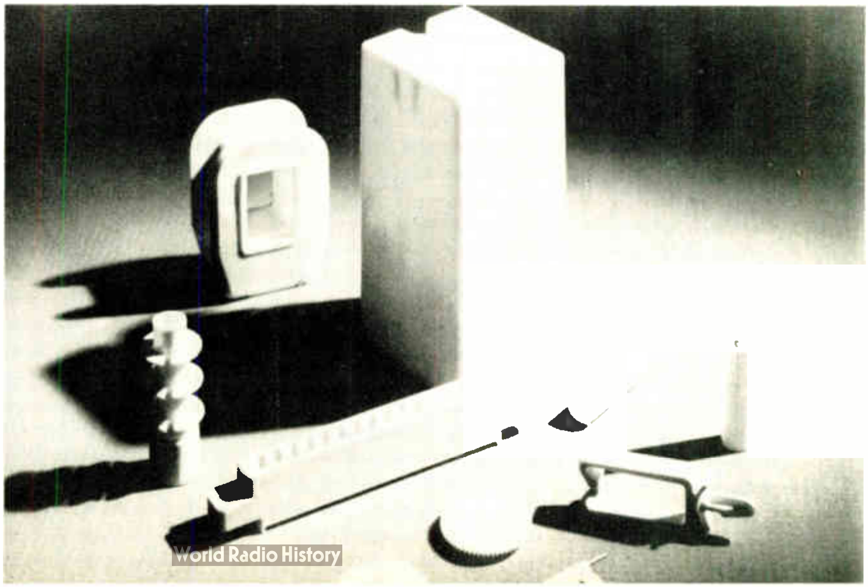
Earlier thermoplastics have established themselves in such parts as trimmer potentiometer housings, and one major manufacturer of trimmers has swung over from the higher-priced diallyl phthalate. Thermoplastics have also made substantial inroads in edge-connector housings and integrated-circuit carriers. In the case of the connectors, a thermoplastic has replaced the costlier thermoset without degrading performance, says Ronald Lovenguth, market development specialist at Celanese Corp., Newark, N.J.

Celanese and Eastman Chemical of Kingsport, Tenn., along with GE, are the principal manufacturers of thermoplastic polyesters. Celanese has been offering its Celanex family of PBTs—polybutylene terephthalate—for about two years. GE's Valox also is a PBT. Eastman's material is a polytetramethylene terephthalate (PTMT) designated Tenite, that Eastman says has similar properties to the PBTs and thus competes head-on. Prices of the materials from the three suppliers are about the same. Celanese's prices are typical: reinforced SEO is 95 cents a pound; reinforced non-SEO, 78 cents; and unreinforced non-SEO, 68 cents.

General Electric Co., Plastics Dept., One Plastics Ave., Pittsfield, Mass. 01201 [338]



Flame-resistant. Plastic self-extinguishes in 5 seconds with no dripping, can be used in a wide variety of component configurations.



New products

Instruments

50-W amplifier covers 105 MHz

Linear unit is unaffected by open and short circuits across its output port

Pushing high rf power into a load usually requires a good match between the load's impedance and that of the rf power source. A small mismatch can reduce significantly the amount of power delivered to the load, while a large mismatch may cause an amplifier to self-destruct—often in considerably less than 5 seconds.

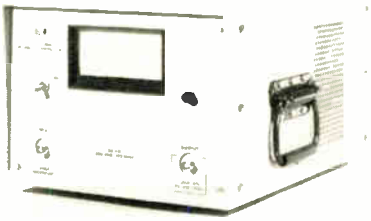
One device that seems to be immune to this problem is the model 350L rf power amplifier, built by Electronic Navigation Industries Inc. This linear instrumentation amplifier produces more than 50 watts of output power over the range from 250 kilohertz to 105 megahertz. It has a fixed nominal gain of 50 decibels, which varies less than ±1.5 dB across the frequency range, and output impedance is 50 ohms. The unit can operate continuously, with as much as 16 dB of overdrive, into any load—including open and short circuits—without damage.

The 350L produces its rated power output at the output connector, regardless of the load impedance. Of course, a mismatched load will reflect part of this power back into the amplifier; nevertheless the 350L handles the situation well. According to ENI, a competitive 50-W amplifier will supply only 12.5 W into a 25-ohm load, whereas the 350L will supply 45 W into that same load, and it will absorb the 5 W of reflected power.

These considerations become important when the amplifier must work into a highly frequency-sensitive and/or nonlinear impedance. Examples of devices with such impedances are the antennas used for broadband rfi/emi testing, ultrasonic transducers, laser modulators, and signal distribution nets.

The 350L has a typical third-order intermodulation intercept point of +56 dB referred to 1 meter (400 W). Second-order distortion is down more than 30 dB at full output, and all harmonics are more than 25 dB below the main signal at 40-W output. The amplifier has an operating range of 0°C to +45°C.

It is unconditionally stable. It will not oscillate under any combination of source and load impedances. Its output voltage is monitored by an average-responding meter calibrated in rms volts for a sine wave. The meter, which has a maximum error of ±3% of full scale, is also calibrated in watts into 50 ohms.



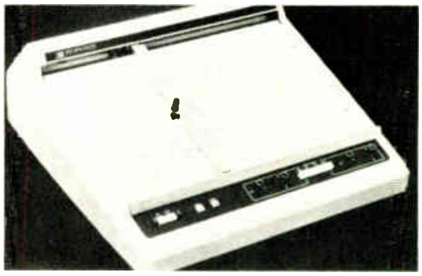
Carrying a price tag of $3,890, the amplifier weighs 42.5 lbs and measures 8¾ by 12 by 17 in. It requires 550 watts of prime power at either 105 to 125 Vac or 210 to 250 Vac. The required line frequency is 50 to 60 Hz.

The unit is normally supplied with BNC input and output connectors. Type N connectors are available as an option.

Electronic Navigation Industries Inc., 3000 Winton Road South, Rochester, N.Y. 14623 [351]

Low-cost X-Y plotter writes fast, quietly

Most high-speed X-Y plotters are not only expensive, but they require complex software that can take up thousands of words of computer storage. But now Hewlett-Packard Co. has developed the model 7210A graphic plotter that can process coordinate pairs up to 20 per second and draw symbols at speeds up to five per second while its built-in microprocessor keeps the load away



from the computer. The 7210A is priced at $3,400. It can be driven by a computer or an intelligent terminal. A typical program in assembly language requires less than 250 16-bit words of memory.

H-P says the plotter is virtually silent even when working at high speeds. It accepts pen-position data in either binary or binary-coded decimal form, and draws any number of different line lengths in any direction without having the computer calculate intermediate points. The resulting graph is free of the step-pattern characteristic of incremental plotters. The 7210A can be used with any type of graph paper up to 11 by 17 inches and has a mechanism that will accelerate the pen to a writing speed of 10 inches per second in 12 milliseconds.

OEM discounts are available, and delivery time is 45 days.

Hewlett-Packard Co., 1601 California Ave., Palo Alto Calif. 94304 [352]

Digital panel meter resolves 1 microvolt

A digital panel meter is able to resolve voltages as small as 1 microvolt and drifts less than 0.5 μV/°C. A 100-megohm input resistance and less than 1 nanoampere bias characteristics enable the designer virtually to ignore the input characteristics as a design consideration. Full-scale range is 19.99 millivolts or

1.999 mV, and accuracy is to within 0.1% of reading plus or minus one digit. Common-mode rejection is 160 decibels at 60 hertz, 100 dB at dc, and normal-mode rejection is 60 dB at 60 Hz. Price is $256, with OEM discounts available.

Digilin Inc., 1007 Air Way, Glendale, Calif. 91201 [353]

Digital thermometer is accurate to within 0.5%

A digital thermometer, called the model 9300, measures to within 0.5% accuracy from test point to readout, and this includes all the potential inaccuracies of probe calibration, probe linearity, interchangeability of probes, signal amplifiers, analog-to-digital converter and ambient temperature changes. A silicon semiconductor al-

lows measurement with a two-terminal dc system and a sensitivity of 2.5 millivolts/°C. This reduces the possibility of problems with thermocouple aging and drift, cold reference junctions, and lead wire transitions. Price ranges from $495 to $595, depending on resolution.

Electronic Research Co., 10,000 W. 75th St., Overland Park, Kansas 66204 [354]

Photometer maintains accuracy to within 2%

A photometer-radiometer, designated the model 11A, measures light intensities over nine decades. The instrument uses a silicon sensor that maintains calibration accuracy to within 2% for six months minimum; the sensor heads are corrected for radiometric and photometric spectral responses with

computer-matched glass subtractive filters. All sensor heads read out directly in appropriate units with lighted annunciator. Radiometric spectral range is 200 nanometers to 1,100 nm.

United Detector Technology Inc., 1732 21st St., Santa Monica, Calif. 90404 [355]

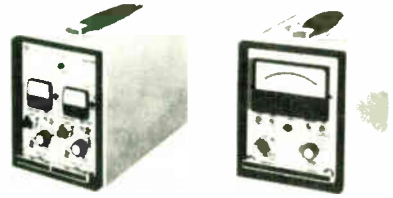
Meter with FET input draws 10 microamperes

A battery-operated volt-ohm-milliammeter with a field-effect transistor at the input can be left on indefinitely without affecting its test performance. Called the model 603, it draws only 10 microamperes, so carbon batteries used in it will last for nearly their shelf life. An autopolarity circuit actuated by pushbutton switches enables the user to measure either plus or minus voltages without switching leads. Because the amplifier circuit of the 603 incorporates a high degree of feedback, both ac and dc meter tracking scales are linear, and the meter movement is automatically temperature-compensated. The instrument can be used over the range of 32° to 120°F without loss of accuracy. On all dc-volt, ac-volt, and decibel ranges, accuracy is within 3%. Price is $150.

Triplett Corp., Dept. PR, Bluffton, Ohio 45817 [356]

Charge amplifiers built for piezoelectric transducers

A line of charge amplifiers is designed for use with piezoelectric transducers in shock, vibration, pressure, force, weight and sound measurement. The 9000-A series units provide both high- and low-level ranges, and the high-gain range has a 10× amplification factor along with a low noise referred

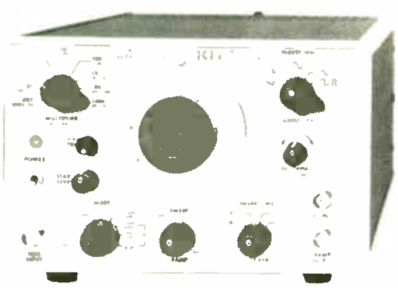


to the input. The series is available in 1, 2, 3, and 6 channels. Dial-in control, internal calibration, meter display, servo control, and power output features are either standard or optional, depending on model. Price ranges from $350 to $600 per channel.

Columbia Research Laboratories Inc., MacDade Blvd. & Bullens Lane, Woodlyn, Pa. 09094 [357]

Function generator offers nine modes of operation

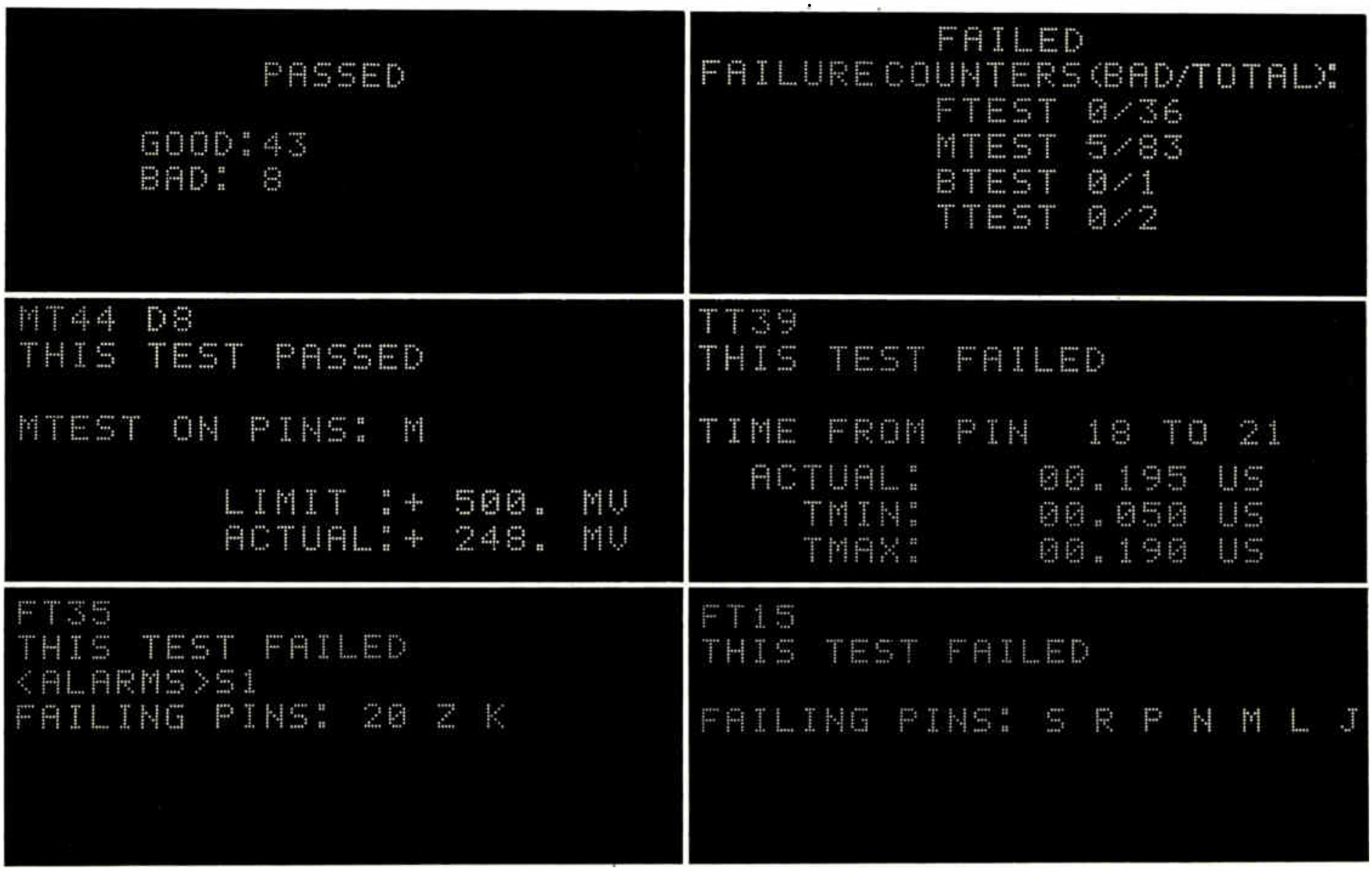
The model 5200 function generator offers nine modes of operation for a wide variety of options. Functions include separate waveform and ramp outputs, pulse, sweep, and burst modes, and external voltage control of the main output frequency. In external and sweep modes, the frequency range extends



from 0.00003 hertz to 3 megahertz. Maximum main output is 20 volts peak-to-peak open circuit, or 10 v across 50 ohms. Maximum ramp output is 10 v peak with a 200-ohm source impedance. Price is $495.

Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass. 02139 [358]

Teradyne's L100 Automatic Circuit Board Test System speaks for itself.



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183 Essex Street
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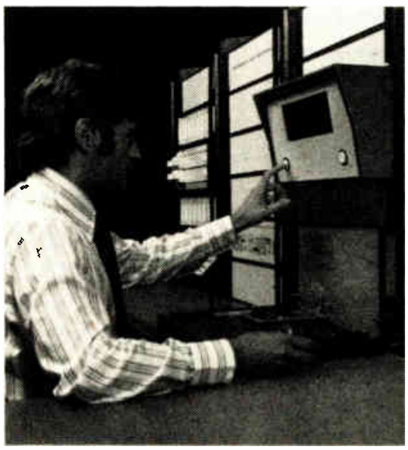


Components

Active filter is compensated

Each of four low-pass units in series spans 50-1 frequency range

A Massachusetts firm, Frequency Devices Inc., seems to have done for active filters what semiconductor firms once did to make second generation operational amplifiers—compensate them internally. When the first 709-type op amps came out, the user had to outboard resistors and capacitors to get the performance desired, and until recently, the same has been true of so-called universal-type, or state-variable, active filters. Parameters such as Q, cutoff frequency, gain, and others were left in the hands of users who would rather not have been bothered with them. And sometimes the user's add-ons produced poor performance.

Frequency Devices' director of engineering, Alan E. Schutz, says that the new filters give users what they want—a black box with the appropriate filter characteristics and simple resistor trimming for cutoff frequency.

The 740 series tunable low-pass filters are offered in four ranges covering bands from 1-to-50 hertz to 1-to-50 kilohertz and have either Butterworth or Bessel response. At the expense of slightly increased offset voltage, an extra decade of response is available at the low end of each filter's range.

Schutz expects to find customers in the laboratory, where tunable filters are needed repeatedly, and in instrumentation design, where frequency cutoff must be an operational variable. Some devices thus will go to engineers who would use them to establish appropriate cutoff frequencies in breadboarding new gear, and then would shift to fixed-frequency filters for production.

The 740s are four-pole devices with cutoff frequency controlled by setting matched equal-value trimmer resistors—one for each pole. If the desired cutoff frequency already has been established, precision fixed resistors can be used. This frequency should not drift significantly since the unit's temperature coefficient is 0.05%/°C.

With state-variable filters, it was necessary to add integrating capacitors and resistors to determine the frequency, to set Q by adding a resistance, and set gain with an additional resistor. And afterward, the user still would normally have only a two-pole filter. The 740s, however, are already four-pole units.

Slope beyond cutoff frequency is 6 decibels per octave per pole for the Butterworth (flat-amplitude response) units. Thus a four-pole device would show a slope of 24 dB per octave. Schutz says that the Bessel-type (flat-phase response) shows essentially the same slope at about twice the selected corner frequency, or −3dB point.

Schutz says he expects the Bessel-response units to fit into the analog-to-digital converter pre-filtering area to offset so-called alias error caused by spurious signals at frequencies greater than half the sampling rate. The Butterworth filters are designed for noise-reduction applications.

Models 740BT (Butterworth) and 740LT (Bessel) filters are available from stock to two weeks. Prices run from $74 in lots of 1 to 9 to $50 for lots of 100 to 249.

Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01803 [341]

Hall-effect read head aimed at credit card jobs

To pack additional information on credit cards, many organizations, including the American Bankers Association and the International Air Transport Association, are turning to magnetic stripes.

Easily added to existing credit-card formats, a single- or dual-channel stripe 0.2-inch wide can store about 750 bits per channel. The problem thus far has been to build reliable equipment to read the information.

The accuracy of most magnetic reading systems depends on the speed at which the magnetic stripe passes by the read head. James Imai, president of Imai Marketing Associates Inc., Sunnyvale, Calif. points out that additional signal dropouts and poorer signal-to-noise characteristics result from the way users shove credit cards into reading machines.

But the Hall-effect head is not affected by reading velocity. Imai, the U.S. marketing representative of Pioneer Electronic Corp. of Japan, will show at the Spring Joint Computer Conference a head developed by Pioneer that makes use of the Hall effect.

The Pioneer two-channel CRH-7201 head reads the 0.25-inch format magnetic stripe that meets proposed ABA and IATA standards. The head generates an output signal that is proportional to the recorded magnetic flux and is unrelated to velocity. Thus, card-transfer speed can vary from 0 to 100 inches per second without affecting the accuracy of the signal.

The output signal at 210 in./s is 5 millivolts peak-to-peak, and crosstalk between channels is 1% maximum.

The head is made by vacuum-depositing a thin film of indium antimony directly onto a main core of high-density ferrite. This is supported by a high-hardness crystallized glass for added strength and reliability. Pioneer is working on other head configurations, and a single-channel type, which will be designated the CRH-7101, will be available soon.

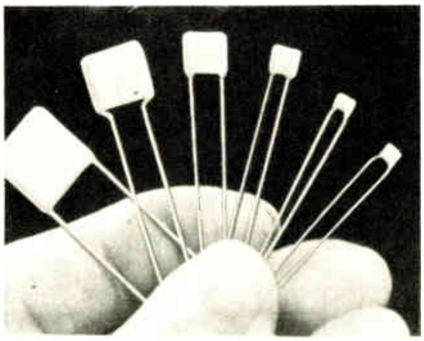
In small quantities, the CRH-7201

sells for $76. Samples are available from stock.

Imai Marketing Associates, Inc., 525 West Remington Drive, Sunnyvale, Calif. 94087 [341]

Monolithic capacitors offer values up to 10 μF

A line of capacitors, called Mono-Kap, ranges in sizes from 0.100 by 0.100 inch to 0.500 by 0.500 inch, with capacitance values from 4.7



picofarads to 10.0 microfarads. The radial-lead, epoxy-coated devices are offered in 50 direct-current working volts and 100-vdcw ratings with a choice of four EIA temperature characteristics: COG, W5R, Z5U, and Y5V. Leads are solder-coated, copper-clad steel, and operating temperature is from −55° to +125°C. Price in 1 to 49 quantities ranges from 15 cents to $14.40.

Centralab Electronics Div., Globe Union Inc., 5757 No. Green Bay Ave., Milwaukee, Wis. 53201 [343]

Broad-range relay replaces specific-voltage types

A broad-range relay is used as a replacement for a variety of specific-voltage types in applications where

many ranges of signals may be presented. The unit will provide dual form C contact activation upon introduction of any operating voltage, from 2 to 120 volts for dc signals of 20 milliamperes maximum and for 60-hertz ac signals. Input power required is 1 ampere at 115 volts ac. Contact rating is 3 A at 30 V adc or 120 V ac. Size of the device is 6¼ by 3¾ by 2 inches. Price is $49.50.

Pentagon Devices Corp., P.O. Box 732, Syosset, N.Y. 11791 [344]

Reed relays attain 50-watt resistive switch compatibility

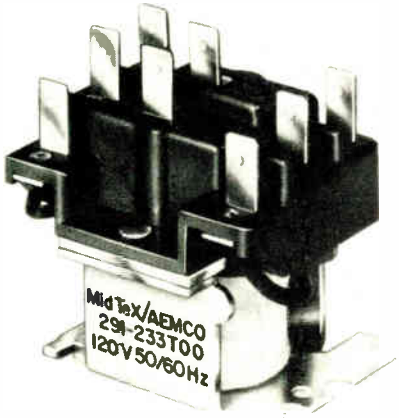
A line of mercury-wetted reed relays series 3000 is suited for lamp, inductive, and small motor loads. The devices which can attain a 50-watt resistive switch compatibility, are available with one to five poles in forms A and C. Form B relays are

available with one, two, and three poles. Coil voltages include 6, 12, 24, 48, and 120 volts dc. The units have gold alloy contacts and a shock-absorbent frame. The switch is replaceable without removal of the relay from the printed-circuit board.

Wheelock Signals Inc., 273 Branchport Ave., Long Branch, N.J. 07740 [345]

Power relay line comes in coil voltages to 240 V ac

A power relay type 291 comes in a double-pole, double-throw configuration and is available in coil voltages up to 120 volts dc and 240 volts ac. Applications include consumer

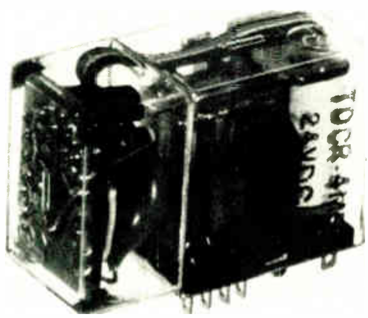


electronics. The terminals are 0.25-inch quick-connect solder, and the associated socket accepts wires pre-crimped to standard 0.25-inch female quick-connect terminals. Delivery is from stock.

Midtex Inc., 10 State St., Mankato, Minn. 56001 [347]

Time-delay relay provides precision performance

A time-delay relay series TDCR is designed for industrial applications and offers a time-delay temperature coefficient of approximately 1 millisecond/°C. Delay shift from use is less than 2% over 150,000 operations, and internal line regulation permits operation to specification, despite line-voltage variations of up



to ±15% of nominal. The unit is available in configurations up to six-pole, double-throw and with various make/break delay combinations, including repeat timing cycles and hold-off and hold-on timing. Price ranges from $15 to $28 in quantities of 1 to 9.

Frost Controls Corp., Pearl St., Bellingham, Mass. 02019 [348]

Infrared solid state lamps (LED's) from General Electric.

No waiting.

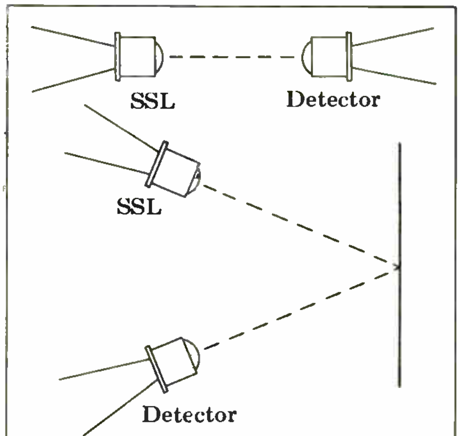
A full line of infrared SSL's (LED's). Now available for off-shelf delivery at competitive prices. And designed for use in a wide variety of applications.

Like optical encoders and tape readers. Detection systems, optical memories, EOT/BOT. Counting devices. Mark sensors, ignition systems. Liquid level sensors, seed planters. And a lot of others.

Compare the range of power outputs and high efficiency of these General Electric SSL's (LED's).

Get complete details on General Electric's infrared SSL (LED) lamps by writing us. Or circling the information retrieval card number. We'll send you a full set of Product Bulletins that will tell you the things you want to know.

And for help in selecting the right lamp and detector for your particular application, write or phone Mr. John W. Hall, General Electric Company, Miniature Lamp Department, Nela Park, Cleveland, Ohio 44112. Phone: (216) 266-2400.



Type	I_f (mA)	V_f (Volts)	P_o (mW)	Rise Time (ns)
SSL 4	100	1.25	0.4	50
SSL 34	100	1.25	0.9	300
SSL 54	100	1.25	1.0	50
SSL 5A	100	1.35	1.5	300
SSL 5B	100	1.35	2.3	300
SSL 5C	100	1.35	2.9	300
SSL 35	100	1.35	5.5	300
SSL 55B	100	1.35	4.8	300
SSL 55C	100	1.35	6.0	300
SSL 15	20	1.30	0.5	700
SSL 315	20	1.30	1.0	700

GENERAL ELECTRIC

Data handling

Array simplifies scanning task

Document digitizer uses photodiode matrix, avoids CRT and laser complexities

Of the various approaches to getting written information into a document storage or facsimile system, the most direct—optically scanning the document and then digitizing the information—has also been the most troublesome. Most systems employ either video image recording, which involves complex analog signal processing, or microfilm techniques, which present mechanical handling problems and severely limit access time. But a new piece of equipment from Dest Data Corp., Sunnyvale, Calif., may simplify the optoelectronic process.

By employing a series of 128-element solid-state photodiode arrays, Dest Data has been able to produce a scanner/digitizer that optically scans documents as large as 8½ by 14 inches at a resolution of either 240 or 120 points per inch, both horizontally and vertically. The scanning rate is 800 kilobits per second, providing a scan time of less than 8 seconds at 240 points per inch resolution or less than 2 seconds at 120 points per inch for an 8½-by-11-inch document.

John Brown, marketing manager, says that by using a solid-state photodiode array and a simple mechanical document platform, the unit, designated the DSD240, avoids the complexities of cathode-ray-tube or laser systems. "There is no need for extensive light shielding, as in CRT systems, nor is there the need for high operating potentials common to both CRT and laser systems," he points out.

Brown says that the spectral performance of the scanner is "broad, ranging from blue to deep red (4,000 to 7,000 angstroms), which is a wider total range than what you get with either a CRT or laser system." The background of the document may also vary in shade and color; a dynamic threshold circuit in the device adjusts the contrast so that stored documents always have the same brightness range between the background and the data.

The scanner looks and operates like a small office copier. Internally, however, a servomechanism moves solid-state photosensor arrays past the stationary document, placed face down on a glass platen and illuminated by a tungsten-halogen lamp assembly.

The illumination assembly is moved with the photosensor arrays over the long dimension of the document. The arrays are sampled sequentially to cause scanning in the cross direction. Output from the scanner is a biphase-encoded serial-bit stream. A buffer interface allows asynchronous operation when connected to a computer or communications systems. The D.D240 is available three months after receipt of order. Price is $20,000 in single units.

Dest Data Corp., 1285 Forgewood Ave., Sunnyvale, Calif. 94086 [361]

Holographic memory stores 12 megabits

Although most of the development work involving holographic memories is aimed at extremely large and complex systems, Optical Data Systems Inc., Mountain View, Calif., is taking a different approach. Instead of trying to build a complex system that might reach the marketplace in five years or so, the company designed a relatively simple system that is ready now.

The Holoscan system [*Electronics*, March 13, p.25] is the first in a series of holographic memory products that will store and retrieve data for read-only applications. Holoscan consists of a holographic-memory film cassette, a transport, a continuous-wave laser for a light source, read-out electronics, and logic.

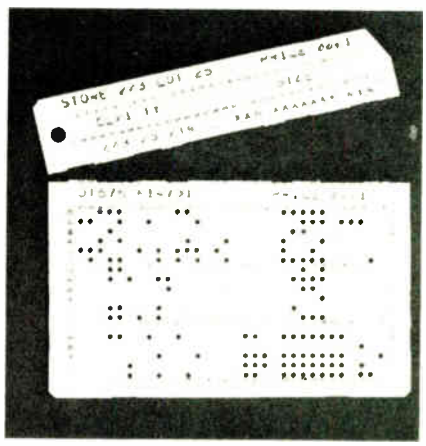
The 12-megabit non-volatile holographic film memory is stored in a small cassette produced at Optical Data Systems under computer control from magnetic-tape data supplied by the user. The cassette is placed in the Holoscan, which can be interfaced with TTL-compatible minicomputers or input/output units. Any block of information within the memory can be accessed in 3 seconds. Transfer rate is serial at 100,000 bytes per second. Error rate is better than 1 part in 10^7, with parity. And the holographic-film memory does not deteriorate with age, nor is it affected by bit dropout, magnetism, or humidity.

Single-unit price is $1,495, with OEM discounts available. The company is shipping the Holoscan, interfaced with a separate keyboard I/O unit, for credit verification applications.

Optical Data Systems, Inc., 556 Ellis Street, Mountain View, Calif. 94040 [362]

Readers process topless 96-column cards

Two card readers for users of IBM System/3 computers have been developed for use with a specially constructed 96-column card. The two-part card is perforated with only printed data on the top portion and both printed and punched data on the bottom. When the printed-only portion is removed, the topless card retains its full data capacity of 96 columns. Applications are in retailing, banking, distribution, and inventory control and warehousing. The readers, models 8603 and 9603, are plug-to-plug compatible with



the System/3 models 6 and 10. When connected to the System/3 model 10, the model 8603 reads 500 cards per minute. When connected to the System/3 model 6, the 8603 reads 750 cards per minute, and the 9603 with the model 6 reads 250 cards per minute. Price of either reader is $6,500. Three lease plans are available, with prices starting at $250 a month for a 36-month contract.

Bridge Data Products Inc., 738 S. 42nd St., Philadelphia [363]

Color graphics generator makes 40-by-60-in. images

A digital graphics generator system can produce multicolored images of up to 40-by-60-inches on paper transparencies and similar materials. The unit converts digitized images from a variety of input media (analog or digital) into pictures, alphanumerics, maps, geometrics, and other display forms. The computer-driven device places digitally controlled microscopic ink droplets of uniform size on the recording medium, and placement is controlled by an electrostatic charge. The system, designed to support image analysis and interpretation, can be programed to display various levels of image enhancement, tonal range manipulation, image rectification, image scaling, superimposition, editing, and differencing.

Data Corp., 3481 Dayton Xenia Rd., Dayton, Ohio 45432 [364]

Data collection system eliminates keypunch

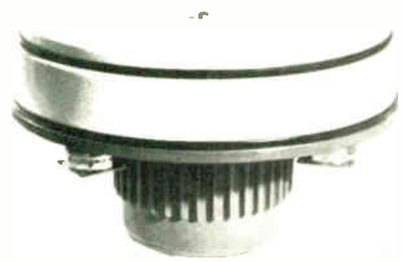
A computer input device, model SDG-2000, automates the collection and conversion of source data. Keypunch operations are eliminated by

an optical code reader that processes cards at the rate of 3,600 to 18,000 per hour, reading edge notches and marked variables. The unit transfers all information directly to magnetic tape. Fixed data is encoded on a single or multipart source document, and variable data can be penciled in at any time for subsequent reading. Hard copy is generated from the tape through an integrated typewriter which can also add variable information.

Bell & Howell Co., Business Equipment Group, 6800 McCormick Rd., Chicago, Ill. 60645 [365]

Storage capacity of 128-track disk goes to 8.96 megabits

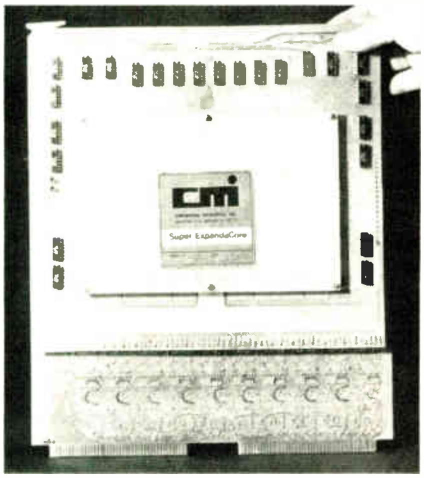
A 128-track disk features a storage capacity of 0.56 to 8.96 megabits. The memory unit offers 70,000 bits per track and a transfer rate of 2.1 million bits per second. Access time is 17 milliseconds. The unit, designed for minicomputer and terminal input/output applications, has a flying-head-per-track configuration.



Also offered are an integral drive system and lifetime-lubricated bearings. Prices start at 8 cents per bit for a single unit, and less than 6 cents per bit in quantity.
Tally Corp., 8301 South 180th St., Kent, Wash. 98031 [366]

Vertical stacking trims size of core memory

A core memory system is plug-expandable from a minimum of 8,192 words to a maximum of 73,728 words. The memory offers up to 20-bit word lengths and a pack-



aging unit called Verti-Cage in which both control and storage cards are stacked vertically. This design is said to reduce the physical size of the memory by as much as 20%. The two-card organization of the memory permits interchangeability of control cards and storage cards and provides for field expansion. A basic 8,000 word configuration is priced at $1,600 in small OEM quantities.
Cambridge Memories Inc., 285 Newtonville Ave., Newton, Mass. 02160 [367]

Semiconductors

Imaging array goes to market

Self-scanning matrix of 1,024 photodiodes functions like vidicon

A two-dimensional self-scanning diode array has become the first solid-state imaging array to go into production. In addition to being useful to the blind [*Electronics*, Jan. 17, p.36], the imager can also track missiles.

The device, made by Reticon Corp., Mountain View, Calif., is an optical array consisting of 1,024 silicon photodiodes in a 32-by-32 matrix. John Rado, Reticon Corp. president, describes it as "functionally equivalent to a low-resolution vidicon camera tube, but with the advantage of higher geometric accuracy as well as low-power, low-voltage operation."

Along with the 32-by-32 matrix of photodiodes are access switches and two MOS shift registers for scanning the X and Y directions—all integrated on a single monolithic chip. The X register is driven by a pair of external complementary square-wave clocks and a start pulse that initiates each line scan. The Y register steps from one line to the next each time an end-of-scan pulse is received from the X register. The photodiodes, which occupy about 8 square mils of chip area each, are on 4-mil centers.

Output of the Reticon, as the company has named its device, is a string of 1,024 pulses—one frame—which is a usable video signal. However, most applications will require an external video signal. Maximum frame rate is about 5 kilohertz. A 50-by-50 photodiode array is going to the Army for a missile target-acquisition system.

In comparing the Reticon to charge-coupled and bucket brigade devices, Rado Says: "We are not anti-CCD, and this is not a contest. All the techniques employ MOS devices and, in fact, with our MOS process we could produce CCDs. But we are not an R&D outfit—we produce commercial devices. Our array is now in production; prototype quantities have been shipped and we can deliver units from stock. The price is about $600 each in quantities of 100."

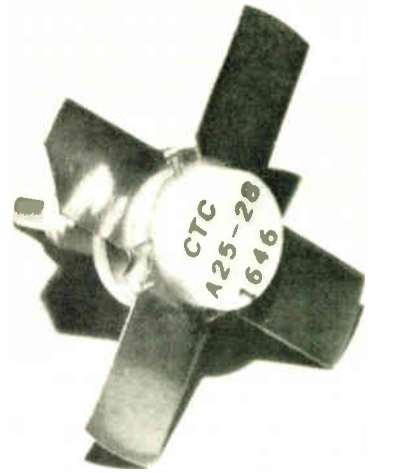
Availability aside, CCDs have one major advantage over the Reticon, and that's density. Reticon's 32-by-32 array is on a chip only slightly smaller than Bell Laboratories' CCD which holds a 128-by-106 array. But Rado says that "we don't pack our diodes as closely as we could, and there is a good reason. Since MOS light sensors are integrating devices—they integrate the incident light over the frame time—with our larger photodiodes, we can work with lower light levels and still produce large signals. We get a larger dynamic range, and our devices don't saturate as fast as the CCDs."

On the other hand, Rado says, the Reticon is superior to CCDs in speed, and this reduces image-smearing problems. A major problem with both CCDs and bucket-brigade devices, according to Rado, is the tradeoff between speed and transfer efficiency. Also, he adds, in a CCD the charge is transferred from point to point along a line, so the whole line is lost if one spot is bad; with a Reticon, if one diode goes bad, only a spot is lost.

Reticon Corp., 365 Middlefield Rd., Mountain View, Calif. 94040 [411]

Linear rf power transistors cover 30-80 megahertz range

Three transistors are designed for operation in the low very-high-frequency range for broadband class C or linear power amplifiers and operate from 38 volts. The units cover the range of 30 to 80 megahertz. The model A3-28 puts out 3 watts, the model A25-28 puts out 25 watts, and the model A70-28 puts out 70 watts. When they are used as a chain consisting of one 3-W, one 25-W and two 70-W devices,

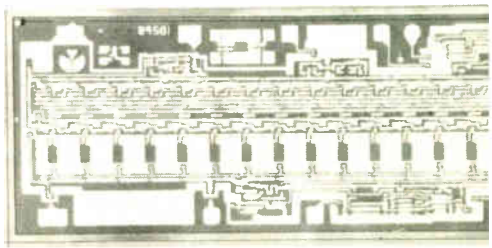


a 140-W output is achieved from a 0.2-W input. Price in 1 to 99 quantities is $8.15 for the 3-W unit, $24.10 for the 25-W unit, and $65 for the 70-W unit.

Communications Transistor Corp., an affiliate of Varian, 301 Industrial Way, San Carlos, Calif. 94070 [414]

MOS LSI photodiode array provides direct digital output

A 16-bit MOS LSI photodiode shift register averages a range of high and low levels of incident light and provides a direct digital output. The circuit is mounted on an eight-lead TO-5 type hermetic package with a transparent top. Light intensity can range from 0.1 mW/cm² to 25 mW/cm² over the temperature range of −55° to 70°C. The 16 diodes, arranged along a 140-mil line on 8.8-mil centers, evaluate light patterns over an integration period. This output is adjusted to achieve thresholds for given light levels, so that the equivalent 1 or 0 is parallel-shifted into the shift register. Output data is held in the shift

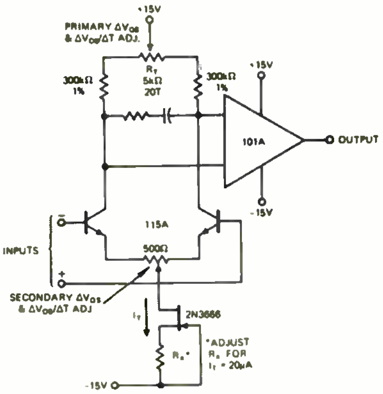


register until clocked out onto a single line.

North American Rockwell Microelectronics Co., P.O. Box 3669, 3430 Miraloma Ave., Anaheim, Calif. 92803 [415]

Monolithic dual transistor has 2 μV/°C offset drift

A monolithic dual transistor uses dielectric isolation and offers a maximum offset of 0.5 millivolt and a change of offset with 2 microvolts /°C. The unit, called the model 114A/115A, is for use with 45-volt

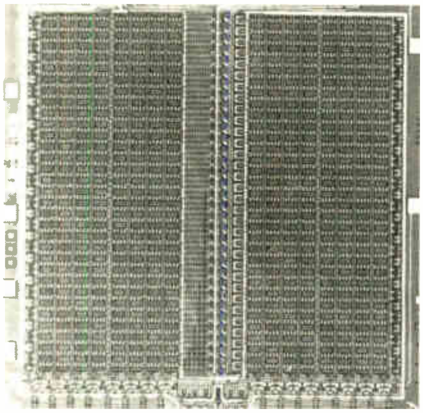


and 60-V power supplies, respectively. The transistor also features reduced collector-to-collector leakage currents and associated output capacitances. Price for 1 to 99 is $6.60; for the 115A, $5.40.

Intersil, 10900 N. Tantau Ave., Cupertino, Calif. 95014 [416]

1,024-bit RAM provides 150-ns access time

A 1,024-bit dynamic MOS LSI random-access memory designated the TMS4062JC features a 150-nanosecond access time. Cycle time is 250 nanoseconds. Applications are aimed at large memory systems, and the device uses a three-clock configuration with no clock overlap window. Differential current sensing of the output allows a high common-mode noise rejection. Information stored in the memory is nondestructively read, but refreshing is re-

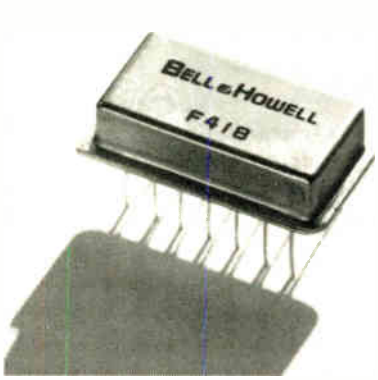


quired 32 cycles every 2 milliseconds. The chip need not be selected during refresh. Price is $10.50 in 1,000-lots.

Texas Instruments Incorporated, P.O. Box 5012, MS/308, Dallas, Texas 75222 [417]

Hybrid FET op amp offers bias current of 10^{-15} A

A hermetically sealed hybrid operational amplifier, with a field-effect-transistor front end, features a bias current of 10^{-15} ampere. The unit, called the F-418, operates over the temperature range of -55° to +125° C, and is supplied in a 14-pin dual in-line package. The unit is inter-



nally trimmed to less than 1-millivolt initial voltage offset and therefore needs no external trimming or adjustment. Applications are in high-impedance circuits such as optical detectors, pH and nerve-cell-potential measurements, sample-and-hold, and long-term integration.

Bell & Howell, Control Products Div., 706 Bostwick Ave., Bridgeport, Conn. [418]

New Products/materials

Hot-pressed boron nitride is designed in wafer form as a p-type diffusion source for the doping of silicon integrated-circuit wafers. The material, known as grade HBG boron nitride, has a boron content of 43.0 to 43.5%. Characteristics include moisture insensitivity, high strength at diffusion-level temperatures, and sheet resistance uniformity. Delivery is from stock.
Union Carbide Corp., Carbon Products Div., Dept. P., 270 Park Ave., New York, N.Y. 10017 [477]

Casting epoxy, a single-component type, is aimed at applications in coils, transformers, and other insulating uses. When poured from the drum, it can be cured in one hour at 280°F, and is supplied as a single material which has been premixed, degreased, and stabilized from two materials. The compound's good wetting properties provide complete impregnation of tightly wound coils or large castings.
Amicon Corp., Polymer Products Div., 25 Hartwell Ave., Lexington, Mass. 02173 [478]

A gold process for plating connectors, switches and other electronic parts is called Autronex EL. The material is an acid-type electroplating formulation for the production of gold deposits with a purity of 99.0% and a hardness range of 190 to 230 knoop. The coatings provide good solderability and resistance to corrosion, oxidation, and galling.
Sel-Rex Co., 75 River Rd., Nutley, N.J. 07110 [479]

A silver, electrically conductive epoxy called Epo-Tek H31 bonds both gallium-arsenide-phosphide and gallium-arsenide chips on light-emitting diodes. The material cures in 45 minutes at 120°C, and has a volume resistivity rating of 0.0001 to 0.0005 ohm-centimeter. The single-component system can be applied directly to the substrate without weighing and can be used with commercial epoxy-dispensing equipment and silk-screening techniques. Trial evaluation kits are available for $15 per ounce.
Epoxy Technology Inc., 65 Grove St., Watertown, Mass. 02172 [480]

New books

Introduction to Computer Organization and Data Structures, H.S. Stone, McGraw-Hill Inc., 1972, pp. 321, $13.50.

Professor Stone has made a sincere effort to identify the elementary components of the organization of a computer. Starting with the concept of a Turing machine, he describes in detail the structural elements of the machine, such as registers, memory channels, instruction components and instruction code. He follows this with a detailed and highly technical description of various methods of data organization, data structures and program organization, and ends with a complicated, professorial, but effective discussion on two sorting techniques.

Unfortunately, he does not avoid a prime pitfall of the erudite professional who attempts to talk to neophytes. In choosing between oversimplification and assumption of a high degree of intelligence on the part of his audience, he elects the latter, assuming that we will understand some inordinately complex notions when only given one or two paragraphs.

Thus, I struggled with the concept of the Turing machine for three rereadings, and had I not been required to read the entire text, I might have given up in Chapter 1. Similarly, a single paragraph (albeit replete with mathematical notation) is devoted to an explanation of the binary system, which assumes inaccurately that the entire audience has grown up with the "new math." As the book progresses, complexity increases, and I would challenge any experienced analyst or programer (except possibly a software specialist) to understand the discussion on threaded trees.

My experience in teaching graduate students leads me to disagree strongly with Dr. Stone's contention that this book could be used as a text in college freshman or sophomore courses. The book can be extremely appealing as a comprehensive text for the budding *programing specialist*; it is not sufficiently general-purpose to appeal to the basic programer-candidate, whose prime exposure will be to Fortran or Cobol, supported by a sophisticated operating system which will exclude him from most of the elements which Dr. Stone describes.

Thus, this book's audience will be software designers, systems programers, and even hardware designers, who all need some insight into the anatomical detail of the computer substructure. The extensive discussion on various forms of data structures is excellent and valuable reading for software specialists.

In summary, this is good reading for the potential specialist, but is not recommended for general audiences.

Dick H. Brandon
Brandon Applied Systems Inc.
New York, New York

Electronic Drafting and Design, 2nd ed., Nicholas M. Raskhodoff, Prentice-Hall Inc., pp. 666, $13.50

Computers and Society, Richard W. Hamming, McGraw-Hill Book Co., pp. 284, $3.95

Solid State Devices, Volume I: Theory, Irving Tepper, Addison-Wesley Publishing Co., pp. 257, $7.95

Modern Control System Theory and Application, Stanley M. Shinners, Addison-Wesley Publishing Co., pp. 528, $14.95

Physical and Solid State Electronics, Kanaan Kano, Addison-Wesley Publishing Co., pp. 451, $13.95

From Electrocatalysis to Fuel Cells, G. Sandstede, Ed., University of Washington Press, pp. 415, $12.50

Time-Sharing Systems, G. M. Bull & S. F. G. Packham, McGraw-Hill Book Co., (UK) Ltd., pp. 140, $9.95

Electronic Circuit Analysis, Couros Ghaznavi & Arthur G. Seidman, The Macmillan Co., pp. 526, $14.95

Introduction to System Theory, Stephen W. Director & Ronald A. Rohrer, McGraw-Hill Book Co., pp. 441, $16.50

New literature

Test instruments. A selection guide to test instruments is available from Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664. The instruments discussed include panel meters, counters, amplifiers, and frequency synthesizers. Circle 421 on reader service card.

Circuit-board test systems. Teradyne Inc., 183 Essex St., Boston, Mass. 02111, has published a 16-page brochure describing the L100 family of computer-operated circuit-board test systems. Hardware and software aspects of the system are covered. [422]

Software modules. A brochure describing the advantages of using software modules to control computerized telecommunications systems is available from Incotel Ltd., 1212 Ave. of the Americas, New York, N.Y. 10036. [423]

MOS LSI data. A 280-page data catalog from National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051, provides specifications for a line of MOS LSI memory and logic products. The catalog also contains application notes and briefs for a variety of MOS functions. [424]

Solar and photocells. International Rectifier Corp., Semiconductor Div., El Segundo, Calif. 90245. A 100-page booklet contains design equations, theoretical considerations, characteristic curves, and application information on solar cells and photocells. Emphasis is on low-light-level applications. [425]

Two-way radios. A catalog covering the RF-1500 series of very-high-frequency frequency-modulated two-way radios is available from RF Communications Inc., 1690 University Ave., Rochester, N.Y. 14610. The catalog includes system diagrams, each labeled to show which accessory is required for a particular application. [426]

Display bezels. Griffith Plastics Corp., Nobex Div., 1027 California Dr., Burlingame, Calif. 94010. Bul-

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New Literature

letin No. 350 describes a line of alphanumeric display bezels for electronic instruments. [427]

Signal converters. A technical bulletin on solid-state signal converters, which transform ac outputs from electromagnetic flowmeters into dc signals that are linear, is available from Emerson Electric Co., Brooks Instrument Div., Hatfield, Pa. 19440 [428]

Disk drives. Pertec Corp. Peripheral Equipment Div., 10880 Wilshire Blvd., Los Angeles, Calif. 90024, has published a brochure providing technical data to help simplify the interface design of the model D5000 disk drive into a customer's computer system. [429]

Coaxial cables. Phelps Dodge Communications Co., 60 Dodge Ave., North Haven, Conn. 06473. Three catalog sheets describe three types of coaxial cables called Styroflex, Spirafil II, and Foamflex. Each sheet offers a general description of construction, along with electrical, physical, and mechanical characteristics. [430]

Test instruments. A 20-page catalog from Bacharach Instrument Co., 625 Alpha Dr., Pittsburgh, Pa. 15238, covers a line of test and measurement instruments. Each product in catalog 4020 is illustrated and accompanied by a description and specifications. [431]

A-d converter. Analog Devices Inc., P.O. Box 280, Norwood, Mass. 02062. A four-page discussion of the features and specificatons of a 16-bit analog-to-digital converter includes information on installation, reference loading, and adjustment of offset and gain. [432]

Switches. A technical bulletin is available from the Oak Switch Div., Oak Electro/Netics Corp., Crystal Lake, Ill. 60014, that details a line of snap-in switches, pilot lights, and outlets designed to be used singly or together. The brochure contains drawings, functional specifications, and photographs. [433]

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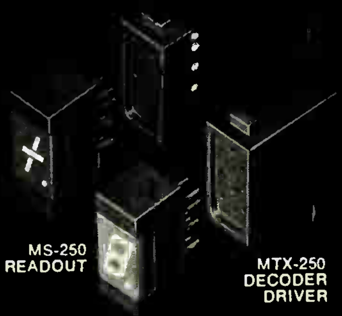
Displays logic state of most 14 or 16 pin IC's with no external controls. Simply clip over DIP package and appropriate lamp will light to indicate a high logic state at each associated lead. For use on popular 5V systems. Fully portable for shop, lab, or field use. Detailed instructions and handy carry case supplied. Shipped prepaid with $89.95 check or money order. Immediate delivery — fully guaranteed.

ALCO ELECTRONIC PRODUCTS, NORTH ANDOVER, MASS

Circle 151 on reader service card

READOUTS WITH OPTIONAL PLUG-IN DRIVERS

Ultra-small ½" x 1" incandescent single plane numeric and symbol displays operate on 2.5V @ 20 mA per segment. A mating plug-in module is also available having a decimal input decoder-driver. Additional details available.



ALCO ELECTRONIC PRODUCTS, NORTH ANDOVER, MASS. 01845

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THE MITE T.M.

NEW HEAT GUN FROM MASTER

SPECIAL INTRODUCTORY PRICE!* **$29.95** ...and the shrink-tube adapter is free! Save $5 over regular price

*Effective Until May 31, 1972

Now bring a new dimension to heat shrinking as well as countless other industrial applications. Easier to handle . . . only two pounds with nozzle . . . perfectly balanced.

Three easily interchangeable color-coded nozzles to speed specific jobs. Silver (standard) . . . used for most shrinkables (475°F.). Blue nozzle for Mylar* (500°F.)...and Black for Teflon* (800°F.) both optional equipment. Nozzles can be changed in seconds.

Draws only 5.4 amps. High impact housing withstands hard knocks of shop use. For information on the new MITE Heat Gun or the full line of Master Heat tools, contact your distributor or write:

*Reg. Trade Name of DuPont

MASTER appliance corporation Racine, Wisconsin 53403 Phone 414/633-7791

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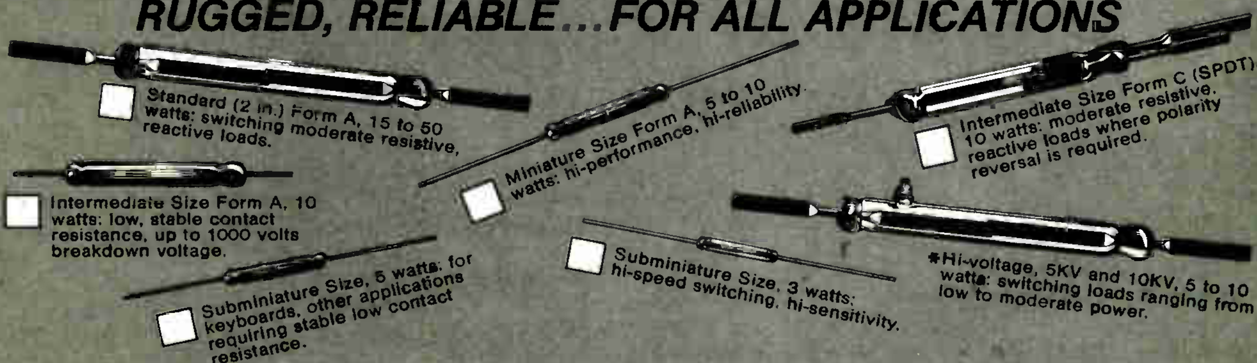
RUGGED, RELIABLE...FOR ALL APPLICATIONS



☐ Standard (2 in.) Form A, 15 to 50 watts: switching moderate resistive, reactive loads.

☐ Miniature Size Form A, 5 to 10 watts: hi-performance, hi-reliability.

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☐ Subminiature Size, 3 watts: hi-speed switching, hi-sensitivity.

*Hi-voltage, 5KV and 10KV, 5 to 10 watts: switching loads ranging from low to moderate power.

FREE SAMPLES!

Check the box next to the GE Reed Switch that meets your requirements, fill out the coupon, and send it to ID², General Electric Co., 316 E. Ninth St., Owensboro, Ky. 42301

Samples not available on this form. For literature on this, and the other types listed, use the reader service card.

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CITY ____________ STATE ____________ ZIP ______

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360-05

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