JULY 25, 1974

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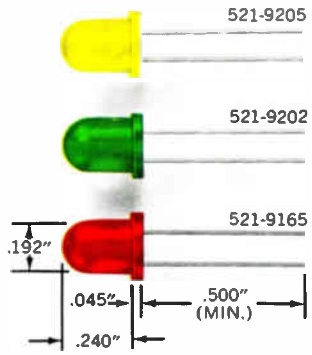
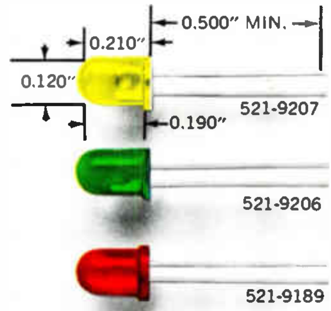
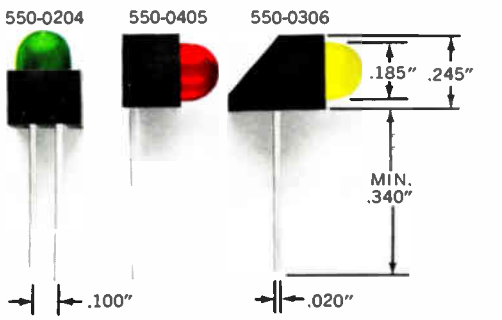


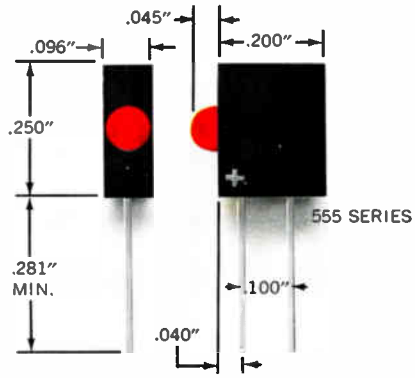
Now available in green, yellow and red. Mini-sized for maximum front panel density and easy panel mounting. High luminous intensity, low cost. Vibration/shock resistant. Solid state for long life. Wide viewing angles. Ideal for applications like panel lighting, film annotation and alpha-numeric displays.



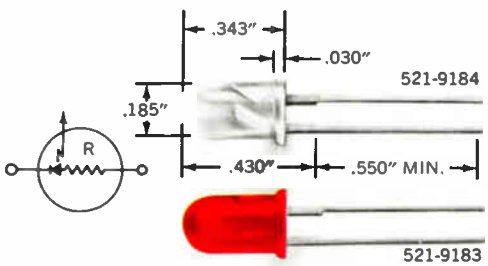
Your choice of green, yellow and red, with axial leads for dense packaging requirements. Wide viewing angle for easy readability. Low power consumption, low cost, IC compatible. 10mA operation for typical brightness. Size is identical to the most popular red LEDs.



Mix 'em or match 'em. LED logic state fault indicators are available in red, yellow and green, in a variety of shapes, some with a built-in integral resistor. Can be driven from DTL and TTL logic. Designed for easy alignment on PC boards so that multiple functions can be displayed.



LED logic state fault indicators available in 14 models with voltage ratings from 1.7 to 14. Suitable for dense packaging on printed circuit boards—up to 10 units to the inch—IC compatible. With built-in series resistor. Polarity identified. Low power consumption.



Available in red or clear LED packages with or without a built-in current limiting resistor. Red LED is also made without resistor. Suitable for circuit status indication, alpha-numeric displays and visual indicators. Features long wire-wrappable leads. IC compatible with solid state reliability. High luminous intensity, low power consumption, low cost.

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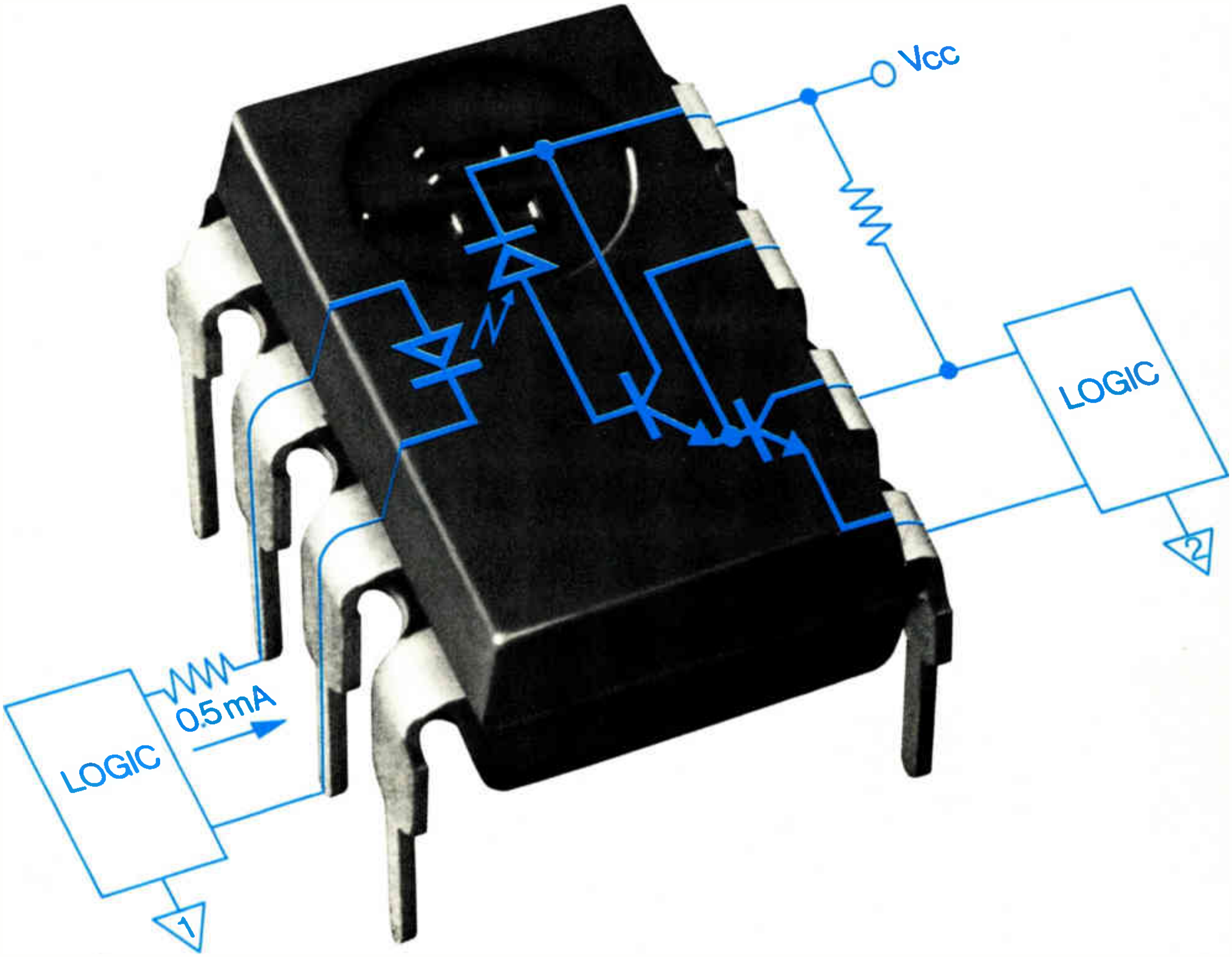

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Now there is a new series of opto couplers from HP that will interface with most logic families. HP's 5082-4370 series isolators can be driven directly from CMOS, MOS, LTTL or TTL.

The unique construction of the 5082-4370 series offers a TTL compatible output voltage with speeds 50 times greater than conventional photodarlington isolators. Current transfer ratio of the 5082-4371 is typically 800% at 0.5mA input current and current transfer ratio of the 5082-4370 is typically 600% at 1.6mA input current.

Select the 5082-4370 for logic and TTL applications; 5082-4371 for CMOS, LTTL and other lower current uses. Performance of both models is guaranteed from 0°C to 70°C.

In 100 quantities, price for the 5082-4370 series starts at $1.80* each.

For a complete design package on our new 5082-4370, hermetic, dual and high speed isolators contact Hall-Mark, Schweber, Wilshire or the Wyle Distribution Group.

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*Domestic USA price only.

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Electronics

The International Magazine of Electronics Technology

Vol. 47, No. 15•July 25, 1974

Highlights

The cover: Can the FCC cope? 106
In grappling with the spread of data communications and cable TV, the FCC has in effect produced new national communications policies. But the agency's limited manpower and budget could critically hamper the new leadership in its fight to implement those policies. Congressional action is called for (see p. 54). Cover is by Art Director Fred Sklenar.

Wanted: narrower bandwidths for digital video, 69
Though digital video communications squander the limited frequency resources available, they are vital to reconnaissance by remotely piloted vehicles, satellite transmissions, and Picturephones. That's why the military, NASA, and Bell Laboratories are all busy researching bandwidth compression techniques.

Tubes containing diodes excel as rf amplifiers, 85
Electron-bombarded semiconductor (EBS) devices, in which an electron beam is aimed at a photodiode, have now added reliability and long life to their main attraction—outstanding performance as high-power rf amplifiers and modulators.

How to design easy-to-test logic boards, 100
The cost of testing logic boards has soared along with their increasing complexity, but can be reduced if board layout is designed to complement the capabilities of automated test equipment.

And in the next issue . . .
New advances of charge-coupled devices in memories and analog signal processing . . . programed logic arrays in digital design . . . technology update on color TV tubes.

Electronics

Publisher's letter

Our cover story this issue is a thoughtful and thought-provoking story about the problems facing the Federal Communications Commission as it tries to cope with the impact of new technology. Looking at it another way, the story is about what the electronics industries can expect as the FCC implements the various decisions it has made since the landmark Carterfone ruling.

Senior editors Ray Connolly, chief of our Washington bureau, and Steve Scrupski, who heads our communications department, put together the report after scores of interviews with Government and industry officials. Their conclusions: the task facing the FCC is enormous and it is going about its work with a distinct handicap in manpower and budget resources. While a lot has been accomplished, there are still a number of obstacles in the way of its top management's desire to accomplish a lot more. Turn to page 106 and read for yourself about the FCC and its new national communications policies.

The nation's computers hold a vast amount of data about the nation's citizens. And there is growing concern about misuse of that information. For example, there are more than 100 proposals in Congress that would in one way or another safeguard the privacy of material stored in these data banks.

The big stumbling block, though, is cost. As Larry Marion, of our Washington bureau, points out in the Probing the News story starting on page 78, "if legislation requires a catalog of facts—such as which parts of the data bank was accessed, and what was reviewed and for how long—the resulting need for memory and the operating costs would be exorbitant." And he cites testimony before Congress that the increased memory capacity required for access-control devices and the development and sale of such systems would have a major impact on the computer industry. For example, one expert is quoted as saying: "Either a computer data bank has access controls or lots of insurance."

The movement toward rigid controls on data banks is just getting under way, but in a few years all such banks—public and private—may be covered by controls. Indeed, some expect that the Federal, state, and local government data files will come under new legislation this year. The big question, though, is whether hardware—and software—will be available to meet the letter of the law.

The computer-privacy story, by the way, carries the first Probing the News byline for reporter Marion, who just recently joined our Washington bureau. After graduating from Drexel University, where he earned a bachelor of science degree in 1972, Larry worked for the Department of Housing and Urban Development. His main assignment was helping coordinate the disaster recovery operation in Wilkes-Barre, Pa., following devastating floods. Then, while working for a master of science degree in journalism at Northwestern University, he spent several months gathering news in Washington. That led to a job on an energy newsletter and then to *Electronics*.

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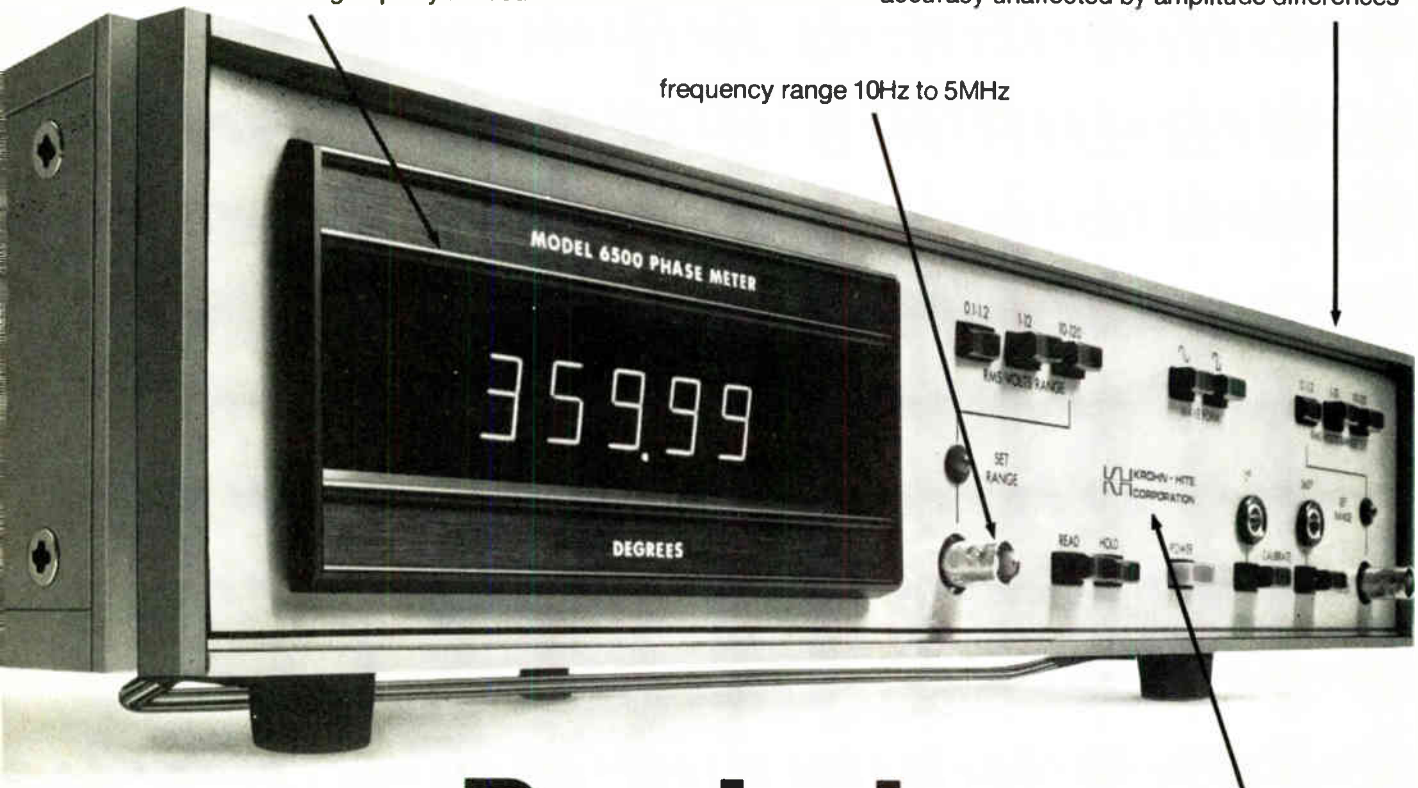

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Circle 5 on reader service card

Readers comment

Counting functions

To the Editor: In your interview with Charles Clough, Texas Instruments' vice president for semiconductor marketing ["Everybody's popping circuits," *Electronics*, March 21, p. 66], he estimates that "the average [U.S.] home now has 3,000 transistor functions."

We would be very much obliged if you could tell us how Mr. Clough has come to this conclusion, which is far beyond all of our estimates for TV and radio sets, two cars, anti-burglar systems, and air-conditioning.

J. Hieke
Siemens Aktiengesellschaft
Munich, Germany

• *Mr. Clough has since increased his estimate to 30,000 transistor functions. The key word is "functions." A simple calculator chip has 6,000 functions, and it's logical that a calculator, several solid-state television sets, a car or two, and radio could easily boost the total that high.*

Protecting with zeners

To the Editor: The idea presented by your Engineer's newsletter, "Zener diodes can give you fast protection" [May 2, p. 118], is not as effective as claimed. This item states that a zener-diode clamp will be made much faster by the addition of a compensating junction. While this does add a small junction capacitance in series with the large zener capacitance, it does not provide the order-of-magnitude reduction in clamp capacitance, as claimed.

The total clamp capacitance is not the series combination of the junction and zener capacitances. To demonstrate this, the required connection from A to B is added to the diagram of the clamp. Note that the voltage that must be developed on each capacitance is determined by the diode it shunts. Addition of the compensating junction does not reduce the voltage to which the zener capacitance C_Z must be charged, so the charge required by C_Z is still $q_Z = C_Z V_Z$. In addition, the capacitance of the compensating diode C_F must be charged with $q_F = C_F V_F$. Thus, the total equivalent clamp capacitance is

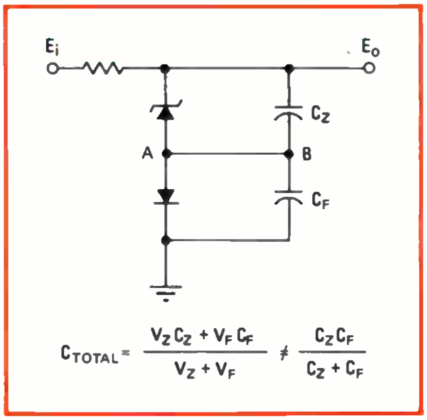
$$C = q/V$$

$$C_{TOTAL} = (V_Z C_Z + V_F C_F)/(V_Z + V_F) \neq (C_Z C_F)/(C_Z + C_F)$$

For a 6-V zener diode,

$$C_{TOTAL} = 0.9 C_Z + 0.1 C_F \neq 0.1 C_Z$$

While the above total capacitance is about 9% less than C_Z, the clamp voltage is increased around 10% by the added junction. Thus, the time to reach the clamp level is increased—not decreased—by addition of a compensating junction.



Jerald Graeme
Burr-Brown Research Corp.
Tucson, Ariz.

Microwaves for rails

To the Editor: This office is engaged in feasibility studies for future transportation systems in the Adelaide, South Australia, urban area. It has occurred to us that microwave communications systems could be used for train-signaling control. We request information on such a system that could satisfy our needs.

Preliminary analysis indicates that the system should have immunity to power-frequency interference from electric trains, the ability to confine signals to railway property, immunity to copper thieves, and ability to measure each individual train's location and velocity at any instant.

Any information on such a system may be forwarded to:

Roger M. Pullem
Director-General
of Transport's Office
Box 1599, G. P. O.
Adelaide, South Australia 5001

The last time someone announced 74C, it was a national campaign.

When we saw 74C coming down the tracks, we knew it would be the hottest and most logical CMOS line in a long time. Flags waved, bands played, and thousands of engineers suddenly found CMOS easier to design in. The only thing missing was Teledyne's big production volume and competitive pricing, and now you've got that too.

Here's what Teledyne 74C delivers: A mere 10 nanowatts per gate typical power dissipation. Operation on 3V to 15V power supplies. A big, guaranteed 1V noise margin. Typical noise immunity 45% of the supply voltage. Hefty outputs that drive MOS and bipolar logic (at least two LPTTL loads).

And 74C really simplifies design. 74C logic functions, pinouts and even numbers are identical to 7400 TTL, and every 74C device is compatible with every other 74C device. I/O specs are consistent (no interpreting a pile of data sheets to calculate what's compatible with what). Not to mention drastic cuts in the need for supply regulation, bypass capacitors and noise filtering.

The first batch is available now:

MM74C00	Quad 2-Input NAND Gate	MM74C107	Dual J-K Master-Slave Flip-Flop
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That's our national platform for 74C. But Teledyne's CMOS campaign has just begun. We'll soon be speaking softly about big values in proprietary devices compatible with 74C and custom CMOS for linear and digital applications. All with ultra-low power dissipation and high noise immunity.

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40 years ago

From the pages of Electronics, July, 1934

AN EDITORIAL:

Synchronized broadcasting*

On July first, the new Federal Communications Commission took over control of radio. It is to be hoped that the new regulating authority will be more receptive to new ideas and technical developments than was the old Federal Radio Commission.

Take the matter of synchronizing broadcast stations for common frequency operation, at which the old F.R.C. repeatedly balked. Today equipment is all ready, complete experiments have been made, and several successful individual installations are in use. Synchronizing is now a demonstrated fact.

Synchronizing, indeed, seems the only ultimate avenue for solution of a whole group of problems that are facing broadcasting. Here are some of the needs for which synchronizing supplies prompt answers:

- Wider channels (15 to 20 kc.) for high-fidelity broadcasting
- Efficient use of broadcast channels
- Channels to meet demands of Canada, Mexico and Cuba
- Common-frequency broadcasting by chain stations with high fidelity
- Positions in the spectrum for stations requiring good local coverage
- Higher wattage on channels, but distributed among synchronized transmitters.

In fact, all the present "headaches" of broadcasting seem to find their solution in this panacea of synchronizing, intelligently applied. We hope the new Commission will give the subject of synchronizing on the broadcast channels careful and sympathetic study.

**Synchronized broadcasting, a technique scarcely heard of today, was designed to eliminate annoying beat-frequency notes caused when two stations transmitted on the same nominal frequency but were, actually, 10 to 20 hertz apart. Such common-frequency operation of a pair of stations many miles apart was used in the early days of radio to increase the broadcast range of a radio station.*

If you have any of these tape transports...

Then it's easy to put time on your tape.

Model 8120 Time Code Generator

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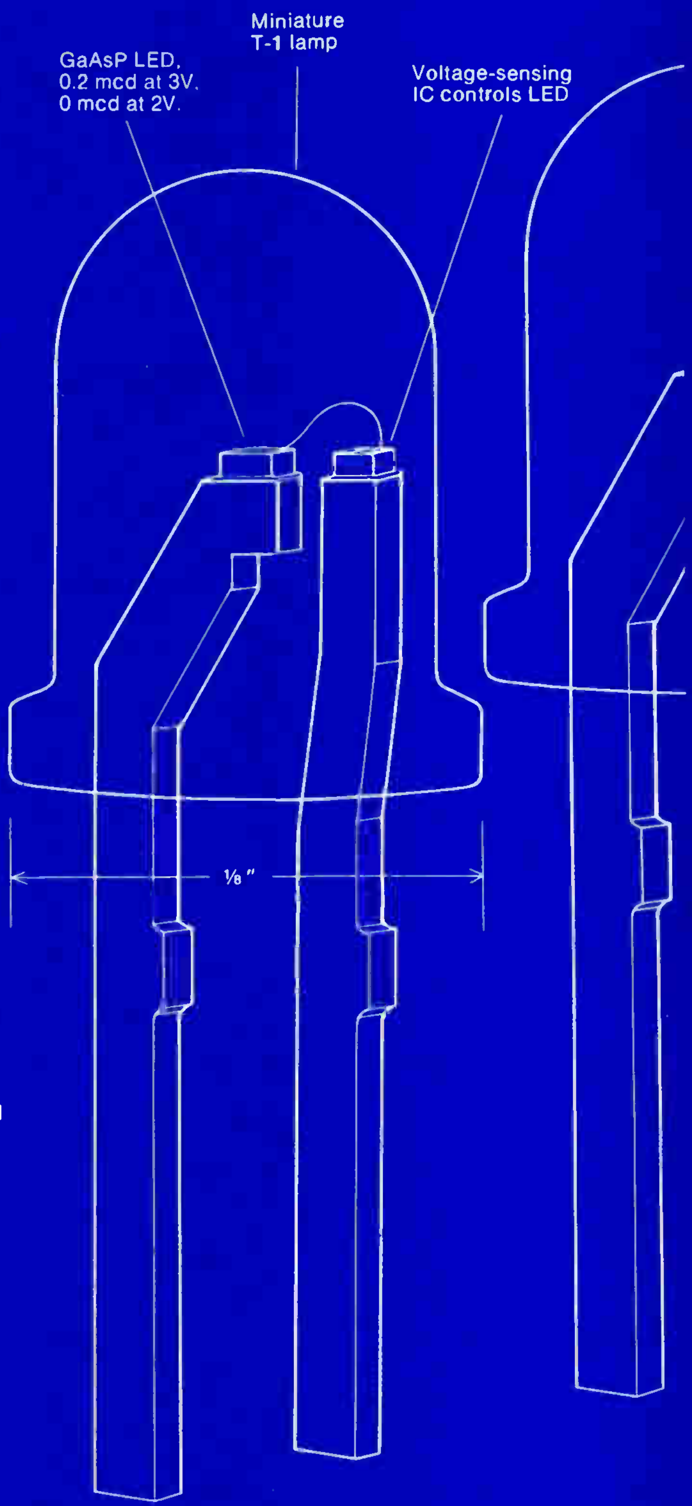


People

Zone refining leads to Science Academy

A reviewer of Bill Pfann's now classic text, *Zone Refining*, took him to task back in 1957 for suggesting that the floating-zone technique for purifying materials would work "ideally in a space station." That was just before the launch of the world's first satellite, Sputnik I, and

Founder. High purity semiconductors began with Bell Labs' William G. Pfann.

the reviewer reproached Pfann for making such a frivolous remark in a serious scientific work. But Pfann's foresight proved to be accurate. Several months ago—and some 17 years later—the very experiment Pfann proposed was conducted aboard Skylab II.

William G. Pfann, not only invented zone melting—a means of making materials of the highest purity—but he also fathered an industry. That is the refining of semiconductor materials, a business estimated to total $150 million a year. More than one third of all chemical elements now can be produced to the highest purity through zone refining. And Pfann expects that the basic technique will be applied still further.

Now, the 56-year-old, soft-spoken researcher from Bell Laboratories has been named a member of the National Academy of Sciences and, in October, he will receive the Industrial Research Institute's award for creativity in science and technology. He is now investigating the possibility of producing new compositions of matter. In particular, he's concerned with making metastable phases of materials, such as diamonds, which, he points out, defy existence according to the usual phase-equilibrium diagrams.

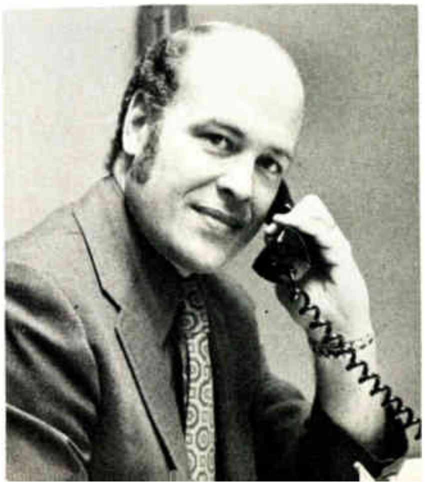
Messenger. In many ways, Pfann is an embodiment of the Horatio Alger experience, but he didn't head west. He came to Bell Laboratories in Murray Hill, N.J., at 17, and, given the prevailing economics in those years, was glad to have a job as a messenger boy at $15 a week. At the same time, Pfann also began night school at the Cooper Union School of Engineering in New York and was graduated with a degree in chemical engineering in 1940.

Today, Pfann holds more than 60 patents and is credited with conceiving and developing the prototype of the first point-contact transistor to be manufactured. As a result of his efforts, he holds the basic patents related to alloying and diffusion methods for making transistors.

Lemmons maneuvers Signetics in C-MOS

When John Lemmons, former manager of the American Microsystems Inc. Santa Clara plant, left that company recently to head Signetics Corp.'s newly formed complementary-MOS department, rumors were rampant. Rumor logic went something like this: AMI is in C-MOS and digital watches, C-MOS is used in digital watches, Lemmons was at AMI and is now at Signetics in C-MOS. *Ergo*, Signetics is set to jump

Logical. John Lemmons will set Signetics straight on the path to C-MOS.



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MOSTEK's MK4102P-6 is fast—275 ns access time! But speed is only one of its features. Just as important, it's easy to use, requiring only one +5 V power supply. All inputs are TTL compatible. And the processing technology is strictly state-of-the-art utilizing a combination of N-channel silicon gate plus ion implantation.

Also, you can accomplish large memory array construction with a minimum of additional circuitry because of the high impedance "off state" coupled with "chip select" input.

What else? Well, the MK4102P-6 is a pin - for - pin alternate for the 2102. But there's no comparison in access time. Check for yourself.

MOSTEK's line of 1K RAMs gives you plenty to select from, static or dynamic. They range from the MK4008-9 (at 800 ns) through two other versions of the MK-4102 (450 ns or 1 μ sec) up to the popular MK4006 (at 400 ns). Check the table below for the part number you need.

When your design requires an MOS memory, remember MOSTEK. Call your nearest MOSTEK distributor or representative or contact MOSTEK, 1215 W. Crosby Road, Carrollton, Texas 75006, (214) 242-0444. In Europe contact MOSTEK GmbH, TALSTR. 172, 7024 Bernhausen, West Germany, Tel. 798038.

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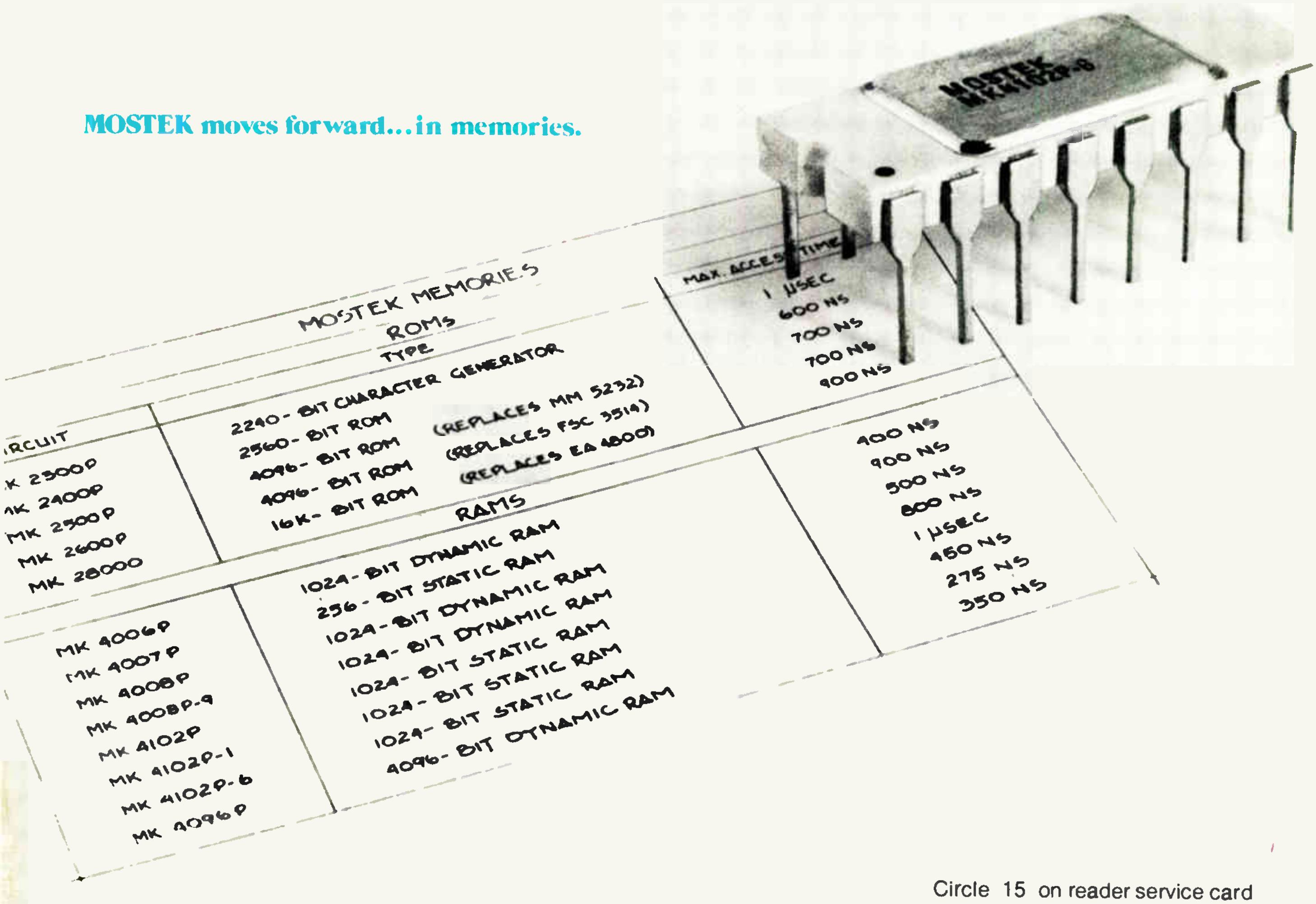

Circle 15 on reader service card

into the digital-watch market.

The unflappable Lemmons admits that the facts are essentially correct. However, the logic, and therefore the conclusion, is faulty and somewhat simple-minded. "Signetics is planning a major push into C-MOS," he says. "And, eventually, that may mean watches. But that is not in the immediate future. What comes first is establishing Signetics as a broad-based high-volume producer of C-MOS devices.

At first glance, this may seem to be a little difficult. Signetics is about the last of the major semiconductor houses to get into the C-MOS act. However, Lemmons feels this tardiness has certain advantages. "In any marketing situation, the best place is, of course, to be first, as the innovator," he says. "But when you are last, the market trends are set, the technology is established. And you've got the advantage of knowing the market strategies that succeeded—as well as those that failed." Lemmons concedes, however, that bringing up the rear is an advantage only as long as the market is still expanding.

"Certainly, the marketplace for C-MOS, in particular, and logic devices, in general, is not expanding at the rate it was a year ago," he says. "But the demand is still greater than the supply, and as long as it stays like that for at least a year or so, Signetics has a good chance of establishing itself.

To be successful, this kind of marketing strategy also requires the man who manages it to have, not only a knowledge of C-MOS technology, but also other logic families and processes, plus experience in engineering, production amd marketing. "I guess that is why Signetics was interested in me," Lemmons says.

His career has provided him perfect background for the job. Following graduation from Arizona State University with a master's degree in electrical engineering, Lemmons worked for six years at Motorola Semiconductor. There he was product manager, successively, of consumer linear IC and high-frequency power and MOS transistors.


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Universal MATE-N-LOK Connectors meet UL and VDE requirements of 600 volts.

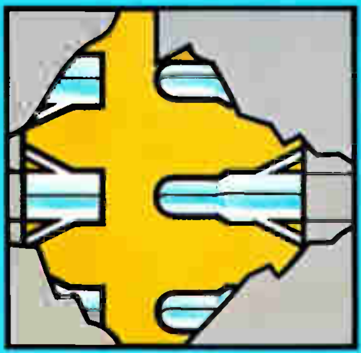
These AMP connectors have dual-lance contacts to provide superior stability. Crimp snap-in contacts rated at 25A. And because pins and sockets can be intermixed in the same housing, a wide variety of keying combinations is possible.

Both contacts and housings have a dual-wire capability, which reduces pin requirements and facilitates daisy-chaining.

Nylon housings are fully polarized, highly resistant to shock and vibration, and include 2 through 15 circuit configurations.

Preloaded pin headers are available for cable-to-pc-board connection.

For today's power requirements: .140 special MATE-N-LOK Connectors.



This addition to our standard product line has .140-diameter contacts, which accept insulation up to .180" diameter—and carry 25A. Contacts cover 24-10 AWG and incorporate the dual-lance feature described in our Universal range. Available in 2 through 9 circuit configurations.

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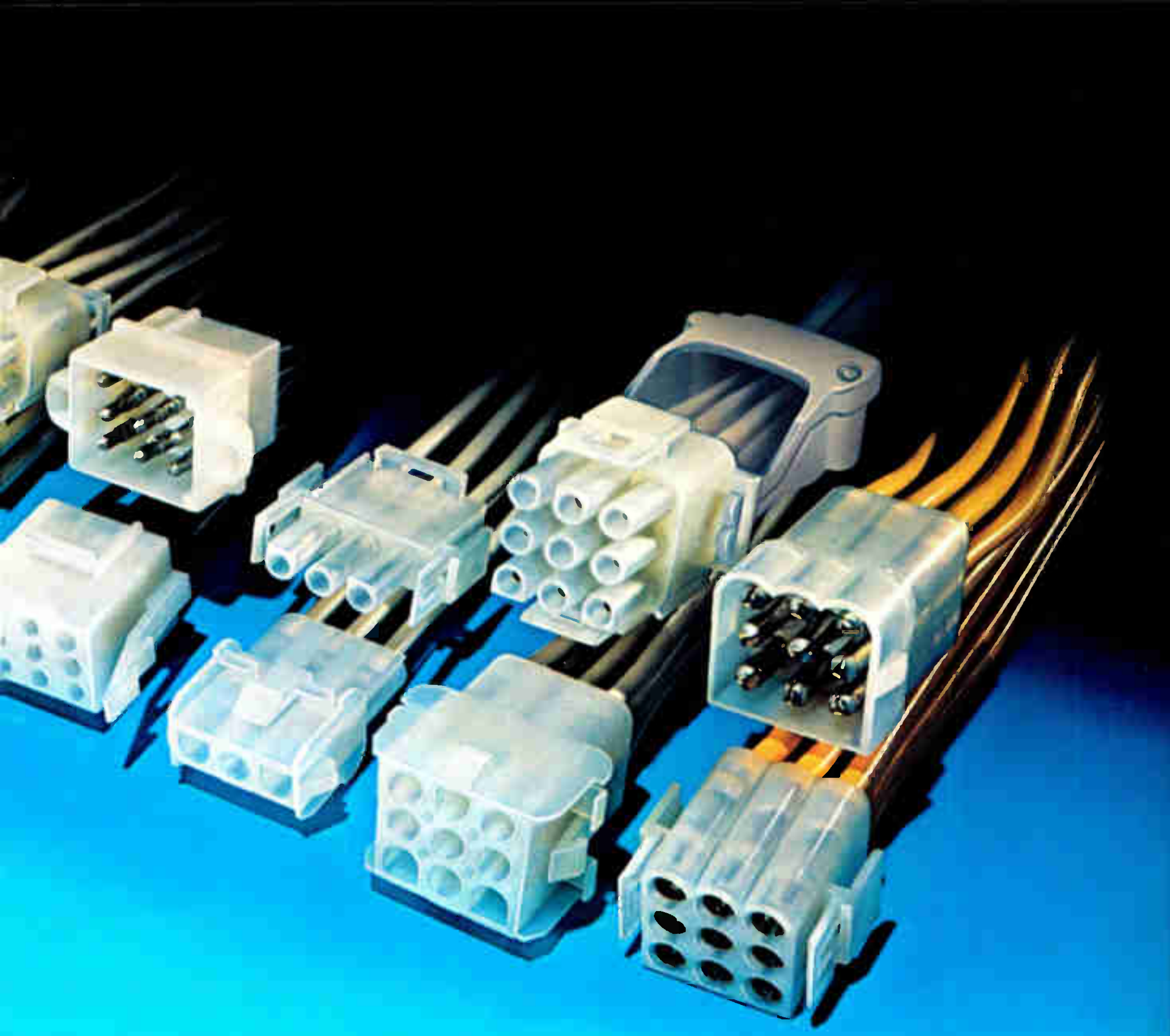
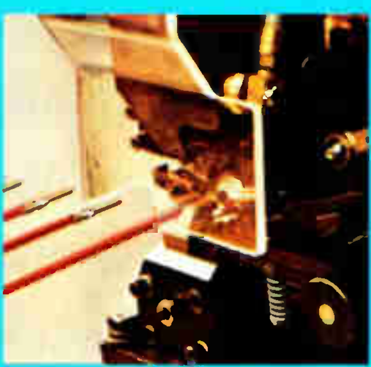


AMP terminating equipment. For low applied cost.



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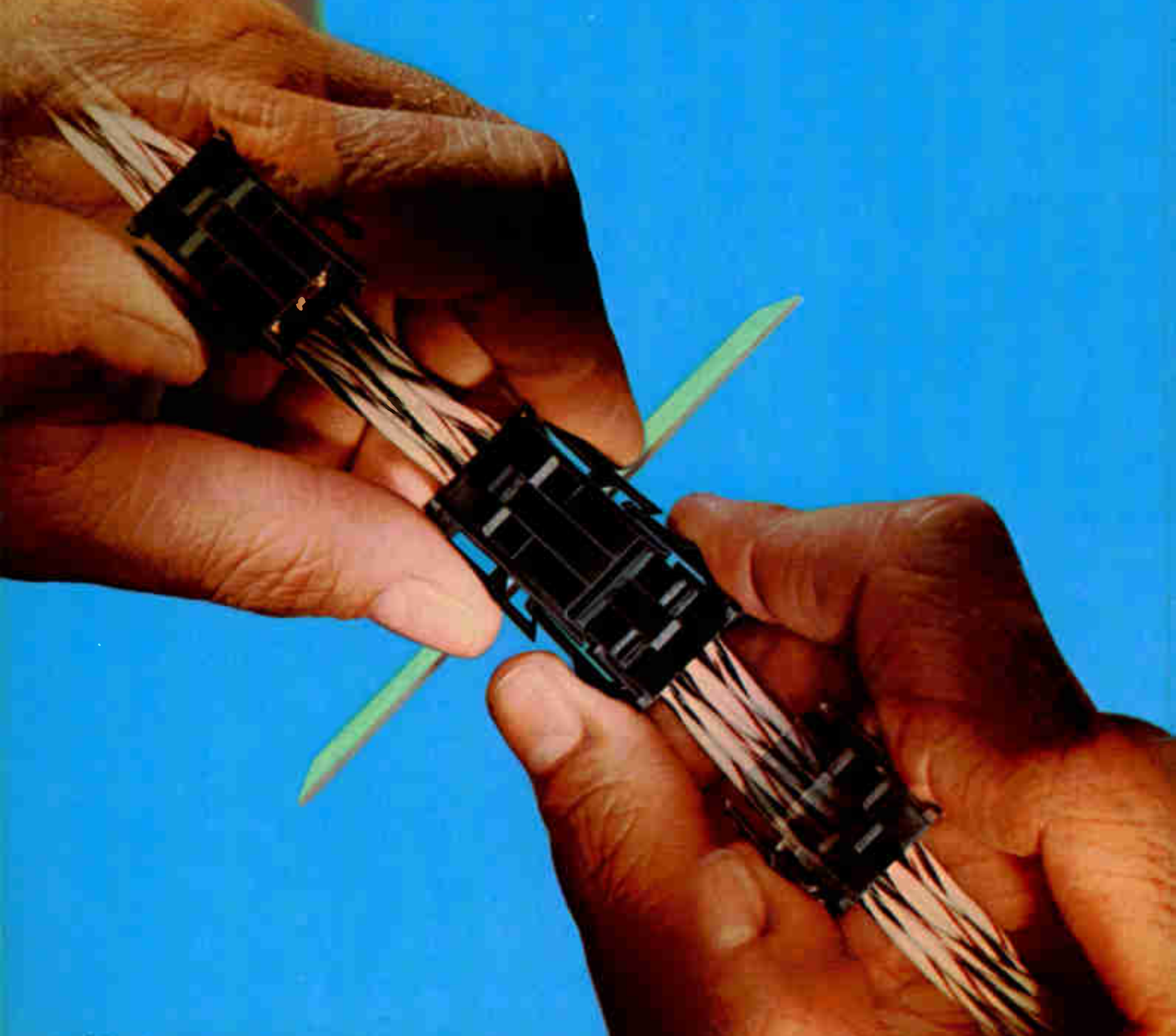

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Circle 21 on reader service card

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Intel's new 8080 n-channel microcomputer is here—incredibly easy to interface, simple to program and with up to 100 times the performance of p-channel MOS microcomputers.

Best of all, the 8080 is real—in production at Intel and available in volume quantities, today. It's also available through distributors along with a growing line of peripheral circuits and a new version of the Intellec 8, a program and hardware development system for the 8080, all supported with software packages, design documentation and manuals, and backed by more than 100 man years of microcomputer expertise.

The 8080 is the inevitable successor to complex custom MOS and many large discrete logic subsystems. It is the industry's first general purpose n-channel microcomputer and the first high performance single-chip CPU, with extremely simple interface requirements and straightforward programming. It runs a full instruction cycle in 2 microseconds.

As such, the 8080 extends the economic benefits of Intel's p-channel microcomputers to a new universe of systems that need fast, multi-port controllers and processors. These systems include intelligent terminals, point of sale systems, process and numeric controllers, advanced

to software, the
puter is here.

calculators, word processors, self-calibrating instruments, data loggers, communications controllers, and many more.

You can use 256 input and 256 output channels, handle almost unlimited interrupt levels, directly access 64 kilobytes of memory, and put many satellite 8080 processors around a single memory.

Interfacing is minimal and design is easy with the 8080 because all controls are fully decoded on the CPU chip itself and inputs and outputs are TTL compatible. There are separate data, address and control buses.

INTEL 8080		
RAM MEMORIES		
8101	256 x 4 STATIC	AVL: 3RD Q
8111	256 x 4 STATIC WITH COMMON I/O	AVL: 3RD Q
8102	1024 x 1 STATIC	AVL: NOW
8107	4096 x 1 DYNAMIC	AVL: NOW
ROM MEMORIES		
8308	1024 x 8	AVL: 3RD Q
8316	2048 x 8	AVL: NOW
PROM MEMORIES		
8702	256 x 8	AVL: NOW
8704	512 x 8	AVL: 4TH Q
8604	512 x 8	AVL: 4TH Q
PERIPHERAL CIRCUITS		
8205	1 of 8 DECODER	AVL: NOW
8210	4K RAM CLOCK DRIVER	AVL: NOW
8212	8 - BIT I/O LATCH	AVL: NOW
8216	BI-DIRECTIONAL BUS DRIVER	AVL: 3RD Q
8201	COMMUNICATIONS INTERFACE	AVL: 4TH Q

INTEL 8080 PRODUCT FAMILY

The 8080 microcomputer has 78 basic instructions, including the 8008 set plus new ones that make possible such features as vectored multi-level interrupt, unlimited subroutine nesting and very fast decimal and binary arithmetic.

Program development for the 8080 can be done either on a large computer using the Intel software cross products (PL/M systems language compiler, macro-assembler and simulator), or on an Intellec 8 development system with a resident monitor, text editor and macro-assembler.

The new 8080 product family includes performance matched peripheral and memory circuits configured to minimize design effort and maximize system performance. Large, low cost RAMs, ROMs, PROMs and I/O devices are available now and we will soon announce other 8080 LSI support circuits.

The 8080 is easier to use and more economical than any high performance microcomputer in sight. It's here now, in volume, from the inventors of the microcomputer and the people who lead the industry in production and design support.

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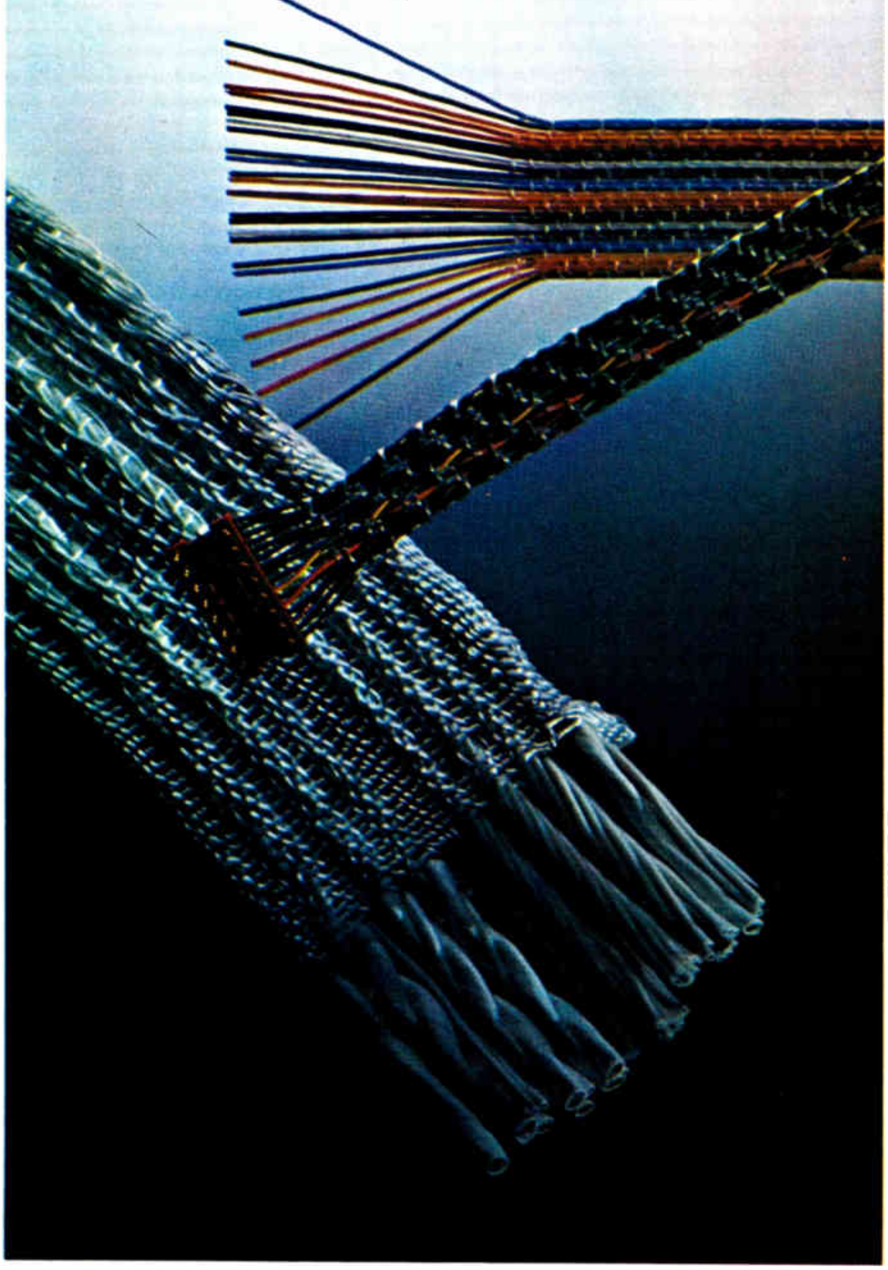

Meetings

IFIP Congress, International Federation for Information Processing, IFIP, Stockholm, Aug. 5–8.

Computer Communications International Conference, IEEE, Stockholm, Sweden, Aug. 12–14.

National Electronics Conference of New Zealand (Nelcon), New Zealand Section, IEEE, University of Auckland, Auckland, Aug. 26–30.

Fifth Conference of the Canadian Medical and Biological Engineering Society, Queen Elizabeth Hotel, Montreal, Sept. 3–6.

International Congress on Data Processing, AMK, Congress Hall, West Berlin, Sept. 4–7.

Preparation and Properties of Electronic Materials, Metallurgical Society of the American Institute of Mechanical Engineers, Sheraton-Boston Hotel, Boston, Sept. 9-11.

International Switching Symposium 1974, VDE, Sheraton Hotel, Munich, Sept. 9–13.

Compcon Fall, IEEE, Mayflower Hotel,Washington, D. C., Sept. 10-12.

Western Electronic Show and Convention (Wescon), IEEE, Los Angeles, Sept. 10–13.

Fourth European Microwave Conference, Microwave Exhibitions and Publishers Ltd., Maison des Congrès, Montreux, Switzerland, Sept. 10–13.

European Solid State Devices Research Conference, Institute of Physics, IEEE, University of Nottingham, England, Sept. 16–19.

International Conference on the Technology and Applications of Charge Coupled Devices, University of Edinburgh, Centre for Industrial Consultancy and Liaison, et al., Edinburgh, Sept. 25–27.

Minicomputers in the Factory, New York Management Center, Delmonico's Hotel, New York, Oct. 7-8.

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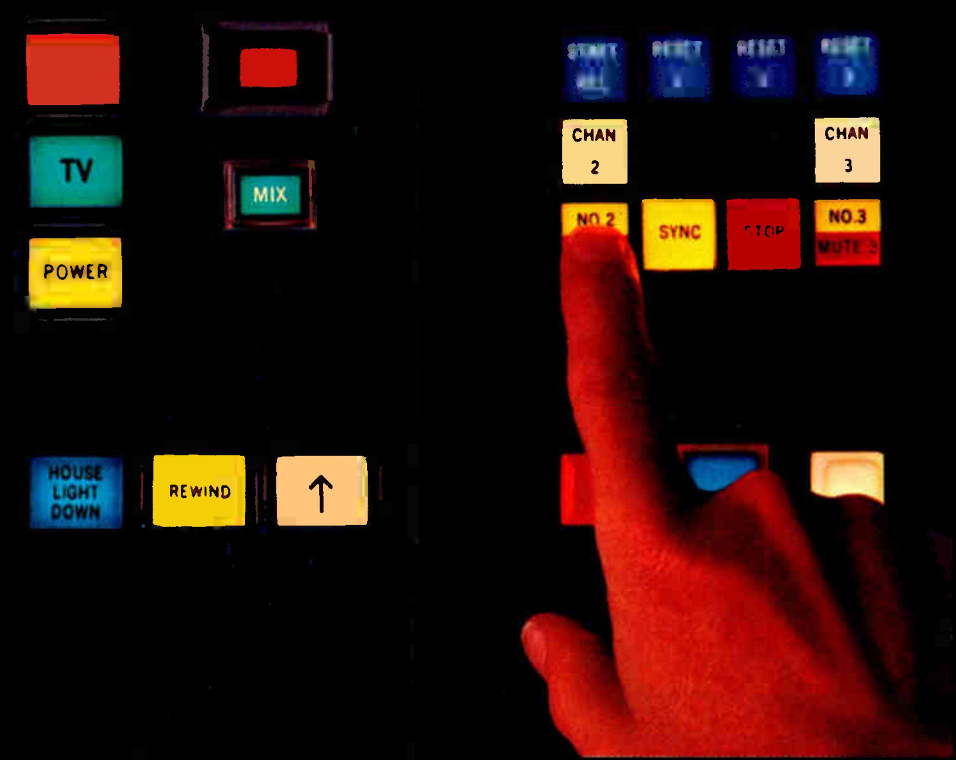

MAIN PHOTO:
Series 3 (right) and Series 4 (left)

LOWER PHOTO:
Series 4, (left) lowest cost, all three energy levels, snap-in mount.

Series 2, (back) with modular design, up to 4 lamps and 4 poles, military versions.

Series 1, (right) with bushing mount, panel seal, military versions.

Series 3, (front) the smallest in our line, with snap-in or matrix mount.

If you've got a particular idea about what a lighted push-button should look like, we've got four important numbers for you: Series 1, 2, 3 and 4.

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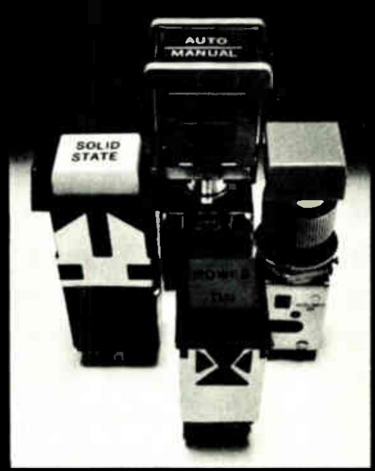
So you get to choose from a long list of options, depending upon the switch you select. Like buttons available in popular, highly consistent colors. Either transmitted or projected. Legending includes hot stamp, engraved or film insert, with an optional hidden legend available. Barriers and housings come in a choice of colors. Lighting is single or multiple lamp. Mounting either single unit, strip or matrix. You can also choose between round or square configurations, and most of them offer front-of-panel relamping without tools.

But your choice doesn't end at the front of the panel. In back of the button, there are three energy levels available—solid-state, low-energy and power. You can choose among solder, quick-connect, P.C. board mount or screw terminals. They're all U.L. and C.S.A. listed, with military-listed variations available. Circuitry can be single-pole, single-throw through four-pole, double-throw. With momentary or alternate action.

And, even though each of the four Series has its own particular advantages, they all have one thing in common: the kind of reliability you'd expect from the company that pioneered lighted pushbutton switches.

If you'd like more information on any or all of the MICRO SWITCH lighted pushbuttons, call toll-free 800/645-9200 (in N. Y. 516/294-0990, collect) for the name of your nearest Branch Office or Authorized Distributor.



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Circle 25 on reader service card

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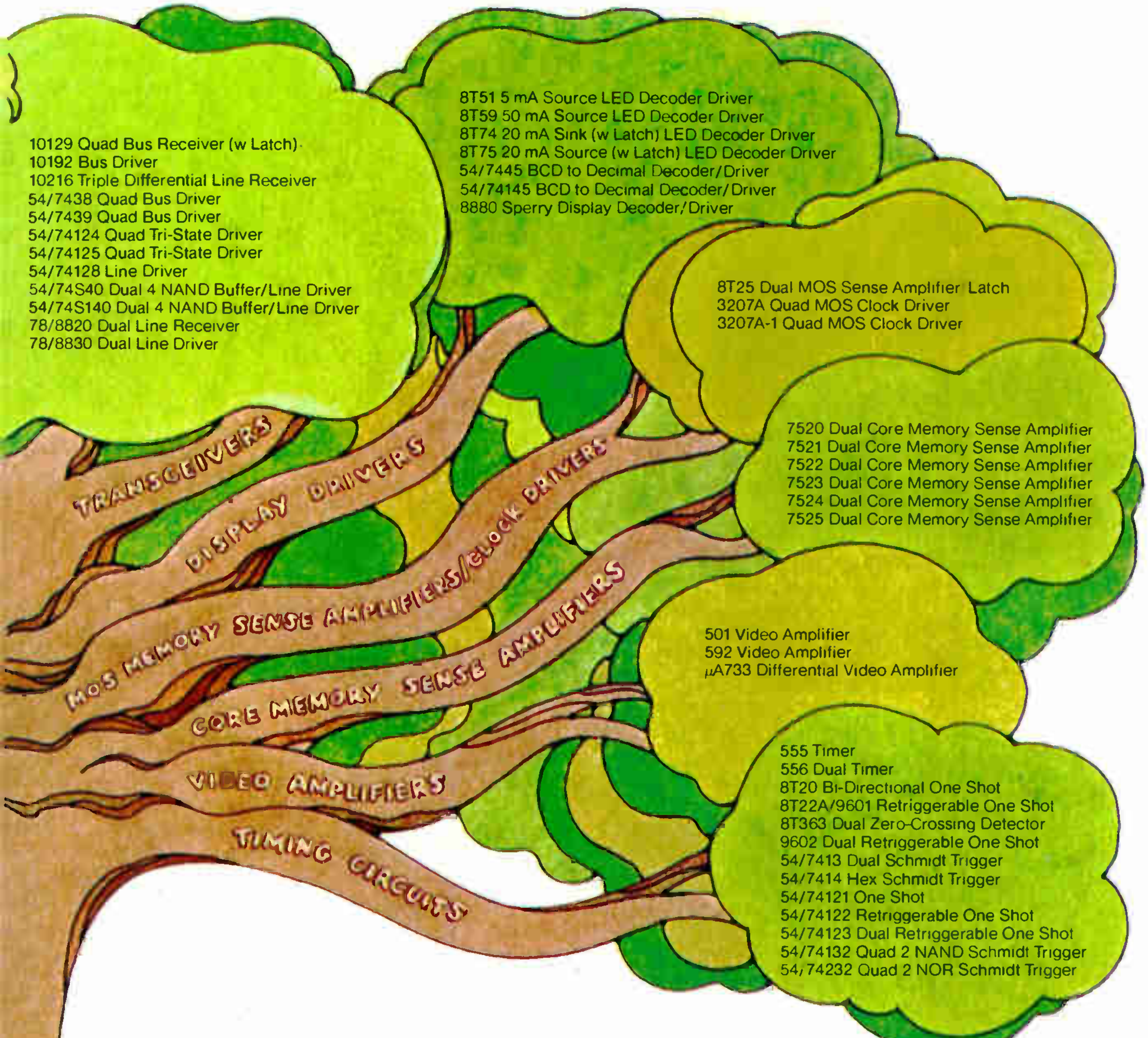

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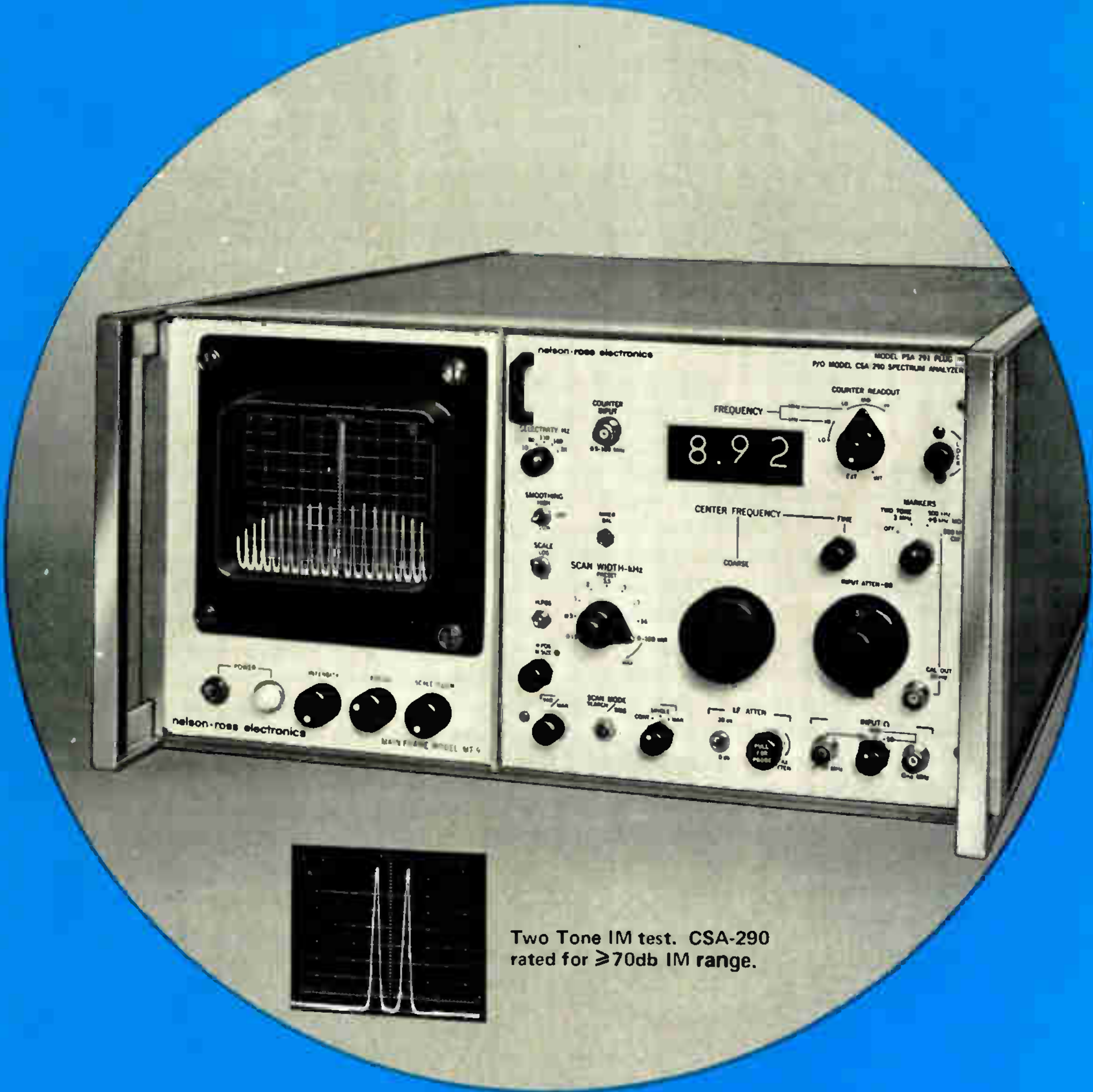

Two Tone IM test. CSA-290 rated for ≥70db IM range.

SSB, FM, AM, MUX—10 Hz to 400 MHz

The Nelson-Ross CSA-290 pinpoints and analyzes all your communications signals from 10 Hz to 43 MHz — to 400 MHz with Range Extender (Model RE-7292). Resolution capability is 6 Hz!

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- **≥70 dB range for two-tone IM distortion tests. (Two-Tone AF Signal Generators, Model TTG-29, optional.)**
- **Field proven reliability; meets rigid U.S. Government environmental specifications. FSN #6625-450-4312**
- **Lowest cost.**

Testing, monitoring and troubleshooting modern high density SSB and FM communications signals requires exceptional selectivity, stability, and a wide dynamic range free of internal spurious responses, image frequencies, and IM. The versatile Nelson-Ross CSA-290 includes all these capabilities, plus foolproof self-testing operation and unique accessories.

And the cost is modest:

Model CSA-290A — Spectrum Analyzer & Probe, 10 Hz — 43 MHz	$4,600.
Model TTG-29 — Two-Tone AF Signal Generator 20 Hz — 20 kHz	$1,200.
Model RE-7292 — Range Extender, for analysis to 400 MHz	$2,000.

The CSA-290A's calibrated Display Main Frame can also be used with more than a dozen popular Nelson-Ross Spectrum Analyzer Plug-Ins; 0.5 Hz to 6.5 GHz. For complete specifications, please phone, write or circle the Reader Service Number.

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C-MOS on sapphire replaces bipolar at McDonnell

McDonnell Douglas Electronics Co. has decided to replace its bipolar IC facility with one devoted solely to C-MOS on sapphire. Although parts won't be produced in quantity for about a year, the first part—a ROM designed to test the process—is due off the line by year-end.

Because of the low power requirements of C-MOS technologies, McDonnell Douglas **is convinced that military avionics is fast moving toward C-MOS on sapphire.** "And it's our opinion, from what we see in Government installations, that a large proportion of future military/aerospace requirements are going to be C-MOS on sapphire," notes John W. Buttrey, director of solid-state technology for the St. Charles, Mo., firm. Planned as a fast-response, low-volume line, the facility is now aimed at satisfying custom needs in-house, but it may eventually solicit a limited amount of outside business.

Monolithic 1.2-GHz decade divider due from Plessey

Plessey Semiconductors next month will introduce a monolithic 1.2-gigahertz decade divider—**double the operating range of previous models of this device.** The highest frequency now attainable in decade dividers is a 600 megahertz part, also sold by the English-based firm. The new device extends direct frequency synthesis and instrumentation to the upper limit of 1,215 MHz. The divider uses a form of emitter-coupled logic, and it is compatible with MECL II and 10K. Unusual for this frequency range, the IC is packaged in a 14-pin dual-in-line package. The part is pin-compatible with the 600-MHz divider.

H-P turns 9830A into interactive data terminal

A new interface from Hewlett-Packard Co. is closing the communications gap between its 9830A desktop calculators and computers. Consisting of cable and a plug-in read-only memory, **the data-communications interface makes the 9830A the first desktop calculator to offer both asynchronous and synchronous data transfer.** H-P says this, in effect, turns the calculator into an interactive terminal.

The terminal can talk to other 9830As as fast as 9,600 bits per second. It can also be operated as a remote batch terminal or as a time-sharing terminal for a large computer system. The basic interface package will sell for $1,500, while the calculator itself has a $6,475 price.

Cheaper LSI may affect views on avoidance gear

Now that the cost of making LSI chips is dropping, previous opinions on various collision-avoidance systems by the Federal Aviation Agency, the Air Transport Association, and general-aircraft users may change. The FAA, **recognizing a need for new studies on comparative costs of various airborne avoidance systems** has awarded a $116,000 contract to Arinc Research Corp., Annapolis, Md., for a six-month study of systems containing LSI.

And alterations to the forthcoming ground-based discrete-address beacon system may be able to provide CAS capability for commercial aircraft over the Atlantic and Pacific Oceans. The Institute for Defense Analyses, Arlington, Va., has received a $223,000 contract for studies of CAS communications capability and reliability.

FAA assistant administrator Gustav Lundquist had promised a recommendation on CAS to Congress by July 1975, but at a recent Senate committee hearing, **he said that it might not be ready until January 1976,** more than six years after the ATA formally advocated the airborne CAS made by McDonnell Douglas.

MLS to be installed at 50–100 airports

Microwave landing systems will go into operation at 50 to 100 airports by late 1977, according to a new Federal Aviation Agency deployment schedule. Says FAA's project manager for MLS, Joseph DelBalzo, **"heavy pressure from the user community" has forced earlier deployment of an MLS system,** so a low-performance modular version will replace category I instrument-landing system radar (200-foot ceiling, quarter-mile visibility) in certain test locations. Several industry representatives will be asked for recommendations on where MLS test systems should be installed.

There were no surprises in MLS testing at Wallops Island, Va., last June, DelBalzo says, and the agency will soon begin reviewing data from six months of flight tests on two doppler and two scanning-beam microwave systems. A contract for two prototype units—based on either scanning beam or doppler—will be awarded in March 1975, he says. **A limited production option for "between 50 and 100 units" will be exercised in June 1976** with the successful prototype manufacturer.

Terabit memory returns with new look

A new, less expensive version of Unicon's trillion-bit laser memory system is on the market. The original, which records data with a laser that burns microscopic holes in a thin metallic film, **was available only in the trillion-bit capacity, cost $1.7 million, and was quite bulky.** Now, Precision Instrument Co. of Santa Clara, Calif., following a company reorganization, is offering the new model 190 in modular form, with a minimum capacity as little as 200 megabytes, for lease or for sale for as little as $400,000.

Bendix switches to Eaton's antiskid system

The Bendix Corp., the country's biggest maker of truck air brakes, **has taken itself out of the antiskid competition** [*Electronics*, July 11, p. 74]. Instead, Bendix dealers will supply the Eaton Corp. system. Marvin Flaks, vice president and group executive, denies that Bendix has dropped its antiskid development. Rather, he says, there isn't enough time before implementation of Federal rules requiring antiskid devices on trucks to test them adequately.

Addenda

The FAA has decided to continue funding development of Philco-Ford's electronic voice switch prototype to the tune of $100,000 a week. The agency will decide by the end of the summer whether to seek new bids. The project is running far beyond its January 1975 target date. . . . Scarcely a month after ordering 100 shipboard terminals for its Marisat maritime communications satellite [*Electronics*, June 13, p. 78], Consat has ordered another 100. **This increases its total purchase from Scientific Atlanta to about $4 million.** . . . Look for samples of sapphire wafers from Monsanto by the first quarter of next year. **The silicon giant is eyeing the market**—now dominated by Union Carbide—and expects a pilot line for slicing and polishing wafers to go on-stream within a few months at its St. Peters, Mo., materials facility.

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Place an order. We'll deliver 10,000 of any of the SCR's listed — in three weeks or sooner.

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Type			Blocking Voltage	Maximum Current, RMS	Gate Trigger Current I_{GT}	Gate Trigger Voltage V_{GT}	Holding Current I_{HX}
TO-92	TO-92	TO-18					
2N5060	IP100	ID100	30V	0.8A	200μA Maximum	0.8V Maximum	5mA Maximum at R_{GK}=1K
2N5061	IP101	ID101	60V				
2N5062	IP102	ID102	100V				
2N5063	IP103	ID103	150V				
2N5064	IP104	ID104	200V				
	IP105	ID105	300V				
		ID106	400V				

See Electronics Buyers' Guide Semiconductors Section for more complete product listing.

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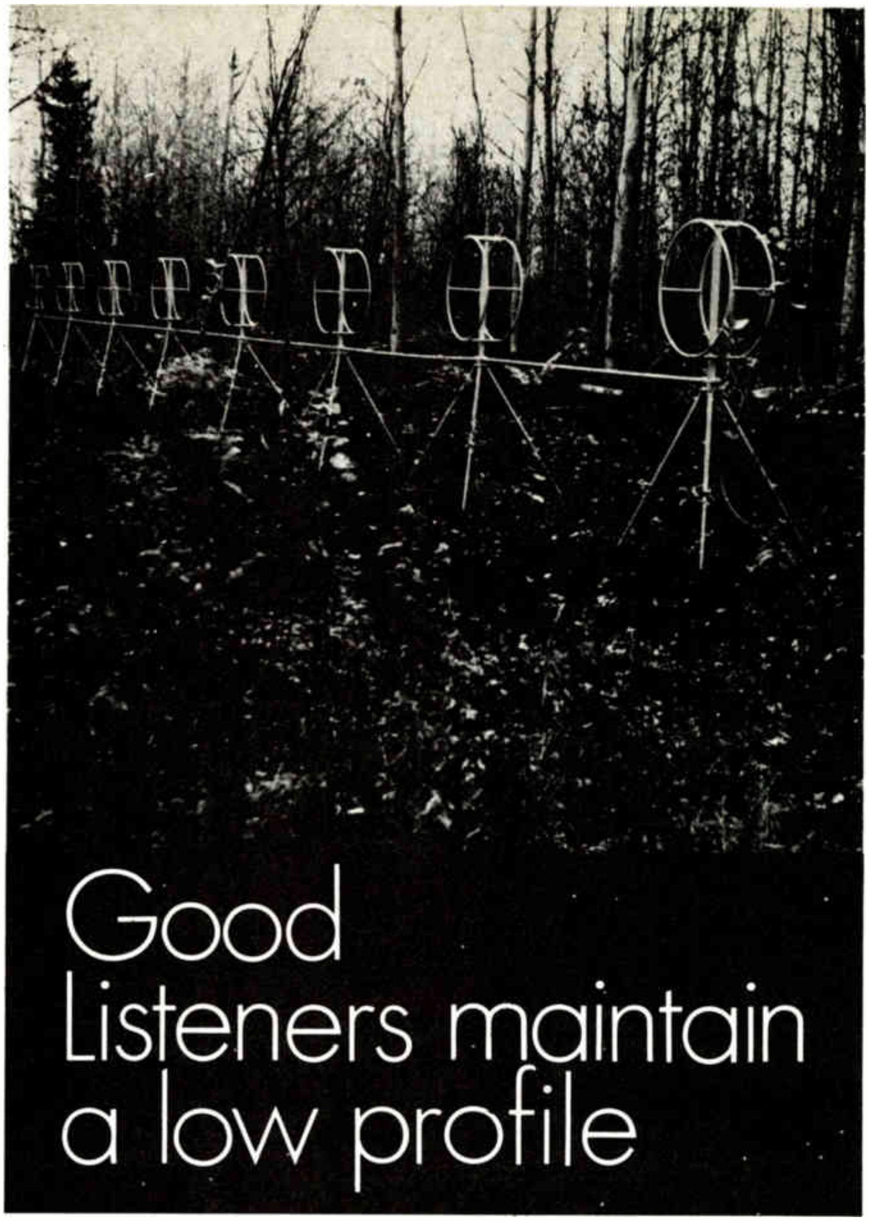

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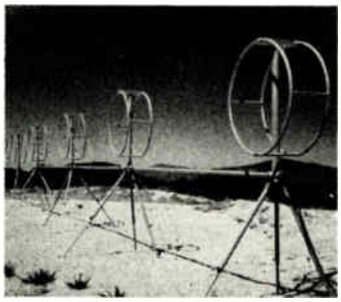

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Even in the solitude of the forest depths, from rooftops, arctic tundra, swamps to sweltering tropics, 'neath snow, sand or ice,
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Silk-screening prints conductors, resistors on circuit boards

Printing replaces usual chemical deposition or etching; price reductions of 10% to 30% promised

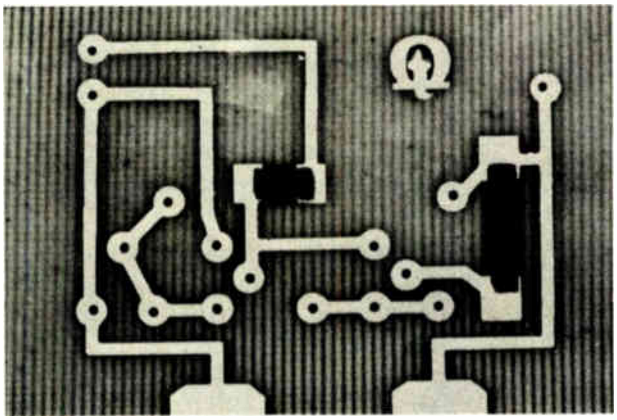
"I've been thinking for the past 10 years there must be a better way to make printed-circuit boards," says Christos G. Alex, division manager of tiny Ohmtec Inc., in Burlington, Mass. From his background in micropackaging, he realized that people in the circuit-board business dislike handling the chemicals needed for etching and plating and the effluents they produce.

And so, after searching for that simpler way, he's come up with a method that does away with those chemicals entirely and relies instead on simply silk-screening the conductor pattern onto the circuit board. Moreover, the same silk-screening process is also used to put resistors on the board.

Besides its ecological tidiness, the new technique, which Ohmtec calls Econostrate, has a cost advantage, as well. Alex asserts it will yield circuit boards 10% to 30% less expensive than comparable boards fabricated by chemical methods. Tooling and set-up time are not reduced because separate masks are needed for each conductor layer and for each type of resistor. However, because the process requires no lamination or etching, the number of steps involved is reduced. With patterns deposited in one step some 1,000 to 1,500 4-by-5-inch units can be turned out in an hour. Board size is limited only by the size of the custom-designed silk-screen printing system, and the company soon hopes to modify the system and offer larger boards.

Double layer. Not only is Ohmtec able to deposit single-layer conductor patterns, but double-layer patterns can be screened on only one side of the board, as well. A proprietary insulating layer separates the two conductive layers, while connection pads are left exposed. This eliminates plated-through holes, a source of unreliability in pc boards that have one layer on each side of the board.

The idea for silk-screening the conductor patterns seems simple, but Ohmtec spent two years developing proprietary conductive materials, based on silver resins with additives. The materials must adhere tightly to the boards, have sufficient conductivity, and be printable with line definitions as small as 10 mils. Conductors also must have a high dielectric strength, offer constant surface roughness, be free of cracks, and be solderable.



Imprinted. Printed-circuit board measures 4 by 5 inches, limited by the silk-screening process. Light lines on the board are conductors, the two dark patches are printed-on resistors.

In addition to being solderable, the conductors can also be handled the same way as a ceramic substrate for wire and chip bonding, Alex says. The Econostrate process is best suited for glass-epoxy boards, he continues, but it can be used with such other materials as polyester, glass, and phenolic. And Ohmtec is investigating using the process on flexible circuits, since it appears that the conductor material will not crack under stress.

Resistors. Ohmtec deposits resistors simply by changing masks and materials in the silk-screen system. Again, the material is proprietary—a carbon resin with additives. Resistors can have tolerances of 5%, 10%, or 20% and power ratings as high as 0.25 watt. Temperature coefficient is a few hundred parts per million per degree C, varying with resistor value. This is quite acceptable for inexpensive consumer products produced in high volume, such as automotive electronics and watches, Alex points out. In the future, he hopes to make available resistors with tighter tolerances and lower temperature coefficients.

While Ohmtec has not yet licensed the system, it is investigating the possibility, says Alex. However, the custom-designed deposition system can use customer-supplied masks, as well as masks designed by Ohmtec engineers. Customer designs, however, may have to be modified to eliminate plated-through holes or to change spacing in the pattern. □

Radar

Accurate 3-d system has one antenna

Three-dimensional radar, which pinpoints a target's height, as well as its range and bearing, has received considerable attention through the years. The latest design comes from the UK's Plessey Radar division, which, by applying new transmitting and frequency-processing techniques, has developed a simplified antenna to provide an accurate, long-range 3-d radar. Called the AR-3D, the system is intended for military air defense and civil-air-traffic-control systems.

Normally air-surveillance radar systems derive their data through two antennas—one for range and bearing, and the other for altitude. These systems are usually limited by the slower-scanning altitude antenna. A recent trend is to get a single 3-d antenna by using "stacked-beam" techniques. These, in effect, create one large antenna from many small ones, but the system needs complex and sophisticated processing equipment to integrate all the data.

Instead, the Plessey radar radiates a pencil beam, formed by an antenna with a feeder having a squint angle in the vertical plane that is a function of the carrier frequency. The beam may be electronically scanned over a chosen vertical angle by changing the transmitter's carrier frequency. Intercepted targets will return signals at frequencies that are a function of the target's elevation. And the height, in turn, can easily be derived from the elevation information contained in the measurement of the frequency. Moreover, the radar inherently scans for elevation with each rotation, considerably speeding up analysis of this data.

Range. Plessey claims the AR-3D radar will with 90% probability detect bombers 300 nautical miles away and fighters out to 180 nautical miles, both flying at 60,000 feet.

The company also boasts of militarily important performance against ground and rain clutter, chaff, and noise jamming, principally because the high-resolution pencil beams carry a range cell of only 15 meters.

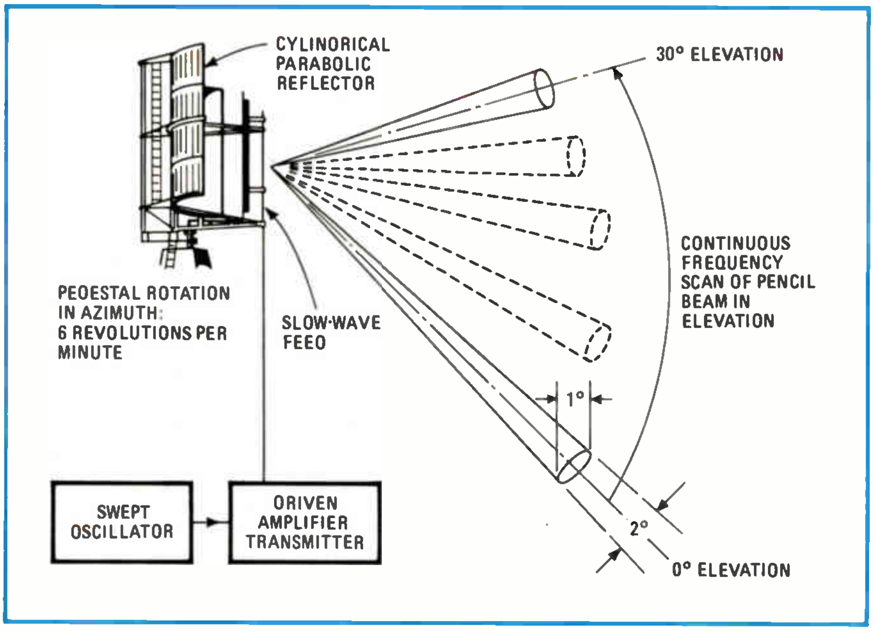
The price of the cheapest mobile version will be about $2.5 million after Plessey gets into production in 1976, says marketing director Allan Carnell.

Thomson-CSF in France and ITT-Gilfillan, Hughes, and Westinghouse in the U.S. are marketing competitive systems. The British Ministry of Defense has put up part of the estimated $5 million to $10 million cost of development and may contribute further toward production.

Selective. The system is frequency-selective within S band, operating in a 200-Mhz bandwidth. There are independent frequency selectors, for each of the 13 elevation channels, each having a bandwidth of about 20 megahertz. The receiver has a compression ratio of 130 to 1.

But Plessey couldn't build the system until it had developed the equipment to analyze the frequency spectrum. Its Allen Clark Research Centre in Addlestone, Surrey, came through with an acoustic surface-

Triple threat. Only a single reflector curved in the horizontal axis is needed by Plessey's 3-d radar. Pencil beam, below, is scanned in vertical plane by varying transmitter frequency. Target altitude is derived from frequency of return signal.



wave filter to do the job.

To obtain elevation measurements, the received signals are separated by filters into a number of channels equalling elevation sectors of about 2° each. Measurements finer than 1/16 of each of the sectors are obtained by measuring simultaneously the frequency of the compressed target responses in each channel.

The range resolution is determined by the target-echo bandwidth, and, since the target return is a swept-frequency signal, the company applies pulse compression to get high resolution. The acoustic-wave-surface equalizers compress the received signals to pulses of 0.1 microsecond, giving the radar a range cell size of 15 meters.

The antenna design has been simplified by a corrugated waveguide structure that produces a slow wave-guide feed. Plessey describes the antenna as a linear array and parabolic cylinder having bandwidths of 1° in azimuth and 2° in elevation, a 30° scanning angle, and 41.3 decibels of gain. It rotates at six revolutions per minute.

The transmitter has peak pulse power of 1.11 megawatts, mean power of 10 kilowatts, and pulse length of 36 microseconds. J.K. Coldwell, AR-3D technical manager explains that each target is "hit" eight times and the system averages the results to derive accurate heights. The minicomputer-driven radar system, which will automatically track a maximum of 80 targets simultaneously, will see about 100 targets per scan and handle about 1,000 in all. □

Corrigan named Fairchild president as Hogan becomes vice chairman

Corrigan

Now that Fairchild Camera & Instrument Corp. has reversed the flow of red ink that until recently plagued it, the man brought in to mastermind that turnaround—C. Lester Hogan—has stepped aside. He has turned over the offices of president and chief operating officer to his 36-year-old protege, Wilfred J. Corrigan.

Hogan becomes vice chairman, where his main duties will be to "represent Fairchild in major business and governmental forums." The move comes as a surprise only to those who haven't watched recent corporate changes at the Mountain View, Calif.-based company.

Jumpers. Corrigan is one of the original seven managers who in August 1968 jumped from Motorola Semiconductor with Hogan when Hogan left as general manager of the Semiconductor division to become head of Fairchild. Starting as group director of discrete devices in 1968, Corrigan became manager of the Semiconductor Components operation in 1971. Last September he was elected an executive vice president and member of the board of directors, with added responsibility for the three divisions comprising the company's Commercial Systems group: Systems Technology, Industrial Products and Inland Manufacturing.

Over the last nine months, the 54-year-old Hogan relinquished more and more of his control over the day-to-day marketing and production activities to Corrigan, spending most of his time acting as a spokesman for WEMA, the electronics industries trade association, and for the semiconductor industry. "This is something that Walter (Burke, chairman of the board) and I have been discussing for about two years," he said. "We made up our minds that at the 'right time,' I would step aside and Wilf would take over."

The decision that the right time was now was based on two things, he says. One was the apparent turnaround of the company during the first quarter of this year when it chalked up record profits. The second was Hogan's growing involvement in Government affairs.

When Hogan arrived at Fairchild the company was a technological leader, but in chaos. With a customer base of about 600 companies, Fairchild had an unhealthy dependence on digital circuits and the computer industry, component yields barely 20% of those of some of its major competitors, and a reputation for late delivery.

Hogan temporarily de-emphasized state-of-the art product development in favor of "second sourcing," sunk $56 million through 1970 into modernizing "antiquated" manufacturing facilities, centralized scheduling and production, and reorganized the marketing group.

Payoff. Hogan's own strategy ultimately paid off. In the first quarter of this year, Fairchild's customer base was about 5,000. Its product lines now include linear, memory, and discrete as well as digital devices, and its diversified customer mix depends on no single industry or company. Moreover, Fairchild earned $10.6 million on $103.8 million in sales. Corrigan, says, "I think the company has reached the point where it can emphasize both high technology and high volume."

Communications

Police to get portable digital terminals

Car thieves are being arrested in greater numbers, and stolen cars are being tracked down faster—thanks to digital communications links in police patrol cars. So successful have the in-car systems been that tests will soon begin on hand-held, battery-powered terminals to be carried by patrolmen not travelling in cars.

The program, funded by the Law Enforcement Assistance Administration, would give the patrolmen the same freedom with digital communications that their portable voice transceivers now give them with voice communications. The terminals would give them direct access to information stored in local law-enforcement data banks.

Three such data banks are used, for example, with the in-car digital system established in Oakland, Calif. One bank contains a statewide list of stolen cars, another, a nine-county most-wanted-persons list, and a third, a local stolen-property list.

In addition, it would be possible for a patrolman to obtain information, once his queries are relayed through a control center at his headquarters, from such national data banks as the FBI's National Crime Information Center in Washington.

Hand-held. Telephone-type keyboard and LEDs characterize portable digital police terminal from Electromagnetic Sciences.

Run-off. Officials at LEAA say two contracts, each with an estimated value of $120,000 and covering five transceivers and a headquarters control unit, will be awarded during July to Burroughs Corp., Paoli, Pa., and Electromagnetic Services Inc., Atlanta. The two systems, which are similar, will be evaluated next year by the District of Columbia police department and LEAA. About the size of a "large calculator," the terminals will contain a keyboard and some sort of alphanumeric display such as light-emitting diodes. After six months of evaluation, bids may be requested for a larger-scale evaluation, say LEAA officials.

These officials predict that the units will sell for about $500 or $600 each when mass-produced. Digital communications terminals in police vehicles cost five to six times more, and the potential market is "practically every police force in the country."

Success. The impetus for the development of the portable terminals comes from the success of the in-car terminals. More than 15 metropolitan police forces throughout the country already have tested or ordered in-car digital communications systems. They include New York, Los Angeles, Kansas City, Mo., West Palm Beach, Fla., San Francisco, Atlantic City, N.J. and Cleveland, Ohio [*Electronics*, Dec. 6, 1971, p. 39].

One of the oldest and best-developed systems, which is in Oakland, has been operating since late 1971. Oakland police lieutenant John J. Vomacka praises its helpfulness in combatting car thefts and says that the officers who have worked with the digital systems installed in 31 police vehicles were "unanimously enthusiastic" about them. One hundred vehicles in the Oakland fleet will be equipped by December 1975 with the units, which have cathode-ray tubes for displaying alphanumeric information.

Oakland will also be installing a digital dispatching system. A control operator will punch into a computer terminal the location of a trouble spot. And the nearest police vehicle, selected by the central computer, automatically will receive the summons information on the vehicle's CRT, according to Vomacka. As part of the system, digital equipment in the vehicle will transmit its location to the central station. □

Solid state

Fairchild to push Isoplanar MOS

If you had mentioned Fairchild Semiconductor's capability in MOS technology around Silicon Valley a few months ago, you'd probably have heard chortles, at best, from the division's competitors. Many of them didn't take Fairchild very seriously in MOS, but that could be about to change. Fairchild is planning a "blitz" of MOS parts, including a microprocessor that will use the division's proprietary Isoplanar processing technology.

Introduced in 1971, the Isoplanar technique uses oxide isolation to reduce circuit size, boost speed, and lower costs by allowing higher circuit-packing density and higher yields. First applied to bipolar devices, it got Fairchild into high-density bipolar-memory devices [*Electronics*, March 1, 1971, p. 52]. Now, the process has been found to benefit MOS designers as well. By eliminating an oxide step and reducing sidewall capacitance, it produces faster devices.

"By the first quarter of next year, we will have very strong lines of shift registers, random-access memories, and one-chip calculators, as well as the microprocessor," says Philip Thomas, general manager of Fairchild's MOS Products division, Mountain View, Calif.

In addition to the microprocessor (see "Micro CPU to star"), the new products include:

- A line of high-speed static shift registers, as well as the first of Fairchild's first-in, first-out memories.
- "Much improved" high-speed versions of the 1,024-bit 1103, 2101, and 2102 random-access memories.
- A high-speed version of the 4-

1000 cm/µsec stored writing speed, four storage modes, and more.

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The 7633 offers four operating modes: Nonstore, normal and fast Variable Persistence and Bistable modes are available at the touch of a button. And, an 8 x 10 div. (.45 cm/div.) mode gives the instrument's top writing speed.

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No special operating safeguards are necessary with the 7633's rugged, burn resistant CRT. This makes it a dependable unit for design bench, hospital laboratory, service facility or classroom. The large 8 x 10 div. CRT is easy to read in both cabinet and rackmount configurations. An alphanumeric readout, exclusive on Tektronix instruments, makes quick on-screen reference and easy interpretation of photographic records. Or, the instrument may be ordered without the readout for $400 less.

Part of the 7000 Series
Select from thirty different 7000 Series plug-ins. You can custom tailor your instrument to meet your immediate need. And expand its capabilities later as the need arises. A 7633 mainframe costs $3650. A typical configuration with dual trace vertical amplifier and delaying sweep timebase sells for $5,550. For rackmount add $100.

Specifications
Vertical System—Accepts all 7000 Series vertical amplifiers. Bandwidth determined by mainframe plug-in unit up to 100 MHz. Left, Alternate, Add, Chop, Right display modes. Chopped rate approximately 1 MHz.
Horizontal System—Compatible with all 7000 Series plug-ins. Fastest calibrated sweep rate is 5 ns/div. Phase shift between vertical and horizontal is 2°, DC to 35 kHz for X-Y operation.
CRT and Display—Internal 8 x 10 div. (.9 cm/div) graticule with superimposed 8 x 10 div. (.45 cm/div) reduced scan area. Nonstore, variable persistence, and bistable in normal or fast and full or reduced scan storage modes push-button selected.
Writing Speed and View Times—From .03 div/µsec until erased up to 2222 div/µsec at 30 sec view time. View time may be increased more than 30 times by using reduced intensity in the SAVE display mode.

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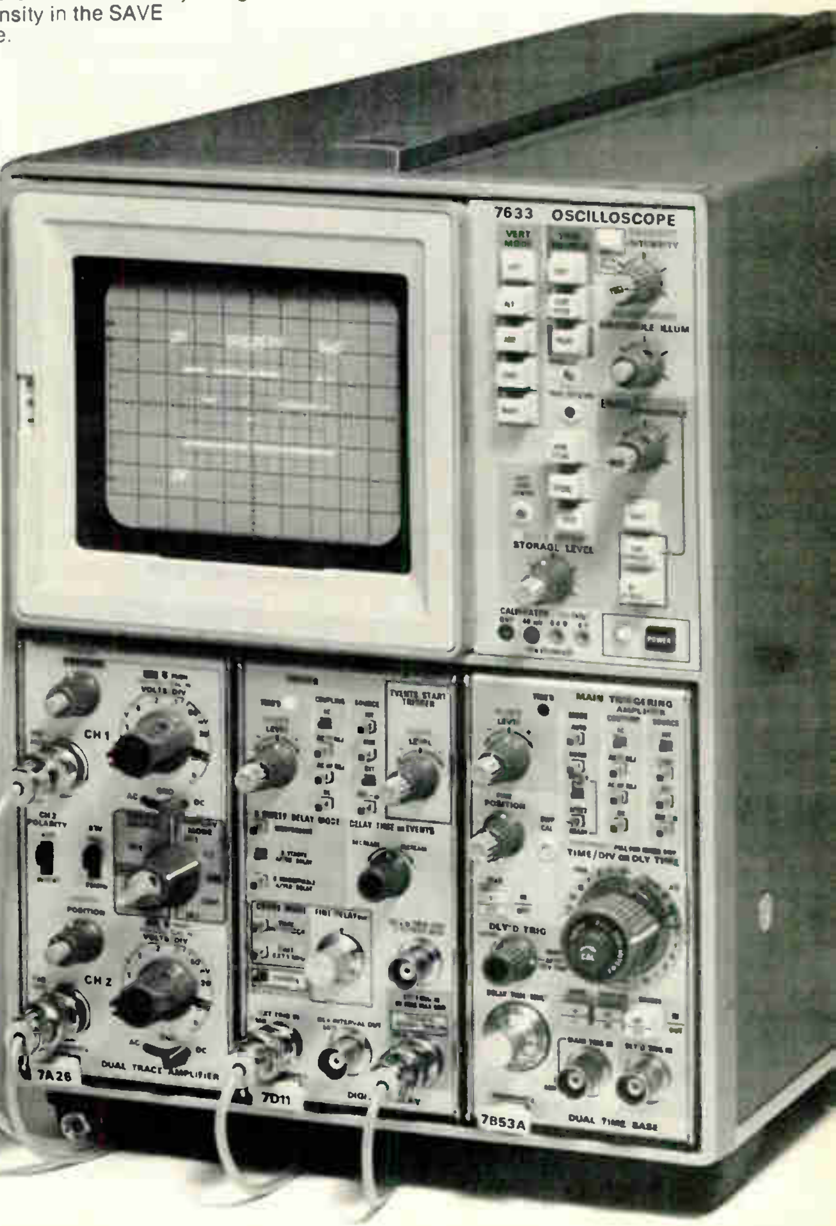

Circle 36 on reader service card

For a demonstration circle 37 on reader service card

Micro CPU to star

An 8-bit, n-channel microprocessor, the F-8, will be the star attraction in Fairchild's forthcoming introduction of Isoplanar products. Sampling of the I/O-oriented device will begin by December.

Cycle time of the F-8 will be about 2 microseconds, the same as that of the Intel 8080. But Fairchild engineers say it will be faster in certain applications.

An important aim of the device design is to eliminate the need that other microprocessors have for substantial numbers of external parts. Both the central-processing unit and a read-only memory chip, which Fairchild also is developing, will have on-board I/O ports and clock generators. And the CPU will include 64 bytes of random access memory, as well as the on-chip interface circuitry. There's enough there so that an F-8 can function in a minimum system with a ROM chip alone, according to Fairchild's Philip Thomas of the MOS Products division.

Overall, Thomas says, "We can save the customer at least 10% in parts cost alone in a typical system".

kilobit RAM that Fairchild is now second-sourcing for Mostek, which will be 100 nanoseconds faster than the original part.

- A family of one-chip, eight- 10- and 12-digit calculators, and a one-chip printing calculator.

"We are sampling this month and will be into volume production within three months with three versions of the n-channel 1,024-by-1 static RAM," Thomas says. They'll be designated the 2102, 2102-1, and 2102-F.

"The first two at 650- and 350-nanoseconds cycle times, respectively, match the standards for these speeds," Thomas continues. "But the 2102-F at 350 nanoseconds is faster, we think, than anything on the shelves".

Fairchild is already sampling 1,024-bit 1103s rated at 220 nanoseconds and has completed testing parts rated at 150 nanoseconds, according to Thomas. "And I suspect," he adds, "that we can make it significantly faster."

Of the Mostek 4-kilobit RAM, the 4096, Thomas says, "we will have one part meeting the Mostek specs at 350 nanoseconds. But another part will be at least 100 nanoseconds faster. It will be designated the 4096-3, which implies we expect to have -1 and -2 versions."

Sampling of these Isoplanar RAMs will begin late in the fourth quarter.

Originally introduced in a product in 1971, the Isoplanar process made quite an impact for Fairchild. While most of its competitors were still struggling to get their first high-density bipolar processes on stream, Fairchild even extended the Isoplanar concept to a family of emitter-coupled-logic devices. The process brought about much tighter circuit designs than before, which allowed operation at subnanosecond speeds and reduced powers per gate [*Electronics*, Feb. 15, 1973, p. 41].

These ECL devices were followed by an Isoplanar complementary-MOS family that is directly interchangeable with RCA 4000 devices, but operate at higher performance levels [*Electronics*, Dec. 20, 1973, p. 25]. The company's first MOS Isoplanar memory product—the 3355, a 4-megahertz static shift register—was introduced in September 1973. □

Lasers

Distributive gallium-arsenide laser moves optical ICs a step closer

In the same way that current is channeled and controlled in silicon integrated circuits, optical ICs can be developed to manipulate light. A recent major step toward such integration of optical systems was the operation of distributed-feedback injection lasers built into monolithic chips of gallium arsenide.

Experimental devices have been demonstrated by both the Aerospace Corp. and Xerox. The new lasers—electrically pumped gallium-arsenide devices—depend for the feedback that sustains their lasing action on a grating deposited on their upper surfaces. Conventional semiconductor lasers depend on optical feedback from mirrors cleaved into their opposite ends, something that can be done only in discrete devices. The new lasers, however, could be integrated in a substrate of gallium arsenide that contains other optical components as well.

Integrated optics are being pursued vigorously in many research laboratories because of the promise they offer for communications systems. Data rates and bandwidth could be much higher—theoretically 10,000-fold—because of the higher frequencies. The military is especially interested in optical data exchange because it appears impossible to intercept, and is resistant to electromagnetic interference.

The use of distributed-feedback lasers as oscillators and amplifiers with other light-frequency equivalents of such elements as modulators and waveguides should make possible integrated optical circuits for compact, low-loss optical-processing systems. The components have been available individually. But they are generally too bulky, and interface losses are too high as signals pass from one element to the next.

Ripple. The lasers developed by Xerox Corp., Palo Alto, Calif., and by Aerospace Corp., El Segundo, Calif., are similar in many respects, and both are developments of earlier concepts. The key to their operation is the use of a periodic perturbation in the surface of a gallium-arsenide chip to which a pulsed high-density current is applied.

Because of refraction, the surface acts like thousands of small mirrors, providing the feedback necessary for lasing. This structure, first described two years ago by Herwig

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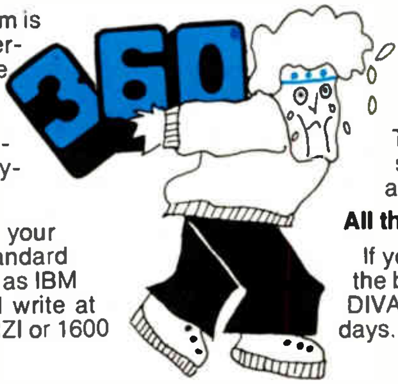

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Recording format	9 track — 0.6″ nom IRG	9 track — 0.6″ nom IRG
Tape loading	Fully automatic: 7 secs approx	Fully automatic: 7 secs approx.
Rewind		
Speed	500 ips	500 ips
Time	45-70 secs	45-70 secs
Start/stop time	IBM compatible (2 msec nom)	IBM compatible (2 msec nom)
Speed variation	±3%	±2%
Transfer rate	320KB max	200KB max
Tape characteristics		
Type	½ inch	½ inch
Reel	Std reels of 10.5″, 8.5″ or minireel; or IBM cartridge	Std reels of 10.5″, 8.5″ or minireel; or IBM cartridge
Environment		
Temperature	50° to 110°F (op)/ –30°F to 150°F (non-op)	50° to 110°F (op) –30° + 150°F (non-op)
Relative humidity	20% to 80% (op)/5% to 80% (non-op)	20% to 80% (op)/5% to 95% (non-op)
Power	208/230 VAC, 3 phase, 60 Hz	115/208/230 VAC, single phase, 50/60 Hz
Dimensions	67″H x 30″W x 29.5″D (stand alone drive)	24½″H x 19″W x 19″D (rack mtd drive)
Weight	900 lbs approx	230 lbs approx
Controls	Load/rewind ■ Rewind/unload ■ Start ■ Reset ■ Power on/off	Load/rewind ■ Rewind/unload ■ Start ■ Reset ■ Power on/off
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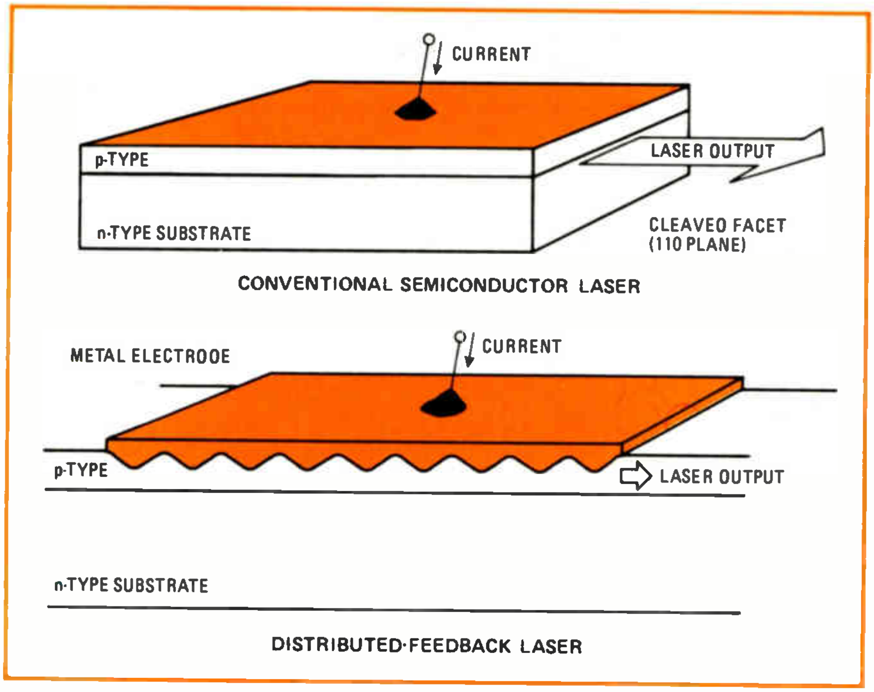

IC laser. Feedback for integrated laser comes from grating on surface. Without cleaved ends, laser could be built into chip with other devices to form optical IC.

Kogelnik and C. V. Shank of Bell Laboratories, had been demonstrated with optical pumping, a technique incompatible with miniature integrated optical systems.

The Aerospace laser, developed by Harold M. Stoll and David H. Seib, members of the technical staff of the Electronics Research Laboratory, is a homojunction device. Although it now operates best at 77 K, it may ultimately be refined to operate at room temperature. The laser is fabricated on a chip 15 mils by 65 mils by diffusing p-type material (zinc) into heavily doped n-type gallium arsenide, forming a thin (1.5-to 1.7-micrometer) junction (see illustration.) The distributed feedback was introduced with a shallow ripple structure machined into the surface with argon ions.

The ripple was made by first spin-coating the surface with photo-resist, then exposing it to a grating pattern (with a 3,500-angstrom periodicity) formed by the standing waves between two interfering laser beams. The pattern was then machined into the material with a beam of argon ions. A single machining went to a depth of only 500 Å, insufficient for lasing. This was followed by shadowing the GaAs grating with aluminum at a glancing angle, then ion-machining. This was repeated three times to final depth of about 1,200 Å.

The grating was then covered by a 3,000-Å layer of evaporated silver-manganese, and an additional 800-Å gold film. This metalization was chosen because of its minimal penetration into the surface of the GaAs. The ohmic contact, which is about 35 mils by 6 mils, is perpendicular to the grating ridges. The unmetalized region surpresses Fabry-Perot oscillations, the feedback mechanism for conventional lasing.

The Aerospace lasers have line spectra at 8,420 Å and 8,459 Å. Definitive measurements haven't been made yet, but spectral width appears to be less than that of injection devices. By changing the grating periodicity, the output wavelength can be varied over approximately a 100-Å range. Power has not been measured, either, but it appears comparable to output of diode lasers.

Xerox's laser is similar in structure, except for an additional gallium-aluminum-arsenide layer 30 μm thick, deposited on top of the grating, which gives a smooth finish that is easy to metalize. □

Communications

OTP favors ways to aid AT&T rivals

The White House communications policy chief has urged Congress to rewrite Title II of the 1934 Communications Act to separate and perhaps free competitive communications services from the rigid Federal Communications Commission regulation that applies to the AT&T telephone network monopoly.

Clay T. Whitehead, director of the Office of Telecommunications Policy, also told Congress that "antitrust laws should be enforced so that regulatory mechanisms cannot become a haven for escape from competition." Whitehead testified during hearings on the communications industry before a Senate subcommittee on antitrust and monopoly, chaired by Sen. Philip A. Hart. The Michigan Democrat is holding hearings on his bill, the Industrial Reorganization Act (S. 1167), to break up large corporate concentrations of industrial power in the U.S. Congressional observers give the bill little chance of enactment.

Support. Nevertheless, Whitehead used the Senate hearing as a platform from which to support limitation of AT&T's "natural monopoly" to the public telephone network, while opening it to free interconnection of customer-provided equipment. Whitehead, who later told the chairman that "the general thrust of my statement does reflect Administration policy," called for change in the 1934 Communications Act, under which FCC operates, to recognize the existence of new technologies and to make it more equitable for a potential competitor to enter the market with them. The way the FCC operates, Whitehead observed, "the would-be provider of a new communications service, rather than the monopolist, is now required to justify his existence, and the monopolist, rather than the would-be customer, receives the protection of the regulatory machin-

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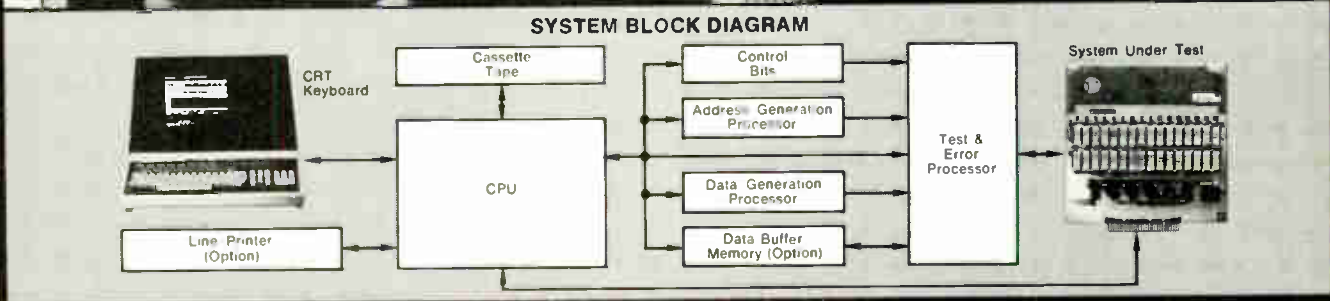

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Circle 41 on reader service card

ery" (see "Can the FCC cope with changing technology?" p. 106).

Monopoly. Future communications policy, the OTP chief said, should recognize four principles:

- The public-utility monopoly in conventional telephone service is still appropriate today.
- The monopoly concept should not be extended to other communications services.
- New competitors should be free to offer any service except conventional public telephone service.
- Any telephone customer should be allowed to buy and use any communications device over telephone lines.

Whitehead hit hard on the interconnection issue, striking indirectly at FCC's pending Docket 20003, which will consider the economic impact of interconnection. He also issued a warning that the Government may look into AT&T's increasing political and legal activity to protect its position. "Business success should be won competitively in the marketplace by providing goods and services that customers want," he said. "It is unbecoming for a company the size and the stature of AT&T to use its legal, political and economic power to seek to extend its monopoly by Government fiat into areas where monopoly is not called for. In my judgment, the Government cannot let such an effort go unnoticed or unchecked."

The efforts by AT&T and other telephone companies were called by Whitehead "the recent aggressive campaign" to declare a moratorium on competition, which he said will injure "the development of new communications services by slowing the infusion of capital and raising the legal fees required to challenge the established carriers in the courts and at the FCC."

Rebuttal. With more witnesses to testify in its behalf at the end of July, AT&T's rebuttal at the session where Whitehead appeared was limited to consulting economist Robert R. Nathan and Robert E. La Blanc, respectively vice president and technology group manager of Salomon Brothers. Challenging Whitehead's assertion that rate-av-

News briefs

Commercial service starts on Westar

Western Union, pulling hard and successfully against governmental foot-dragging, began commercial service on the U.S.'s first domestic communications satellite on July 15. Using the original Morse telegraph key, Western Union chairman and president Russell McFall sent Morse's own first message "What hath God wrought?" from New York to Los Angeles via Westar.

Originally planned in January 1970 as part of the White House's "Open Skies" recommendations, the domestic satellite did not receive a go-ahead from the Federal Communications Commission until December 1972, almost three years later. However, anticipating the move, Western Union had contracted in August of that year with Hughes Aircraft Co. for the Westar which, finally, was launched last April 13.

Modem firm builds display system

International Communications Corp., Miami, Fla., is venturing outside of the data-modem field for the first time with a new cathode-ray-tube data-display terminal that's a teletypewriter replacement with editing capabilities. Built around the Intel 8008 microprocessor, the 40+ terminal has all the control functions built into a read-only memory. The microprocessor also aids in editing and fault diagnosis, and it performs calculations on displayed data. The 40+ operates at 1,200 bits per second in an asynchronous mode or 2,400 b/s, synchronously.

Fairchild's Polish deal rejected

Fairchild Camera & Instrument Corp.'s March 1973 petition for a license to supply Poland with integrated circuits and production know-how has been rejected by the Commerce Department's Office of Export Administration on the grounds that the ICs may be used in Polish military applications. However, Fairchild may yet appeal the decision to Commerce secretary Frederick Dent or to the National Security Council.

Bunker Ramo wins $10 million bank contract

Bunker Ramo Corp.'s Information Systems division, Trumbull, Conn., and the Bank of America have signed a $10 million contract to equip the bank's domestic offices with a newly developed data-communications system built by Bunker Ramo. Called the Community Office On-Line System (Cools), the system will enable the bank's 5,500 counter and desktop CRT terminals around the country to access information in the bank's central computers.

Electronic equipment sales rise 7.1%

U.S. electronic equipment sales rose 7.1% to $31.6 billion in 1973 from $29.5 billion in 1972, according to the Electronic Industries Association. Communications and industrial electronics recorded the biggest gain, up 12.9% to $12.9 billion for a 41% share of the total U.S. market. Sales to the Federal Government rose 1.9% to $10.8 billion, but the small increase was insufficient to prevent the Government share of the total market from registering its third consecutive annual decline, down 1.8% to 34.2%.

In addition, consumer electronics also posted a dollar increase for the year of 4.2% to $6.6 billion, but the consumer share of the total market also dropped fractionally to 21.5% in the face of the large industrial market growth. Replacement component sales of $920 million reflected a sharp 29.6% increase from the year before.

FAA's bright-radar order totals $2.5 million

The Federal Aviation Administration has ordered 111 extra-bright radars costing about $2.5 million from ITT Aerospace/Optical division, Fort Wayne, Ind. The systems will be used at approximately 35 airports by traffic controllers in towers that are subject to extremely high and variable light levels. The FAA has already installed 213 of the units at other airports.

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eraging could be retained for the basic telephone network, while allowing competitive pricing for the 5% of Bell System revenues that are subject to competition, Nathan asserted, "You can't draw such a nice line." Putting communications on a cost basis completely will mean that "we are in for trouble." □

Calculators

Reaction is cool to TI patent

In the wake of the announcement by Texas Instruments that the company had been issued a patent covering a miniature electronic calculator, [*Electronics*, July 11, p. 43] it's still difficult to tell how well the semiconductor and calculator giant intends to protect its development—or if it can.

TI's announcement of the patent award included a terse statement that the company would make licenses available to the industry "in the near future." But there doesn't appear to be any stampede of competitors toward Dallas to get licenses; nor has TI been after them to start any licensing negotiations.

Harvey Lowhurst, patent counsel for National Semiconductor Corp., says the TI patent doesn't apply to National. In its specific interpretation, he says, the TI patent would apply to a specific design. And because National's calculators are of a different design, they wouldn't be subject to the TI patent.

"If the patent is interpreted generally as applying to all calculators," he continues, "National is covered by a cross-licensing agreement the company signed with TI in the mid-1960s which encompasses all ICs. And in our view, the calculator chip is just another IC."

Officials at Bowmar/Ali Inc. haven't been contacted by TI about a license, and they believe their own patent, issued last December, protects their calculator business. A spokesman says, "Our patent covers a broad combination of an IC chip and hand-held calculator using a keyboard and LED readout." And Berry Cash, executive vice president of Mostek Corp., says he's "sure it will be challenged," referring to the TI patent. Mostek, which marketed the first single-chip calculator, now manufactures and sells personal calculators through Corvus Corp., a wholly owned subsidiary. □

Detective. User keys in number, provides a fingerprint. Fingerscan does the rest.

Commercial electronics

Fingerprint file controls access

With about 100 bills in Congress aimed at safeguarding data in computer installations [see p. 78], the search is about to begin for a most vital part of any security system: a device that limits access to authorized persons only. Orders already have been placed for the first automatic fingerprint reader capable of controlling access to commercial facilities, including computers, according to Calspan Technology Products Inc., Albany, N.Y.

Calspan's Fingerscan unit is used by a person wanting to access a computer data bank or a controlled-

access area such as a bank vault or apartment complex. The person seeking entry first registers an identifying number on the small keyboard in a console the size of a coin-operated telephone. Marketing manager Frank G. Woods says that a scanner then compares the applicant's fingerprint to the file print stored in a central-processing unit.

If the scanned image and the file image match, the applicant is permitted access within 2 seconds. If the two do not match, the applicant is instructed to place another finger on the scanner. If the second finger image and file image do not match, then the processor sounds an alarm, denies access, or sends a signal to the police.

Potential. Widespread commercial applications are being predicted by Calspan officials, who say that computer-access accounts for only 25% of the potential market. "Computer-access was something totally unexpected when we first planned the unit a few years ago," says one Calspan official. Then, the unit was anxiously awaited for use in police installations, banks, and apartment buildings.

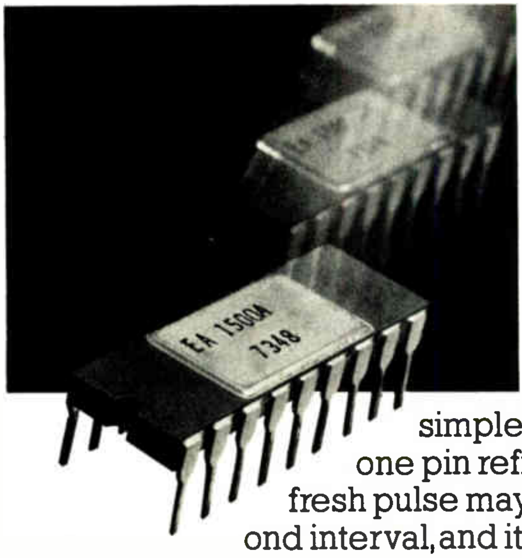
System prices will vary according to the number of terminals and storage capacity of the central unit. A standard system can store a maximum of 500 sets of fingerprints and handle 15 terminals, Woods says. The unit's maiden commercial appearance is at the International Identification Association's annual meeting July 29 through Aug. 1 in Washington, D.C.

Fingerscan's accuracy is rated at one incorrect access in 1,000 attempts, although Calspan officials said the system can be "tightened up" to reduce this to one error in a million or less.

Systems will sell for $20,000 to $30,000, or more, depending on the number of Fingerscan terminals. A computer-access consultant said the system "is much too expensive" for widespread use by data banks with hundreds of terminals, but one Government official familiar with the potential market said intensive commercial development could bring the price down. □

NEW TOP-SPEED MOS RAM.

N-CHANNEL, OF COURSE



With a guaranteed maximum access of 60 ns, EA's new 1024-bit RAM is ready to take its place in the fastest MOS memory system you can build.

We designed the EA 1500A to make your system as simple as possible.

For example, the RAM is fully decoded, can be OR-wired to expand capacity and needs only two supplies, +15v and −15v. Power dissipation is only 0.22 mW/bit in action and 0.045 mW/bit on standby.

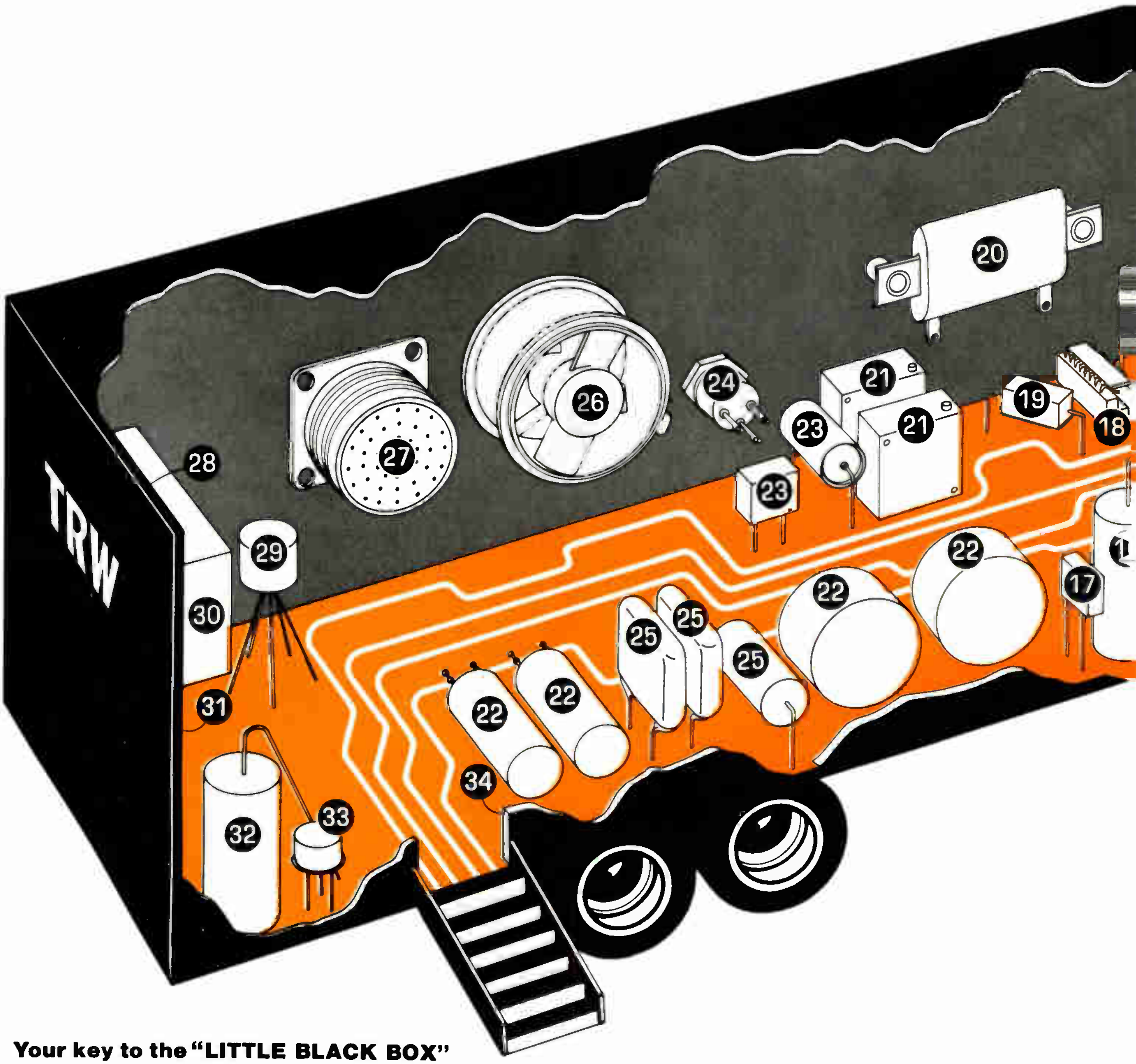
To achieve low power, we had to make the RAM dynamic—but we made the refresh technique as simple as you can imagine. One pulse on one pin refreshes the entire memory. The refresh pulse may occur anytime within a 2-millisecond interval, and it will not interfere with read/write cycles. Your memory is never busy.

The EA 1500A in an 18-pin silicone DIP costs only $13.00 in quantities of 500.

It's in stock right now at our nationwide distributors, Cramer Electronics, and at Electronic Arrays, Inc., 550 East Middlefield Road, Mountainview, Calif. 94043. Phone (415) 964-4321.

electronic arrays

Circle 47 on reader service card



Your key to the "LITTLE BLACK BOX"

1. **CONNECTORS,** Printed Circuit
2. **PRINTED CIRCUITS,** Multilayer
3. **CONNECTOR SYSTEMS,** I C Logic
4. **SOCKETS,** Tube
5. **BARRIER TERMINAL BLOCKS,** "Jones" Type
6. **FILTERS,** RF Bandpass
7. **CONNECTORS,** Rack and Panel
8. **DIODES,** High Speed Power
9. **DARLINGTONS,** Monolithic
10. **AMPLIFIERS,** Magnetic
11. **TRANSFORMERS,** IF and RF, TV
12. **CAPACITORS,** Variable Mica, Compression
13. **CAPACITORS,** Solid Tantalum
14. **SOCKETS,** Transistor
15. **TRANSISTORS,** RF Communications
16. **RESISTORS,** Wire Wound, Molded
17. **RESISTORS,** Thick Film (Metal Glaze)
18. **SOCKETS,** Integrated Circuit
19. **RESISTORS,** Flame Proof
20. **RESISTORS,** High Voltage, High Frequency
21. **TRIMMERS,** Wire Wound
22. **POTENTIOMETERS,** Multi Turn
23. **CAPACITORS,** Metallized Film
24. **TRANSISTORS,** Power, Switching
25. **CAPACITORS,** Film
26. **FANS,** Miniature Precision, AC or DC
27. **CONNECTORS,** Cylindrical
28. **FASTENERS**
29. **TRANSFORMERS,** Pulse
30. **MOTORS,** Miniature
31. **POWDERED METAL PRODUCTS**
32. **RESISTORS,** General Purpose
33. **TRANSISTORS,** Single Sideband, Linear
34. **CABLE HARNESS & ASSEMBLIES**

News update

Low-price TV camera selling well in Japan The Japanese were presented a year ago with a portable TV camera that was priced at $770 [Sept. 13, 1973, p. 62]. The price since then has risen to $1,028, but Tokyo Shibaura Electric Co., developer of the single-tube camera, says it's selling the 200 or so units it's producing each month. Sales are 40% each to schools and industry, with the remainder to individuals. When will the camera be available in the U.S. and other countries? Just as soon as the equipment gains Underwriters Laboratory approval, says Toshiba. Why the low price? Toshiba manages to get good performance from vidicon with a standard antimony trisulphide photoconductor rather than having to use an expensive photoconductor.

Electronic license plates to be road tested soon If you're intending to hijack a truck, it might be a good idea to carry out the caper soon because the Department of Transportation has a plan to make the job much harder. The plan centers on an electronic license plate that was announced prematurely last year [Sept. 13, 1973, p. 50]. But now that bugs have been worked out by Information Identification Inc. of Fort Worth and its parent, Hoffman Electronics Corp., El Monte, Calif., tests will start soon. Ten trucks and a police helicopter in the New York City area will be equipped with the plates—actually, transponders—and interrogation gear in the copter.

Maker of road call box to do own marketing Electronic license plates are fine for truckers, you might say, but what has anyone done lately for the poor motorist? Well, here comes help—specifically, the so-called Help Box, a roadside call box from which a computer is signaled when a motorist needs help. The boxes were to be sold by ADT Corp. of New York [May 24, 1973, p. 36], but now the manufacturer, Solid State Technology Inc. of Wilmington, Mass., will do its own selling. Solid State is setting up a U.S. distributor network, while ADT retains international rights. The reason for the switch, according to Solid State's Bob Santoro, director of operations, "We are a younger and more aggressive company."

Victor puts off systems, still eyes point-of-sale The last major electromechanical calculator maker to convert to electronics was Victor Comptometer Corp., and a year ago it was still in the throes of that change [Sept. 13, 1973, p. 41]. Since then, it has solidified its high-end position with the industry's least expensive line of programables and entered the low-end derby with a $49.95 hand-held unit. But plans for more systems-oriented products, such as a small billing and accounting system scheduled for this year, have been tabled for the present, indicates James Sheridan, new Victor president and formerly Litton Industries senior vice president responsible for Monroe, Sweda, and Kimball Systems divisions. The firm is still considering the point-of-sale business, and will bring its first stand-alone electronic cash register to market later this year.

Fairchild seeks buyers for its CCD camera There was some excitement among competitors and on Wall Street last summer when Fairchild Camera & Instrument Corp. introduced a commercial charge-coupled-device camera [Aug. 30, 1973, p. 36]. Although not intended to meet TV broadcast standards, the MV-100 was aimed at surveillance, medical instrumentation, and process-control markets. And perhaps equally important, Fairchild hoped its little marvel would help it gauge the market potential for a CCD camera. In fact, the MV-100 was billed as the first in a series of cameras that eventually would replace vidicon-tube TV cameras. A year later, Fairchild says it's "negotiating" with potential customers in an attempt to increase sales from the "several" it has sold to individual experimenters, R&D labs, and Government labs.

Hughes delivering parts made with pad-relocation Hughes Aircraft Co. decided to revive its pad-relocation technique last year [Sept. 13, 1973, p. 40] with a $428,000 contract for parts for a data-transmission system. Pad relocation, the Hughes version of full-wafer LSI (something like the discretionary-wired LSI promoted but dropped by Texas Instruments) was said by Hughes to be highly reliable. Since then, the firm has been delivering parts to its customer, General Atronics Corp. of Philadelphia, a Magnavox subsidiary that's building high-frequency codem (coded modem) equipment for the U.S. Naval Systems Command. The parts, using pad relocation to substitute good logic cells for bad ones, will be delivered during the rest of 1974.

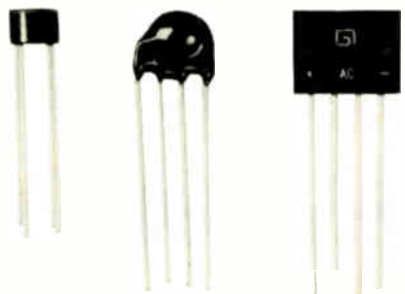
Macrodata soft-pedals patent-protection actions Macrodata Corp. is playing its patent cards close to the vest. Last year, president William C.W. Mow said that, since his company had received a patent covering the basic techniques used in memory testing, he has decided to "protect his interest" [Sept. 13, 1973, p. 35]. He added that he intended to get royalties from competitors who he said are violating his patent, or make them quit manufacturing. Now, Mow won't say much about his fight. He discloses that a few letters have been written, but that Macrodata hasn't gone to court. Beyond that, Mow is mum. **—Howard Wolff**

Intended to bring *Electronics* readers up to date on news stories of the past months.

A CHECK

ON ¾A AND 4A BRIDGE RECTIFIERS

	GENERAL INSTRUMENT	MOTOROLA	VARO	UNITRODE	SEMTECH	DIODES INC.
1—Who has a 4A rated bridge rectifier?	☑	☑	☐	☐	☐	☐
That does not require heatsinking?	☑	☐	☐	☐	☐	☐
At 85¢* each in 10K quantities?	☑	☐	☐	☐	☐	☐
2—Who has a ¾A rated bridge rectifier?	☑	☐	☑	☐	☐	☐
Available in three case styles?	☑	☐	☐	☐	☐	☐
All at 20¢* each in 10K quantities?	☑	☐	☐	☐	☐	☐
3—Who has a bridge rectifier that can replace 4 rectifiers at no additional cost?	☑	☐	☑	☐	☐	☐
4—Which is the first and only company using flame-retarding materials (classified 94V-0) in the construction of its rectifiers and bridge rectifiers?	☑	☐	☐	☐	☐	☐
5—Which company should be checked for the lowest priced bridges, anywhere?	☑	☐	☐	☐	☐	☐



75WOM .75A 20¢*
WOM 1.5A 25¢*

75KBD .75A 20¢*
KBD 1.5A 25¢*

75KBP .75A 20¢*
KBP 1.5A 25¢*
KBL 4.0A 85¢*

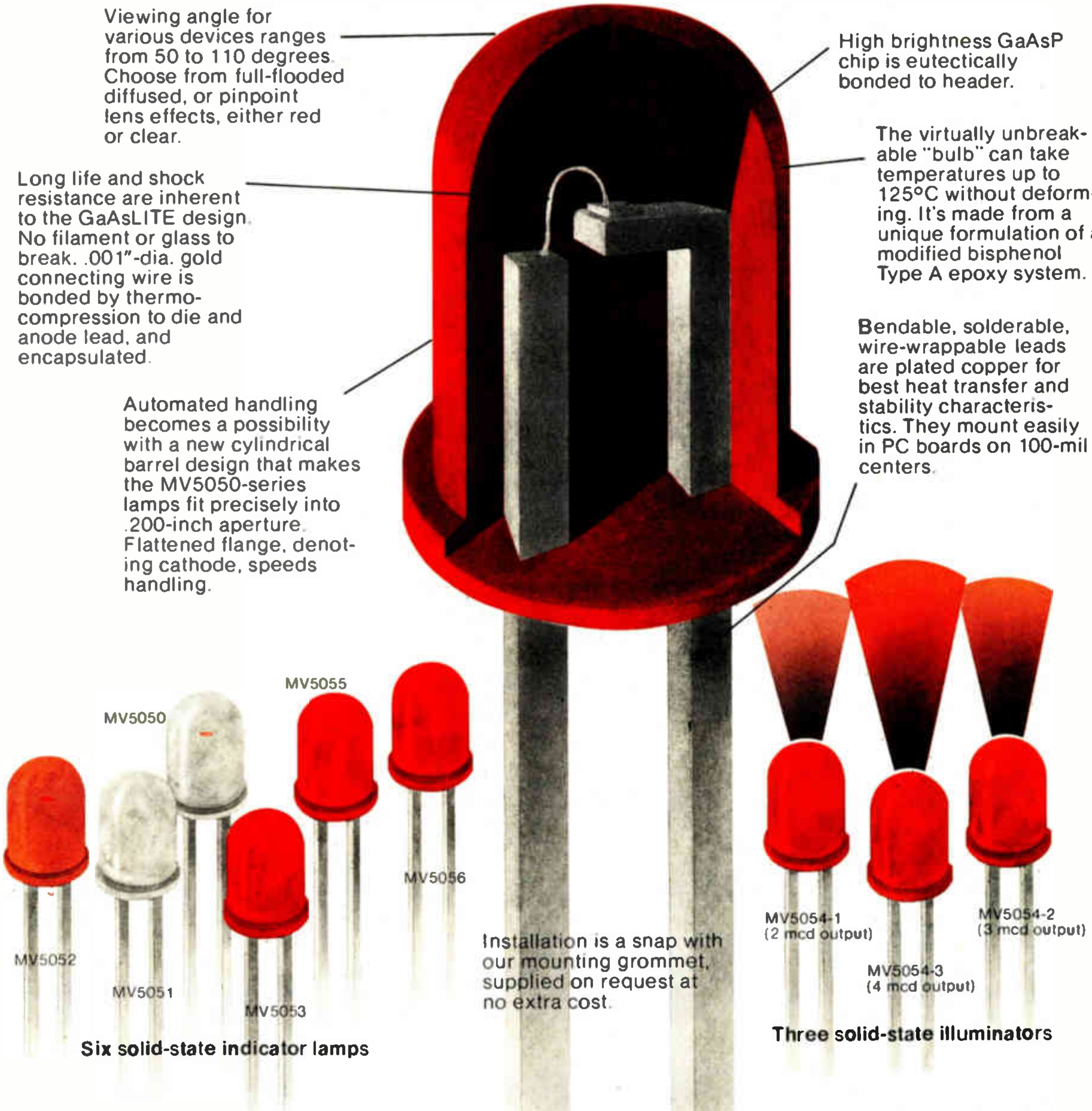
*PRV @ 400V or lower, 10,000 units scheduled within 60 days.

GI'S GOT IT!

For complete information on GI's bridge rectifiers, call toll-free 800-645-1247 (In New York State call 516-733-3235) or write, General Instrument Corporation, Semiconductor Components Division, 600 W. John St., Hicksville, N.Y. 11802.

GENERAL INSTRUMENT CORPORATION
SEMICONDUCTOR COMPONENTS

MV5050-series GaAsLITEs: Worth looking into.



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Washington newsletter

U.S. not opposed to IBM/Comsat plan; FCC to decide by fall

The Federal Communications Commission is aiming for a September decision on **IBM Corp.'s proposal to enter the domestic satellite business in a joint venture with Comsat General Corp.—and the Justice Department's antitrust division has no plans to oppose it.** This disclosure came from officials at the two agencies as IBM and Comsat General formally filed with the FCC their plan to acquire the two-thirds interest in CML Satellite Corp. now held by cash-hungry MCI Communications Corp. and Lockheed Aircraft Corp. [*Electronics*, July 11, p. 26]. IBM Satellite, a new subsidiary, would hold 55% of the stock, while Comsat General would increase its present one-third share to 45%.

The Lockheed-designed satellites proposed for use by CML may not be used by the new company. In any event, since the would-be owners plan a joint system study to evaluate the needs of a commercially attractive system, **the old CML target launch date of 1977 for its first satellite will slip at least a couple of years—possibly more** if opposition to the venture develops before the FCC.

Economics of solar plant confound systems designers

Systems design engineers in industry and the universities are calling the Naval Research Laboratory by the score to express interest in its **plan to develop energy-collecting components for the first solar-powered electrical generating plant** [Electronics, July 11, p. 26], but they find the economics of the NRL proposal mind-boggling. Respondents are being asked "to brainstorm" **systems "that may be fabricated and installed in large quantity for perhaps one tenth or less of the cost of 'radar' types of platforms and reflectors, as well as low-cost reactors."**

The 100-megawatt plant, as conceived by NRL, "may consist of thousands of upward-reflecting, off-axis paraboloidal solar collectors," 20 to 60 feet in diameter, that, by causing the **"dissociation of a polyatomic gas like SO_3 in a closed-cycle circulation system"** would provide chemical energy for ultimate transformation into electricity.

FCC policy post to be headed by Wiley aide

Watch for **Werner H. Hartenberger to be named chief of the Office of Plans and Policy at the Federal Communications Commission** by chairman Richard E. Wiley. Hartenberger, now administrative aide to Wiley, will fill the vacancy created late last year when Walter R. Hinchman left the post to become chief of the FCC Common Carrier Bureau. In a related move, a new FCC consultant position will be created for Walter E. Sutter, now assistant director of the White House Office of Telecommunications Policy. Sutter will advise the commission on a variety of matters, including spectrum management.

Space Shuttle orbiters, controls make progress

Rockwell International has just received $483 million as NASA's second payment toward the $2.6 billion cost of designing and building two Space Shuttle orbiters, and **Honeywell has already delivered the first breadboards of the shuttle control subsystems** to the agency, having spent only $14 million to develop them—less than the budgeted cost, says an official. After tests and evaluation, the two-axis accelerometer, servo-actuator drives, and other controls will be manufactured for two shuttles. **Remaining design and development of major components will begin in fiscal 1975,** NASA says.

Changing the status quo in communications

If the Federal Communications Commission, just turned 40, is showing its age, so is one of its principal concerns, the American Telephone & Telegraph Co. The difference in the two patterns of aging, however, is that the FCC cannot adapt to change without a mandate from the Congress, while AT&T does not want to change at all.

Clay T. Whitehead, director of the White House Office of Telecommunications Policy, summed it up neatly in early July when he advised a Senate subcommittee that "our regulatory mechanisms and the structure of our common carrier communications industry are becoming obsolete." Whitehead believes "we should seek to redefine the regulatory framework within which the FCC and the industry operate, rather than cast blame on those who seek to do the best they can under an outdated regulatory framework." The redefinition, he suggests, will have to come from the Congress through a revision of Title II of the Communications Act of 1934, by which the FCC was created and under which it operates (see p. 35).

Saving the FCC

The need to rewrite the rules under which the FCC operates is critical if the commission is to continue to function effectively. As things stand at the moment, it is on the verge of being overwhelmed both by petitions for new applications of communications technology spawned by two decades of rapid innovation in electronics and by continuing disputes with AT&T and its competitors over who may serve a given market and how.

Some communications specialists find it remarkable that the FCC has somehow thus far succeeded in bending a 40-year-old regulatory system, designed with only telephone and telegraph services in mind, to accommodate altogether new technologies and services. To Whitehead, however, what is more remarkable about such decisions is "the difficulty and the slowness with which they were made." This, he says, shows "how the regulatory apparatus of the 1930s has come to be a major impediment to the natural growth of new communications services."

Though Whitehead and AT&T agree—along with many others in communications—that the time has come to change the rules under which the FCC operates, they are poles apart on the nature of those changes. Where Whitehead favors limiting AT&T's monopoly to telephone services and permitting competition for new communications services, AT&T is vigorously opposed. Still, an increasing number of communications interests are beginning to agitate for congressional action to alter the FCC's outmoded regulatory structure (see p. 106).

Priorities and prospects

But the Congress has yet to receive anything resembling a firm proposal to reconsider the 1934 communications act. And with the pressures of an impeachment proceeding and a national election still before it, the Congress is unlikely to give much thought to the FCC this year. In 1975 the story may be different.

Whenever the time comes, there are many opponents of the AT&T monopoly, as well as a few of its supporters, who believe the company's adamant stand against competition of any kind will cast it as the corporate bad guy in any congressional hearing. Calls for the dismemberment of AT&T into a number of independent operating companies are few and insignificant now, although there is an increasing number of voices heard in Washington suggesting that AT&T be required to spin off its manufacturing arm, the Western Electric Co.

Even the OTP's Whitehead has touched on this politically sensitive subject, noting that "a restructuring of the communications industry may be necessary if competition and monopoly are to co-exist constructively." And last year the Department of Justice indicated its antitrust division's interest in AT&T's activities by issuing an eight-page civil investigative demand for company documents relating to interconnection of customer-provided terminals to the telephone network [*Electronics*, Dec. 20, p. 50].

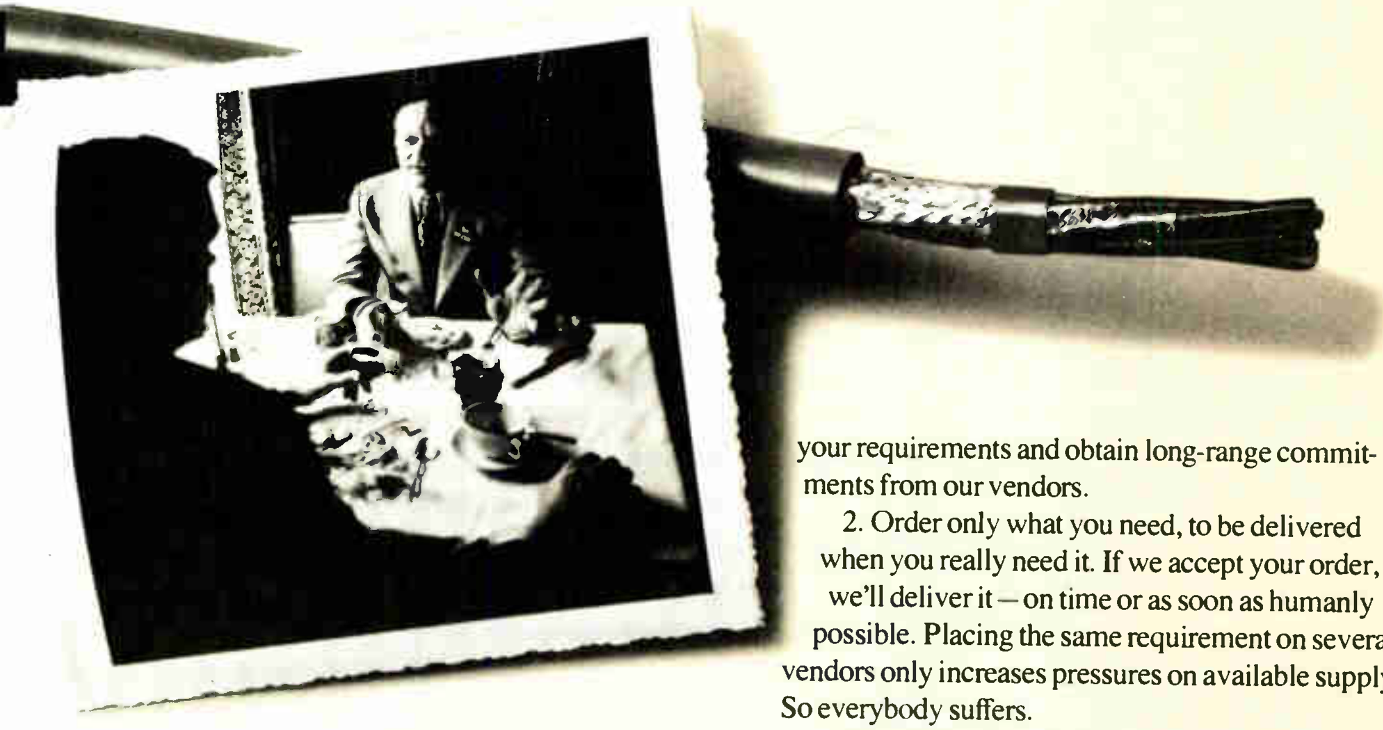
Interim action

Yet any antitrust action would involve years of litigation before it could be resolved. And since there is no promise of any congressional consideration of the FCC regulatory structure for at least a year, where can the communications industry look for relief in the interim? It must of course look to itself.

Altering the status quo cannot be done easily or quickly. But if the communications services industry is to flourish in a competitive atmosphere, the people who develop the technology that make innovation possible must give more thought to the politics of its implementation. To generate support for competition, rather than monopoly, will require much more lobbying in many more places than the industry has undertaken in the past. **—Ray Connolly**

Yes We Can is a two-way street.

A word to Brand-Rex customers on ways to help reduce supply problems.



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We understand the trouble you're having in getting the wire and cable you need. And we're doing something about it.

Our "Yes we can" program is not a hollow slogan, it's a coordinated, company-wide effort to make supply shortages less of a burden to you. And we've taken dozens of specific steps, large and small, in pursuit of this goal.

But we're not there yet. To make the program really work, we need your help.

Here are some things you can do:

1. Keep us posted, as far in advance as possible, of upcoming wire and cable needs so we can schedule your requirements and obtain long-range commitments from our vendors.

2. Order only what you need, to be delivered when you really need it. If we accept your order, we'll deliver it—on time or as soon as humanly possible. Placing the same requirement on several vendors only increases pressures on available supply. So everybody suffers.

3. Talk with our engineers before finalizing specifications, so we can match your requirements against available materials—and where necessary be open to recommended substitutes or design changes.

4. Understand that there is only so much either we or our vendors can do to eliminate supply shortages. You can help by accepting the shorter-than-specified cable lengths that are part of all manufacturing processes—if you can use them. That's one way to minimize waste.

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Circle 55 on reader service card

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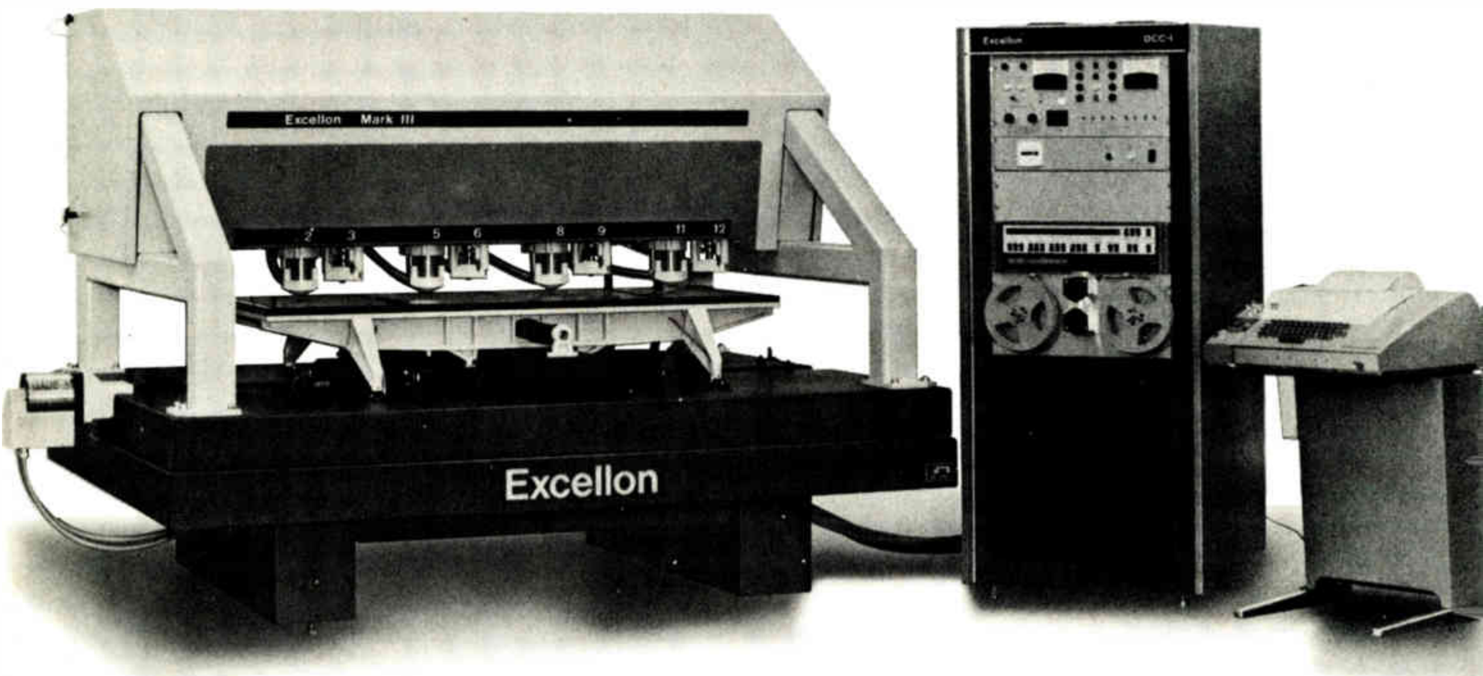

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Ship positioning system works in heavy weather

When a midget submarine was missing off the coast of Florida last year, not even the most sophisticated tracking and rescue gear could locate the vessel in time to save the crew's lives. To avoid that happening again, the Florida foundation that operated the sub turned to a new and far more accurate French acoustic measuring technique. Others are interested in the approach, too, and CIT-Alcatel, developer of the technique, is moving into the much bigger market of offshore oil rig positioning.

By next summer a modular computer-controlled dynamic positioning system based on this technology will be in operation aboard the French-owned Pelican deep-sea oil drilling ship. At depths of up to 3,000 feet—almost 10 times deeper than most current drilling operations—the system locates position on the seabed with an accuracy of less than 1% of water depth in good weather or about 6% in storm conditions.

Noise. The French company is in competition with Honeywell, the world's biggest manufacturer of acoustic positioning systems. Key to CIT-Alcatel's technique, developed from its work with the French navy's advanced submarine fleet, is its ability to operate effectively amid all the din of propellors, thrusters, and drilling rigs—which would put most acoustic devices out of action.

The fully redundant system is based on one or two on-board acoustic interrogation transducers, two seabed transponders located close to the drilling hole on the sea floor, and a series of directional hydrophone arrays suspended about 6 feet under the hull of the drilling ship. The position is calculated by analysis of the pyramidal geometry formed by signals from the three sets of instruments.

The transducers transmit signals to the transponders. Each transponder has its own interrogation frequency—plus special identification code, if necessary—on which signals are received from the transducer above. The two transponders signal back up to the hydrophones on a shared frequency. This has two advantages: only a single reception channel is needed, and detection errors on the hydrophone can be picked up independently of the transponder.

The programed interrogation of the transponders allows oil drillers to leave transponders in position at a drill hole, move off to tap another potential site nearby, and return to the first hole later, using the transponders as homing beacons. □

Around the world

Multiplexing slashes shipboard 'spaghetti'

Modern ships carry a host of electronic equipment—for communications, radar, navigation, and other duties. But, even with the increasing use of digital technology, the various elements still talk to each other through bewildering mazes of wires and cables. Now, Ferranti Ltd.'s Digital Systems division is turning to digital-multiplexing techniques so that the navigation and radar-gear can communicate through only two twisted pairs of wires, cutting the shipboard "spaghetti" by many orders of magnitude.

The Ferranti Serial Signaling Scheme divides the various inputs from compass, rudder, radar, and input terminals into encoded 14-bit data packets and transmits them digitally over the single cable. A demultiplexer then redivides the packets and sends them to their designations. Because the transmission speed is 3 megabits per second, the system can handle extremely high data rates from the many terminals and sensors in large ships. Optimum transmission distance is 300 meters, ideal for most warships.

Digital control shifts bus gears

The bus driver's lot often isn't a happy one. But to help him out, the Ford Motor Co. and Ferranti Ltd. have developed a prototype of a transmission that's shifted by digital circuitry. Called the electronically synchronized transmission assembly, the system uses an almost old-fashioned nonsynchromesh transmission with a conventional clutch to connect the engine to the gears. But it employs a host of digital circuits to operate the hydraulic actuators, which avoids the drift problems of analog controls.

Ford and Ferranti claim that the system makes gear changing a finger-tip operation. A driver sets the lever of a smaller version of the normal gearshift to the desired gear. The system does the rest, operating the clutch, gearshift mechanisms, exhaust brake to slow the engine, and accelerator. Six prototype units are now participating in a 12-month road test.

40 heads made on one substrate

Multiple fixed heads allow faster access to magnetically stored data than movable heads, but they increase cost and make it difficult to obtain the high track density possible when conventional heads are used. What's more, the number of heads that can be bunched together has been limited. Now, though, researchers at Hitachi Ltd.'s research laboratory have developed batch-processed 40-head units made on a single ferrite substrate. Initially, leads and two-turn coils are fabricated by deposition and etching of conducting and insulating layers using hybrid-IC manufacturing techniques. The two-turn coil is built as a multilayer helix perpendicular to the substrate. Subsequent deposition and electroplating of permalloy over the coil is used to form magnetic yokes, with thickness of the coil setting the air gaps.

NATO Starfighter replacement awaits U.S. Air Force move

Decision on replacement of 350 to 400 aging F-104 Starfighters and F-100s by Belgium, Holland, Norway and Denmark will probably come in early 1975. U.S. government officials promised a steering committee of the four NATO countries, which visited the U.S. last month, **to push up the U.S. Air Force's choice between the Northrop YF-17 and the General Dynamics YF-16. That would give the Europeans a chance to phase in with the U.S. program.** Previously, the Belgians and possibly the Dutch were expected to decide on a Starfighter replacement before the end of this year.

Though the four NATO countries have agreed to coordinate their selection, it is not clear that they will manage to do so. The Belgians, who are considered likely candidates for the French Super Mirage F-1, could make their decision this fall in what some observers see as an effort to pressure their NATO colleagtes into buying the French planes.

Involvement with the U.S. would offer the advantages of standardization within NATO, help in sharing R&D costs, and would probably result in a lower cost per airplane. **Total Starfighter replacement costs for the four countries are estimated at about $2 billion**—part of which would be offset by manufacturing deals with the four countries' aircraft and electronics industries. **A substantial part of the offset packages consist of avionics.**

French look to Russia, elsewhere for computer support

The French government is working out new ways to dodge U.S. dominance in the European computer business. **One long-term bet is a plan to build fourth-generation computers and the components to go with them in partnership with the Soviet Union.** Senior Russian officials conferred with top French government computer planners in Paris earlier this month and agreed to work together to produce a successor to the current East European third-generation systems.

In the meantime, France's Compagnie Internationale pour l'Informatique is struggling to find enough money to keep it finacially abreast of its Unidata partners Siemens and Philips. While its private industry shareholders, Compagnie Générale d'Electricité and Thomson-Brandt, continue to bicker with each other, the French government is re-examining the case for a foreign partner for CII as an alternative to nationalization. The European Community's recent accord to put more political muscle behind the European computer industry **has made Siemens the current favorite to take a share in the French company—a move which would establish it as effective leader of Unidata.**

CII's partners would be just as happy to see the French accept a U.S. partner, like Honeywell-Bull, in the hope of an eventual foothold in the U.S. market, but the French still want an all-European solution. And the sooner the better, since all the uncertainty is beginning to damage CII's image among computer buyers, both in France and elsewhere.

Sweden may ban commercials on video recordings

The Swedish government has named a commission to study different possibilities of prohibiting or significantly limiting advertising on videotapes or disks. The government's directive to the commission suggested **that tapes designed for private use, at home, or in libraries or hospitals have no commercials.** Ads might be allowed, however, for tapes shown specifically as sales promotion aids. Should the commission find a total prohibition impossible, it might suggest limits—such as allowing advertising only in special parts of a tape, similar to the advertising trailers played at European movie houses.

Behind the government move are worries that the video recording business might boom in the future, seriously affecting advertising income to the press. Moreover, there is no commercial television in Sweden, and there is some indication that the government **sees a threat to the publicly-owned TV system.** Viewers may stop watching broadcasts if inexpensive, commercial video recordings were to become popular. **Already a commercial video-cassette operation is being tested in Sweden.** A company headed by American advertising executive Andrew Karnig, a former vice president of J. Walter Thompson, is supplying cassette players to restaurants and pubs. Programs feature sports and entertainment, and there are 30-second commercials between the 15-minute programs.

Budget squeeze slows French phone expansion

The French target of 12 million telephone lines in operation by 1978 is beginning to move out of range of the government's financial firepower. **The manufacturing plants are there, but the orders are slowing down. Companies claim that the problem is money.** Inflation has eaten away at the budgets, and the available cash can not pay for the number of lines scheduled for this year.

A parliamentary commission has called for an extra $640 million this year, and it now seems likely that telecommunications and posts minister, Pierre Lelong, may be able to find an extra $250 million or so—probably through higher call fees. Next year, the commission wants to hike this year's current budget of $2.2 billion to a massive $3.8 billion. The best that ministry officials are hoping to arrange for is $3.1 billion.

Meantime, CIT-Alcatel has pulled off a big export order for its E-10 electronic switching system with a sale to Syria. The French company will deliver four exchanges to start with and will follow up with a manufacturing plant to supply the electronic exchanges for the rest of the country's phone network.

Japanese announce another cassette system for home video

Toshiba and Sanyo Electric Co. have introduced another contender in the home video-tape-recorder sweepstakes. They have jointly developed an 0.5-inch cassette color system based on a cassette introduced earlier by Sanyo for a black-and-white portable recorder. The cassette has two reels side-by-side. That arrangement contrasts with the one-reel cartridge recorders made by Matsushita Electric Industrial Co. and Sony Corp. and the two-reel, back-to-back cassette recorders developed by Philips. The initial announcement only disclosed details of the cassette system, but each company says it will soon announce and start sales of recorders. **Standard playing time of the cassettes is 30 minutes, using 20 micrometer thick tape.**

Membrain dickers for Honeywell test division

Fast-growing Membrain Ltd. is seeking to greatly expand its share of the automatic test equipment market by attempting to buy Honeywell Ltd.'s test systems division. Informed industry sources say that merger talks are underway in a deal that could increase Membrain's expected 1974 turnover of $3.3 million by 50%. **A merger asset would be the consolidating of Membrain's almost exclusively commercial market with Honeywell's largely military one.**

Meet a brand new company with a 15-year reputation for reliability.

The Components Group of Digital Equipment Corporation.

Now you can buy the components and peripherals that support the world's most popular minicomputers.

Separately. In quantity. At extremely low prices.

From us. The Components Group of Digital Equipment Corporation. A new group, formed to supply proven, reliable computer components to the volume buyer at the lowest possible prices.

The products, described in detail on the following pages, are all used by Digital as components and peripherals in the PDP-8 and PDP-11 minicomputer systems, the most popular minis in the world. Our components – like our computers – are designed to deliver maximum price/performance.

Our peripherals can be interfaced readily with all commonly-used minicomputers. Additional products will be available in the near future; product families are planned to provide a range of capabilities.

Until now, if you wanted Digital components, you had to buy an entire system.

Not any more.

Now, if you order fifty pieces or more, you can buy any of these components completely unbundled. Volume buying will get you price breaks you won't believe – just check out the prices on the next couple of pages.

And you can have our components off the shelf. When we've established our nation-wide network of warehouse/depots (due this fall), volume deliveries will be made as fast as we can process your order.

Behind our commitment to deliver stands the entire Digital manufacturing capability – over two million square feet of manufacturing space in the United States, Puerto Rico, Canada and other countries overseas. These are the same facilities that have produced more minicomputers than anyone else, the facilities that manufacture and test the peripherals that support these computers. To meet your demands in the next year alone, we're planning several new plants in the United States and Canada and retooling present production lines to Components Group specifications.

To deliver these components quickly and to maintain our high standard of reliability, the Components Group is planning a network of warehouses. At these depots, products meeting our rigid specifications will be stocked for off-the-shelf delivery.

Our warranty is simple: all hardware is fully warranted for a specified time. If, during this period, any product should prove defective, you simply return it to the nearest depot for fast repair or exchange.

Over the next few years, we expect the cost of computer hardware – especially the cost of the computer itself – to keep going down. Entirely new applications will open up. Volume production of proven components and peripherals enables us to sell at greatly reduced prices. Our low-cost, high-quality products will provide our customers with an opportunity for enhanced profits and a competitive edge in an increasingly price-conscious market.

Terminals and peripherals.

Our cassette mag tape system. Under $1600 in quantities of 100.

Priced below even paper tape, the TU60 is a truly reliable dual cassette system. We designed it to stand up to repeated use—with cassettes spec'd at a minimum of 1000 passes, and an error rate that's a full order of magnitude lower than most other systems.

Our proprietary cassette design reduces the possibility of hard error. The extra-thick 1 mil mylar tape is specially coated to resist extreme temperature and humidity.

The TU60's reel-to-reel drive increases tape life even more—there are no capstans, pulleys, pinch rollers, or brakes. DC servo-controlled motors reduce stretching and provide precise start/stop characteristics.

To reduce noise interference and ensure that even very low data levels will be read accurately, the TU60 employs an independent high-threshold data block detector and low-threshold data peak detector.

And the TU60 can't accumulate error from tape-speed fluctuation due to power variation or mechanical difficulties: the read electronics adapt themselves to the tape speed by means of a phase lock loop. Other error-reducing features include redundant dual-track recording, automatic leader detection, and CRC-type error control.

Because the TU60 places the burden of recording-reliability on its electronics, not its mechanics, less maintenance is required to keep the system in good working condition. And when maintenance is necessary, it's no problem. The top flips open, everything is accessible, and the two main modules can be replaced in minutes.

Our new DECscope video terminal. Under $950 in quantities of 100.

The VT50 is the most inexpensive CRT display terminal in the world. It'll give you fast, quiet alphanumeric video capability for the cost of a slow, noisy teletypewriter. Hardcopy output is available too, with our optional low-cost copier.

For a groundlevel budget price, you get 12-line, 80-column good-quality display—64 ASCII-standard upperface characters, each on a 5x7-dot matrix. After displaying 12 lines, the page scrolls upward from the bottom; its speed can be adjusted by the user.

The keyboard is an easy-to-use, audible, typewriter-style board, with 3-key rollover to permit fast typing. Our optional copier fits right into the desktop display cabinet.

The VT50 is fast—a full range of baud rates are switch-selectable up to 9600. Interfacing is with a standard 20mA current loop, with inexpensive EIA option.

Installation is easy, just plug it in. The VT50 has few moving parts, so maintenance is simple. Its keyboard is the same field-proven model we use on the LA36 teletypewriter. And its low heat output means no fans, less noise, and low power consumption.

At such an incredibly low price, the VT50 will go far. And fast.

Our remote terminals. Starting at less than $600.

The RT01 and RT02 terminals provide easy, low-cost interactive data entry and retrieval.

Uncomplicated keyboards make it easy for untrained personnel to enter or retrieve data. There's no need for confusing, numerically-coded instructions. The RT02 will even prompt the inexperienced operator by spelling out on the display what information is needed next.

The RT01 displays up to 12 digits of data in a Nixie™ numeric readout. For non-numeric response, it has programmable status indicators. The 16-key pad will input 30 ASCII characters.

The RT02 costs more and gives you more. A 64-character gas-discharge alphanumeric readout that displays up to 32 characters at once. 16-key or 58-key input. Interactive display prompting.

Both terminals are ASCII-compatible, so you can interface them to any computer with a Teletype™ port. EIA modem interface is also available.

Both have simple displays and few moving parts, for built-in reliability and ease of maintenance.

Logic modules and interfacing.

Digital is the world's largest seller of solid-state modules. We give you the widest choice you can get—over 400 pretested modules, most of which we use ourselves, in our computers and controllers. We also carry a full line of compatible hardware, power supplies, plug-in boards, cabinets, racks and related equipment.

If you do your own interfacing, our Logic Products Handbook and Logic Systems Design Handbook will provide general support and solutions to specific standard problems. The Components Group will also supply, in volume, custom interfaces, custom modules, and custom variations of our standard terminals. Complete descriptive literature on any of these topics is available.

M Series modules.

These high-speed logic modules for computer interfacing use monolithic TTL circuitry to give you high speed, high fanout, large capacitive drive capability and excellent noise margins, in frequencies up to 6MHz. Some of our newer M Series modules also employ current MOS technology.

K Series modules.

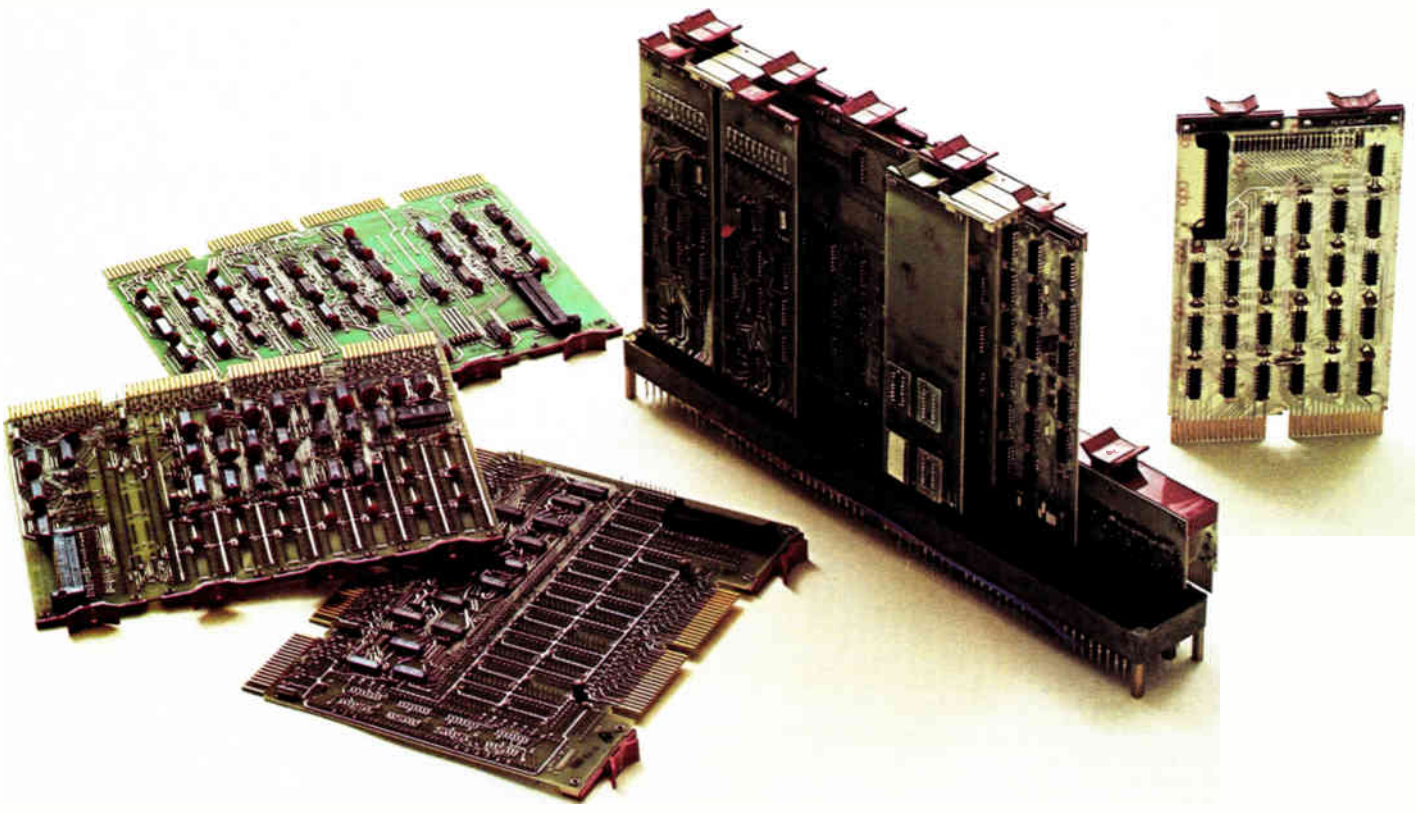
These noise-resistant modules are principally used for industrial control applications where noise-resistance is more important than speed. Frequencies from DC to 100KHz are typical, 5KHz frequencies can be obtained. K Series modules are designed for easy system checkout and troubleshooting and will fit both standard NEMA enclosures and computer mounting racks.

A Series modules.

For communications between the computer and the outside world, these analog modules give 10-bit and 12-bit performance in a family of mutually compatible functions—multiplexers, operational amplifiers, sample-and-hold circuits, A/D and D/A converters, reference voltage sources, and multiplying A/D converters.

DECkit interfaces.

Our DECkits provide pre-tested, fully-documented interfaces for a number of common interfacing situations. Basically just a few modules and a prewired systems unit, they eliminate design time, breadboarding, and wirewrapping in a number of areas. Complete descriptions of the specific interfaces are available.



The start of a new family of component computers.

The PDP-8/A. $572 in quantities of 100 (CPU & 1K RAM).

For minicomputer applications, the PDP-8/A computer-on-a-board gives you speed and performance at an extremely low price.

The newest, smallest member of the PDP-8 family of minicomputers, the 12-bit PDP-8/A uses only proven, readily available, multi-source MSI semiconductor technology. We know it's reliable, and we can deliver in quantity, starting in late 1974.

To reduce the size and enable low-cost, user-tailored memory capacity, we've added expandable semiconductor memories: ROM, RAM, PROM, and ROM/RAM combinations, expandable from 1K to 32K words. Cycle time is 1.5μsec.

The PDP-8/A uses the same powerful instruction set as the PDP-8/E and is fully compatible with other PDP-8 family hardware, operating systems, and high level languages (such as BASIC, FORTRAN IV, FOCAL).

The PDP-8 Omnibus™ backplane facilitates direct interface with more than 60 PDP-8 options and peripherals. Seven commonly-used options are available on two option boards: serial-line interface, 12-bit parallel I/O, front-panel control, and real-time clock on one board: powerfail/auto-restart, memory extension, and bootstrap loader on the other.

The PDP-8A gives the user the flexibility, reliability, and expansion capability of a minicomputer at an extremely low price.

The MPS microprocessor series. $476 in quantities of 100. (CPU & 1K RAM).

The MPS microprocessor series of modules gives you a simple, versatile 8-bit controller that's inexpensive and easy to use. It will replace hard-wired logic in control applications and perform processing tasks in many new applications.

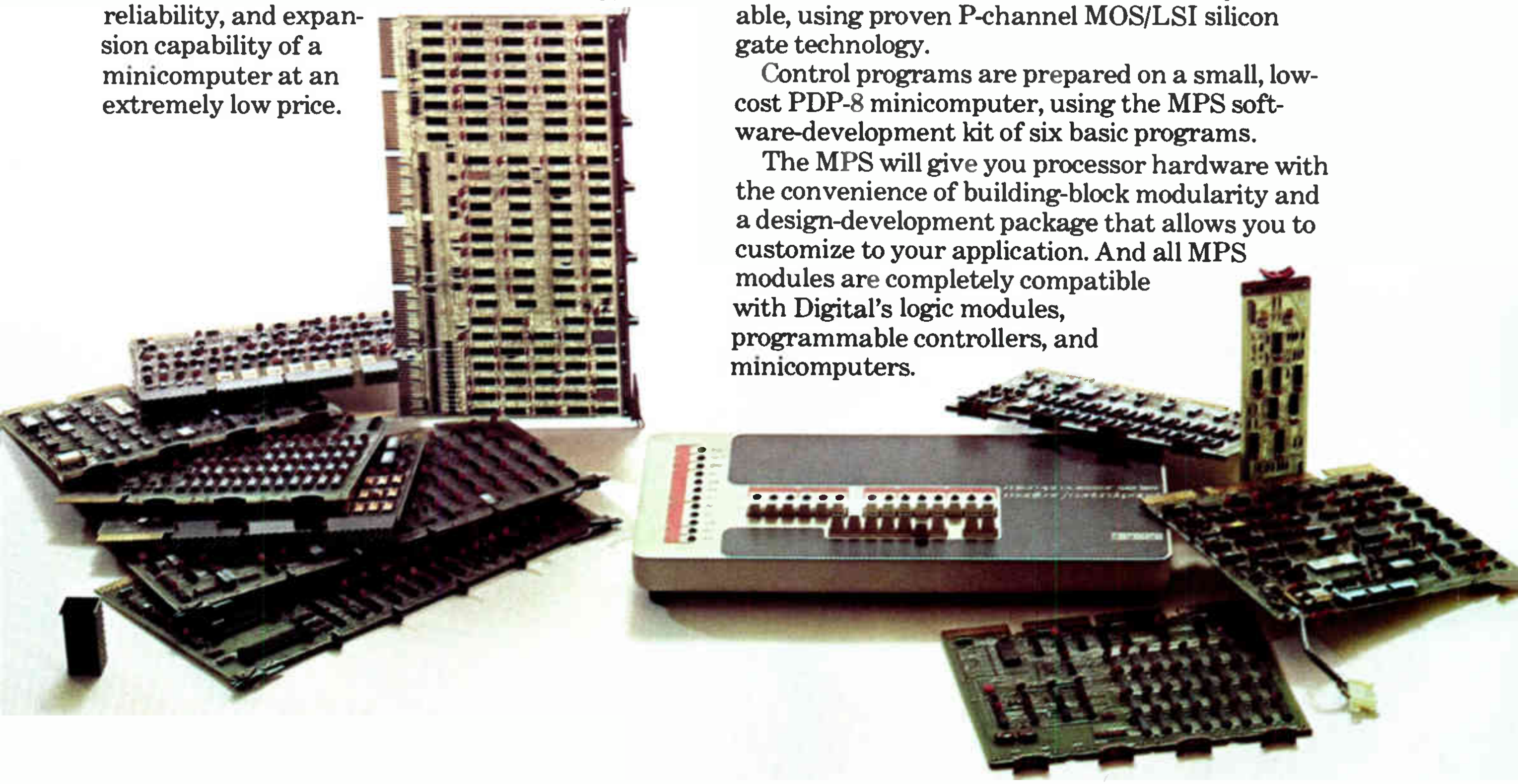
The MPS consists of four building-block modules and an optional control panel. A basic fully operational processor can be assembled from as few as two modules: the CPU and a memory module.

The CPU module with 8-bit parallel processor, 48 data-oriented instructions, and 12.5 μsec cycle time, can directly address up to 16K words of memory. There are two memory modules: the Read-write Memory module consists of a fully-self-contained random access memory (1K, 2K or 4K words) and all address decoding logic; the Programmable Read-only Memory module contains up to 4K words of UV-eraseable, completely reprogrammable semiconductor memory. The External Event-Detection module provides power-failure detection and automatic start, with 6 interrupt request inputs. The Monitor/Control Panel, which can be cable-interfaced to the CPU, will perform such typical functions as monitoring data paths, memory, and addresses, handling general system operational and diagnostic checks, and entering programs.

We designed the MPS to be immediately available, using proven P-channel MOS/LSI silicon gate technology.

Control programs are prepared on a small, low-cost PDP-8 minicomputer, using the MPS software-development kit of six basic programs.

The MPS will give you processor hardware with the convenience of building-block modularity and a design-development package that allows you to customize to your application. And all MPS modules are completely compatible with Digital's logic modules, programmable controllers, and minicomputers.



EVEN THE BIGGIES HAVE TO BEAT THEIR OWN DRUM SOMETIMES.

It's about time we made some noise about the fact that we're one of the top three manufacturers of modular regulated DC power supplies. What does that mean to you? Plenty! ACDC Electronics provides one of the most extensive lines of standard power supplies in the industry...over 500 models ranging from approximately 6 watts to over 500 watts. There are five series in our series-pass power supply line. Of these, the most popular is the OEM. Although they are known for their economy, these OEM power supplies offer the same reliability you have come to expect from all ACDC products. Our new high efficiency switching power supplies offer the latest in technology. They're smaller, cooler, and more efficient than series-pass supplies and operate quieter and more reliably than most other competitive models. And, there's even more for us to "boom" about. ACDC's ability to tailor a power supply to specific applications is virtually unlimited. Some typical units range from miniature 400 Hz airborne power supplies to 3000 amp power systems for state-of-the-art computer complexes, incorporating such features as auto-progression, margining, sequencing, transistor switching, phase control and series regulation as well as special packaging configurations. Complete information is contained in our new 1974 catalog. To get your personal copy, just write to us on your letterhead, or, if our short form catalog is enough, just circle the reader service number. *Like the broken drum, you just can't beat ACDC power supplies.*

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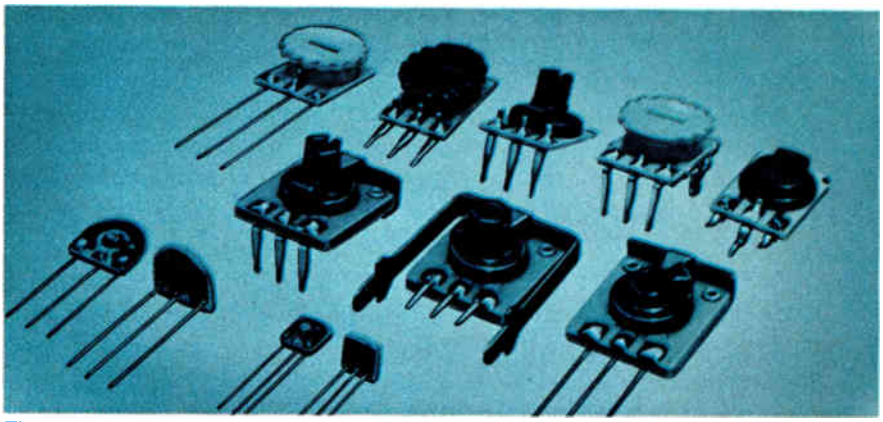
With the options now available, standard cermet and carbon trimmer resistors take on new dimensions of application.

Centralab is meeting the high performance demands of navigation equipment, aircraft radio, calculators, instrumentation and automotive electronics. High volume and low cost are ancillary benefits.



There's maximum versatility in the Centralab trimmer resistor line. Four series are available with a variety of options including mounting brackets, leads, knob styles and colors.

Regardless of the application, if you're looking for a trimmer resistor with power handling capacity, small size, reliability, or any number of other critical parameters, you'll find the right combination in the extensive line of standard designs and options available from Centralab. And if you're looking for high volume at low cost you should know that Centralab can provide production runs in the millions with unit costs of less than 10 cents, depending on the type you select.

Compare the Centralab Series M trimmer with a conventional TO-5 size. The Centralab 1/20 watt unit requires 2/3 less space. That's a significant advantage for miniaturization.

Our four series of carbon or cermet trimmers offers you 18 standard models, in sizes from 1/4″ to 3/4″, from single to quad sections, in ratings from 1/10 to 3/4 watt. You can select from a wide range of resistor values — 100 ohms to 10 megohms in carbon, 100 ohms to 1 megohm in cermet. With standard resistor tolerances as low as ±10%. To simplify assembly, all units can be furnished for vertical or horizontal mounting with your choice of three tab leads — including the new Snap-Tite® rigid PC mount — or with tinned wire leads.

Knob selection is equally varied and gives you the choice of universal, screwdriver, edge-adjust and a new thin-profile style just .130″ high. All knobs are flame retardant and come in four standard colors.

FIXED RESISTOR CAPABILITY

Complete resistor networks can be supplied on the trimmer base plate. As many as 9 fixed resistors can be added to the quad units, 3 on a single section. And, because you also want the assurance of better tracking and stability, we offer ratio matching as a part of our fixed resistor capability.

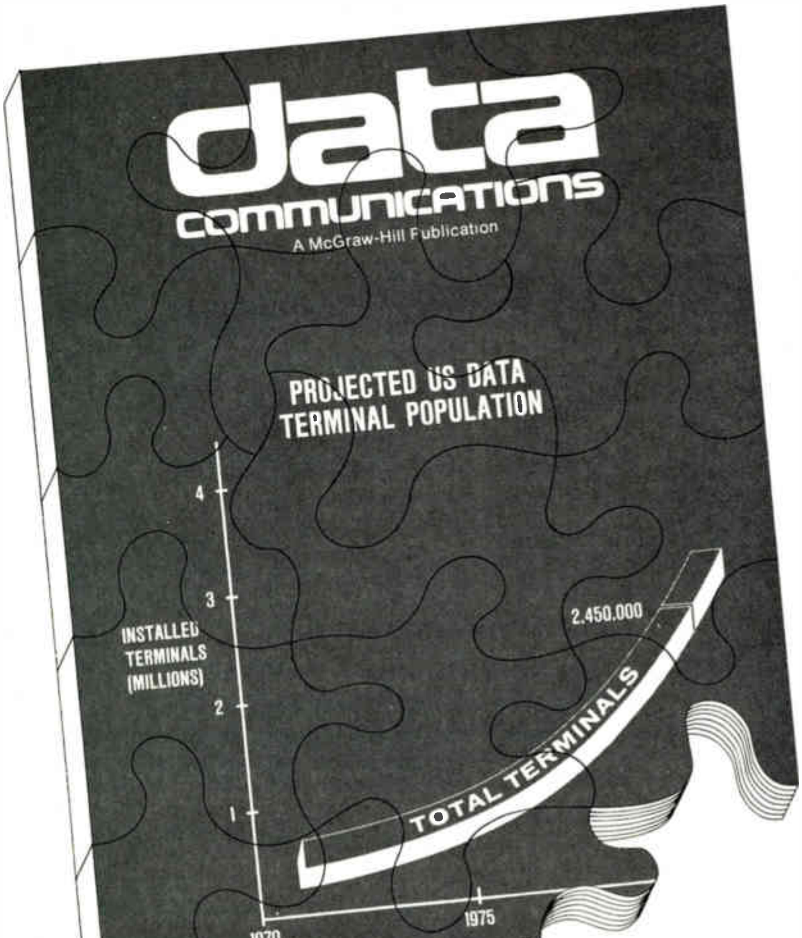
Multiple sections — double, triple and quad — plus fixed resistors are every-day requirements being met by Centralab trimmers.

Even with all these features, there are other reasons why you can confidently specify Centralab trimmers. One is the ceramic substrate that gives them performance unmatched by phenolics. First of all it gives you the setability you need. But in addition, you get higher wattage in a smaller space. They're conservatively rated at double the wattage capability of phenolics. Ceramic bases mean they'll withstand higher operating temperatures — greater dimensional stability — no flux migration during flow soldering.

Centralab can help you match up their world of options and standard designs to give you new dimensions in trimmer resistor specification. Complete data, including new simplified part descriptions for each trimmer family, is included in a new Specification Guide. Write for your copy today. Ask for Catalog 1549T.

Circle 62 on reader service card

Data Communications–the new business every business must have.



Data communications is indeed a puzzle to most of the people working in the market. In fact, many don't realize that they have data communications needs or what their needs are.

The people responsible for planning a data communications system for their company must decide alternative systems approaches, carriers, hardware, and vendors—all in the context of economics, government regulation, and future technology development.

Putting together all the pieces of this puzzle—that's what the new McGraw-Hill magazine, **Data Communications,** is all about. **Data Communications** will be published bi-monthly.

Our editorial is 100% data communications and we know our approach is correct because we have tested it with two pilot issues, a year apart.

Our audience is 100% data communications because to qualify, they must have responsibility to buy, specify, recommend or approve the purchase or lease of products associated with data communications.

Our subscribers are 100% request verified—not only are they qualified but each one of the 25,000 has individually requested **Data Communications.**

If you want to cover the fastest-growing market in our economy, take a full-year's schedule of full pages in **Data Communications** for only $7,800, which includes color, bleed and special positions. We'll even do your color separations at minimal cost.

For complete advertising information, contact your nearest McGraw-Hill office.

data communications
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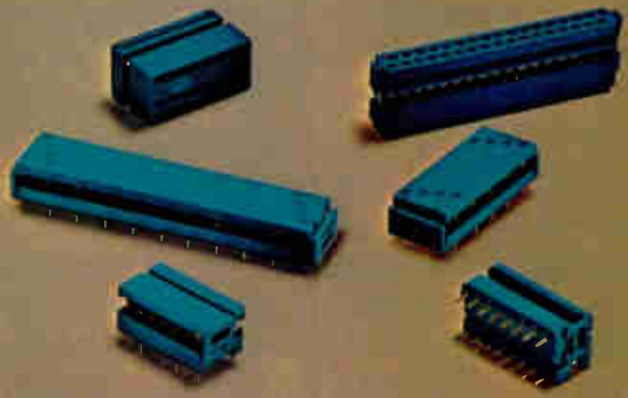
the magazine and the market.

We're putting it all together for you.

Start with our new Blue Streak™ cable

. . . it's loaded with features designed to lower your installed costs. For instance, every fifth conductor is color coded for quick identification and the Blue Streak immediately identifies polarity. The unique cable construction permits clean conductor separation for breakouts and easy insertion into connector assemblies. Available in 50 conductors or less — solid or stranded wire — this U/L listed self-extinguishing cable is the perfect companion for the new one-piece connectors.

New cable connector system...It's designed to lower your installed costs.



Our new insulation displacing flat cable connectors install in 1/3 the time

. . . simply because they come to you in *one* piece. Two benefits result; assembly of the connector itself is eliminated and the time consuming job of lining up the cable on the connector is no longer necessary.

To install — simply insert the cable end into the connector and crimp. It's that easy — fast — and reliable! Speaking of reliable — our new connectors feature an exclusive "tulip" contact design which provides 4 contact points per conductor. In addition, the front of the "tulip" contact is designed to act as a strain relief on the wire.

We'll be more than happy to send you a test report on contact reliability.

A perfect crimp every time

. . . because our Blue Streak hand tools feature the Shure-Stake® principle which makes the tool responsible (not the installer) for the compression connection. Your installer must complete the set compression stroke before the connector can be removed. It's as fool proof and reliable as a compression connector tool can be. A full line of bench mounted tools with interchangeable dies are also available.

The Ansley Team — One Piece Connectors — Shure Stake® Hand Tools and Blue Streak™ Cable — all combine to offer you the most reliable connection package at the lowest installed cost.

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Circle 65 on reader service card

"We've Got A Great Instrument"

Carl Pehlke, President and Chairman

In fact, we've got a lot of great instruments. Perhaps we've grown complacent. Maybe we haven't been ardent enough in telling our customers Texscan IS the world leader, with a complete line and a single source that no other has.

With our design and design capabilities, we're coming on even stronger in the CATV, sweeper, spectrum analyzer, oscilloscope, attenuator and oscillator business.

We'll be telling you more later. For now, though, why is Texscan *the* leading supplier? For openers, take a look at the chart below:

	Number of Models		
PRODUCT	**TEXSCAN**	**TELONIC**	**WAVETEK**
Laboratory Sweep Generators	26	8	7
Spectrum Analyzers	6	0	0
Display Oscilloscopes	3	3	1
Attenuators	83	18	8
Oscillators	149	0	0
Filter types	8	6	0

Based on latest catalog information

Texscan

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BOURNS trims more circuits than anyone else in the world!

here's why...

NOBODY KNOWS MORE ABOUT TRIMMERS THAN WE DO

Marlan E. Bourns, President of Bourns, Inc., invented the modern miniature TRIMPOT® trimming potentiometer. This company pioneered the industry, and has maintained its leadership position for over a quarter of a century.

WE GIVE YOU WHAT YOU NEED

Bourns has the broadest line of trimming potentiometers in the industry. We produce just about any type, shape, size, style you're likely to need. We make them more readily available via a large factory inventory . . . and 91 stocking distributors.

Ready to simplify your specifying? Standardize on Bourns "Top Twenty". . . they cover 90% of your application requirements. Write for our **Top Twenty Designer's Portfolio.**

YOU CAN DEPEND ON BOURNS

Trimming potentiometers are the *most* cost-effective method of adjusting, regulating and controlling circuits . . . and they will remain so for the foreseeable future. Bourns is the *most* capable, straightforward and reliable supplier of trimming potentiometers. Depend on Bourns.

QUALITY, SERVICE, VALUE — Bourns is No. 1
. . . you can depend on it!

BOURNS INC

Circle 67 on reader service card

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Drop-outs. White dots in video-telephone picture are areas of significant change in face-to-face communications in 1/60 second. These are the areas that will be refreshed.

Problem: cut video bandwidth

Solution: choose from compression techniques being pursued by such varied agencies as the military, NASA, and Bell Laboratories

by Larry Armstrong, Midwest bureau manager

Digital video transmissions require 48 to 50 megabits per second. That's too much for the military, NASA, and AT&T. So all three are working to pare that figure, with the result that there are now several systems that can send recognizable pictures at 1 Mb/s or less.

Military interest centers on use in remotely piloted vehicles for strike and reconnaissance. Each vehicle will contain a TV camera and transmitter to return images to a ground or air-control station. Antijam operation is important: the idea is to squeeze out as much redundancy as possible and then put back the missing parts later in a controlled fashion. In this way, the enemy is forced to spread his jamming power [*Electronics*, June 27, p. 33].

While observers agree that NASA doesn't need to press as hard as the military, the capacity of satellites is limited. Reduction from 6 bits per picture element to 2, therefore, means a threefold increase in channel capacity.

Closer to home, Bell Laboratories is looking at similar procedures for the obvious Picturephone application and has plans to use video-compression techniques in the photocomposition of telephone directories. Although Bell admits that it has no on-going hardware programs, it's studying two-dimensional coding with the Harr, Hadamard, and fast-Fourier transforms and with differential pulse-code modulation, requiring a frame memory at transmitting and receiving ends of the system. It's also working on color pictures.

Prototypes. Although most of the work is still in the research—even theoretical—stage, at least two programs will pay off this fall in prototype hardware for real-time processing and transmission.

At Wright-Patterson Air Force Base near Dayton, Ohio, the Air Force Avionics Laboratory has started building a hardware processor, designed for remotely piloted vehicles (RPVs), that compresses video transmissions to 1 Mb/s. The Air Force team breaks a typical picture frame, containing 512 by 512 elements, into 4,096 subpictures of 8 by 8 elements each, runs them sequentially through an analog-to-digital converter, and holds them in

Probing the news

4,096-bit random-access memories.

The arithmetic/logic unit, built of Schottky transistor-transistor logic, performs simple two-dimensional Harr or Hadamard transforms on the data, depending on the ROM chip plugged into the system. Both transforms require only addition and subtraction during processing, and the simpler ALU that performs these two operations also helps keep the weight of the payload for the pilotless planes to a minimum.

Smaller. Facing even larger problems are researchers at the Naval Undersea Center in San Diego, Calif. While the Air Force work is directed toward large-body, high-speed RPVs, the Navy team is limited to a 1- to 2-pound system.

Built around LSI charge-coupled-device circuitry developed by Texas Instruments, the hardware processor reduces the image bandwidth by means of the sophisticated, analog-cosine transform, followed by differential pulse-code modulation. "We cannot go with direct digital implementation because of its complexity," explains Harper Whitehouse, assistant director for science at the Navy lab's sensor and information technology department.

Instead, the Navy first unravels the vidicon output by ignoring every alternate frame and thus obtaining a frame of 256 by 256 elements. This frame is broken into columns, each 23 elements wide, and each column is processed a line at a time, column by column, at a 5-megahertz rate. The frame takes about a quarter of a second to process, giving an effective rate of 3.75 frames per second. The differential pulse-code modulator compares the bandwidth-reduced analog data to the previous line, quantizes it, and feeds the digital output to the transmitter.

Work at NASA-Ames in Sunnyvale, Calif., is focused on developing hardware for real-time, digital Hadamard-transform systems for satellite use. The NASA technique, unlike that used at Wright-Patterson, divides four successive frames into blocks of 4 by 4 by 4 picture elements for transform coding. Because the method works in three dimensions, a sizable memory is required: the hardware package includes a set of disk memories, 64- and 1,024-bit static RAMs, 256- and 512-bit shift registers, a standard TTL ALU, and a 6-bit a-d converter.

The compression system for planetary exploration at Jet Propulsion Laboratory, Pasadena, Calif., uses a new two-dimensional simpler transform developed by Robert F. Rice, senior research engineer.

With it, JPL has achieved simulated transmission rates of less than 0.25 bit per picture element, although Rice cautions that some of the concepts might not extend to ground applications. □

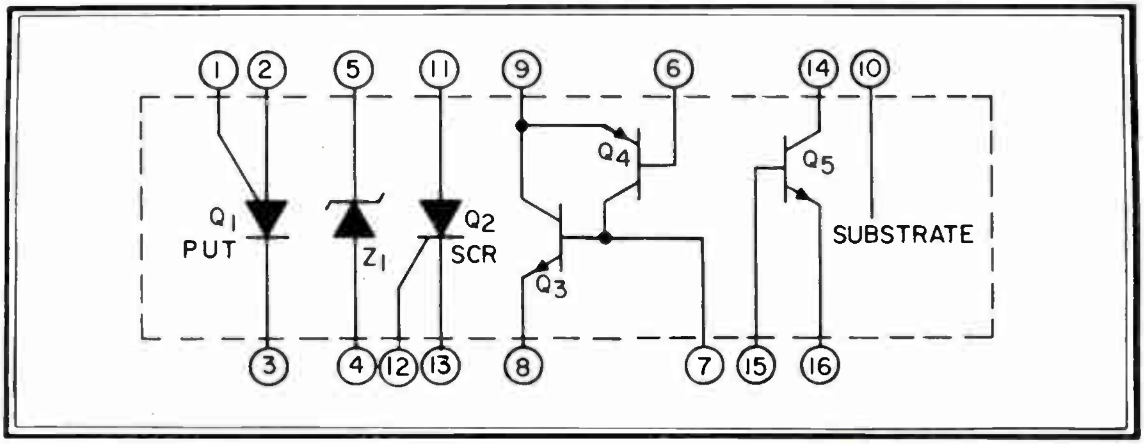
Adding—and subtracting—the picture

Traditionally, pulse-code-modulation techniques have been used to digitally describe video-scan frames of 512 by 512 elements. Each element is quantized as one of 64 different shades of gray and transmitted as a binary code using 6 or 8 bits per element. Differential PCM is an attempt to cut down the information transmitted by sending only the difference between that element and a previous one—the same element in the preceding frame or line, or its immediate predecessor. Either way, the difference has already been digitized for the PCM format.

However, most researchers feel that the redundant information can be sorted out better if the elements are in a different domain so that pictures are mathematically transformed without significantly altering their meaning. Most of these transforms try to approximate the Karhunan-Loève transform that is accepted as the best for block-image processing. Perhaps the closest is the cosine transform, an analog technique that yields the real part of the complex numbers that result from a high-resolution fast-Fourier transform.

Harr and Hadamard transforms might be called the poor man's Fourier transforms. Although the Fourier version is better, because it requires multiplication and division, it is difficult to implement. Both Harr and Hadamard versions can be built with add-subtract modules alone.

An industry first.



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Communications

Plugging in to phone management

Systems that control use of WATS and other lines result in savings of 15% and up for companies with elaborate phone setups

by John N. Kessler, New York bureau manager

Special reduced-rate phone services—like Wide Area Telephone Service lines, tie lines, and specialized common-carrier links—can shave a lot of money from a large corporation's communications bills. Now, though, a new and fast-growing telecommunications market is springing up to help coordinate a company's complex mix of phone services—and to cut another 15% to 20% off the bills. The basis of all the systems being offered is a computer—either a minicomputer or a microprocessor. In the simpler systems the computer keeps logs of all calls, and in the more sophisticated systems, it routes calls over the least expensive path.

This new, computerized adjunct of the telephone market is confined—at least at first—to telephone customers with more than 100 lines and 50 or more trunks, which might include WATS, foreign exchange (FX), direct distance dialing (DDD), tielines, and specialized common-carrier links. With such facilities, telephone bills can easily top $10,000 a month.

For companies equipped with communications facilities of this magnitude, telephone service can easily represent the second or third highest corporate overhead. In terms of numbers, such firms form an elite group of the 197,000 users of private automatic branch exchange (PABX) and Centrex systems. About 20,000 have more than 200 lines, according to Harry Newton, a New York City telecommunications consultant.

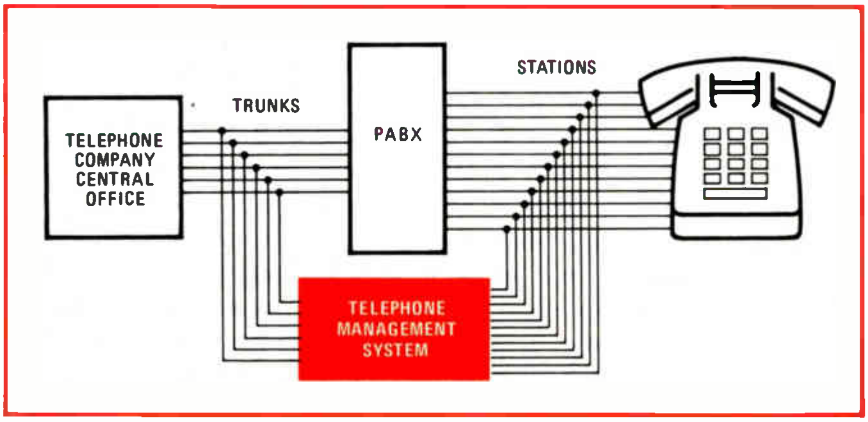
Marketing. Newton estimates that a little more than 100 computerized telephone-management systems will be installed by the end of the year. This represents an equivalent sales volume of about $6 million, including leased systems. But he expects this figure to grow to at least $20 million in three years—a fairly conservative figure, considering the potential $1.2 billion market. In three to five years, Newton says, the cost of computerized telephone-management systems will drop, and the economic benefits will likely be reaped by smaller users, too.

One of the big unknown factors is whether the Bell System will decide to compete in this emerging market by developing its own system. The Bell System is evaluating a number of independently developed systems, which—if approved—will be recommended to operating companies for lease to subscribers.

The only Bell System installation to date is one purchased from Vitel, Mountain View, Calif., the manufacturing subsidiary of the Continental Telephone group. It's installed at Transamerica Corp. of San Francisco.

Control. There are two basic types of systems. Passive systems monitor lines and trunks, providing hard-copy printouts of what extensions called what numbers, how much each call costs, when each call was placed, when it ended, and how each call was routed—for example, via WATS or DDD. The active systems provide two basic additional functions: they can restrict telephone usage of certain phones to, say, local and WATS trunks, and they can force a caller to use the least-expensive line or trunk.

Both systems link a computer with magnetic tape and a clock connected to each phone line and/or trunk. The dc pulses from each extension and the time of day are monitored. The tapes can be collected periodically and processed on a computer to yield hard-copy printouts. Depending on the software, various types of printouts can show individual extension use, department usage, peak-calling periods, the toll charges for each extension, the routing of each call, and hourly distribution of call minutes, based on time or trunks used. Special programs can also screen out incom-



Getting the most from phones. This diagram shows typical installation of a computerized telephone-management system. Such systems can log calls and also route them.

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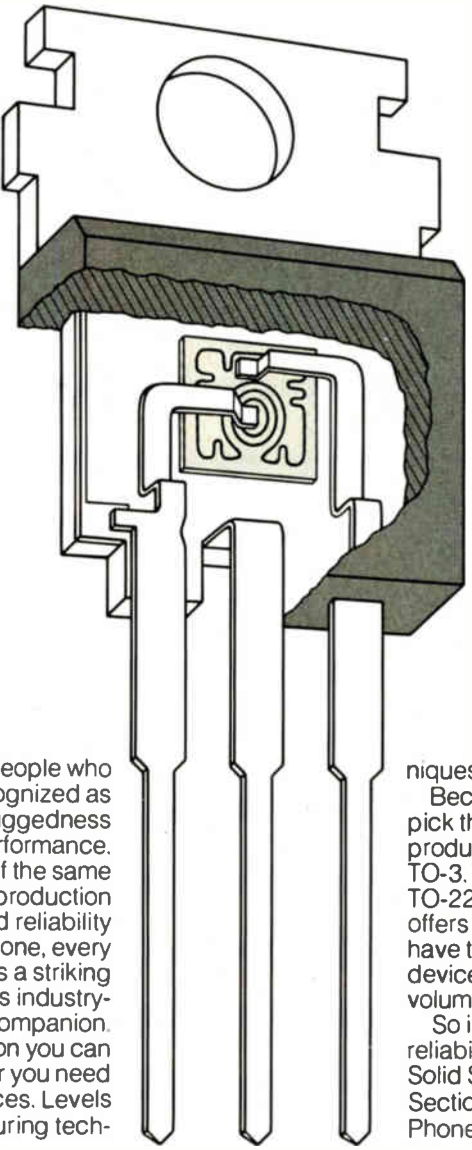

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pleted calls, wrong number, local calls, and extension calls.

The active systems can be customized. Each extension can be assigned a calling area, limiting the caller to local calls, specific exchanges, or WATS lines, or can be permitted everything, including FX and DDD. For example, with the TMS System developed by Dextel Corp. of New York, such restrictions can be changed for different times of the day, according to the availability of trunk facilities.

Action Communications Systems Inc., Dallas, uses a separate piece of hardware it has dubbed a Watsbox to give a caller to an outside line. The Watsbox is connected to a PABX or Bell System Centrex. To place a call, the user enters his authorization number. The Watsbox then automatically selects the most economical route for long-distance calls and records time and billing information. As with some other systems, Watsbox features include replacing of frequently used long-distance numbers with a two- or three-digit code. If the circuits are all busy, the system will also notify a caller of the number of call requests already stacked up.

One of the most unusual systems, in terms of hardware, is the Alston Call Account System, made by the Alston division of Conrac Corp., Duarte, Calif. The common control functions that format the data are handled by an Intel microprocessor. The microprocessors, which handle 240 lines each, can be added together to make larger systems. While there is no magnetic tape, there is an Ascii code plug at the back of each unit that can be connected to a tape, teleprinter, or teletypewriter.

Accurate charges. Besides simply cutting bills, computerized telephone-management systems have other economic benefits. Their use will enable companies to optimize telephone facilities by eliminating or adding trunks or lines. For some organizations, such as law firms and advertising agencies, these systems provide a definitive cost index of phone charges that can be billed realistically to individual clients. But as Edward Parsons, vice president of Interconnect Corp., Miami, a subsidiary of Milgo Electronic Corp., Miami, puts it, "the users will have to become more sophisticated in evaluating the assignment and usage of telecommunications facilities."

The "big brother" aspect in any system that records who calls when and for how long is an inherent economic asset. For example, Nat Freedman, president of Dextel, has a customer that was able to determine the cost of employees calling a certain New York City number that turned out to be Dial-a-Joke.

The future of the industry, in terms of electronics, says Freedman, is toward smaller, less expensive systems. Some units, he believes, will eventually be incorporated in the PABX itself. And this, in turn, will change the PABX from simply a switching device to an intelligent system. □

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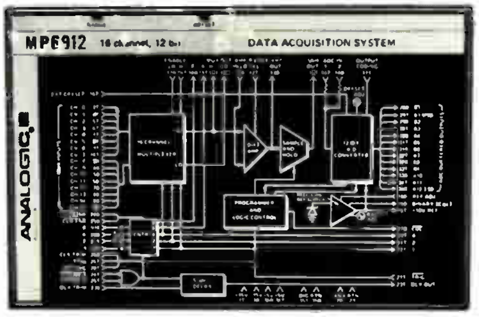

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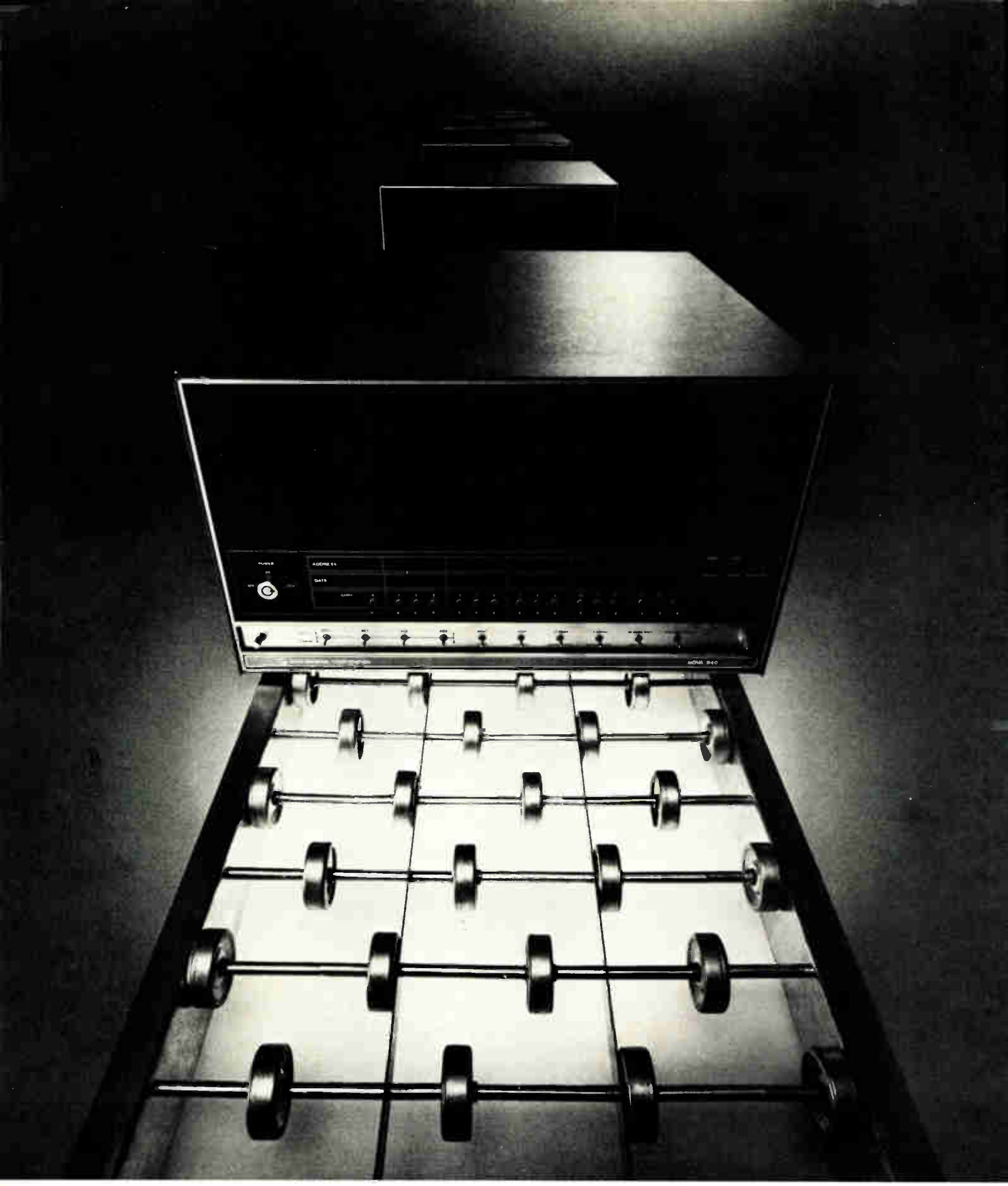

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Government

U.S. to require computer security

Legislation would force Federal and local governments to limit access to data banks; big purchases delayed as law is awaited

by Larry Marion, Washington bureau

Computer privacy is coming, but it isn't going to come cheap. That's the message for hardware makers in bills that are starting to make their way through the Federal legislative process. When these measures, seeking better security for government data banks, are boiled down into a law—and experts expect one this year—security devices for Federal, state, and local government data banks containing personal information will be mandatory. Senate committee statistics indicate that there are dozens of Federal installations alone and hundreds more at other levels of government.

Access controls, including substantial record-keeping systems, would require installation of costly security systems. Ruth M. Davis, director of the National Bureau of Standards Institute for Computer Science and Technology, says the majority of the privacy requirements would be met by "hardware implementation."

Computer security has been a major concern for the last few years as hundreds of cases of computer manipulation for personal profit have been uncovered. Banks, telephone companies, and retail outlets have investigated various methods of limiting access to files containing information, such as accounts receivable and cash deposit totals. Time-sharing centers have been especially interested in preventing fraudulent billing schemes.

Development needed. Experts in industry and government expect access controls to be offered by computer vendors within the next three or four years, but Davis and another expert, Rand Corp. analyst Willis Ware, say that these systems are not now available on the commercial market. Davis says that techniques and systems developed for the military could be adapted by commercial firms "when the incentive is there." Such techniques—including voiceprints, fingerprints, hand geometry, and magnetic cards—can be circumvented or have not been sufficiently developed, Davis has told a Senate committee. Experts say the cost of secure-access devices, between $20,000 and $30,000 per four-terminal data bank, may be too high.

Technology lags. That's what Ruth Davis says about security and privacy hardware. She directs NBS computer science institute.

Davis sees security as "a whole new market for the future. No one has gotten beyond the superficial level of computer-security devices. At this time, we don't have the slightest idea what the total cost of security will be, but preliminary studies indicate the cost to the Federal Government would be between $750,000 and $5 million at the upper end of the spectrum, plus up to $1 million per year in operating costs, depending on which legislation is passed. Encryption techniques [guidelines on encryption are soon to be issued] will result in a four-fold increase in transmission."

Rapid application of current technology, plus development of new technology, will be needed to meet the demands of the proposed legislation, she notes. And increased transmission lines and facilities would be needed to handle the extra load.

Bills. Despite the warnings about cost and technology, there's no shortage of bills in the congressional hopper. The legislation includes formation of a Federal privacy board, to be responsible for annual reports on the size and number of Government data banks with personal information. Other proposals that are included in many of the more than 100 computer privacy proposals include requirements for recording each access to a system and keeping that information for two years or more.

Davis, at hearings of the Senate's constitutional rights subcommittee of the Judiciary Committee and the Senate Government Operations Committee, warned that such a requirement for information accessed only once in nine months would double a file's contents in seven years. Davis also noted that merely recording each access by the operator's name is not too difficult, but if the legislation requires a catalogue of facts—such as which part of the data bank was accessed, and what was reviewed and for how long—the resulting need for memory and operating costs would be exorbitant. She indicates that costs of increased memory capacity and the development and sale of access-control systems would have a major impact on the computer industry.

"Either a computer data bank has access controls or lots of insurance—those are the only two options I see in response to the security-privacy legislation now before Congress," says Rand's Ware, who is also a technical consultant to Wema. He warns that it will be more difficult to apply access control to some computers than to others. For the data-bank operator, Ware says the new legislation would mean that more memory capacity would be devoted to housekeeping.

Packages coming. As for the vendor hardware, Ware says, "In the next three years, most hardware manufacturers will offer hardware-software security packages as part of a security safeguards system. And right now, there are not many gadgets around that can authenticate if the user is who he says he is." Most of the proposed bills permit aggrieved citizens to sue computer data-bank owners if the owner/operator does not comply with privacy guarantees in the legislation, including prohibitions against improper disclosure of personal information.

The final Senate committee proposal should be before the floor for a vote by the end of the summer, according to Congressional staffers. They expect House action before Christmas. A computer-privacy bill is inevitable this year, they say, because it is a "computer-privacy-conscious" Congress. Sen. Sam Ervin (D, N.C.) a prime sponsor and mover of the computer-privacy legislation, makes the same prediction.

Impact. Already the specter of legislation has had an enormous impact. General Services Administrator Arthur F. Sampson has announced a new policy of submitting computer-procurement proposals to Congress before requesting bids, and the GSA now reviews the security requirements and features of in-house computer proposals from other executive agencies [*Electronics*, June 27, p. 30]. Proposed major system purchases for the Internal Revenue Service, the Veterans Administration, and the Justice Department are being held.

The GSA delay in future computer and telecommunications procurements stems from the recent furor among the agency, Congress, and the White House Office of Telecommunications Policy over a large computer-procurement proposal issued in February but withdrawn in May. GSA wanted to purchase up to 10 large computer centers for it and the Agriculture Department—all connected by a dedicated network. OTP objected to the size of the purchase, the failure of GSA to try for leased telecommunications systems, and the absence of detailed cost estimates for the package.

GSA will issue an amended request for proposals this summer for a smaller computer system without a telecommunications network. The agency temporarily will use its Federal telecommunications system but issue an RFP on a telecommunications network next year unless Congress intervenes. □

Sweden's watchdog

Sweden's Data Inspectorate—the world's first data-bank watchdog—has made its first major decisions. The rulings are expected to have long-range effect on private data banks in that country. Perhaps the most important is rejection of a plan by the nation's banks to establish a national repository of information on all Swedes to be used for credit and other financial transactions. Each bank will be permitted to operate data banks only on its own customers.

The Swedish privacy laws and those being submitted to the U.S. Congress have basic differences. The American versions are concerned to a major extent with computer security, as well as privacy. On the other hand, the year-old Swedish law [*Electronics*, July 19, 1973, p. 72] prevents, among other things, keeping records of highly personal matters, gives each citizen the right to get a free printout of his "dossier," forces data banks to correct errors or eliminate names on request, and gives citizens the right to sue data banks.

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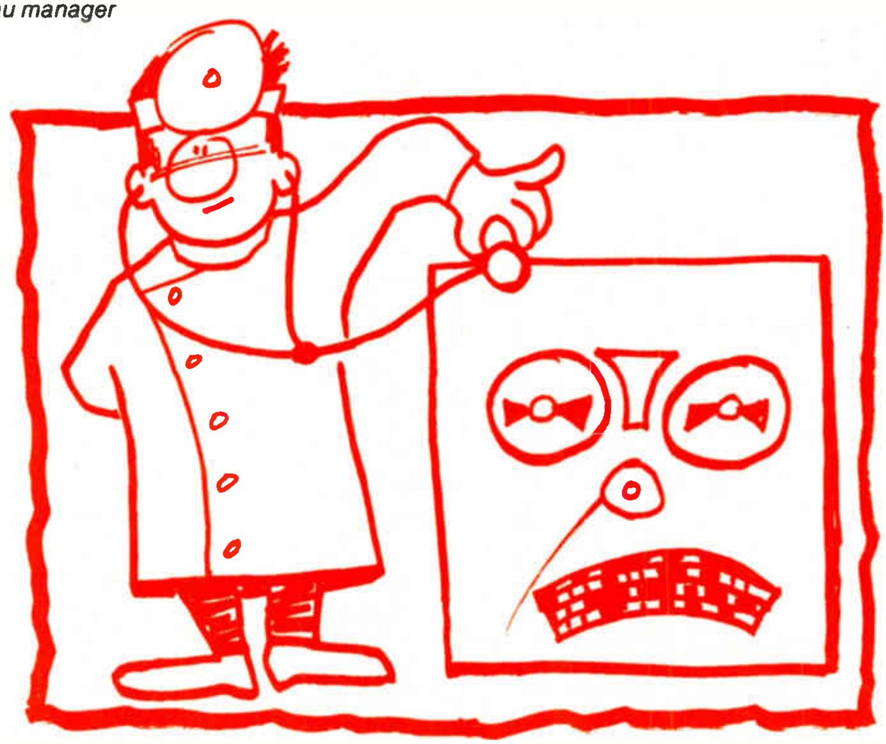
Instrumentation

Power woes create a market

Line monitors appeal to banks, insurance companies, research labs, and others worried about variations in voltage and current

by Bernard C. Cole, San Francisco bureau manager



If you think you've been affected by the power-generation problem, pity the operator of an elaborate computer installation facing questions. Should data be checked to see if a sudden voltage drop has skewed it? Has the uninterruptible power system malfunctioned? Has a power variation made test results faulty?

The answers are being supplied in more and more cases by power-line monitors. These instruments range from $300 strip-chart recorders that record voltage, current, or frequency to elaborate power-line-monitoring systems costing as much as $25,000 for their multiparameter capabilities. In the words of one maker of such equipment, "It's like selling insurance."

There is still only a handful of firms in this infant industry. One of them is Programed Power Inc. of Menlo Park, Calif.

"Last year's fuel and energy crunch woke up a lot of people in the electronics and computer industries," says president Lee Cooper. "They found out that, much to their dismay, they can no longer take for granted what comes out of that electrical socket in the wall. Since then there has been an incredible rush of companies looking for instruments to help them determine power needs."

Although PPI's main motivation since incorporating in January 1972 has been the development of uninterruptible power systems, the company has found a lucrative sideline in its model 3200 power-line monitor. It falls midway between the other models on the market in terms of cost at $3,200 and combines the portability of less expensive models with the sophistication of more expensive monitoring systems.

Sales for the monitor last year totaled only $200,000. This year, PPI expects to gross between $600,000 and $1 million. Among the company's customers are Aetna Life and Casualty, the American Broadcasting Co., Brookhaven National Laboratory, Control Data Corp., Univac, E. I. DuPont, Ford Motor Co., Eli Lilly and Co., Montgomery Ward, NASA, the Army, Navy, Air Force, and the Departments of State and Defense, the Stanford Research Institute, and the University of Michigan.

On the East Coast, Data Research Corp. of Fort Lauderdale, Fla., finds business getting better and better. According to Linda Stark, sales manager, the company's sales amounted to only $200,000 in the fiscal year ending July 31, 1972. But last year's figure doubled to $400,000, and while the numbers haven't been totaled for 1974, company officials say flatly that 1974 will be even better than last year.

One of the causes of Data Research's optimism is the success of its Powerguard, a $485 model. The instrument is being offered by General Electric as part of its instrument-rental program, and, says Stark, the giant corporation is enthusiastic about customer response. Leasing, incidentally, is an important business for Data Research. "A customer will take an instrument for two or three months to find and correct a problem," explains Stark.

The company's business mix runs around 70% to 90% computer users, and a good part of the remainder is from Government agencies. And, says Stark, some of her company's instruments even keep an eye on uninterruptible power systems, which are supposed to eliminate the power problem entirely. One bank, she says, thought that the bad data coming from its computers was due to power glitches. But installation of a monitor showed that the power system was to blame.

One would tend to think of the power-monitor business as a one-piece sale aimed at a particular problem. But that's not so, says PPI's Cooper. Actually, the situation is just the opposite.

"A few weeks with a monitor on the line and customers realize that the power environment, even excluding brownouts and voltage reductions, is not a constant one. It isn't even one with just a few predictable variables that can be guarded against by altering the equipment or inserting buffers to protect the sensitive electronic components."

For one thing, the impedance of power lines can cause transients and voltage drops, especially when large loads are tied into the same power loop. Current loads from motors, large transformers, mercury arc lighting, and even auxiliary power sources can drop line voltage 10% to 20% for longer than 30 milliseconds. Add this to the typical power variations of ±5%, and computer operations, for example, would be marginal at best. And there is also the problem of voltage continuity.

Remedies to many of these problems exist in the form of motor-generator sets, line conditioners, or voltage regulators to buffer delicate electronic systems from incoming power disturbances and in uninterruptible power sources to maintain complete and regulated output for both transient and long-term disruptions or outages.

"But the power network isn't a steady-state environment," says Cooper, "and as a result some form of monitoring is virtually mandatory, if only to provide records of the quality of the electrical service and give some idea of how to alter safeguard procedures." □

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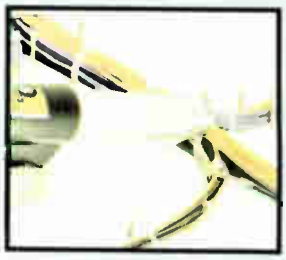

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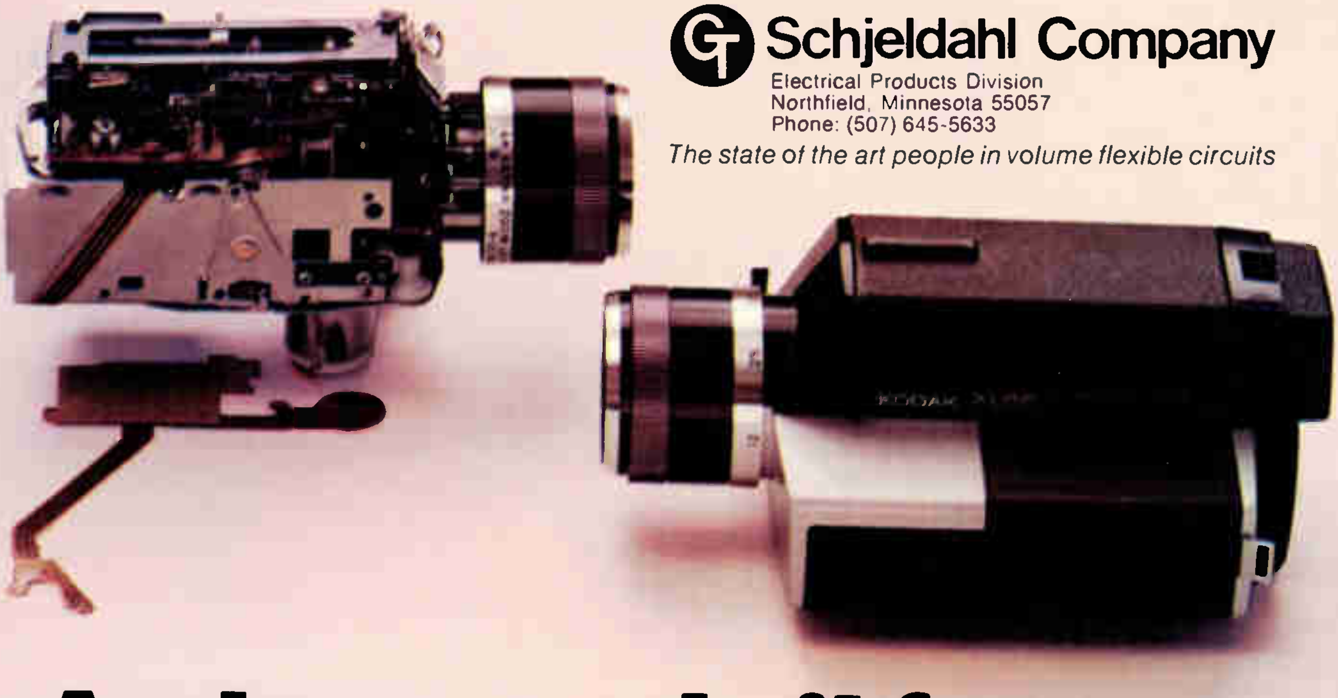

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Semiconductors inside tubes make high-performance rf amplifiers

Rf power amplifiers and modulators with unprecedented voltage-rise-time and gain-bandwidth capabilities will soon be obtainable, now that it's possible to build reliable, long-lived electron-bombarded semiconductor devices

by David J. Bates, *Watkins-Johnson Co., Palo Alto, Calif.*

☐ Electron-bombarded semiconductor (EBS) devices, which are essentially semiconductor diodes in the same envelopes as modulated electron beams, are now coming on the market as radio-frequency amplifiers and modulators that far outperform either vacuum tubes or semiconductors acting on their own. The idea is not new—an EBS device, after all, is just a photodiode illuminated by a high-energy electron beam instead of light—but only in the past few years have the problems of reliability and lifetime been solved.

No EBS device is in actual systems use yet, but their unusual features will soon make them an attractive alternative in many high-power, wideband digital and analog systems. For instance, their gain-bandwidth and power-bandwidth or voltage-rise-time capability is 100 to 10,000 times greater than that of existing competitive devices. A high-voltage modulator has produced 800 volts output with less than a 1-nanosecond rise time, for a dv/dt of nearly 10^{12}v/second. A high-current modulator has produced 100 amperes output with 2-ns rise (and fall) time, for a di/dt of 50,000 A/microsecond.

Besides an electron gun and diode, an EBS device contains an rf input section and an rf output assembly (Fig. 1). The gun is biased negatively with respect to a semiconductor diode, either a conventional pn junction or a Schottky diode. The electron beam, which illuminates the diode with electrons having energies in the 12- to 15-kilovolt range, is controlled by a pulse from the rf input section. The rf output assembly takes the signal from the diode, which is reverse-biased well below avalanche threshold in order to keep leakage currents low when the electron beam is turned off.

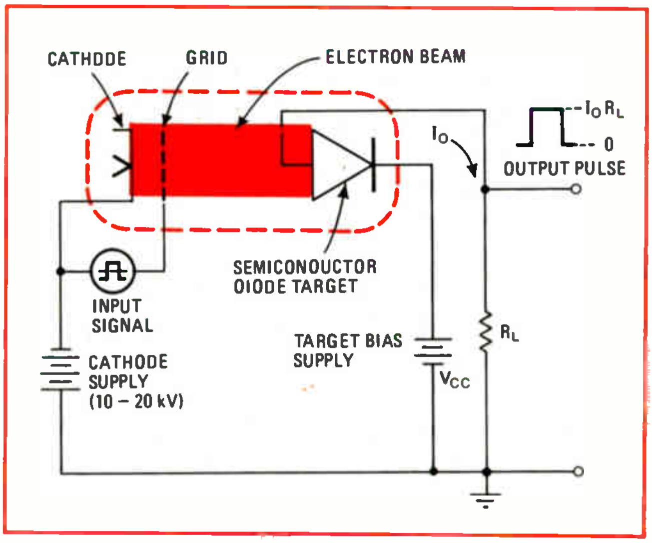
While the electron beam is on, however, electrons penetrate the depletion region of the diode (Fig. 2) and generate hole-electron pairs—one pair for each 3.6 electron-volt loss (more or less) of incident electron energy. This results in a current gain, from electron beam to diode current, of 2,000 or greater. The diode current then is applied to a load to develop the output pulse.

Three types

Figure 1 shows the most basic kind of EBS device. Known as the density-modulated type, it has some of the characteristics of a vacuum-tube triode. Since its output current is related to the grid voltage by an approximate three-halves power law, it is not used for applications that need linearity. However, the density-modulated device has a transconductance per unit area of cathode that is about 1,000 times greater than in a conventional planar-grid triode. This gives it much greater gain-bandwidth or voltage-risetime characteristics and makes it excellent for modulator applications.

A second type of EBS device is deflection-modulated (Fig. 3). Here, a traveling-wave modulation structure deflects the beam to illuminate a diode, and the amount of diode current is proportional to the deflection voltage. In an actual device, a deflection mask is inserted in front of the diodes to collect electrons when no input signal is applied. Highly linear amplifiers can be built with this technique. With two target diodes, the device can be operated in a highly efficient class-B operation—half of the input sine wave would deflect the beam in one direction and illuminate one diode, and the other half of the sine wave would illuminate the other diode.

The deflection-modulated device has no analog in ei-



1. Grid control. One type of electron-bombarded-semiconductor (EBS) device is similar to a vacuum triode. It uses a control grid to modulate the electron beam and hence the diode current. The output, taken across a load, can be of either polarity.

ther the vacuum-tube or semiconductor realm, so its performance cannot be compared with that of an existing device. However, it has achieved 50 watts linear rf output over a dc-to-300-megahertz frequency range.

A third type of EBS device creates a density modulation of the beam at the diode by modulating the electron velocity and then allowing the electrons to drift over a suitable path length. However, this type device seems not to offer as immediate applications as the first two types and has remained relatively undeveloped.

From concept to reality

The major difficulties in developing an EBS device arise from the need to put a semiconductor device with a high electric field at its surface into a vacuum envelope with a thermionic cathode. This can produce mutual contamination problems between the diode and the cathode, while the high temperatures required for the vacuum-tube process can affect the semiconductor diode's reverse breakdown voltage. Similar breakdown problems are caused by the high electric field at the interface between diode and vacuum. Then, too, bombarding even a passivated semiconductor with energetic electrons creates positive-charge traps. Finally, simply operating the diode at a high level of power dissipation means a lot of heat must be removed.

Early EBS devices used bare-junction mesa diodes, but the reverse breakdown voltages of these diodes quickly deteriorated during operation. Surface passivation with a thermal oxide over the junction region corrected this difficulty, but the charge traps continued to degrade the breakdown voltage. The effect was particularly evident in p-on-n diodes, which, unfortunately, are preferable for rf devices, because they have higher carrier drift velocities than the n-on-p type.

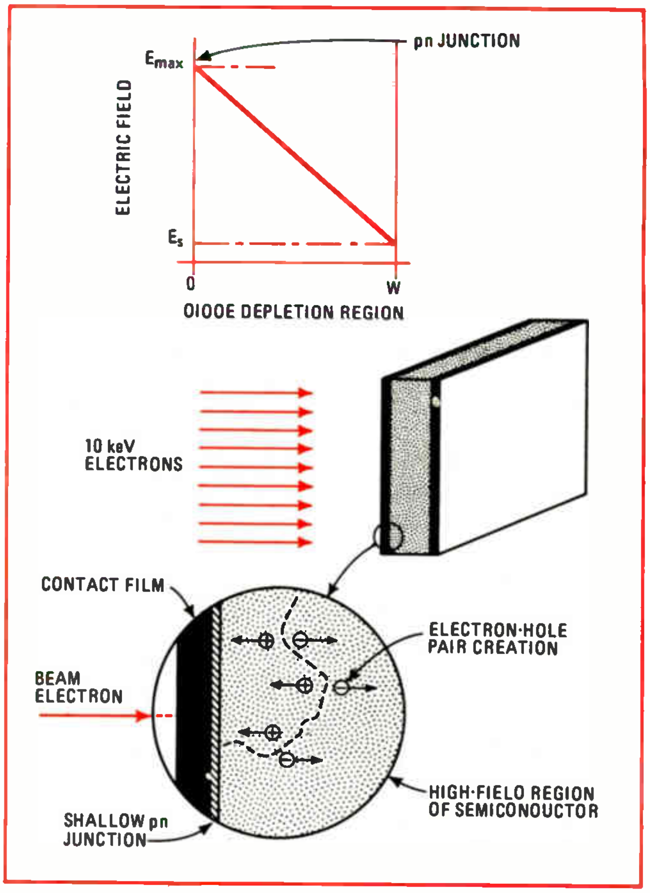
The problem was solved with a radiation-hardened passivated planar diode developed in association with Signetics Corp. This diode has a thick deposit of phosphosilica glass over the thermal oxide, and conventional beam-lead processing methods are used to form a metal electron-beam shield slightly above the surface of the oxide-glass passivation layer. The shield is located directly above the junction of the planar diode (Fig. 4).

Thermal problems were solved by attaching the diode to a heat sink by a method of silicon-gold void-free bonding. Such a diode can be operated with about 50 W continuous-wave output power and a maximum rise in diode junction temperature of 100°C or less.

How reliable?

The two elements that will wear out first in the EBS device are the semiconductor diode and the thermionic cathode. Still, cathode life is expected to be greater than 30,000 hours, and diode life should ultimately be many times the cathode life.

Several deflection-beam rf power amplifiers are on cw life test at Watkins-Johnson. As of June 24, 1974, two of these have accumulated 12,600 and 11,210 hours, respectively, with no change in operating characteristics. Eight devices have operated for 70,160 hours at diode dissipation densities between 20 and 35 W/mm^2 without failure, resulting in a mean time to failure of 78,000 hours at a 60% confidence level. Since each device contains two diodes, the total diode operating time is 140,300 hours at an MTTF of 156,000 hours, or about 17.8 years at a 60% confidence level.



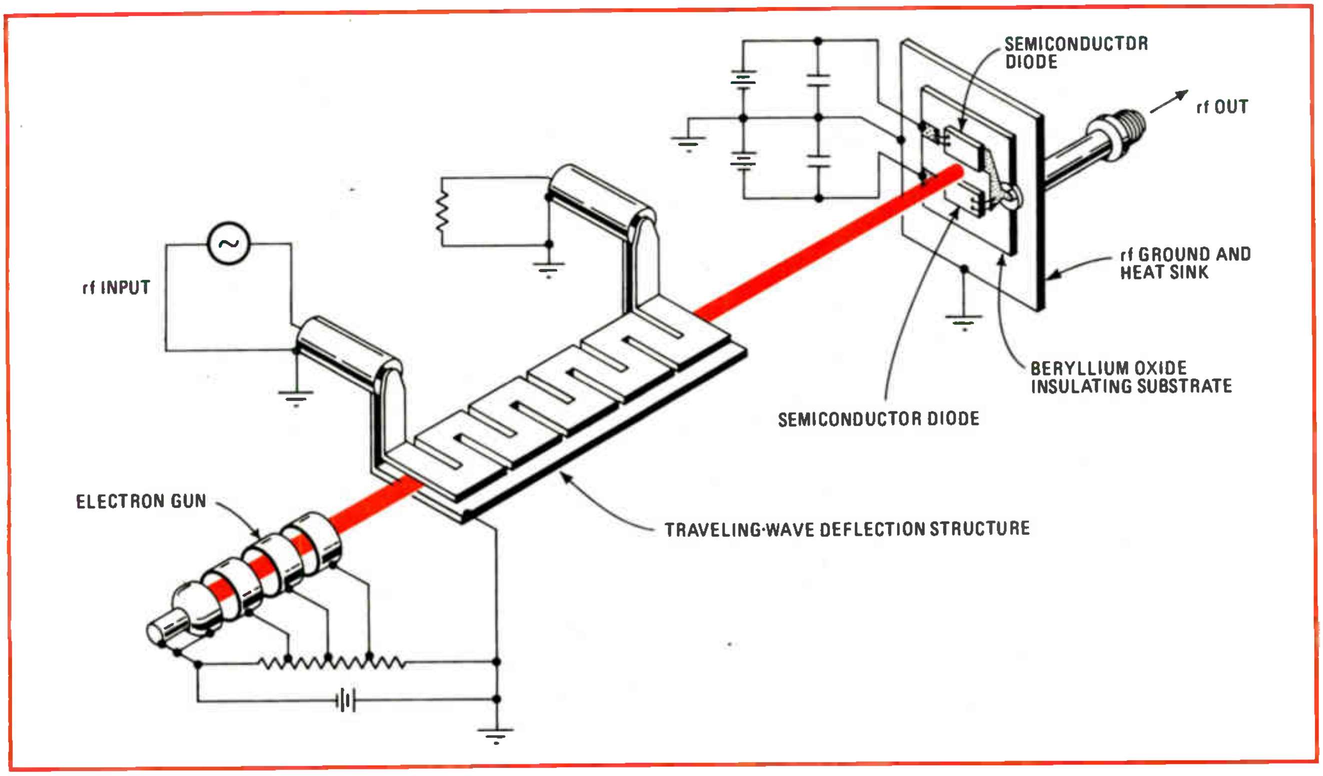
2. Close-up. When high-energy electrons strike a reverse-biased diode, they create electron-hole pairs in the diode depletion region. The high electric field then sweeps carriers out of the region to the output circuit. Result is current multiplication.

In addition, four high-voltage modulators have completed 22,350 hours with one failure for an MTTF of 10,900 hours at 60% confidence level.

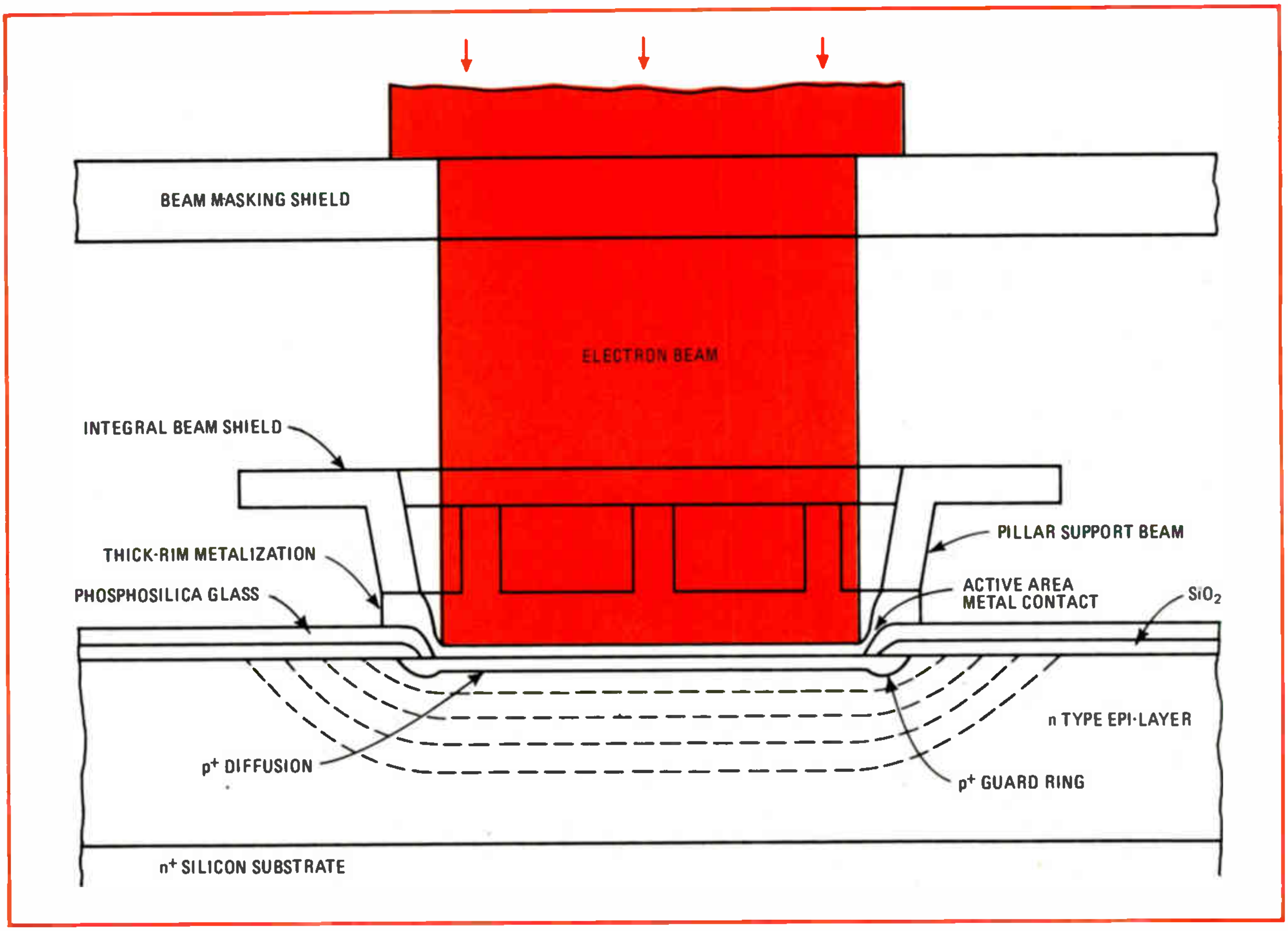
A good selection

Various versions of the density and deflection-modulated devices have been developed. Examples are: single-target-grid-controlled, density-modulated devices, which can be operated either Class C or Class A, and deflection-modulated amplifiers with either single targets for Class-A and Class-C operation or dual push-pull connected targets for Class-B operation.

In a planar-grid density-modulated device, for example, on-off signal ratios greater than 100,000 have typically been measured. This unit, which can be operated up to a 4% duty factor, provides 400-V output with 12-V input into a 100-ohm load, and a total rise time of 4 ns has been achieved (measured from the 10% point of the input waveform to the 90% point of the output pulse). This performance makes the device desirable for many fast-pulse modulator uses, such as optoelectronic modulators, electronic countermeasure deception repeaters, and pulse radar and dual-mode ECM systems. As a traveling-wave-tube grid modulator, the unit provides 400-V output into a 100-ohm load in shunt



3. Beam bender. In a second type of EBS device, a traveling-wave structure deflects the electron beam, making it strike one of two diodes. This gives Class-B operation for good linear amplification. Amount of diode current depends on degree of beam overlap.

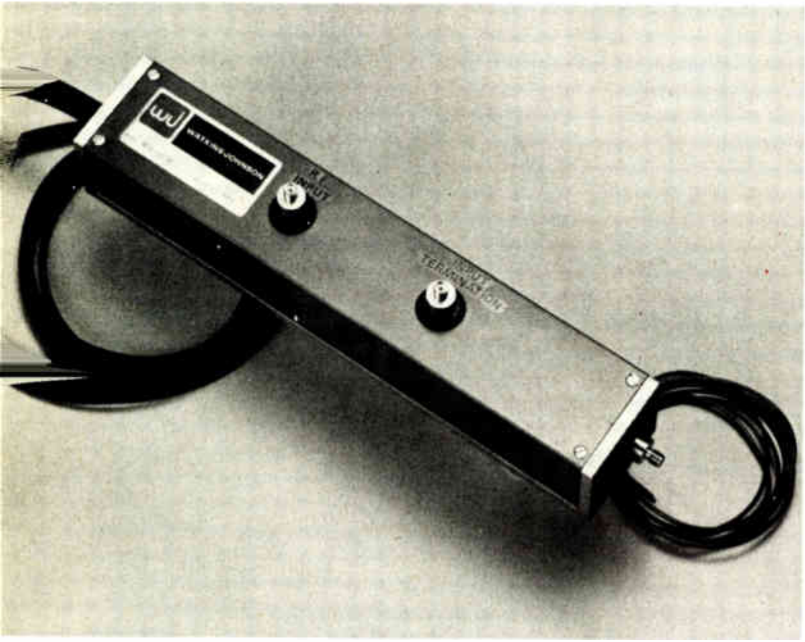


4. Shielded diode. An integral metal shield, formed by beam-lead-type process during diode manufacture, protects the diode's oxide and phosphosilica glass layers from the electron beam. This device was developed jointly by Watkins-Johnson and Signetics Corp.

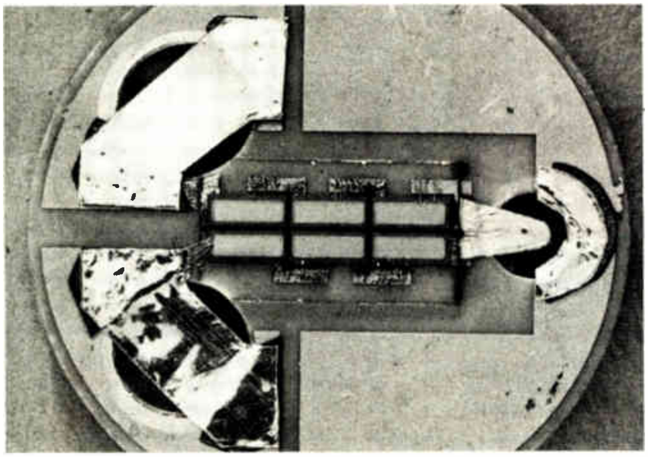
with 30-picofarad grid capacitance, with a total rise time plus delay of less than 12 ns. A modified version that can provide 850-V output is expected to be available within six to 12 months.

A high-current modulator also has been developed to produce 100 A into a 1-ohm load with a 2-ns rise time and up to 250 A at lower load impedances. Values of di/dt of 5×10^{10} A/s and peak powers of 12 kW have been achieved. Within the next 12 months, peak powers of 30 to 40 kW are expected, and ultimately 100 to 200 kW per device should be achievable.

A conduction-cooled cw low-pass rf amplifier, which uses a deflected beam, has a pulsed output power of 200 W from dc to 160 MHz. The cw or average-power capability of liquid- or forced-air-cooled versions is 50 W. A slightly different version of this device will give 25 V cw from dc to 310 MHz.



5. Ready to go. A completed EBS device is supplied in a configuration like a traveling-wave tube's. This unit, Watkins-Johnson's type 3650, is a deflected-beam video pulse amplifier with a gain of 25 decibels and a rise time of less than 1 nanosecond.



6. On target. Six diodes, arranged in two parallel sets of three and mounted on beryllium oxide heat sinks, comprise the target for a deflected-beam EBS device. A sheet beam from the electron gun illuminates each set of diodes alternately.

The linearity of a Class-B EBS is excellent: third-order intermodulation distortion for balanced two-signal operation is approximately 15 decibels down at saturation, and for 3-dB back-off from saturation, the third-order intermodulation signals are 25 dB below signal level. Total phase deviation from small signal to saturation is in the order of 3°. Recently, 500 W of pulsed rf power at 1,500 MHz with a bandwidth of 105 MHz was demonstrated. Performance improvements are expected in the next six to 12 months—over 100 W cw from dc to 300 MHz, and 50 W cw from 100 to 400 MHz and with 1,000 W pulsed rf power in the frequency range of 1 to 2 gigahertz with 5% to 10% bandwidth.

A deflected-beam video pulse amplifier will yield ±120 V output with 1-ns rise time into a 50-ohm load with approximately 25-dB gain. Operated as a cathode-ray-tube modulator, it will produce 80 V peak to peak to turn a CRT beam on or off. A bandwith of dc to 200 MHz, or the equivalent pulse rise time of 1.5 ns, has been measured with a 50-ohm load in shunt with a 5-pf capacitance (which is typical of the grid capacitance of some CRTs). Operated as a pulse amplifier, the same unit has produced 100 V output into a 50-ohm load at a 500-megabit data rate.

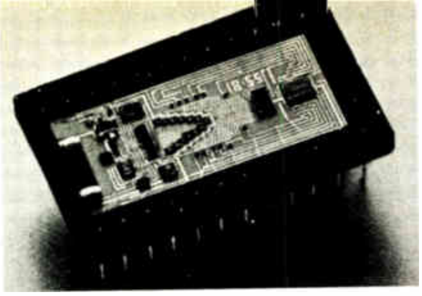
Thus, it is suited for a wide variety of linear video-amplifier requirements, and especially for rapid modulation of CRTs, electro-optic modulators, and high-power avalanche or Gunn devices. The output voltage will probably be increased within the year to ±250-V pulse at 10% maximum duty, or ±70 V cw into 50 ohms.

Where EBS devices will go to work

The primary impact of EBS power devices on the market in the next five years will most likely be in the areas of: high-voltage or high-current, very fast modulators; linear video amplifiers for fast pulse generation; modulators for data transmission systems, which will operate up to a 2-gigabit data rate; and linear rf amplifiers having a few hundred watts of cw output power or 1-to-2-kW pulsed output power for frequencies below 2 GHz.

Though in some cases the EBS device will replace an existing device, the greatest potential seems to lie in amplifiers beyond the capability of existing devices. As an example, a 400-W cw transistorized rf amplifier has been reported as operating at 0.96 to 1.18 GHz with a gain in the order of 20 dB. This amplifier, however, required more than 20 high-power transistors plus 28 hybrid power splitters and associated circuitry needed to combine all the transistors, whereas, in the near future, a single EBS device should give similar performance.

The major factor governing the share of applications captured by EBS devices will be price. The relative simplicity of the devices assures that the cost of large quantities will be reduced below $1,000, and in some cases well below $500, depending upon the requirements. The associated power supplies are expected to cost under $1,000 and in some cases, for low-duty application, under $500. Thus, complete laboratory-instrument amplifiers will be cost-competitive with existing medium-power TWT amplifiers and will complement them in the frequency range from dc to 2 GHz. □



Which hybrid converter: single-switch or quad?

When carefully fabricated, a single-switch hybrid analog-to-digital converter (shown above) outperforms quad-switched types; it provides 12-bit resolution with better than 0.024% accuracy over −55° to +125°C

by Richard D. Tatro, *Micro Networks Corp., Worcester, Mass.*

☐ Though single-chip ICs are successful enough as low- to medium-precision digital-to-analog converters, they still lack the precision and stability necessary for truly high-resolution (12-bit and up) conversion—both d-a and a-d. Discrete designs, on the other hand, because their various components seldom heat up identically, must employ expensive, complex circuitry to avoid temperature-induced errors.

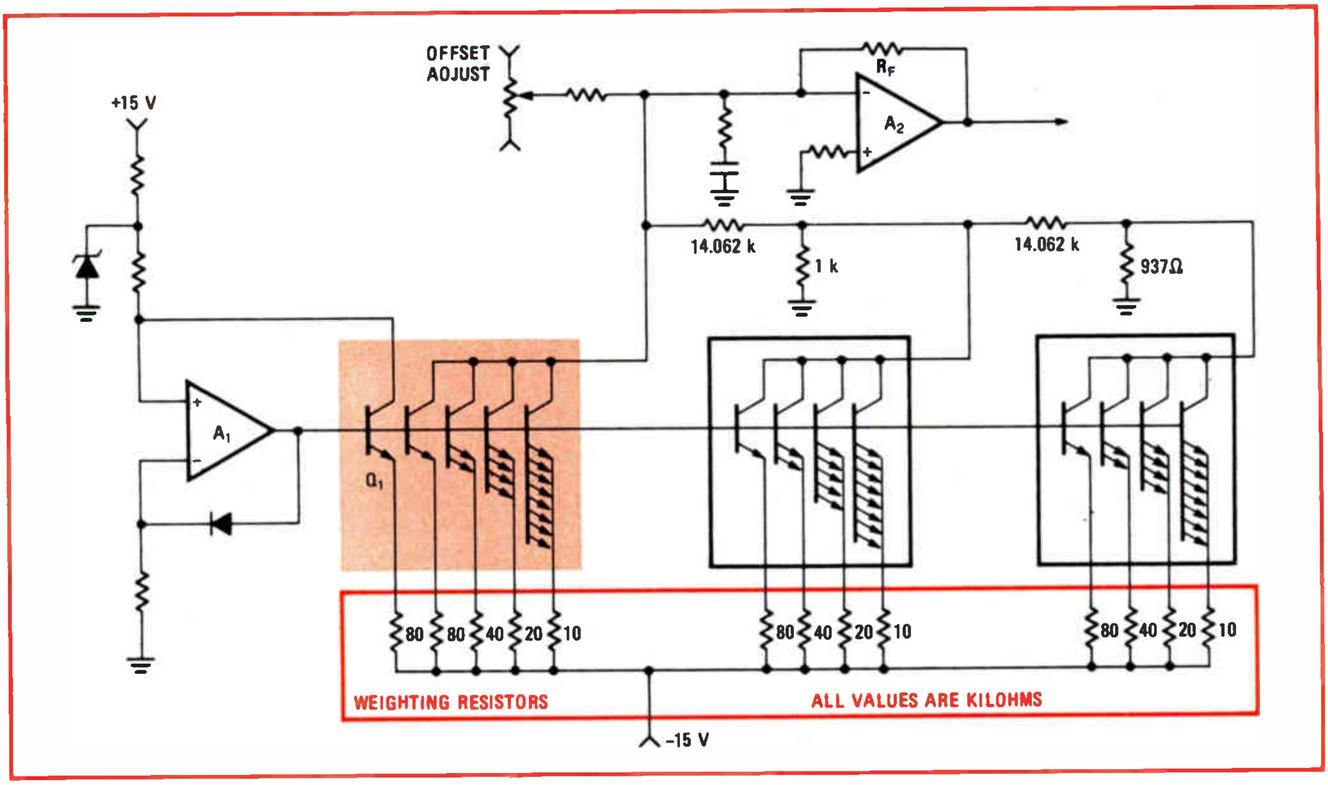
Hybrid designs get the best of both worlds—the combination of a thin-film resistor network with several semiconductor chips results in a converter capable of 12-bit resolution over a broad temperature range. But some hybrid designs are better than others. Quad switches are very popular, but the older single-switch hybrid circuit can yield better results if it is fabricated properly—that is, if it uses a well-stabilized resistor network and has all of its semiconductor chips mounted in close thermal contact with each other.

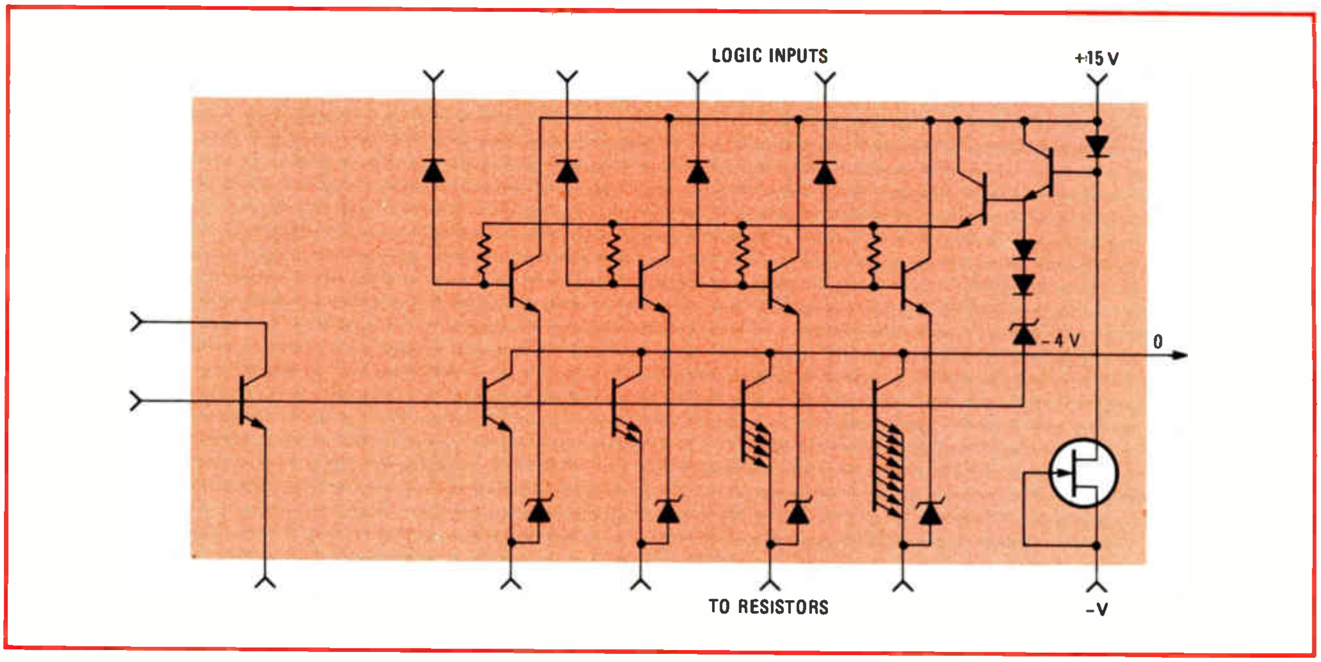
Because a-d and d-a converters come with a multitude of different and sometimes conflicting specifications, it is important for the user to understand their design and operation, even if he never intends to build one.

The two most important parts of a digital-to-analog converter, which in turn is the heart of the successive-approximation type of a-d converter (see "Three approaches to a-d conversion," p. 92), are its resistor network and its switching circuitry. The design approach that uses quad monolithic switches and precision resistor networks is shown in the simplified block diagram of Fig. 1. Since this general approach has been well covered in the literature,[1,2,3] only a brief description of its operation will be given here.

Operational amplifier A_1, in conjunction with the reference transistor Q_1, provides the base line voltage to all

1. Quad switching. In this simplified block diagram of a 12-bit d-a converter, temperature-sensing transistor Q_1 and op amp A_1 vary base line voltage to switching transistors to compensate for their V_{BE} variations with temperature. Digital inputs are shown in Fig. 2.





2. Current steering. Detailed view of single quad switch of Fig. 1 shows how logic inputs control switching of current into resistors. Use of multiple transistors ensures uniform heating by making all transistors in the quad circuit carry exactly the same current.

of the switching transistors. This voltage varies with temperature in such a way as to compensate for the temperature-induced changes in the base-emitter voltages of the switching transistors. The result is a fixed, temperature-independent voltage across the weighting resistors, which thus deliver fixed currents to the output amplifier circuit (A_2 and associated resistors). The base bias resistor also reacts to variations in the minus supply to maintain fixed currents.

Details of the quad

The expanded diagram of the current switch in Fig. 2 shows how the current is steered from the switching transistors when a high signal is applied at the switch inputs. To maintain V_{BE} tracking, multiple transistors are used, the current subdividing exactly equally between them. As only a limited number of transistors can be kept in close enough proximity to maintain thermal tracking, and as four bits is a good breaking point for BCD applications, the popularity of quad switches is understandable. Using three quad switches with three identical resistor networks, 16:1 scaling resistors can be made to convert 12 binary bits. The quad also allows 10:1 scaling networks to be used to convert three-decade BCD with ease.

But there are limitations and problems with this approach. They are generally the same as with discrete approaches, although all the switch errors are lumped to one specification. Resistor errors can also be lumped if thin-film resistor networks packaged in one or two chips are used. What remains the same, however, is the error budget, which includes the switch error, tolerance of the resistors, and offset and bias current of the operational amplifiers or comparator. Then, too, temperature coefficients of the components must be considered with all components held at exactly the same temperature.

One other disturbing aspect is the tendency of the servo amplifier, A_1 to latch up. Although several schemes can be made to work, including the one shown in Fig. 1, care must be taken both in component selection and layout.

All these considerations affect both linearity and accuracy. In terms of accuracy alone, the output amplifier must be zero-adjusted and the output voltage range trimmed to compensate for switch error, resistor tolerance, and reference error. These adjustment pots will then also contribute errors with temperature.

The table summarizes the error budgets for the linearity and accuracy of the switch and resistor portion of the circuit of Fig. 1, based on typically available component parts. Not shown are output amplifier or comparator errors, which, however, also have to be added in.

As the table shows, at 125°C linearity could be as bad as 0.09%—nearly 1 least significant bit at 10 bits (0.05% = ½ LSB). Although admittedly it is not a fair assumption that all possible errors will have their worst-case values and will have signs that make them additive, this sort of thing can and does happen often enough to be a very real problem. After all, a 12-bit converter with 10-bit linearity is no better, and is perhaps worse, than a 10-bit converter.

The table further shows that a range adjustment of approximately 10% is necessary to bring this converter to its desired output, and even then it could still have an inaccuracy of slightly more than 1 LSB. In addition, there are errors caused by differences in temperature between parts internal to the hybrid circuit and between those parts and the adjustment pots.

If it does nothing else, this discussion of error sources should alert the potential purchaser of a high-resolution converter to the necessity of studying its specifications before he buys. If the specs say ½-LSB linearity at 25°C, take a moment to make the calculation of x°C times y ppm/°C to see if you have a 12-bit or a 10- or even a nine-bit converter. If they say accuracy is adjustable to ½ LSB, find out what the untrimmed accuracy is, and

TABLE: MAJOR SOURCES OF ERROR IN THE QUAD-SWITCH HYBRID A-D CONVERTER					
ERRORS IN LINEARITY			ERRORS IN ACCURACY		
Parameter	Typical	Maximum	Parameter	Absolute	Matching
Switches	2 ppm/°C	5 ppm/°C	Switches	0.01%	0.01%
Source resistors	1 ppm/°C	2 ppm/°C	Source resistors	2%	0.012%
Scale and feedback resistors	1 ppm/°C	2 ppm/°C	Scale and feedback resistors	2%	0.006%
Worst-case total	4 ppm/°C	9 ppm/°C	Zener diode	5%	–
Worst-case total at 125 °C	400 ppm (0.04%)	900 ppm (0.09%)	Worst-case total	9%	0.028%

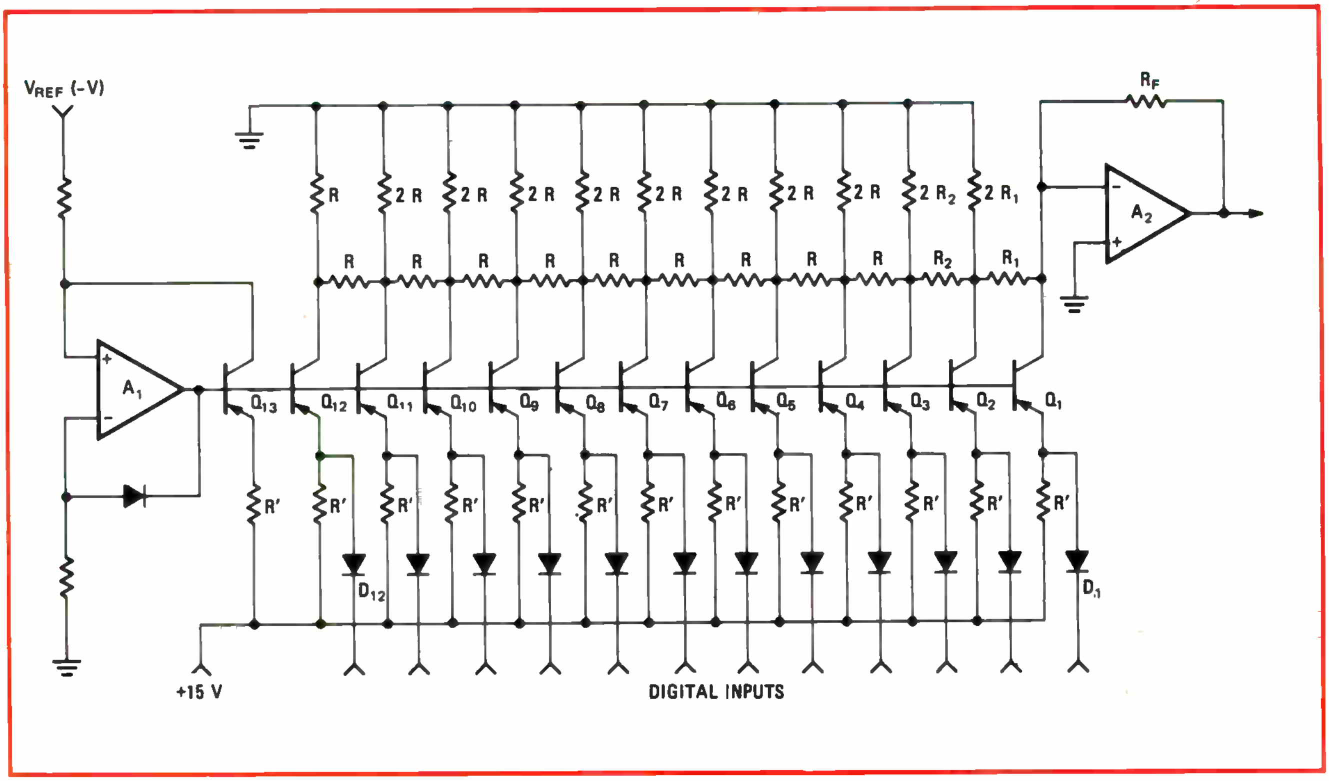
how much it must be adjusted to obtain the ½-LSB figure. The same applies to output zero adjustments. Perhaps more wisely, you should simply go a step further and look for a converter that requires no adjustments and is guaranteed to meet its specs over a wide range of temperatures.

The circuit of Fig. 1 can be completely constructed in hybrid form with substantial improvements in accuracy and temperature effects from those shown in the table. Experience has shown that while ±½ LSB linearity for 12 bits is obtainable, the practical range of holding ±½ LSB is only −25° to +85°C. Although several IC manufacturers offer quad current switches, they are not usually completely interchangeable.

The single-switch hybrid circuit

Consider now the circuit of Fig. 3. The base voltage is developed in much the same way as in the circuit of Fig. 1. However, the current switching is quite different: all the current switches are of equal value and are divided through the output R/2R resistor network. This circuit is fast because the current-steering effect maintains a fairly constant current through the resistors, and because the common-base switch configuration allows for fast switching. RC time constant effects are small in the output circuit because of the low resistor values used in the R/2R ladder. Finally, the fact that all the currents are equal means there is no need to put transistors in parallel and also simplifies the thin-film resistor network design, since all resistors can be equal and generally smaller in value than those used in the approach of Fig. 1.

To those familiar with converter design but not with hybrid techniques, this design may seem to have several obvious defects. It is virtually impossible, on a production basis, to select 13 transistors with exactly equal values of V_{BE} and ΔV_{BE} with temperature. Even if it were possible, there is still the problem of holding them all at



3. Older is better. "Old-fashioned" single-switch design uses same temperature-compensation scheme as quad switch, but much simpler current-steering technique. Superbeta transistors cut from the same wafer and mounted in intimate thermal contact with each other are secret of how this circuit works. Common-base configuration makes circuit fast as well as stable.

Approaches to a-d conversion

Analog-to-digital converters divide up into three basic types: parallel, integration, and feedback. Parallel conversion requires a considerable amount of decoding circuitry and the use of ($2^n - 1$) comparators (where n is the number of bits to be resolved). In general, while being extremely fast, it is quite expensive and is usually limited to low-resolution converters. At the other end of the spectrum is the integrating converter, for which the dual-slope integration technique is the most popular. This design approach is quite economical for high-resolution converters, but conversion time is very long. The entire middle ground belongs to the feedback converter.

In general, the feedback converter uses a digital-to-analog converter with logic circuitry in a comparator feedback loop to generate a digital output. Most popular of these are the counter or ramp a-d, the tracking a-d, and the successive-approximation a-d converter. All are based on the generation of a digital number that, when converted to an analog value which matches the analog input, is signalled that it is correct by the comparator.

The counter method is relatively slow, requiring up to ($2^n - 1$) clock pulses in order to attain the digital output. The tracking converter, which is a special-purpose device, acquires the signal in up to ($2^n - 1$) clock pulses but uses the comparator output as an up/down counter control and continuously "tracks" the analog input. For slowly changing analog inputs it does this with very little time delay.

Most popular because of its speed and versatility is the successive-approximation converter. This device requires more complex logic but results in a unit which completes a conversion in (n + 1) clock pulses. Briefly, the logic first turns on the most significant bit (MSB), producing a one-half scale output from the d-a converter and testing the input to determine if it is higher or lower. The resultant output from the comparator then decides if the test "1" is to be retained in the output register or returned to "0". This is repeated for each subsequent bit until the analog input has been "approximated" to 2^n with (n + 1) pulses. The extra pulse is required to signal the completion of the conversion and to reset the register for subsequent conversions.

It should be noted that the output from the comparator produces a serial output signal prior to the completion of the conversion, at which time a parallel output is available from the successive-approximation register. It should also be noted that the analog input must be held fixed during the conversion. If the analog signal is a changing signal it is necessary to use a sample-and-hold circuit to provide a fixed input to the successive-approximation converter.

the same temperature. A 1°C difference between the most-significant-bit (MSB) transistor and the other transistors will result in over ½ LSB linearity error (1°C would cause a 1.85-mV change in V_{BE}, resulting in a deviation of more than 0.015% in the output current when there are approximately 12.5 volts across the current-source resistor). As the current gains of the transistors would have to be very high and reasonably well matched in order to obtain an initial match better than several millivolts, this approach is totally impractical.

This same circuit, however, when constructed in the hybrid form shown in Fig. 4, is capable of ½ LSB linearity from −55° to + 125°C. Initial accuracy is well under 0.012% maximum, while accuracy over the temperature range of −55° to + 125°C is better than 0.024% with an external reference voltage.

To achieve such specifications, "superbeta" transistors with current gains of 500 at the switch current are used. Further, all transistors come from the same wafer to ensure exact tracking of V_{BE} with temperature. The chips are mounted so that they are all either at exactly the same temperature or at least at temperatures which will not change relative to each other with changes in input conditions or external temperature. Naturally, the V_{BE}s of the devices will not be the same but may vary by as much as 5 to 10 millivolts. This variation is not significant, however, as it results in less than 1–2 ppm/°C linearity error and the initial error will be eliminated in trimming.

Putting it all together

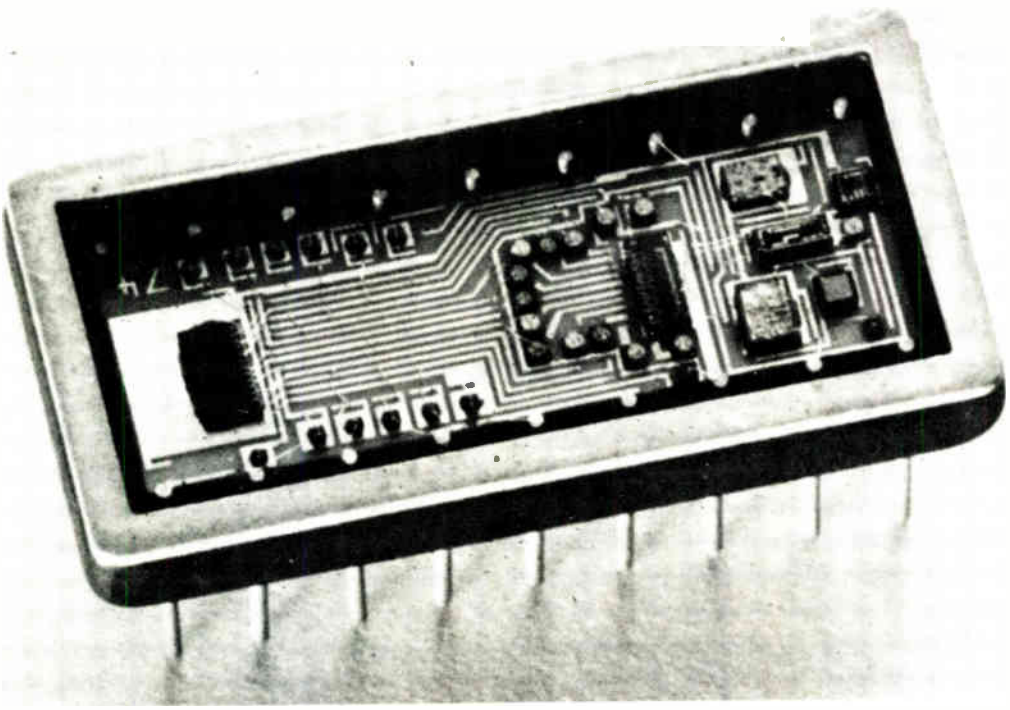
The completed circuit is assembled and then trimmed functionally. Supply voltages are connected and the inputs are set to the desired condition. In the case of a 0-to-+10-V unit, the output voltage is initially set to zero by trimming the operational amplifier balance resistor. With the most significant bit turned on, the source resistor associated with that bit is trimmed for an exact 5.0000-V output, the second bit trimmed to 2.5000 V and so on down to the LSB trim of 0.0024 V. As a result, absolute worst-case "add up" errors of well under ½ LSB (0.012%) are realized. The trimming system sensitivity is such that adjustment can be made as close as 0.1 mV and 12 individual trims do not add up to a large error. Trimming can also be done on a "summation" basis— that is, trimming Bit 2 with the MSB "on", Bit 3 with 1 and 2 "on", and so on, so that errors average out even smaller.

It can be seen that all errors in the error budget are trimmed out for each bit with a single adjustment. With proper device selection and construction and with a stable resistor system, this accuracy can be held over a wide temperature range. At −55°C, the transistor gain has fallen off by about half, but with a high initial gain this has little effect on the circuit. At temperatures in excess of 125°C, the circuit accuracy is still excellent, as diode and transistor leakages do not become significant until almost 150°C.

Resistors—the key to stability

Nickel-chromium resistor films have been used in hybrid circuits for many years,[4] although only in the last few years have adjustment techniques been available for high-accuracy trimming. The NiCr film is vacuum-deposited on an ultra-smooth substrate to a thickness on the order of 100 angstroms. The substrate may be glass, ceramic, or oxidized silicon. Somewhat thicker depositions are used with ceramics because of their greater surface roughness.

The deposition is performed at a closely controlled pressure and rate to obtain the degree of oxidation of the nickel and chromium that will result in a film of low temperature coefficient and high stability. Without breaking vacuum, a layer of nickel is evaporated onto the NiCr and followed by a layer of gold. The gold



4. Intimate contact. Key to success of hybrid design is tight thermal coupling between circuit elements. Switching transistors in this model MN360 12-bit d-a converter are all mounted within an area of 16 mm², while transistors that must track each other are mounted side by side. Result is a maximum nonlinearity of ±½ LSB over the full temperature range from −55° to +125°C with no adjustments needed.

forms the interconnect paths and bonding contact, while the nickel forms a barrier layer to prevent interaction between the NiCr and the gold.

The delineation of the resistor networks is a two step-etching process using photomasks. Following temperature aging to stabilize the film, the wafer is diced into chips and handled in subsequent circuit operation as a passive IC.

In all of the hybrid circuits shown, the resistors are deposited on silicon substrates. When ceramic substrates are used, all pattern metalization, including the resistors, can be put on the substrate. The decision whether to put a resistor network chip or resistors on the substrate is based on a number of factors, including cost, physical size, and ease of handling and trimming.

Substrate preparation also employs photo etching techniques to etch detailed patterns in gold on ceramic substrates.

The circuits shown use two types of chip-mounting techniques: eutectic and epoxy. In general, all electrical contacts are made by eutectic bonding and all non-electrical contacts with epoxy. Both techniques result in excellent mechanical strength, but eutectic bonding is superior for circuits that are sensitive to a very small amount of contact resistance.

One of the important features of hybrid design is the close thermal coupling between elements. Consider Fig. 4, which shows all the switch transistors clustered in an area about 4 millimeters square, while the transistors that need to track each other are side by side. Also, the resistors are closely spaced, and all circuit elements that are important to linear operation have been especially designed to have constant power consumption and therefore constant temperature.

All connections are made by thermocompression-bonding 0.001-inch (25-micrometer) gold wire.

The completely assembled device is then connected for operation in the trimming fixture, and the resistors trimmed by vaporization of the NiCr until the desired output voltage or current is attained. YAG lasers are used for this trimming step, the spot size being adjusted to less than 0.001 in. to allow sensitive trimming of resistors with 0.001-to-0.003-in. line width. The laser energy has no effect on the circuit operation, with the occasional exception of certain integrated circuits that require some shielding to reduce noise. Following trimming, the circuit can be checked right in the trim fixture to ensure that all bits of the converter add up properly.

The packaged unit is then hermetically sealed to insure long-term stability and submitted to environmental screening—five 0°-to-100°C liquid-to-liquid thermal shocks, 10,000–30,000-g acceleration, and gross leak tests. If required, most Micro Networks Corp.'s devices can be visually inspected before sealing to high-reliability test documents and also can be tested to fine leak requirements down to 10^{-7} cubic centimeter/s. All devices are designed to meet full environmental shock, vibration, and moisture-resistance specifications. □

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Five points to keep in Logic-Circuit

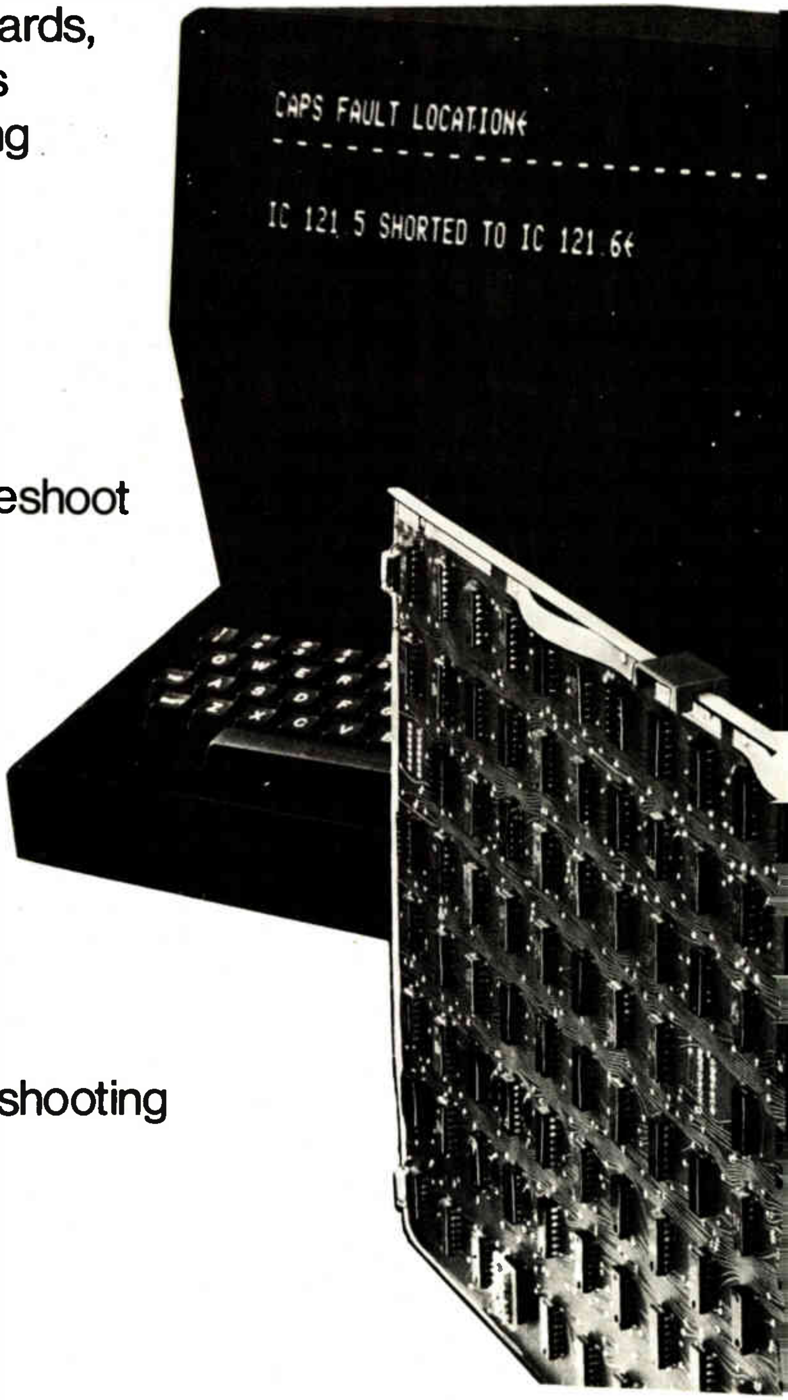
1. When testing complex boards, you spend most of a tester's available time troubleshooting defective boards.

2. Troubleshooting can be time-consuming and costly.

3. Not all test systems troubleshoot equally well.

4. Software is the least understood and the most important part of any test system.

5. The system that provides the best hardware/software integration minimizes troubleshooting time and expense.



mind when evaluating Testers...

It is the last point on the facing page that separates the GR1792 Logic Test System, with its CAPS software package, from all other logic-circuit testers. Among other things, CAPS removes the human element from troubleshooting as much as possible. In fact, it actually makes troubleshooting fun!

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Interfacing a teletypewriter with an IC microprocessor

by Steven K. Roberts
Cybertronic Systems, Louisville, Ky.

The lengthy software service routine generally required to interface a teletypewriter and an IC microprocessor, such as the Intel 8008, can be eliminated by the circuit shown here. A shift register and some control logic are all that it takes, bringing total component cost to only about $6.50.

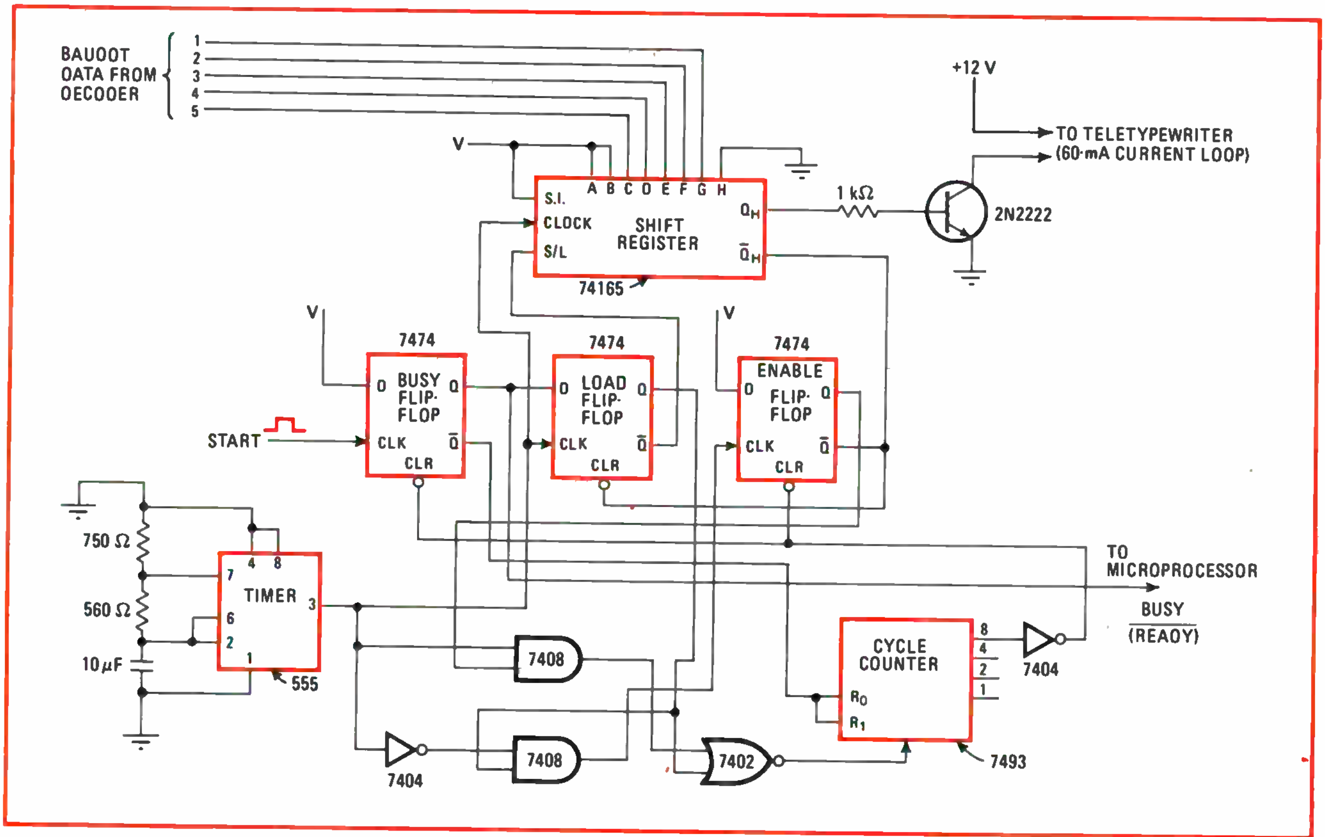
In the 8008 system, synchronization with the central-processing unit is accomplished through this microprocessor's READY line, making modification of the teletypewriter itself unnecessary. The hardware configuration given in the figure is designed for a 10-character-per-second Model 28 Teletype, which uses the five-level Baudot code. If the intended application will not easily accommodate data storage in the Baudot code, conversion may be accomplished with a read-only memory, such as National's MM5221TM. (A Model 33 Teletype presents no decoding problem.)

During the time that the input parallel data is valid, the circuit receives the START pulse, which sets the BUSY flip-flop and takes the READY line low. The BUSY flip-flop also removes the reset from the cycle counter and enables the LOAD flip-flop, which is set on the next clock pulse. This action loads the data at the input to the shift register and increments the cycle counter once.

On the succeeding clock pulse, the ENABLE flip-flop is set, and the data in the register begins to shift to the right. For each shift pulse, the cycle counter is incremented by one until it reaches a binary count of 8. Then, the BUSY and ENABLE flip-flops are both reset, and the READY signal is restored to the microprocessor so that the central-processing unit can resume operation.

In the data character presented to the shift register, bit H, which is constantly held low, corresponds to the teletypewriter START pulse. Similarly, the register's A and B bits are tied high, corresponding to the teletypewriter STOP pulse. Since the STOP signal must be applied to the teletypewriter for approximately 1.5 times longer than the other pulses, the BUSY flip-flop is reset on the falling edge of the clock, during the time that bit A is present at the register's Q_H output. The serial output of the register switches the 60-milliampere teletypewriter current loop through the transistor.

The clock signal for the circuit is derived from the IC timer that is free-running at approximately 75 hertz. For teletypewriters that operate at 6 characters per second, the clock frequency should be about 45.5 Hz. □



Software bypass. Digital interface circuit provides synchronization between a teletypewriter and a microprocessor chip through the latter device's READY line. Normally, a long software routine is needed to make the interface. The input data is in the parallel Baudot code, and the output is for a 10-character-per-second teletypewriter. A free-running IC timer is used to produce the clock signal.

Diode pair senses differential temperature

by Don DeKold
Dekolabs, Gainesville, Fla.

Normally, a germanium diode functioning as a temperature sensor relies on the linear variation of its forward voltage with temperature. But a pair of germanium diodes can be made to serve as a differential-temperature comparator if the circuit exploits a much less used temperature-dependent diode property—the logarithmic variation with temperature of the reverse saturation current. The resulting circuit is useful for industrial-control applications.

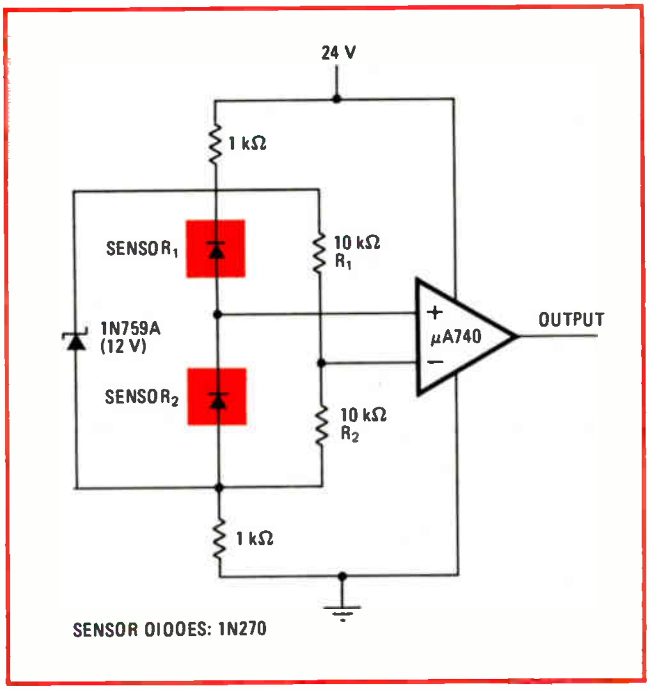
When one diode ($SENSOR_1$) is at temperature T_1 and the other diode ($SENSOR_2$) is at temperature T_2, the circuit output will change state as the temperature differential (T_1–T_2) approaches and crosses a differential threshold, $\Delta T_{1,2}$. For the circuit shown here, $\Delta T_{1,2}$ is 13°C—when (T_1–T_2) is less than 13°C, the circuit's output is low; and when (T_1–T_2) is greater than 13°C, the output goes high. The circuit has a fairly wide and useful temperature range of 20°C to 120°C.

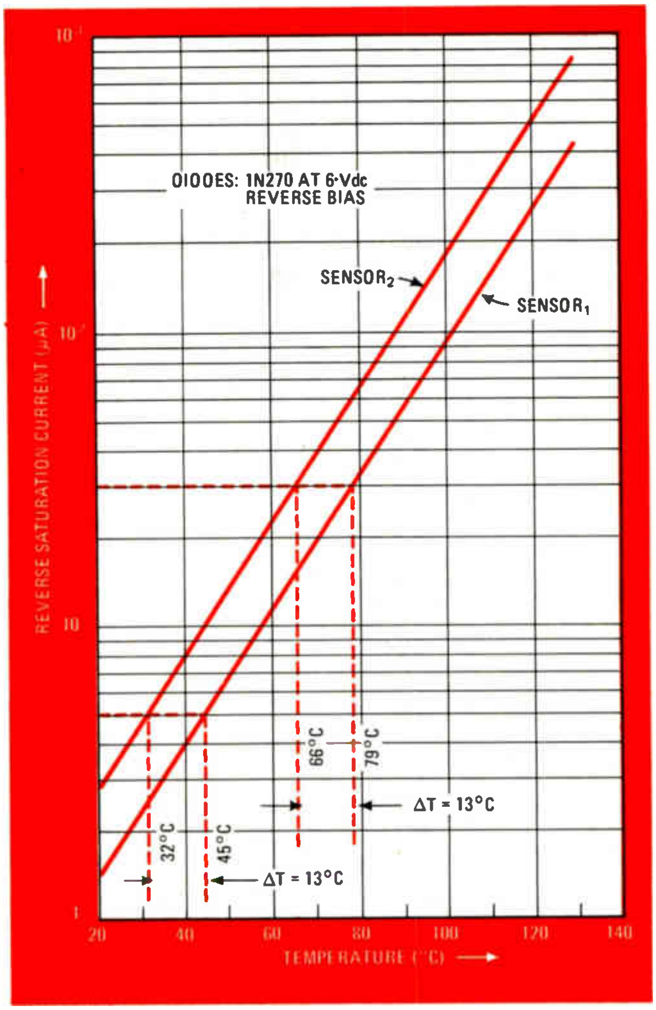
The two diodes, along with resistors R_1 and R_2, form a resistance bridge. The right-hand side of the bridge consists of equal resistances that divide the bridge voltage in half, establishing a reference voltage at the inverting terminal of the FET-input operational amplifier. The noninverting op-amp terminal receives the temperature-dependent voltage, which is derived from the division of the bridge voltage across the diode temperature sensors.

In general, the reverse saturation currents of two unmatched diodes are different at a single temperature. However, when plotted as a function of temperature on semilog paper, the two reverse-current characteristics will be parallel to each other. That is, a diode's reverse current may vary from one unit to the next at a single temperature, but it will increase in an identically proportional manner from one unit to the next as a function of temperature.

For instance, for the type 1N270 germanium diodes used here, the current doubles every 13°C. The doubling is highly regular, producing a nearly linear semilog plot over a fairly wide temperature range, as shown by the graph of reverse saturation current versus temperature for two type IN270 diodes.

Now, when a diode is reverse-biased, it in effect becomes a temperature-dependent current source with a reverse saturation current that is only negligibly influenced by the actual magnitude of the reverse voltage. But as the reverse voltage approaches zero, the reverse current decreases. When two diodes are connected in series, therefore, the voltage across them will divide equally only when their currents are the same, a condition that occurs at a fixed temperature difference between the two. This equal-current temperature differ-





Temperature comparator. Unmatched germanium diodes have different reverse saturation currents at the same temperature. But this difference remains proportionate with changing temperature so that the temperature differential between the two currents stays the same, as shown by the graph. A differential-temperature comparator can be built by connecting two unmatched diodes in a bridge configuration.

ential is the $\Delta T_{1,2}$ threshold for the circuit.

The diode having the lower reverse saturation current acts here as SENSOR$_1$, so that practically all of the bridge voltage will be dropped across it. This keeps the voltage at the noninverting op-amp input below that of the inverting op-amp input, and the circuit's output is low. As the temperature of SENSOR$_1$ increases, its reverse leakage current will also rise.

When SENSOR$_1$ is $\Delta T_{1,2}$ degrees celsius above SENSOR$_2$, the voltages at the op-amp inputs will be equal. With an additional temperature increase of SENSOR$_1$, most of the bridge voltage will then be dropped across SENSOR$_2$. This raises the voltage of the noninverting op-amp input above that of the inverting op-amp input, causing the circuit's output to go high.

Various operating conditions can be set up for the differential-temperature comparator by interchanging the locations of the low-current and high-current diodes or by switching the input connections to the op amp. Different diode pairs will provide different values of threshold temperature. Basically, $\Delta T_{1,2}$ is determined by the ratio of diode leakage currents at a fixed temperature, and this current ratio increases as the comparator differential increases. Diodes with identical reverse currents at the same temperature produce a $\Delta T_{1,2}$ of 0°C.

A FET-input op amp must be used here to assure that there is practically no loading of the bridge diode divider. Minimal loading is particularly important if the absolute temperatures to be compared differentially are low. □

Generating nanosecond pulses with TTL monostables

by Robert J. Broughton
Yale University, New Haven, Conn.

Narrow fast pulses—with widths down to a few nanoseconds and rise and fall times of 2 ns—can be produced by a circuit based on transistor-transistor logic. The circuit's output pulse width is variable, and pulses as wide as 220 ns can be obtained.

The trick is to take the difference between two pulses generated by a pair of standard TTL monostable multivibrators. The input signal is applied to the edge-triggered inputs of MONO$_1$ and MONO$_2$. Those two monostable inputs are wired in parallel, while the Schmitt-trigger monostable inputs are kept high by the 2-kilohm resistors tied to the supply voltage.

MONO$_1$ is wired to produce a 30-ns pulse, which is conditioned by a Schottky-TTL NAND gate, G$_1$, to speed up its rise and fall times. Similarly, MONO$_2$ generates an output pulse that is complementary to the one generated by MONO$_1$ and that is conditioned by a second Schottky-TTL NAND gate, G$_2$. The width of this pulse is adjustable from 30 ns to more than 250 ns.

The third and last Schottky-TTL NAND gate, G$_3$, accepts the conditioned pulses from gates G$_1$ and G$_2$. The output of this gate is a fast narrow pulse whose width is the difference between the pulses produced by MONO$_1$ and MONO$_2$. An output pulse having a width of 8 ns and rise and fall times of 2ns can be easily obtained with the generator circuit. □

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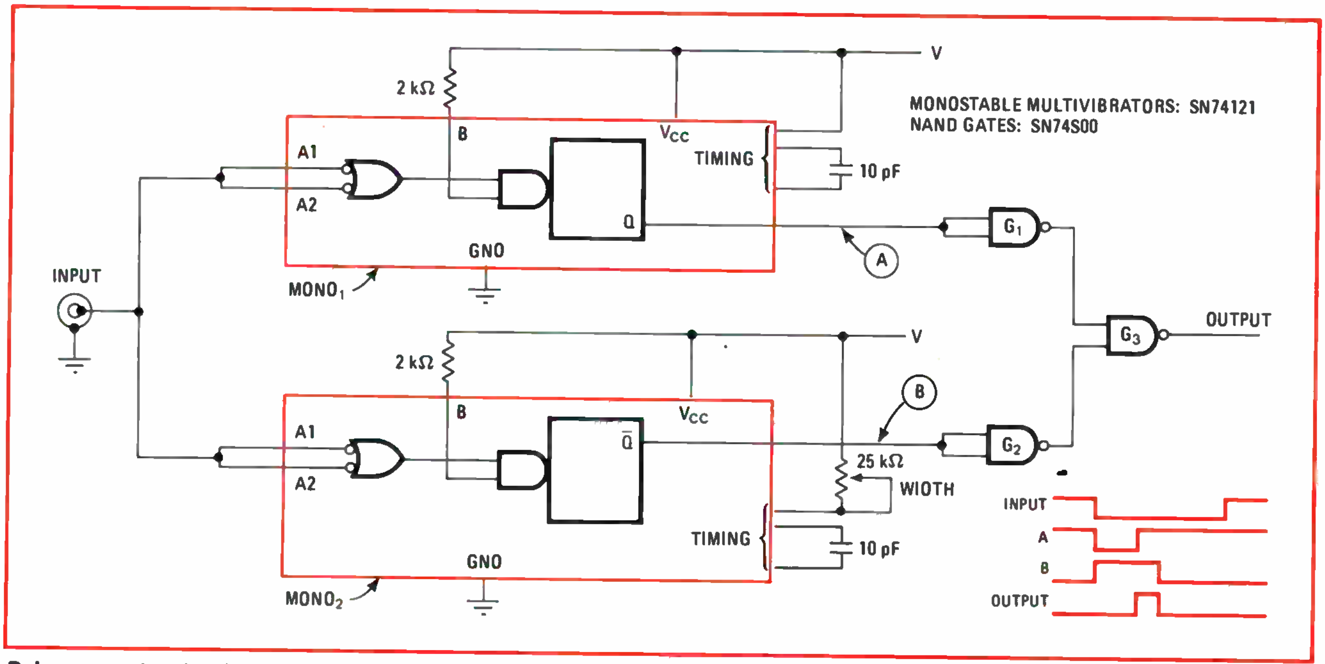

Pulse generator. A pair of standard TTL monostables can be made to produce sharp nanosecond pulses by using a Schottky-TTL NAND gate to accept their complementary outputs. The pulse width of MONO$_1$ is fixed at 30 ns, while the pulse width of MONO$_2$ is variable from around 30 ns to better than 250 ns. Gate G$_3$ takes the difference between these two pulse widths. Output rise and fall times are 2 ns.

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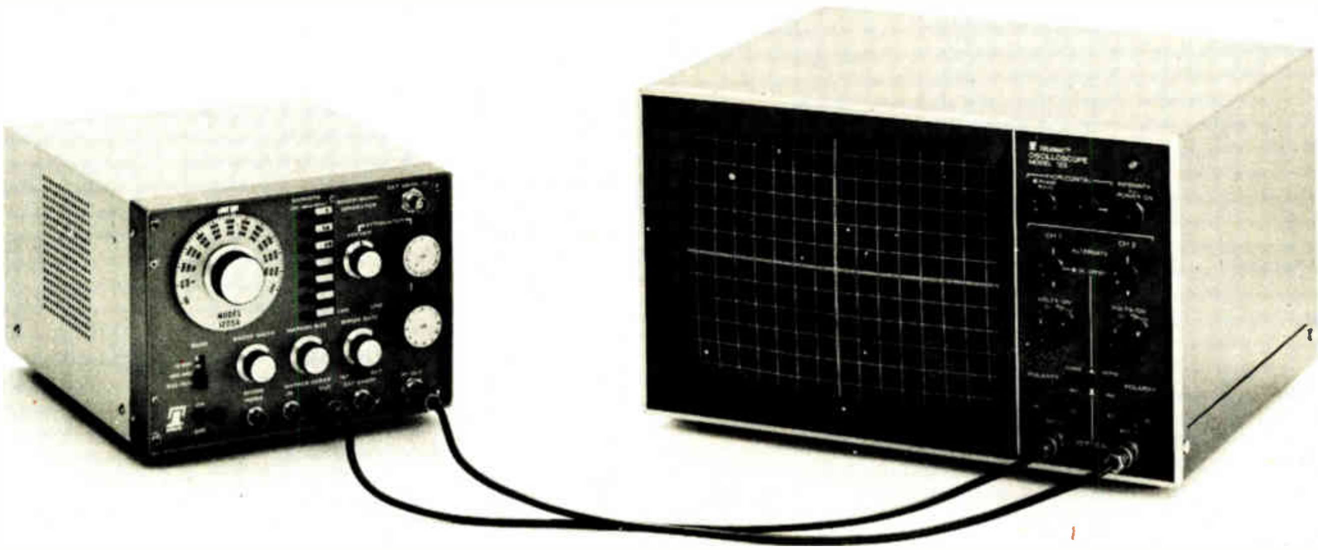


Designing logic boards for automatic testing

The test engineer should team with the circuit designer to lay out logic boards for easy testing, fault isolation, and troubleshooting; this foresight can yield large over-all economies in manufacture

by David Schneider,
Test Systems Division, General Radio Co., Concord, Mass.

☐ As the capabilities of digital logic boards have been increased, so has their complexity. As a result, the costs of testing and diagnosing failures of these boards have become such a serious threat to economical fabrication that manufacturers have assigned top priority to testability.

Surprisingly, the difficulties seldom are the fault of the test technology itself. Efficient automated systems for high-speed go/no-go logic testing and fault-diagnosis are coming into widespread use. However, the basic requirements of testability are often overlooked when logic boards are designed and laid out.

Testing problems can be solved simply by far-sighted design techniques. Many of these suggestions will not increase fabrication costs at all; they only require the design engineer to think about testability. Other suggested modifications will increase fabrication costs, but these costs clearly need to be weighed against the savings in over-all testing costs.

These suggestions must also be weighed against such other factors as possible increases in manufacturing error or increased susceptibility to noise. The design and test engineers are not expected to implement all of the recommendations to increase testability, but rather to understand the fundamental principles of testability.

Some of the techniques described in this article are intended to help design testability into TTL and DTL circuit boards. But the principles are valid for all logic families, and use of the techniques will enhance the capabilities of any test system to diagnose virtually any type of logic-board failure. In addition, application of these principles can ensure the cost-effectiveness of any automatic diagnostic software system.

Planning for diagnosis

The key to efficient fault diagnosis is the capability to rapidly isolate each defect. A typical logic-test system applies bit patterns to the input pins of the logic board and senses the resulting patterns on the output pins. The test system judges each output pattern as right or wrong. If wrong, the incorrect pattern frequently initiates a fault-localizing algorithm that seeks to identify the defective component(s).

Efficient fault-diagnosis depends on visibility of the logic board. That is, the ability of the test system to see, in detail, the operation of the board. Although some signals normally connect directly to external pins for interfacing with other boards, these pins may not provide sufficient visibility.

The best test-point locations in the production boards are usually the same points that the design engineer uses to check operation of his prototype circuits. The internal signals that tell the design engineer the state and operation of his circuits are often the same signals the test engineer will want to monitor.

Junctions of large fan-ins and fan-outs, as shown in Fig. 1, are also ideal locations for test and control points. At a fan-in, a number of signals combine to form one result signal, whereas at a fan-out, one signal is used at several places. Examples of fan-outs are master-clock and master-reset signals, which branch out to many devices.

The outputs of flip-flops, counters, and other ICs with memory are valuable indicators of the states of the circuits. Access to those points simplifies test generation and also allows for rapid diagnosis of failures of these ICs. Further, because these memory elements often control other sequential logic, they can prove useful in revealing the operation of that logic, as well.

Whenever an input stimulus to the board has to pass through many levels of intermediate logic to get to the output of the board, direct access to the buried logic can be simplified by adding test points that allow intermediate logic to be bypassed or placed in a desired state. Another testing problem arises if designers employ redundant static logic to prevent dynamic problems or to ensure fault-tolerant operation. A few extra test points will break up the logic into nonredundant parts for testing purposes and will confirm the operating condition of these circuits.

Initializing memories

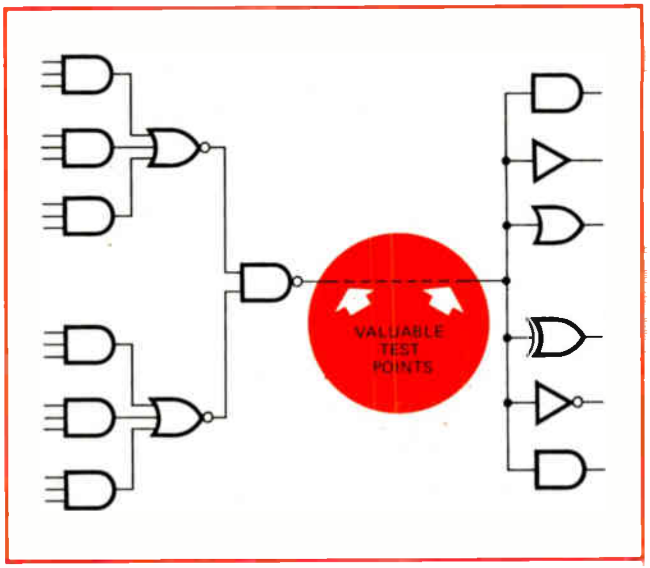
Frequently, memory elements start out in unknown or random states when power is applied to the board, and they must be set to known states before a valid testing routine can begin. If all the memory states are strongly connected (each state can be reached from any other state by exercising the board's inputs), then memory elements can be initialized. But the sequence of input stimuli, called a homing sequence, required to reach a given state, may be both hard to devise and exceedingly long. What's more, most of the logic elements may be required to function properly to achieve certain initial states, thereby inhibiting fault-diagnosis.

Means of placing memory elements in known initial states should be designed into the logic board from the start. Depending on circuit complexity, it may be also desirable to set memory elements in several different known states. This permits independent initialization and simplifies generation of certain internal states required to test the board adequately.

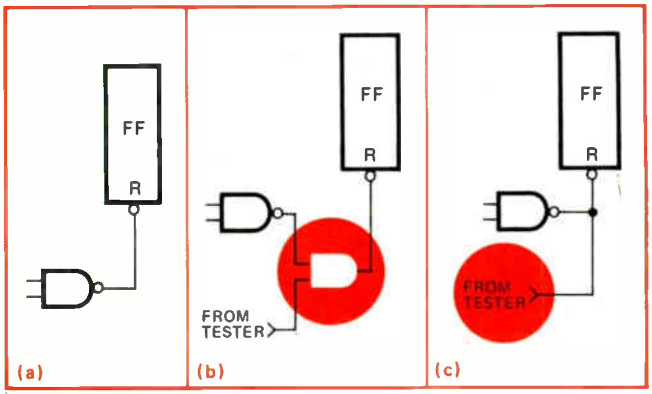
A designer should provide external pin connections through which the tester can apply reset signals directly to memory elements. Sometimes extra logic gates may be required. In the case of a flip-flop reset by an internal board signal (Fig. 2a), a logic gate can be added so that a signal from the tester can reset the flip-flop (Fig. 2b). Sometimes the tester signal can be wire-ORed with the normal reset signal (Fig. 2c). Though safe for DTL, standard and low-power TTL circuits, high-power and Schottky TTL circuits cannot be driven low safely for more than one second. When not being driven, the tester line may serve as a sense point.

Where an output of an IC feeds back into the same IC, as in a flip-flop, a shift register, or counter, the output may be driven low by using the wired-OR technique as shown in Fig. 3(a). For example, driving the Q or $\bar{Q}$ output low initializes the "slave" stage of a master-slave flip-flop, but leaves the "master" stage unchanged.

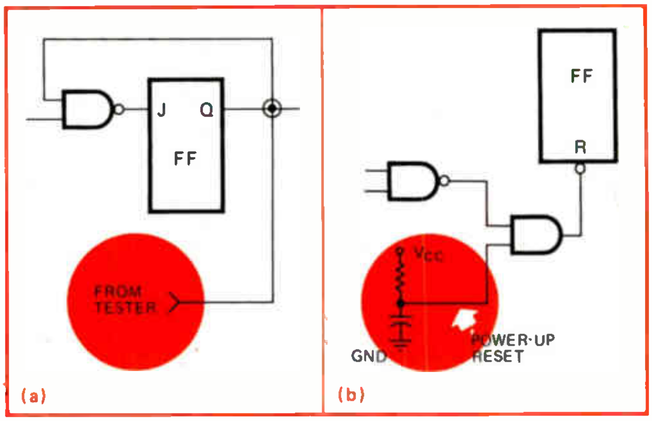
If external pins are not available for an extra reset, a designer can add a power-up reset that remains low momentarily after power is applied, as shown in Fig. 3(b). Set, reset, and load lines of flip-flops and other memory elements are often left unconnected, tied to V_{cc} or to ground, or tied to V_{cc} through pull-up resistors. If a set-reset is tied directly to ground or V_{cc}, it cannot be



1. Take the pulse. Junctions of large fan-ins are natural points to bring out to connector pins for efficient automated testing. Conversely, fan-outs, such as those at master clock and master reset points, are natural points for applying control signals from an automated tester. They, too, should be brought out to connector pins.

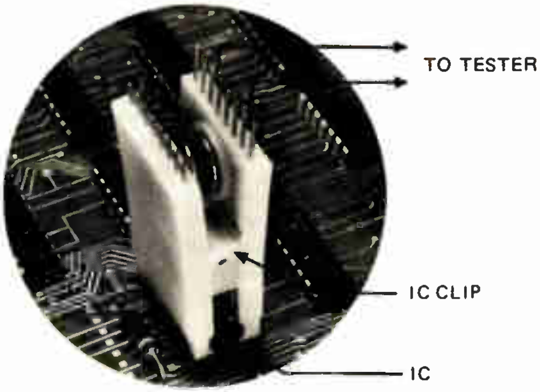


2. High or low? Initializing flip-flops takes the guesswork out of determining their state. By adding an extra gate to the circuit as shown (b), the tester can provide the reset signal. The wired-OR technique, shown in (c), does away with the additional gate, but caution must be exercised with high-power and Schottky circuits, since they may not be driven low for more than 1 second.

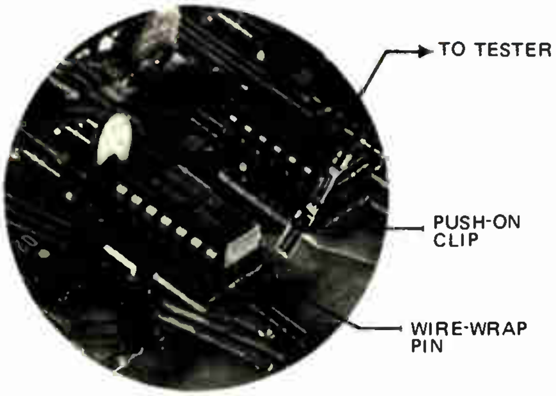


3. Feed it back. Where an output of a flip-flop feeds back into a driving IC, the output can be reset by using a wired-OR technique as in (a). If an external pin is not available for reset, then a power-up reset can be added by using an RC network as in (b).

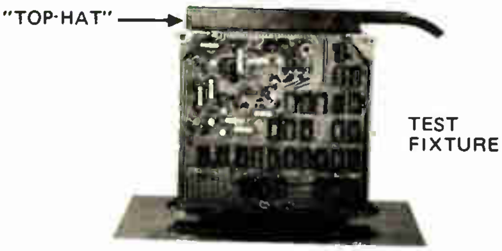
SOME PACKAGING TIPS



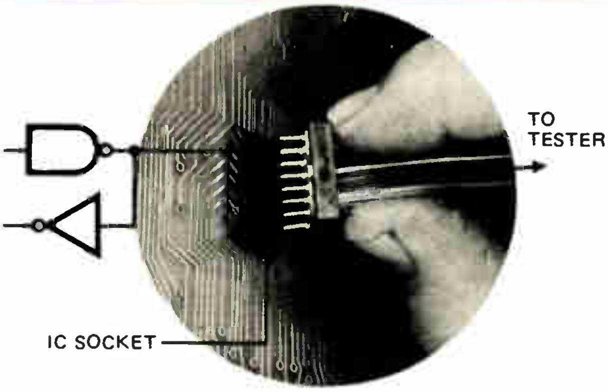
Leave sufficient clearance around socketed and soldered ICs so that test clips can be attached.



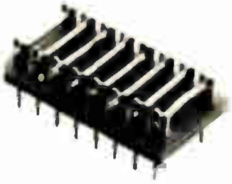
If crowding is unavoidable and will prevent use of an IC clip, mount a wire-wrap pin to allow connection of a push-on clip.



Since normally only the bottom edge of the board is used for system connections, the designer can run out connection fingers to the top and sides of the board for test connections.

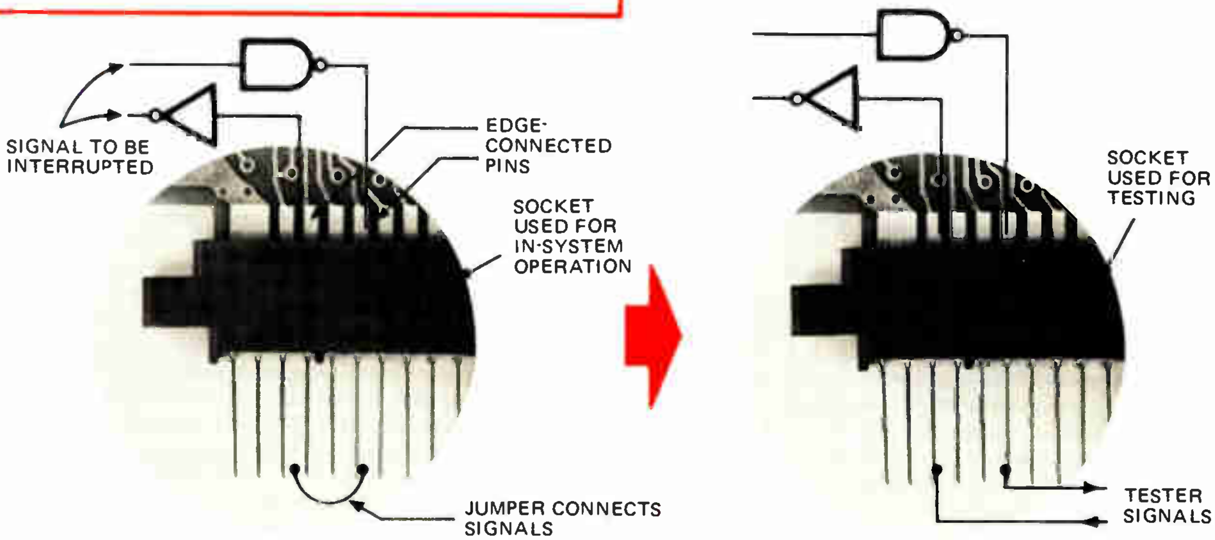


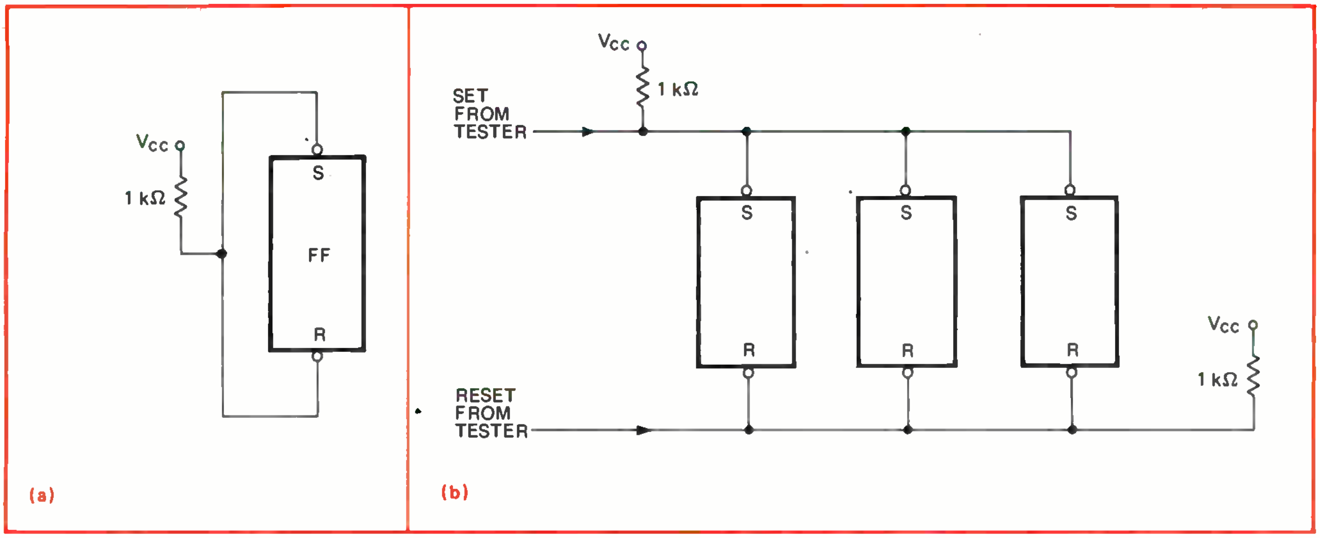
Extra IC sockets can be added for test and control points. Sometimes signals can be wired to unused IC sockets for connection during testing.



A jumper plug, which is removed during testing, can interrupt feedback and other signals.

Bring out test and control points to connection fingers. During normal system operation, they may be jumpered. However, they are readily accessible during board tests.





4. Tandem reset. If a set-reset line is tied through a pull-up resistor to V_{cc}, the line may be driven low by the tester so long as the same resistor is not used to pull up both set and reset lines of the same element as in (a). However, the same pull-up resistor can be used for several sets and resets as in (b). Both set and reset signals are provided by the tester.

driven by the tester and is lost for test purposes.

Instead, a source of logic high should be designed to come from a pull-up resistor, and a source of logic low from a pull-up resistor driving an inverter. The designer should avoid using the same resistor to pull up set and reset lines of the same memory element as shown in Fig. 4(a), since the memory element can not be initialized because of an internal race. However, Fig. 4(b) shows how a single pull-up resistor should be wired so that several sets or resets on different memory elements may be accessed simultaneously for initialization.

If a design is already in production and a set-reset line is unconnected, an IC clip can be used to access the line and drive it low momentarily.

Unmask the culprit

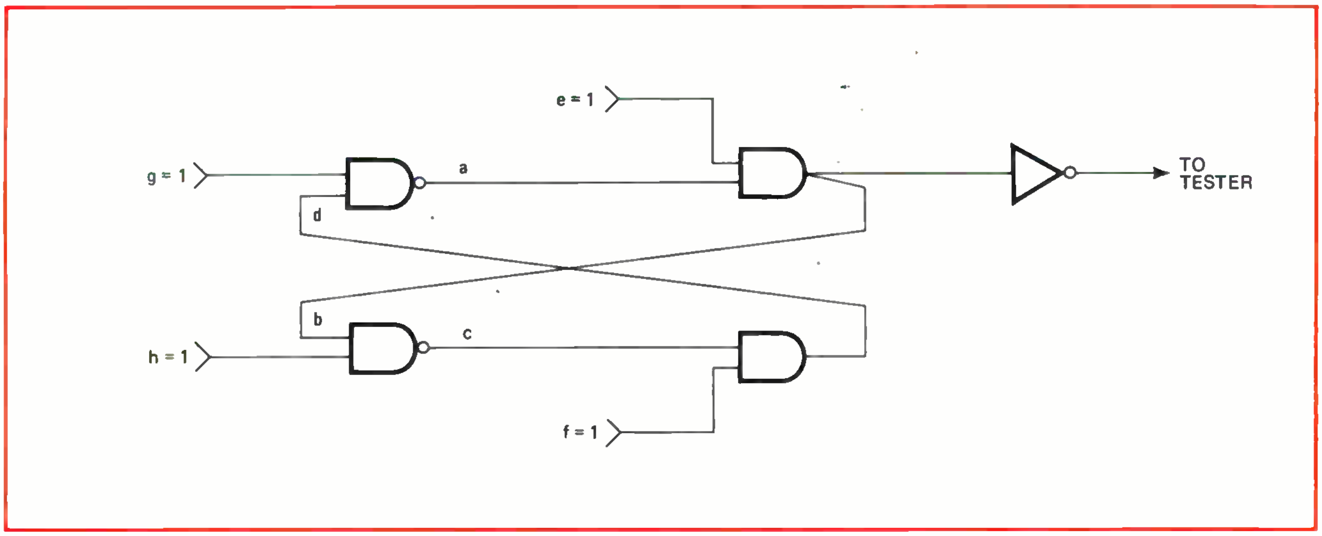
Feedback loops with many logic elements hinder fault-diagnosis because the effect of the fault at one point in the loop may affect all points in the loop. For example, in the simple circuit shown in Fig. 5 where e, f, g, and h = 1, the faults d stuck low, a stuck high, b stuck high, and c stuck low are indistinguishable.

Because the defective device is, in effect, disguised, it cannot be uniquely isolated. The loop can be broken if the signals e and f are set to 0, but it may be difficult to manipulate these signals. Other means are frequently needed to break feedback loops.

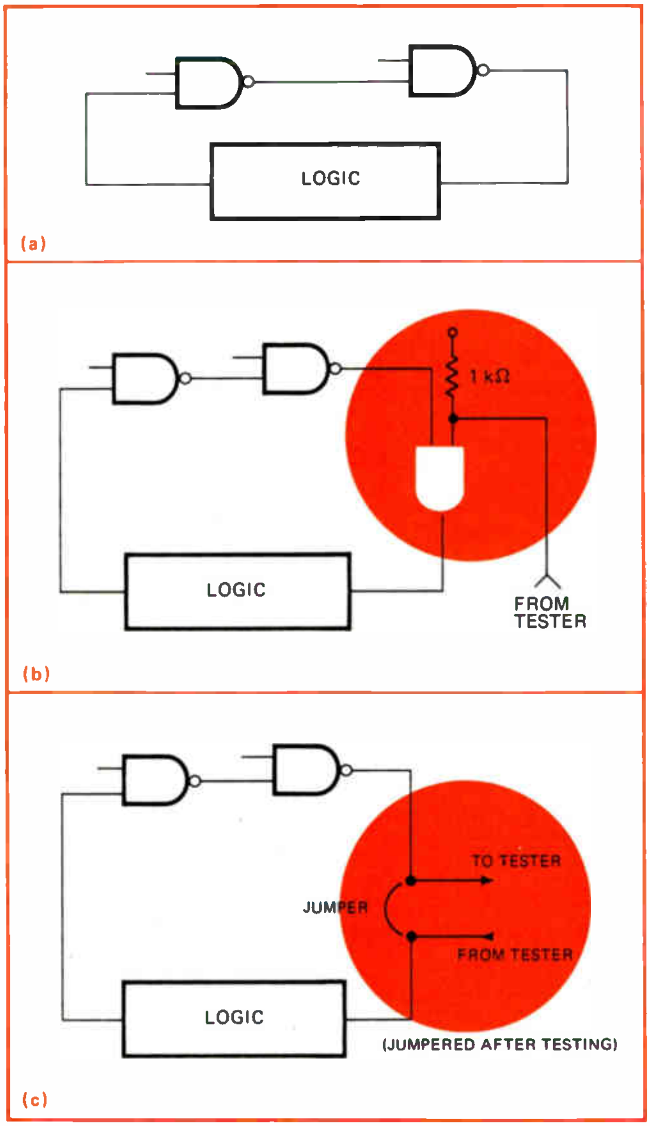
A designer should provide a means of inhibiting the clock of each memory element to break the feedback loop and to provide known reference points. A hypothetical logic circuit with feedback is shown in Fig. 6(a). One way to break the loop is to insert a gate to interrupt the feedback path as shown in Fig. 6(b).

Alternatively, the feedback loop can be brought out to external pins, which are connected by a jumper for normal operation as shown in Fig. 6(c). Removing the jumper interrupts the feedback and provides the tester with both a drive and sense point.

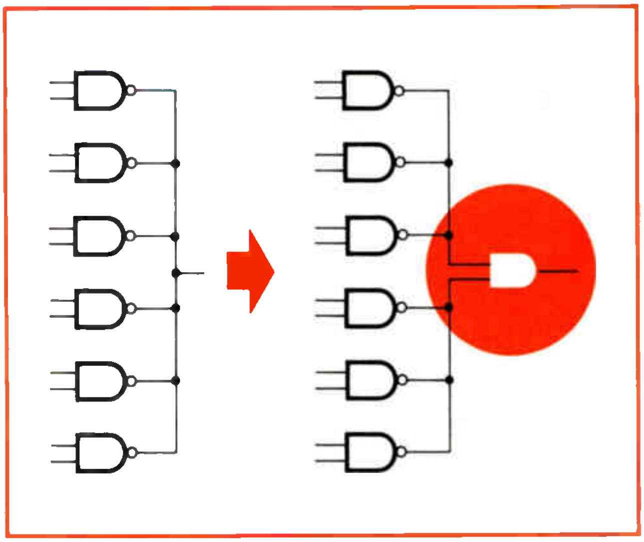
Like feedback loops, large wired-OR fan-ins also thwart fault resolution. To solve the problem, the fan-in



5. Disguised. Feedback loops, which are common in many latch circuits, can disguise faults. If, for example, f, g, and h are all high, d stuck low appears identical to a or b stuck high or c stuck low. A way to break loop must be provided.



6. Break the loop. Feedback loops shown in (a) can be broken by inserting gates as in (b). The loop can also be opened mechanically by wiring the circuit as in (c) and providing jumpers when operating.



7. Tough to test. Large wired-OR connections suffer from poor fault resolution. Partitioning the connection into smaller groups and linking them with an AND gate or a jumper, improves fault resolution.

can be partitioned and the subsections linked by an AND gate, as shown in Fig. 7.

Stop the clock

Testing time can often be shortened by substituting signals generated by the tester for internally generated signals on logic cards. Such substitution is particularly valuable when cards contain relatively slow timing circuits, such as one-shots with periods longer than a few milliseconds, which hinder high-speed testing. Internal clock signals should be defeated by adding extra logic or by physically interrupting the signals.

On the other hand, fast timing circuits, such as pulse generators, should have test points connected to their outputs to allow testing by pulse-catching circuits in the tester.

Digital circuits sometimes employ long counter chains that can require huge numbers of test patterns if tested in a conventional way. For instance, a 24-bit counter requires 2^{25} or about 33 million test patterns, which is highly inefficient and greatly prolongs test time on a general-purpose test system.

When counters are directly loadable, the number of patterns can be drastically reduced by connecting control signals to the direct load lines of a long counter chain. Another technique is to break the connections between cascaded counter stages, thereby enabling each stage to be clocked independently with a minimum number of clock pulses.

There are several ways to accomplish this. One is to attach a driver to pull down the cascade line, being careful not to impair the counter internally. Or the cascade lines can be physically interrupted by bringing out test points to a connector. These are shorted by a jumper during normal operation. Perhaps extra logic can be added so that counter stages can be clocked independently of the carry-out from earlier stages.

Packaging for efficient testing

A careful logic-board layout can make major contributions to efficient testing. For instance, analog and digital circuits should be packaged on separate cards, if possible, because analog and digital circuits are often tested by different test equipment.

In general, partitioning large logic boards into smaller independent sections also eases the test burden. So does using separate V_{cc} paths and tri-state logic, which helps to isolate a desired section during testing.

If ICs are mounted in a uniform layout with all No. 1 pins in the same relative position, test technicians will be able to speedily identify each connection. Each IC should be marked clearly with an adjacent silk-screened reference designation on the board.

If possible, complex LSI devices such as universal asynchronous receiver/transmitters, computer chips, and long-shift registers should be mounted in sockets, rather than soldered directly in the board. This speeds removal for testing and replacement. □

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CAN THE FCC COPE WITH CHANGING TECHNOLOGY?

New leadership is handicapped by limited resources and static budget that doesn't reflect shifting workload

by Ray Connolly and
Stephen E. Scrupski,
Senior Editors

□ In the mid-sixties, the Federal Communications Commission had an image problem. "Is the FCC dead?" asked one magazine article in 1966, "Is the FCC Obsolete?" asked another in the same year, and in 1967, Kenneth A. Cox, then an FCC commissioner, presented a commissioner's side of the story in an article called "Does the FCC Really Do Anything?" But in recent years, as outsiders and insiders agree, the FCC has done a great deal, despite limited resources and an unchanged organizational structure at a time when communications technology is undergoing rapid changes.

Since 1968, when the FCC issued its landmark Carterfone ruling that customer-provided equipment could be attached to the switched public telephone network, the agency has continued to break new ground. Its series of decisions has in effect produced new national communications policies, the most controversial of which opt for competition—competition between long established entities like AT&T and TV broadcasters on the one hand and, on the other, an increasing number of corporate newcomers anxious to cultivate new markets.

Having written those policies, however, the FCC now faces the far harder task of getting them implemented. Moreover, it must do so not only in the face of mounting opposition from established interests but also with a new chairman, new commissioners and new key staff members (see "How the FCC works," p. 113).

The most fundamental problem of all, however, is the size of the FCC's total budget and its distribution within the commission. In the fiscal year that began July 1, the

FCC will be operating with a budget authority of less than $50 million—merely a footnote to a total Federal expenditure that will exceed $300 billion (and AT&T spent almost $1 billion on marketing alone in 1973).

By far the largest chunks of those limited funds are allotted in the initial budget request to the Broadcast and Field Operations Bureaus, which get $9 million and $10.6 million, respectively. Field operations employ more than a quarter of the commission's 1,800 regular personnel in spectrum monitoring, inspection of licensed station equipment, operator licensing, and a host of other routine chores.

Similarly, the Broadcast Bureau devotes the bulk of its resources to regulating the nation's radio and TV stations and is relatively uninvolved in new technologies. "Broadcast gets as much money as it does," says one insider, "just because it was there first. Licensing broadcasters used to be our [the FCC's] most important function. It is still important, of course, but it hasn't changed much." Nor, it should be added, is the broadcast field a significant growth area in today's electronics business.

The TV and radio broadcast industries are put at $4.1 and $1.6 billion, respectively, by the Department of Commerce. But in 1974, they are expected to provide electronics with an annual equipment market of only $179 million [*Electronics*, Jan. 10, p. 120]. The interconnect market, for one, can be far larger. For example, radio and TV's $179 million is $1 million less than the value ITT Corp.'s E.F. Eddy places on U.S. shipments of PABX and key systems this year. Eddy also notes his estimate is conservative because of "numerous industry imponderables and a lack of aggressive marketing strategy."

FCC's biggest impact: carriers

Unquestionably the most important FCC operation, in terms of its impact on new applications and the markets they represent, is the Common Carrier Bureau. Close behind is the Safety and Special Radio Services Bureau, with its responsibility for land-mobile communications and other, nonbroadcast, uses of radio in aviation, marine, amateur, and police operations.

Nevertheless, the fiscal 1975 budget request for the Common Carrier Bureau was less than $6 million—two thirds that of Broadcast—while the Safety and the Special Radio Services Bureau was allocated less than $4.5 million in the request to the Congress.

Yet the explosive growth in telecommunications applications, plus the commission's advocacy of competition between AT&T and new specialized common carriers, has far outstripped the small increases in the Common Carrier Bureau's budget and staffing employed to regulate the industry on a timely basis. The bureau must not only oversee a domestic telecommunications industry that accounts for an estimated $1 billion in hardware annually when the output of AT&T's captive Western Electric Co. is factored in—but it must also recommend policies to FCC commissioners on a variety of controversial issues ranging from interconnection to domestic satellites.

For the Safety and Special Radio Services Bureau, the biggest immediate problem is implementing the commission's recent decision, under Docket 18262, that expanded land-mobile operations in the 900-megahertz band [*Electronics*, May 2, p. 52].

Who coordinates FCC's technology? That job, among others, belongs to the Office of Chief Engineer run by Raymond E. Spence, Jr., who is among the first to recognize that more than technology is involved: "Ten years ago we simply found a piece of the spectrum that was lying around and gave it to an applicant. Now things are much more complicated." As Spence points out, more than a year before the FCC ruled in favor of expanding land mobile up into the 900-MHz region, it came up with an interim resolution of the problem by taking the top 13 uhf TV channels and making them available to mobile operations. Such decisions are "no longer engineering issues. They become political as well as economic and social issues."

Spence agrees that the FCC "spends too much on broadcasting and not enough time on other developing issues." One way this handicaps the commission and his office is to limit their ability "to weigh engineering factors in their own right." On the matter of interconnection, for example, Spence's office proposed equipment certification standards in the fall of 1972. But in the summer of 1974, the commission has yet to act on the plan.

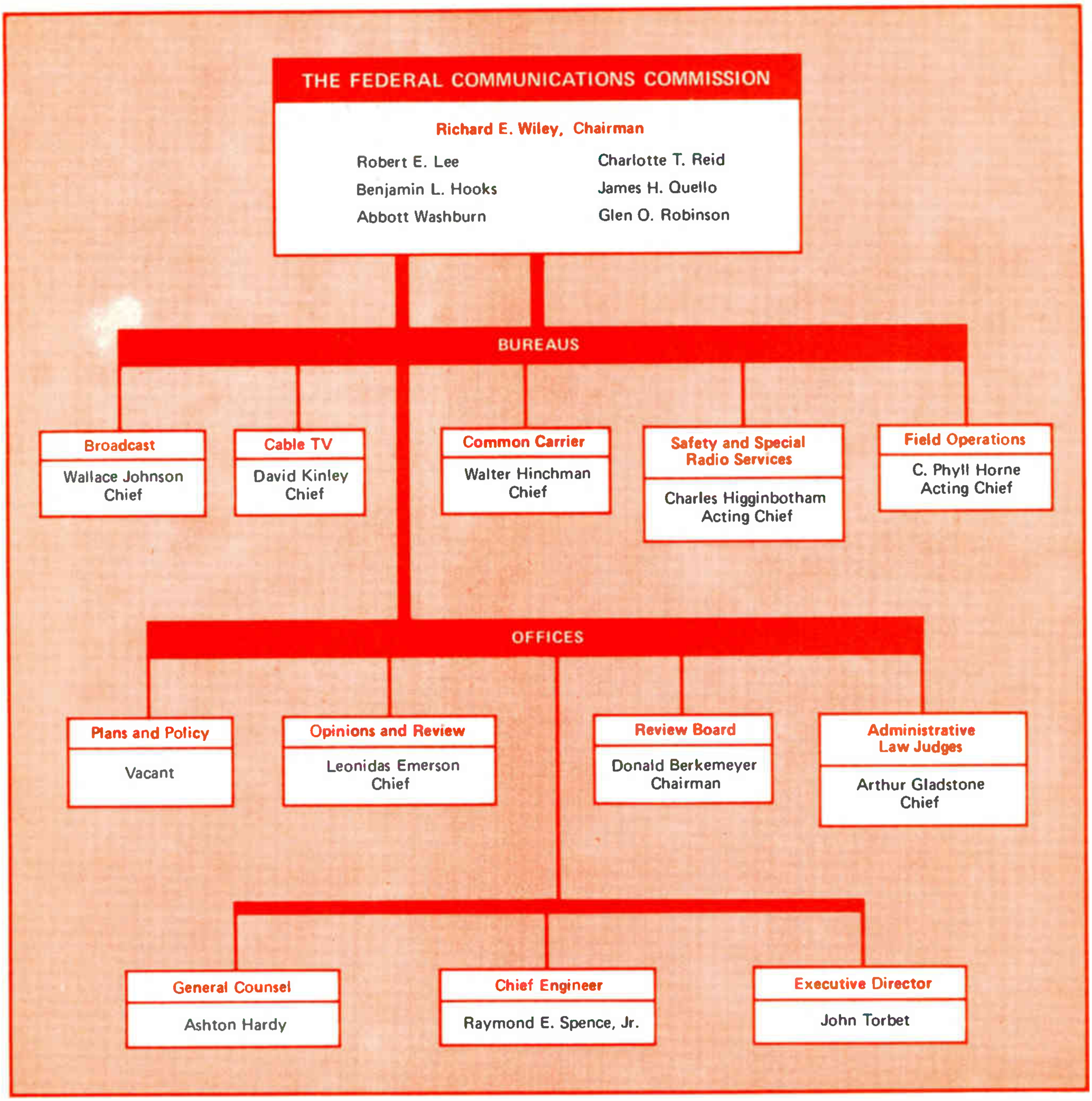
Drowning in paper

Virtually everyone who deals with the FCC and many of its own staffers agree that it is close to being overwhelmed by the controversies created by each new application of technology. The FCC is employing "a structure of the forties to try and deal with the problems of the seventies," says Bernard Strassburg, who retired last year after 31 years with the commission, the last 10 of them as Chief of the Common Carrier Bureau.

During Strassburg's tenure the commission marched off in a variety of new directions, most of which encouraged competition with the existing communications establishments. After the Carterfone interconnection decision there came, for instance, the computer-communication inquiry, the first and second phases of a major investigation of AT&T's structure and operations, and the domestic-satellite decision.

"When I came to the commission," Strassburg recalls, "we only had voice communications to regulate and the industry was one tenth the size it is now. But the FCC had as many people back then as it has today. Now we could do the job with the same number of people if the tools had changed—computer files, and so forth—but the tools haven't changed."

Throughout all its bureaus, the commission appears to lack adequate legal staff—a critical inadequacy because of the increasing number of challenges to commission actions by AT&T and its new competitors. "We're talking about policies that come as a result of engineering advances, not the engineering itself," explains one FCC lawyer. "We have 13 lawyers who share four secretaries in the Common Carrier Bureau—that's it. How can we be expected to cope with AT&T with that kind of staffing?" Former commissioner Kenneth Cox, now a senior vice president with MCI Communications Corp., a specialized carrier, concedes that the FCC generally and the Common Carrier Bureau in particular is



"thin in experienced personnel" right at the time when "they and we are having a problem with Bell." Cox contends that "there is a lot of indecision on the commission because of the inadequacy of the staff. They are facing new problems and don't have the numbers or—more important—the kinds of people to handle the problems."

Most of the new problems over competition fall in the Common Carrier Bureau's domain. Compounding those problems is the Common Carrier Bureau's recent reorganization under its new chief, Walter Hinchman. An alumnus of the White House Office of Telecommunications Policy (OTP), Hinchman moved into the bureau from the FCC's Office of Plans and Policy. And chairman Wiley is still trying to fill Hinchman's planning post with someone "who can take me up to the mountaintop periodically and give me the big picture."

But some FCC staffers and industry sources are already expressing concern whether Hinchman—who is continuing Strassburg's advocacy of competition—can make the transition from planning to administration quickly enough to maintain bureau momentum. Hinchman's reorganization of the bureau structure [*Electronics*, May 2, p. 53] has reduced the level of effort in economic analysis just at a time when it may be most needed—the recently opened Docket 20003 will comprise a study of the economic impact of interconnection on Bell System operations. If history is any guide, AT&T can be expected to inundate the commission with data in support of its contention that unrestricted interconnection will result in higher telephone rates for the average user.

Support for the commission in the form of both economic and engineering studies also comes from the

OTP—except that some within the FCC wish the commission had OTP's operation in house. That view is held by Strassburg, even though he already believes that OTP has given "an added dimension to the FCC." The White House group "is in a position to do the kinds of studies the FCC should do." In the FCC's cable vs satellite studies, Strassburg says he "frankly welcomed OTP's efforts. They don't have an axe to grind. I just wish the FCC had the same type of capability—the dollars and staff to bring to bear on some of these issues."

The need for studies of the economics of communications like Docket 20003, rather than engineering cost analyses alone, is also supported within OTP. Outside the FCC, too, AT&T's problems over forecasting the communications market stem from its heavy reliance on engineering data, instead of marketing data, suggests OTP's Sebastian Lasher, recalling the observation of psychologist Abraham Maslow that "if the only tool you have is a hammer, you tend to treat everything as if it were a nail." AT&T now has a new marketing organization, but nevertheless Lasher feels that, even if the company were inclined to share its "highly sensitive and proprietary" marketing studies with the Government, "it probably would not constitute good public policy to rely too heavily on any single firm's projections."

Such judgments, of course, leave the FCC with few options except such dockets as 20003 as a means of improving its expertise in communications economics. And, as one outside analyst observes, "this leaves the commission, once more, in the position of having to rely on selective, secondhand information it has received from others."

Self-implementing tariffs

A handicap of even longer standing at the FCC is the statutory rule, established when the commission was set up, that a new common-carrier tariff goes automatically into effect 90 days after filing with a 60-day advance notice. No one at the FCC, including its chairman, disputes the argument of AT&T's competition that the rule is outdated. AT&T has opposed any change.

Chairman Wiley, for example, would like to have Congress alter the rule so that new tariffs could be held in abeyance for as long as it takes to adjudicate the issue, perhaps nine months or a year, if necessary. MCI's Cox concurs. "In the past," he notes, "tariff challenges have been based on overcharges, so that redress could be made in the form of lower rates and rebates. Now, however, the challenges are from competition, and rebates to users do not balance the competitive scales. They certainly don't do MCI any good."

In fact, they may do MCI and other special carriers like Data Transmission Co. (Datran) sufficient damage to be fatal, according to William Melody, well-known communications economist and faculty member of the University of Pennsylvania's Annenberg School of Communications.

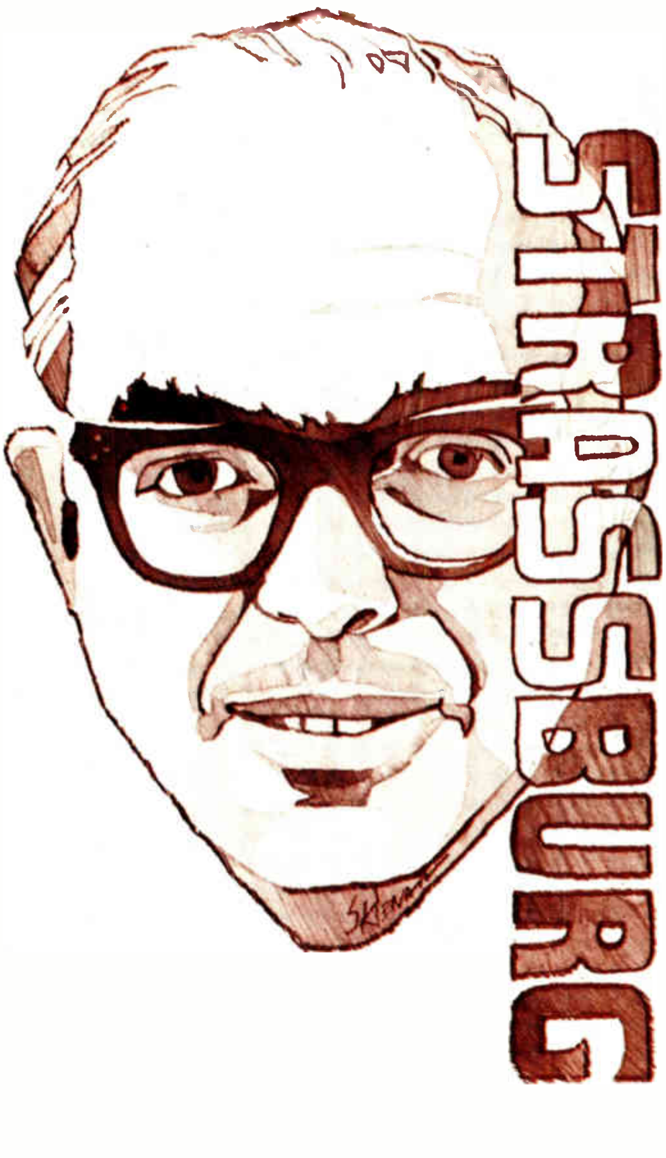
AT&T's so-called "hi-lo" competitive tariff for voice-grade private lines, for example, went into effect on June 13—after AT&T's 60-day voluntary suspension of the original effective date, but before the commission could rule on its validity. The tariff, Bell's first departure from nationwide rate-averaging concept, offers lower charges on high-density routes while raising charges on low-density routes.

Survival issue (or for whom does Bell toll?)

This kind of competitive response by AT&T to MCI, Datran, and others, combined with other legal actions in courts and state public utility commissions, could "wipe out" the specialized carriers, Melody believes. Other boosts to AT&T will come from its proposed, low-price data-under-voice microwave system for use with its Dataphone Digital Service, and also from the competition to special carriers provided by the so-called "value-added" carriers offering packet switching services over AT&T lines [*Electronics*, May 2, p.105].

Melody says he is becoming convinced that small special carriers, with their limited financial resources, will ultimately be no match for the AT&T monolith. Because of the long drawn out proceedings before the FCC and the courts, the economist contends that special carriers—for whom the FCC has said it will not provide any protective umbrella—may win individual legal battles, but eventually lose the financial war because of the costs of competition and legal counsel.

MCI chairman William McGowan naturally opposes this view, adamant in his belief that "special carriers are



here to stay" and convinced that "the Government won't let us go under."

Nevertheless, AT&T is by all accounts proving more responsive than ever to the thrust of new commission rulings on the issue of competition, interconnection, and the development of new land-mobile markets at 900 MHz, in which it will share heavily under the FCC's May decision on Docket 18262.

Mobile radio controversies

Despite the fact that AT&T and other wire-line common carriers will eventually have the use of 40 MHz of the 115 MHz opened up in the 806-947-MHz band for land-mobile use, AT&T has petitioned for reconsideration by FCC, as have others. Rather than 40 MHz, wire-line carriers would like to have the full 61 MHz they originally sought, without any reserve.

AT&T not only opposes the frequency limitation as one that would unnecessarily raise its equipment costs by half, but it is against the stricture that land-mobile operations should be handled by a separate subsidiary to prevent cross-subsidization of cellular service by other services. Moreover, the company wants a modification of the rule that would prevent it from providing and maintaining mobile radio units and also charges the FCC with "a desire to promote competition for the sake of competition" in leaving unregulated those systems that will be known as "entrepreneur-operated common-user systems."

The post-decision appeals seem guaranteed to go to the courts for final adjudication. Consequently, these proceedings, too, could drag on for another year or more.

Because of the FCC's inability to deal in a timely way with controversial—and, in the case of specialized carriers, perhaps life-or-death—issues, petitioners before the commission are turning increasingly to the courts and, in some cases, to state regulatory agencies. Similarly, established entities like AT&T, which see a threat to the profitable *status quo*, also are turning to the courts and the states and, if need be, to the Congress to delay or get relief from FCC rulings. In addition, some states are taking independent action on such critical subjects as interconnection.

ITT's E. F. Eddy has noted that this "trend toward polarization of opinion regarding interconnection" is one "with the greatest potential impact on the industry's future." AT&T, he points out, "has found eager allies among the National Association of Regulatory Utility Commissioners (NARUC), which represents the state regulators. [State regulators have tended to be most sensitive to possible intrastate rate increases for residential users and thus have lent willing ears to Bell's warnings of such effects of interconnection.] In this environment of strong feelings, there has already been direct confrontation between several states and the FCC: the well-known North Carolina proceedings [which have threatened action that could effectively bar non-Bell telephone equipment in the state] and the rulings of the attorney general of Nebraska and the state of Oklahoma, which insist that interconnect companies obtain certification as common carriers."

Though the FCC has asserted jurisdiction over the states in these matters, and has the tacit support of the Justice Department, Eddy is not overly optimistic. "It seems unlikely that the nationwide, Federally controlled program of certified direct interconnection envisioned by the FCC staff and its PBX Advisory Committee will come to pass in the near future."

As a result, Bell may continue to impose charges for the protective interface circuits that it says are necessary to prevent harm to its network. These charges, when added to the price tags carried by non-Bell interconnect equipment, have made it more difficult to close sales, the competitors complain. They would prefer to build in whatever protective circuitry is required and, after certification, sell it for direct connection to the network.

Meanwhile, Eddy notes that even though Bell is just beginning to wage heavy war in the competitive marketplace, Bell already "manages to retain about 76% of all jobs on which they bid against interconnect."

North Carolina Utilities Commissioner Hugh A. Wells explained his state's action to exert jurisdiction on interconnection by claiming that—in three years of adopting a "wait and see" attitude after Carterfone—he found only Federal inaction. North Carolina moved, he said, because "good regulation abhors a vacuum." The FCC record on interconnection, according to Wells, "reflects more indecision than purpose and more guesswork than information."

One of several vocal opponents to North Carolina's assertion of intrastate jurisdiction on interconnection is William H. Borghesani, Jr., Washington counsel for the National Retail Merchants Association (NRMA) that

strongly advocates interconnection. The state's action, he insists, "could nullify interstate access to the common and indivisible public telecommunications network." But that issue between North Carolina and the FCC is now before the U.S. Fourth Circuit Court of Appeals at Richmond, Va. "Hopefully," Borghesani says, a decision will come before the end of 1974.

Borghesani says he sympathizes with the view of one FCC lawyer, who likens the long delay between the 1968 Carterfone interconnection policy decision and its still unresolved implementation, to the continuing battle over school desegregation (see "How the FCC works," p. 113). Yet he sees the North Carolina case and similar battles as but "pieces of a mosaic" that is AT&T's war.

Cable TV: paper problems

The FCC's Cable Television Bureau has by far the smallest budget of the five bureaus. And most of its request for $2.2 million early this year for fiscal 1975 will go for paperwork—the processing and licensing of cable systems under rules requiring certification of all systems by 1977. In the six years before the certification ruling of March 1972, only 600 applications had been processed. Cable plant investment of about $1 billion in 1972 has been forecast as growing to $2.5 billion by 1978 and more than $8 billion in 1983.

Like their Broadcast Bureau counterparts, cable staffers are heavily involved in "software issues" such as the uses of cable, rather than its technology. But some of these concerns seem likely to have a significant impact on CATV equipment makers.

At the moment, the cable bureau is caught up in a program introduced this year. Known as "re-regulation," it's an effort to simplify CATV licensing by modifying and in some cases eliminating excess paperwork.

Consequently, much of the work on technology is being left to an industry-oriented group known as the Cable Television Technical Advisory Committee. For example, an Electronic Industries Association (EIA) panel is in the process of turning over specifications for a "cable-compatible" TV receiver to the advisory committee after two years of work [*Electronics*, July 11, p. 77]. The design would boost a viewer's receiver costs, but could also cut cable service costs by 10% to 15% since, observes Teleprompter Corp.'s Hubert Schlafly, it "avoids additional boxes, eliminates unnecessary circuitry, and accommodates wireless remote controls."

Even more important, the policy concerns of CATV regulation by the 50 states and even smaller jurisdictions like cities and counties clearly worry the industry and its suppliers. Equipment-specification writers fear what they call "three-tier regulation" by Federal, state, and local authorities, and the possibility of its leading to conflicting requirements.

The FCC notes through its cable bureau chief David Kinley that it has preempted local regulation and fran-

chising of pay-cable systems, but the commission's authority is being challenged and the fundamental issue is not yet resolved. What's more, the challenge to the FCC has the support of such anti-cable-television groups as the National Association of Theater Owners, fearful of first-run movie distribution, and the long-established National Association of Broadcasters. The NAB argues that it is only concerned with program "siphoning" by CATV of network programs, notably sports events, but it is generally viewed as unhappy with CATV's threat to the broadcast industry's dominance and revenues.

Interactive systems

Technologically, there are still a number of problems about two-way interactive CATV systems, in which the subscriber orders up his own programs and services. In its 1972 order on CATV, the FCC noted that, in future two-way offerings, "activation of the return service must always be at the subscriber's option." Yet the Urban Institute, a Washington-based public interest group, says its Cable Television Information Center (CTIC) "knows of no two-way subscriber response test now underway that conforms to the FCC dictum." For example, says CTIC, "Subscribers on the Tocom system in Rossmor Leisure World, Arizona, and the Thetacom Subscriber Response System in El Segundo, Calif., cannot prevent their channel selections from being monitored."

The Urban Institute believes that such monitoring for commercial interests like rating services and the measurement of advertising effectiveness "may be harmless" when properly handled in the aggregate. But it clearly fears that other uses contain a threat to privacy since "there is no way to obtain aggregate data without polling individual receivers."

Though the FCC has yet to rule on the technicalities of the CATV privacy issue, the institute believes the problem could be resolved since "two-way cable is developmentally still in the prototype stage." Computers could be programed not to store individual viewing data, it points out, and "the technology could permit certain channels not to be monitored at all."

The OTP, which regularly inputs to the FCC, is drafting legislation on the cable privacy issue for the Administration. It would, explained Vice President Gerald Ford in June, "prohibit 'snooping' and monitoring of communications entering and leaving a citizen's home via cable TV. I would forbid disclosure of identifiable information about the viewing habits of subscribers to cable television systems without their consent."

What's to be done?

Clearly the FCC has problems that go beyond small budgets poorly distributed, a limited staff, and few resources to conduct or contract for independent R&D. To some, the fundamental problem is an approach to regulation that tends almost automatically to stifle innovation. OTP chief Clay T. Whitehead once observed, "The FCC has a way of asking the would-be entrepreneur to prove his service is worthwhile, to prove that his service is economical, to prove that the public wants it, before he is even allowed to try. I think you can see that kind of discourages innovation."

Among others, former chairman Dean Burch has suggested disentangling the FCC from its present dilemma by reorganizing it into two bodies. Burch, now a White House adviser, was a premier advocate of competition in communications. His straightforward, no-nonsense approach to complex regulatory issues has some communications specialists calling him "the FCC's Harry Truman," despite his conservative Republican background. Like Burch, former commissioner Cox believes "it would be a good idea to split the commission into two commissions—one concerned with common carrier and safety and special radio services and the other with broadcasting and CATV matters."

But John Sodolski, Communications division vice president at the EIA, opposes a split or massive reorganization, as does retired commission executive Strassburg. Sodolski likens reorganizations generally to firing the coach when the team is doing poorly: "It doesn't make the team any better." He believes the commission may not be a model of efficiency, "But it does work."

Former bureau chief Strassburg believes the FCC needs better tools and more staff to "develop a greater depth of understanding of what's going on and the implications of technological developments." Moreover, he sees a need for a systems analysis capability "to give early warning of emerging problems."

One eye-opening Strassburg suggestion: since the FCC has "no systematic effort in monitoring technology—the public's money is spent on this at Bell Labs, and it spends $400 million a year—the commission should have the benefit of knowing what they are doing.

How the FCC works

Created by the Communications Act of 1934, the Federal Communications Commission has been likened to a court. But it is more than that—instead of merely interpreting existing law, it can break new ground to accommodate new uses of communications technology.

Though the FCC is called "an independent agency" and reports to the Congress, the President names its seven commissioners, and the necessary Senate approval of his nominees is, more often than not, a routine procedure. Executive control is also exercised through the White House Office of Management and Budget, which must bless the FCC's annual budget request. The only constraint upon the President is that no more than four of the commissioners may be of the same political party.

The FCC is charged under the law "to make available to all the people of the United States a rapid, efficient, nationwide, and worldwide wire and radio communications service with adequate facilities and reasonable charges." Moreover, it is authorized, among other things, "to study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio [in the all-inclusive sense of frequency-spectrum management] in the public interest."

Richard E. Wiley, an ambitious and determined 40-year-old lawyer from Peoria by way of Chicago, has been trying to do just that ever since March 8, when he succeeded Dean Burch as chairman. Having become a commissioner in January, 1972, after 15 months as FCC general counsel, Wiley moved into the top job with three of the seven seats on the commission vacant, fewer than 1,800 of the more than 2,000 staff positions filled, and a budget of less than $50 million for the Federal fiscal year that began this July 1.

Since that time, a fifth commissioner, former Detroit broadcast executive James H. Quello, has been confirmed by the Senate. For the remaining vacancies President Nixon late in May nominated Abbott Washburn, former chief of the U.S. delegation to the Intelsat Conference, and Minnesota law professor and communications lawyer Glen O. Robinson and also renominated Robert E. Lee to a fourth seven-year term, all of whom the Senate confirmed this month.

In reaching a policy decision, the commission's principal resources for technological assessments include the staff office of the Chief Engineer and the five operating bureaus he works with but which report directly to the commissioners. The five are the Broadcast, Cable Television, Common Carrier, Safety and Special Radio Services, and Field Operations Bureaus.

With these limited resources, the FCC must not only represent the U.S. in international communications activities but also try to implement such domestic policies as:

- Setting rules for interconnection of customer-provided equipment with the Bell system.
- Overseeing the establishment and operation of competitive domestic satellite systems.
- Controlling the expansion of land-mobile communications through new frequency allociations in the 900-megahertz region.
- Providing a fair shake for the infant cable-television industry in the face of stormy opposition from over-the-air broadcasters.
- Monitoring the explosive growth of computer-to-computer communications.
- Refereeing what shapes up as the most controversial issue of all—competition between AT&T and the newly formed specialized common carriers for new commercial and industrial services such as high-speed digital data communications.

When not wrestling with the political and technological questions raised by these issues—each the subject of at least one major policy decision since 1968—the FCC must find time for more routine matters such as regulating more than 12,000 radio and TV broadcast stations, ruling annually on approximately 1,000 station license applications, and regulating and licensing another 1,800 nonbroadcast stations for aviation, police, marine, amateur, industrial, and other uses.

Then there is what one FCC attorney calls "our software side," involving judgments on such time-consuming and often politically touchy matters as how much and what kind of TV advertising should America's children be exposed to. Another, dubbed "the fairness doctrine," involves deciding on a case-by-case basis what persons or groups should be granted free time on a radio or TV station or network to counter a biased presentation on a controversial issue.

"I am not surprised—though I am troubled—by the fact that there seems to be no way that we can resolve these issues in a timely way," sighs one long-time commission staffer. "Interconnection by itself has been running on since Carterfone in 1968, and it is still not resolved. It's like school integration—the Supreme Court supposedly decided that 20 years ago, yet new questions come up every week. And just when you think you have answered one, there are two more in its place.

"What does amaze me," he concludes with a wan smile, "is that the FCC works at all. But so far it has somehow managed."

We must know more about new technology to make decisions in the most informed way." In Strassburg's view, Bell Labs is "a quasi-public resource."

What is chairman Wiley's goal? Not only does he oppose a commission break-up or reorganization, but, he says, "I want to pull this place together." While he believes the FCC needs more and better people—including some engineers—he says he is more immediately concerned "not with any huge growth but with keeping the good people we've got."

But a large majority of those who work with and for the FCC agree that the agency needs much more than better personnel policies and a sharpened image if it is to keep pace with changing technology and the new applications it is bringing. Clay T. Whitehead, director of the Office of Telecommunications Policy, is convinced, for example, that substantive changes may have to come from Congress as major revisions of the 1934 Communications Act.

Whitehead's suggestion that competition may permit less regulation of some segments of communications is a view shared by chairman Wiley. But there is little that Wiley or the commission can do about that without action by Congress. Until then, the FCC must continue to plod along, understaffed, overworked, and close to being overwhelmed. □

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Driving LEDs directly from C-MOS logic outputs

by C.D. Patterson
Gandalf Data Communications Ltd., Ottawa, Ont., Canada

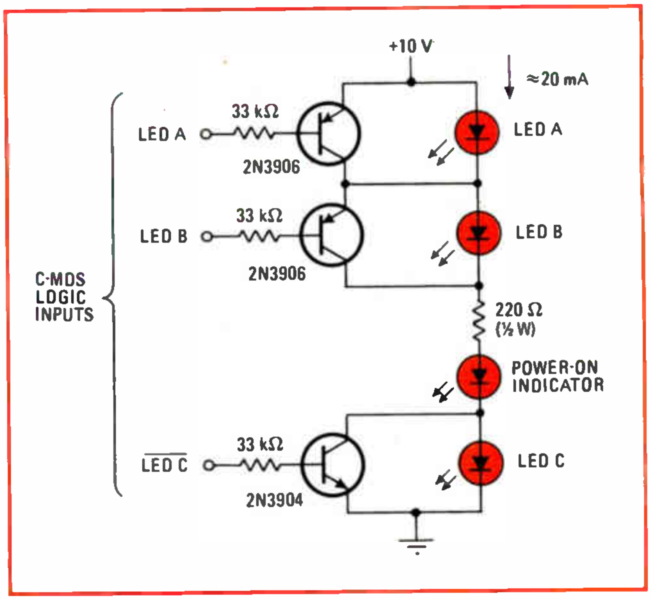
If a complementary-MOS logic system requires a number of light-emitting diodes in its display, the power dissipated in the display may be far more than that for all the rest of the circuitry.

To get a nice bright display, each LED should receive more than 15 milliamperes of current. If the requirement is for, say, four LEDs, then something like 60 mA must be provided by the supply. In addition, each LED must be driven from a high-current C-MOS inverter, such as a 14019 device wired as a current sink.

One way to cut down on current consumption is to connect all the LEDs in series in a 20-mA current chain, as shown in the figure. Each LED can then be controlled by shorting it out with a transistor.

A pnp transistor will allow a LED to turn on for positive C-MOS levels, while an npn transistor will allow a LED to turn on for negative C-MOS levels. Also, since the transistor can be operated with less than 0.3 mA of base current, normal C-MOS logic outputs can provide sufficient current for driving the LEDs.

LEDs controlled by pnp transistors should be inserted at the top of the chain, and those controlled by npn transistors at the bottom. This avoids excessive reverse emitter-base voltages. □



Current-saving design. Inserting a bipolar transistor between a C-MOS logic output and a LED indicator permits the C-MOS logic device to control the LED. The current supplied by the C-MOS logic-level output is sufficient to turn on the transistor, which, in turn, causes the LED to go out. A pnp transistor is used for positive logic signals, and an npn transistor for negative logic signals.

Transistor gain boosts capacitor value

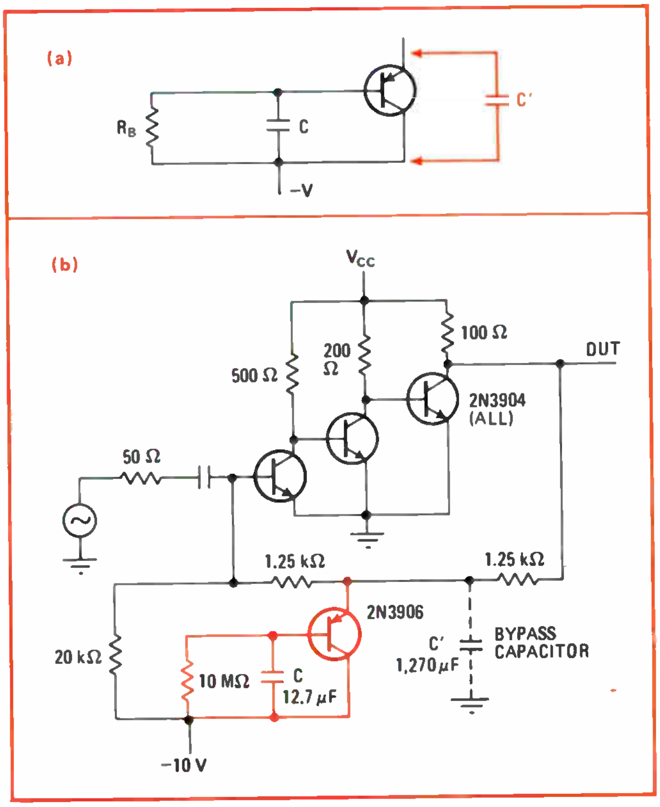
by L. E. Schmutz
Massachusetts Institute of Technology, Cambridge, Mass.

In many applications, designers try to avoid specifying large capacitors. Besides being expensive, they are usually leaky, have poorly toleranced values, and are physically large. But such large-capacitor problems as these can be circumvented by using the gain of a transistor to multiply capacitance. A simple circuit will do the job, allowing a much smaller capacitor to be used instead.

In the circuit of (a), the effective capacitance, which is shown in color, is the result of the gain of the transistor:

$$C' = \beta C$$

where C′ is the effective capacitance value, C is the ac-



Capacitance multiplier. A large effective capacitance (C′) can be obtained from a small capacitor (C) by using transistor gain to multiply the actual capacitance value, as shown in (a). The technique is especially convenient in reducing the size of the bypass capacitor in a cascaded emitter-coupled amplifier (b). Here, the capacitance needed is decreased by a factor of 100—from 1,270 to 12.7 μF.

tual capacitance value, and β is transistor gain. The resistor that biases the transistor must have a large value, since its actual resistance is divided by the gain of the transistor.

$$R_B' = R_B/\beta$$

where R_B' is the effective resistance value, and R_B is the actual resistance value. (The effective resistance caused by capacitor leakage is also decreased by transistor gain.)

This capacitance-multiplier circuit is particularly useful in reducing the size of the bypass capacitor in a feedback-stabilized cascaded amplifier, like the one drawn in (b). Cascaded emitter-coupled amplifiers are widely used in applications requiring high ac gain and good frequency response. However, they normally require elaborate biasing schemes to compensate for the lack of gain uniformity between discrete transistors.

Sometimes, a direct-coupled cascade is employed so that dc feedback can be used to stabilize the bias for the transistors. Capacitor C′ then bypasses the ac component to ground, maintaining the amplifier's large signal gain. But, with this approach, the resistance seen by capacitor C′ is reduced by the gain of the amplifier, making it necessary for C′ to be very large to achieve ordinary low-frequency break points.

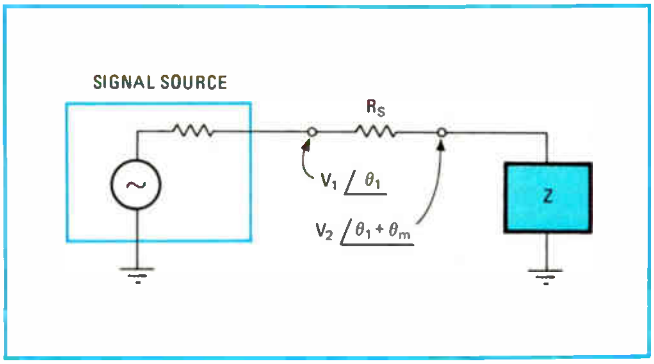
If the low-end half-power point of circuit (b) will be 10 hertz, the value of capacitor C′ climbs to a whopping 1,270 microfarads. But when the simple capacitance multiplier of (a) is used instead, the value of the bypass capacitor (C) can be cut down to 12.7 μF, a 100-fold reduction. □

Measuring complex impedances at actual operating levels

by Jim Walworth
Honeywell Inc., Tampa Division, Tampa, Fla.

Complex impedance is usually measured with a vector impedance meter or a network analyzer. The vector impedance meter supplies its own signal source at a fixed level, which is sometimes lower than the normal operating level of the device under test. This approach can cause problems if the device involved is nonlinear. The network analyzer uses a dual directional coupler and measures the impedance relative to a 50-ohm system.

A simpler and equally effective means of measuring complex impedance is often overlooked as a useful data-gathering technique. By inserting a noninductive resistor in series with the unknown impedance, voltage and phase measurements can be made on each side of the resistor. This procedure allows in-circuit parameter measurements at the normal operating levels of the circuit. Additionally, the method requires less test equipment and is more versatile since data can be reduced graphically or mathematically.



1. Test setup. Unknown complex impedance Z can be determined by measuring the voltage drop and phase shift across noninductive resistor R_s. Complex impedance Z can then be found graphically with a modified Smith chart or mathematically with a calculator.

The circuit illustrated in Fig. 1 shows the voltage and phase relationships that must be determined. R_S is the noninductive resistor in series with the unknown impedance, Z. The signal source can be an external source or the circuitry that normally drives Z. The complex voltage at the input to R_S is $V_1 \angle\theta_1$; and the complex voltage across the unknown impedance is $V_2 \angle\theta_1 + \theta_m$, where θ_m is the phase shift across R_S.

Unknown impedance Z is calculated using vector algebra. The series combination of R_S and Z form a voltage divider, and $V_2 \angle\theta_1 + \theta_m$ is given by:

$$V_2\angle\theta_1 + \theta_m = V_1\angle\theta_1\left[\frac{Z}{R_S + Z}\right]$$

Solving this equation for Z yields:

$$Z = R_S\left[\frac{V_2\angle\theta + \theta_m}{V_1\angle\theta_1 - V_2\angle\theta_1 + \theta_m}\right]$$

or:

$$Z = R_S\left[\frac{V_2\angle\theta_m}{V_1 - V_2\angle\theta_m}\right] \quad (1)$$

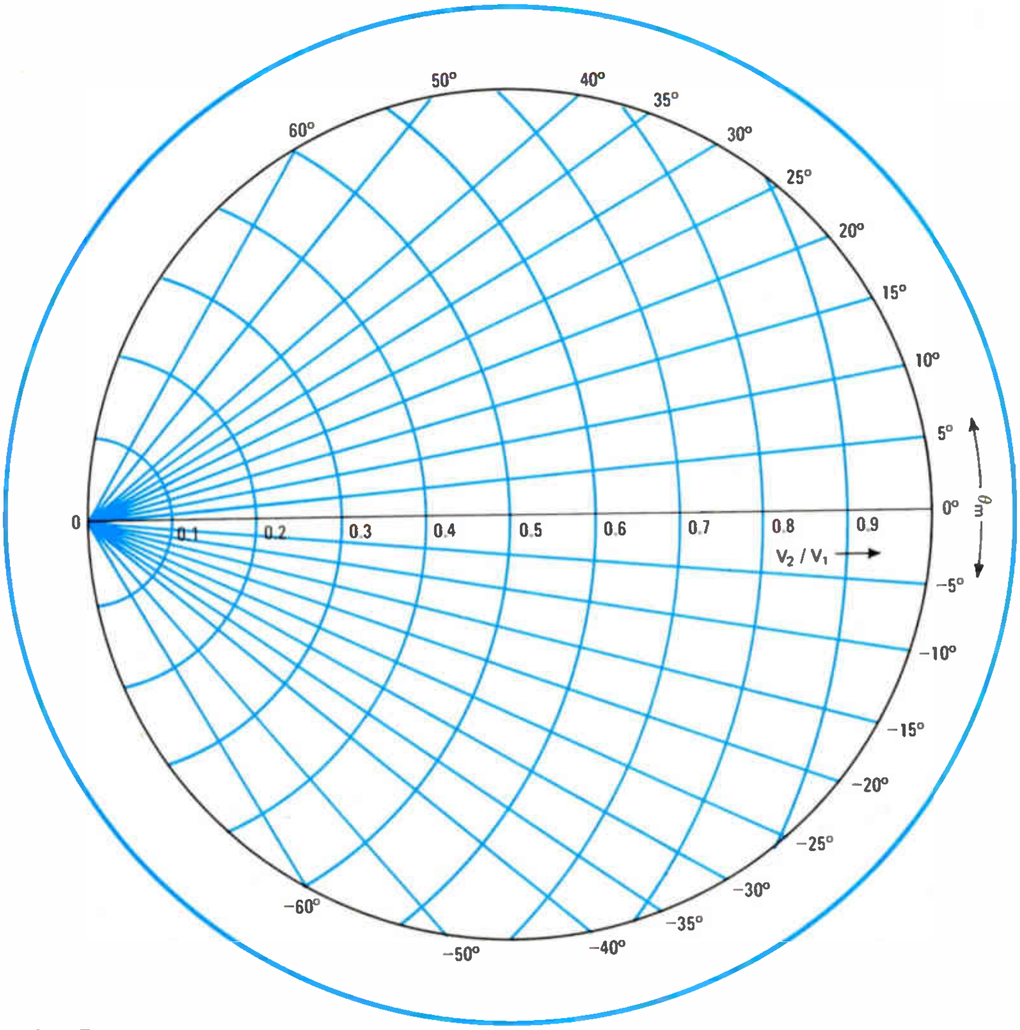
The term θ_m is the relative phase across the resistor and, therefore, the desired phase parameter to measure.

The last equation for Z can easily be solved with some of the scientific calculators now available, or it can be solved graphically. Normalizing Eq. 1 in terms of resistance R_S produces:

$$\frac{Z}{R_S} = \frac{(V_2/V_1)\angle\theta_m}{1 - (V_2/V_1)\angle\theta_m} \quad (2)$$

If this equation is plotted in polar coordinates, it forms a circle having its center point at −1. If it is plotted on a Smith chart, the circle's center lies at the far left side of the chart with a radius of V_2/V_1 and an angle of θ_m.

Figure 2 is a Smith chart showing the contours of Eq. 2. It now becomes a simple matter to determine an unknown impedance quickly by measuring the voltage



2. Graphical solution. The value of complex impedance Z, normalized with respect to noninductive resistor R_S, can be found graphically from this modified Smith chart. The chart establishes the coordinates for the voltage ratio of V_2/V_1 and the relative phase shift of θ_m.

ratio of V_2/V_1 and its relative phase, θ_m.

Suppose an unknown complex impedance is to be measured. The first step is to estimate the relative impedance magnitude and choose a noninductive resistor having such a value—511 ohms, for this example. (Optimum accuracy is obtained when R_S approximately equals the absolute value of Z.) By using the test setup of Fig. 1, the following data is then taken:

$V_1 = 1.0\ V$
$V_2 = 0.6\ V$
$\theta_m = -10°$

and:

$(V_2/V_1)\underline{/\theta_m} = 0.6\underline{/-10°}$

The point, $0.6\underline{/-10°}$, is next plotted on the modified Smith chart of Fig. 2, and the impedance, Z_n, which is normalized to 511 ohms, can be read off the chart in the conventional manner:

$Z_n = 1.28 - j0.58$
$Z = (511\ ohms) \times (1.28 - j0.58)$
$Z = 654 - j296 = 718\underline{/-24.5°}$

This procedure should be repeated until the computed magnitude of impedance Z is the same order of magnitude as the estimated value for resistor R_S.

The same equation—Eq. 2—can be solved mathematically on a scientific calculator. For this example, the measured data can be reduced to:

$$Z = 726\underline{/-24.29°} = 661.7 - j298.6$$

The mathematical solution is more accurate than the graphical one, but the graphical technique is quicker. The accuracy of the results depends on the tolerance and quality of the resistor used, the accuracy of the test equipment, and the accuracy of the data-reduction technique.

A modified Smith chart can also be a powerful analysis aid when VSWR measurements are to be made at low frequencies. A series resistor is chosen equal to the characteristic impedance, Z_o, of the system, and voltages V_1 and V_2, as well as phase θ_m, are measured. The maximum acceptable VSWR circle is drawn on the chart, and $(V_2/V_1)\underline{/\theta_m}$ is plotted at each frequency of interest. Since the chart is normalized to Z_o, all points of $(V_2/V_1)\underline{/\theta_m}$ falling outside of the circle are out of specification. □

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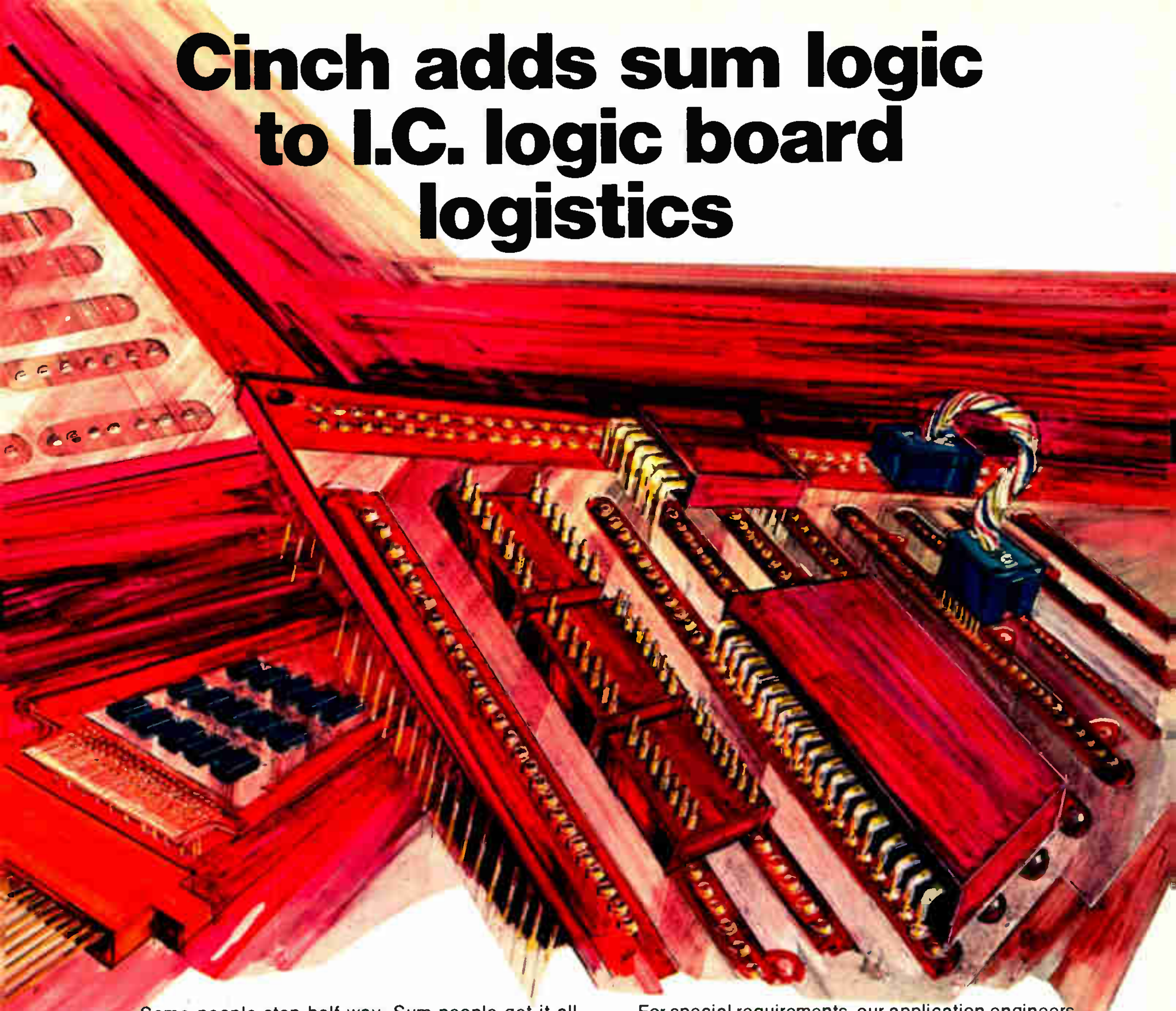
Cinch adds sum logic to I.C. logic board logistics



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*T.M. Gardner-Denver

TRW CINCH CONNECTORS

Circle 119 on reader service card

Dimmer lights last longer

A recent Engineer's Newsletter [March 21, p. 122] contained design ideas for conserving power in circuits and/or systems. But this power-saving idea from Calvin R. Graf of Sunnyvale, Calif., comes with a bonus—it could also extend lamp life. Whenever the whiteness of the light from an incandescent lamp is unimportant, **place a diode in series with the lamp so that its terminals receive pulsating dc instead of continuous power.** This more than halves the bulb's power consumption and also **extends its life because the lamp now operates at a lower temperature.** Of course, the tungsten lamp light also appears yellow rather than white, but if you're not going to work or read by it, who cares?

In the case of a dial or pilot light, solder a silicon diode in series with each lamp or the lamp string. Where lighting must be left on continuously but is not required for reading, as on walkways and in exit signs, outdoor night lights, and the like, **a silicon diode the size of two 25-cent pieces can be inserted into the bulb socket.**

A quick way to do time computations by calculator

Here's a time-saving way of doing time computations directly on your four-function pocket calculator. **Just go to a 24-hour-type time designation and add filler zeroes,** says Nicholas Bodley of New York, N.Y. The technique is also useful for calculations involving degrees.

Place a filler zero between the hours' number and the minutes' number, and another zero between the minutes' and seconds' numbers. For instance, 11:31:42 becomes 11031042. **Add or subtract,** treating the filler zeroes as "real" zeroes. Then, **if the resulting minutes' and/or seconds' number comes to 060 or more, adjust it by using the correction constant 940.** The constant should be added after an addition, subtracted following a subtraction. For example, 11031042 plus 4033011 makes 15064053, which is corrected by adding 940000 to make 16004053 (or 16:04:53).

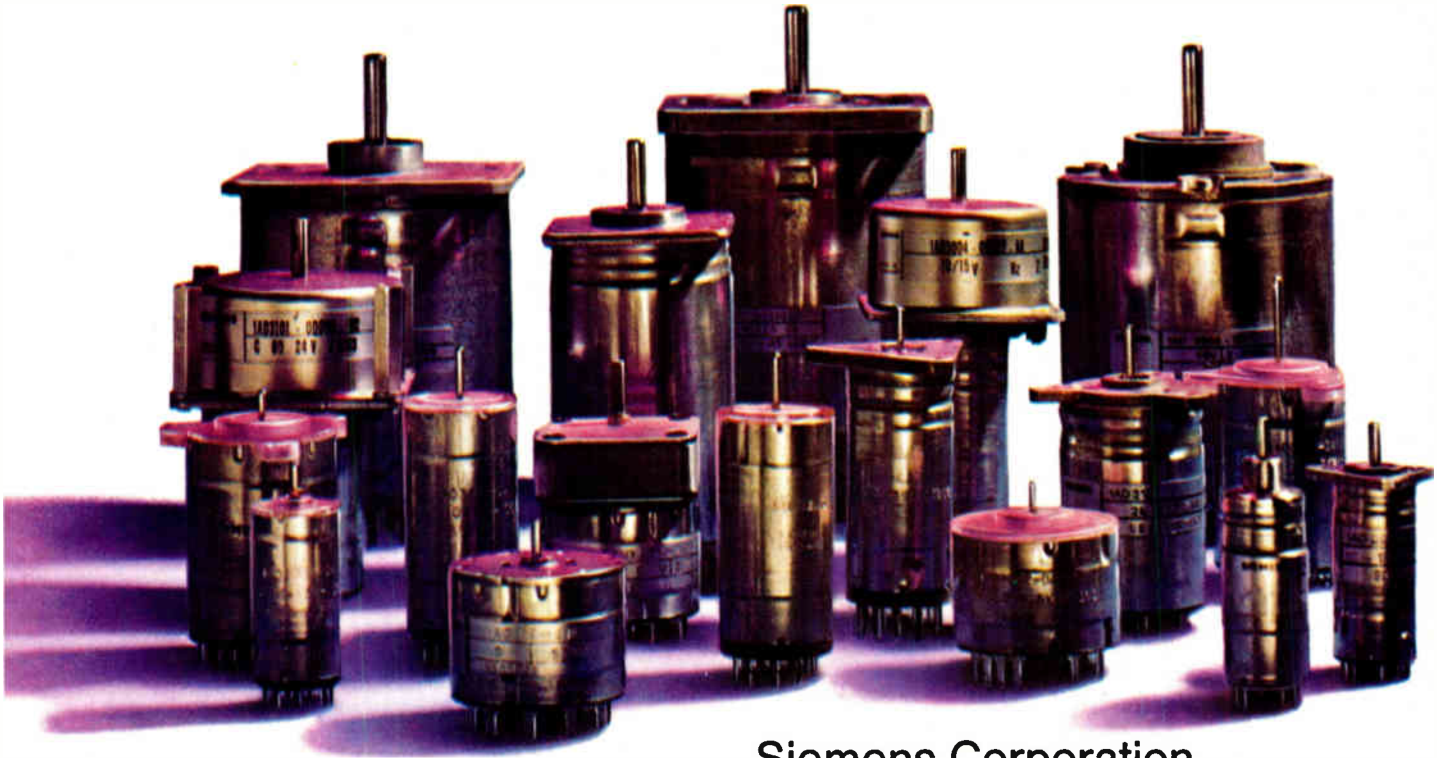
And if you're interested in calculator algorithms, a handy pamphlet is available for $2 from Mallman Optics and Electronics, 836 South 113 St., West Allis, Wis. 53214

A mix of logics drives Nixie, LED displays best

For Nixie tubes and LED lamps, **large drive currents are essential but high speed isn't**—two requirements that industrial designers find they can meet if they **mix standard C-MOS circuits with a high-noise-immunity logic like Teledyne's Hi NIL family.** The Hi NIL is used for inputs and outputs, to take advantage of its guaranteed 3.5-V input noise immunity and up to 65-mA output drive current, and the C-MOS is used for the internal logic, which benefits from its typically microwatt-level quiescent power dissipation.

Fighting off that old feeling

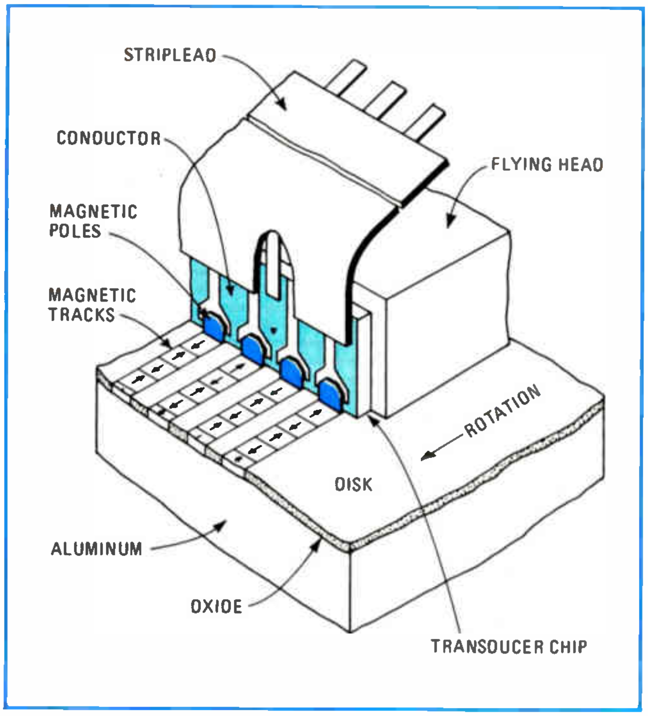
Feeling obsolete in the face of a relentlessly shifting technology? **Pick up a copy of "Maintaining Professional and Technical Competence of the Older Engineer."** Just published by the American Society of Engineering Education, the 256-page paperback deals specifically with the societal, organizational, and psychological phases of engineering obsolescence and **suggests ways of preventing technical obsolescence in people and organizations.** It costs $4 from ASEE Publications Sales, Suite 400, One Dupont Circle, Washington, D. C.—**Lawrence Altman**



Small thin-film transducers point to fast, dense storage systems

In present high-speed disk-storage units, the number of bits per square inch is limited by the large size of the fixed read-write head—but really small magnetic heads can now be fabricated by integrated-circuit processes

by William Chynoweth,
Honeywell Information Systems Inc., Oklahoma City, Okla.,
and John Jordan and Wolfgang Kayser,
Honeywell Information Systems Inc., Phoenix, Ariz.



Flying head. Thin-film transducers (color), on their substrate chip, are mounted on the trailing edge of a head that "flies" less than 100 μin. above the surface of a rotating disk.

☐ The fastest way to access the data in a magnetic-disk storage system is to span the disk tracks with a fixed head containing a separate transducer for each track. But the conventional fixed head also limits storage capacity because only 50 or so transducers can be squeezed across an inch of disk radius—the tracks read by a single fixed head can be only as close together as the transducers and their housing permit.

Moreover, the biggest total storage capacity and the fastest data transfer rates are obtained when bits are packed as densely as possible along each individual track. But densely packed bits require a short gap length in the transducer, although density is limited by other factors as well.

All this accounts for much of the present interest in replacing individual wirewound horseshoe-shaped transducers with much smaller, thin-film versions in which the magnetic structure and winding are fabricated in rows on the same substrate. The other important advantages of batch-fabricating the devices in this way are a high level of production repeatability and much reduced cost.

One thin-film-transducer project, called Pedro, was started in 1967 at the General Electric Co. and continued after 1970 by Honeywell Information Systems. But work on this technology is also under way at NCR Corp., Burroughs Corp., Minnesota Mining and Manufacturing Co., IBM Corp., and Sperry Univac in the U.S., as well as at Compagnie Internationale pour l'Informatique in France.

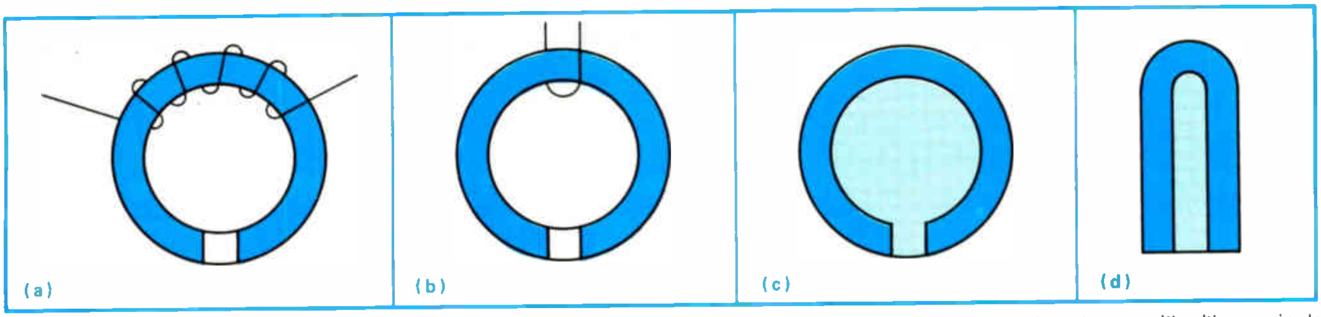
The aim of the GE-Honeywell project was to develop designs for thin-film transducers and to evaluate the technology's strengths and weaknesses. By 1970 enough progress had been made for several laboratory models of disk files to be built, using thin-film transducers to obtain track densities of 100 to 400 per inch of disk radius and flux reversal densities of 4,400 to 10,000/in. along the tracks. (Moving-head disk-storage systems attain similar bit and track densities because the single transducer in the head can be positioned very precisely, but their performance is much lower because moving the head into position is a relatively slow process.)

Honeywell's laboratory models were followed by an engineering model of a 6-megabyte disk file, built around standard disks like those used on commercial storage units. It has 100 tracks per inch and 5,100 flux reversals per inch, and it has demonstrated an uncorrected error rate of one in 10^9 bits.

By now, current trends in memory organization are under evaluation to see where the batch-fabricated thin-film heads can best be applied. That, presumably, will be in one or more products in the next generation of bulk-storage systems.

Thin-film transducers

The significant differences between conventional and thin-film heads lie in the construction of the magnetic recording transducer. Both kinds of transducers have the same elements—namely, a loop of magnetic material that is completely closed except for a small gap where the recording field is produced, and a winding of one or more turns of an electrical conductor. A varying current in this conductor creates fluctuations in magnetic flux



1. Evolution. Thin-film transducers have evolved from the classic, wound ring with a gap in it (far left), past ring shapes with either a single turn of ordinary wire or completely filled with a conductor (center left and right), to a conductor-filled horseshoe shape (far right).

that are captured by the recording medium moving past the gap. Conversely, externally imposed flux variations from the recording medium induce a fluctuating voltage in the conductor. But these elements take very different physical forms in conventional and thin-film transducers.

The thin-film transducer has evolved from the conventional ring-type with an air gap into a horseshoe shape in which the conductor fills the gap entirely. This "turn-in-gap" head is shown in Fig. 1 with just a single turn. But thin-film multiturn transducers have been investigated at Honeywell and elsewhere, in both vertical and horizontal form (Fig. 2).

The thin-film elements are fabricated by film deposition and photoetching processes that are closely related to integrated-circuit fabrication and can produce very short and shallow gaps and very narrow and closely spaced elements with great accuracy. A complete thin-film transducer may be only three times as thick and roughly the same height as the gap spacer in a conventional transducer, and multichannel magnetic recording heads can be fabricated as easily as single-channel heads.

The film's very thin cross section permits it to have an extremely short gap, which is essential in high-density recording—because closely spaced magnetic variations in the recording medium cannot be resolved by too long a gap. But this cross section also gives the transducer properties that are quite different from those of transducers made of bulk materials.

To begin with the advantages, track spreading and crosstalk between transducers are negligible. The very small broadside dimension makes the magnitude of side fringing fields drop off rapidly in real distance (as distinguished from distance as a proportion of transducer dimension), creating only small coupling of magnetic fields between neighboring transducers.

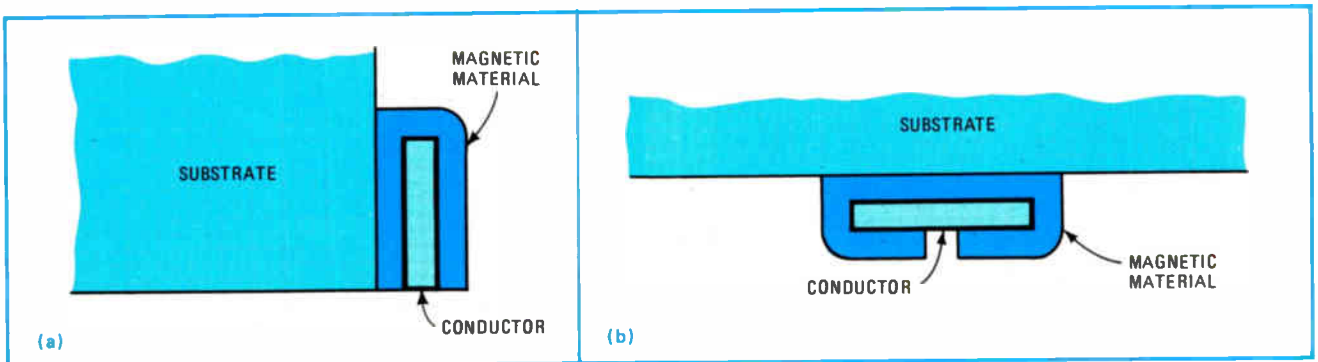
Also, resolution is improved because the thin pole tip is about as long as the gap. In conventional transducers, the tip is many times longer than the gap, but its corners are still within the magnetic field of the recording medium and can produce small but spurious signals that interfere with the gap signal. In thin-film transducers these "contour anomalies" produce effects in the same frequency range as those that are limited by the gap length and are more nearly in phase with them, so that their interference is less. As a consequence, the resolution for a given gap length can exceed that of a conventional transducer, particularly when the head is not in contact with the recording medium—as is usually the case in disk-storage units.

One disadvantage of vertical film transducers is poor low-frequency read performance. As in conventional transducers, the response to recorded variations with wavelengths greater than the length of the transducer drops off very steeply. These variations, which are also caused by the head contour, determine the low-frequency limit of the recording system. But in thin-film transducers, the rolloff begins at a much higher frequency than with conventional transducers.

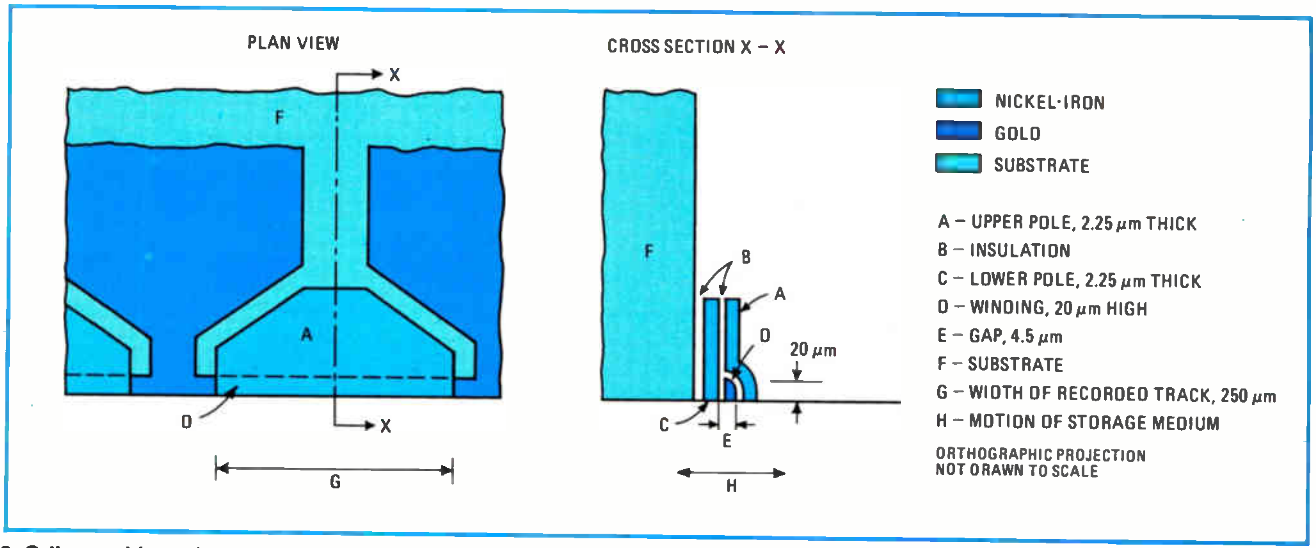
Furthermore, although the efficiency of a thin-film transducer is high, using the "winding" as the gap spacer results in an extremely high write-current density. And, although the read voltage is quite high, its absolute magnitude is very small.

Design considerations

The basic input parameters for the design of a thin-film multitrack head, like those for a conventional head, are linear recording density, track density, and oper-



2. Horizontal or vertical. Thin-film transducers can be deposited either vertically against one side of a substrate (left) or horizontally underneath it (right). Both orientations consist of successive depositions of magnetic and conductive materials, appropriately masked.



3. Orthographic projection. Vertical orientation of Pedro transducer comprises two layers of nickel-iron and a layer of gold. Gold layer extends upward to form pad for external connection. Note resemblance of cross section to the letter "h."

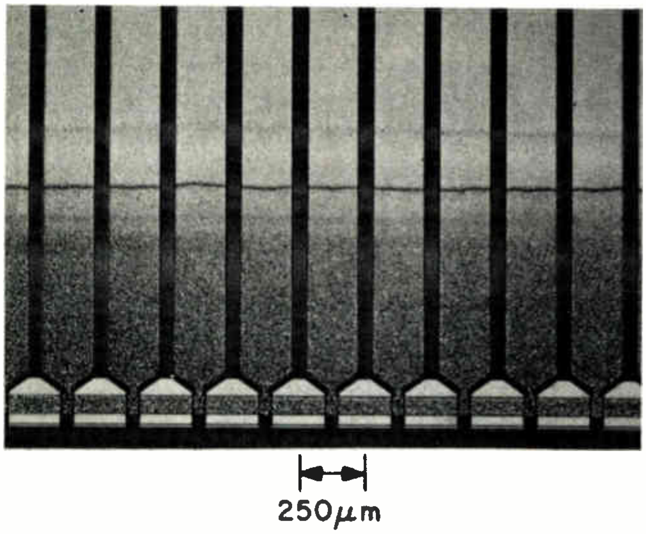
ating frequencies. Secondary parameters, derived from these basic inputs, are transducer dimensions, recording mode, and the height at which the transducer "flies" over the recording surface—usually 30 to 120 microinches, depending on the shape of the head and the kind of air bearing that the shape creates.

In the Pedro program the basic requirements were 100 tracks per inch and 4,400 flux reversals per inch, the same density as on the Honeywell DSU 180 or the IBM 2314 disk files. Standard commercial oxide coatings and conventional flying height of 70 to 100 μin. were used. The gap length was chosen as 4.5 micrometers, which is about 180 μin.

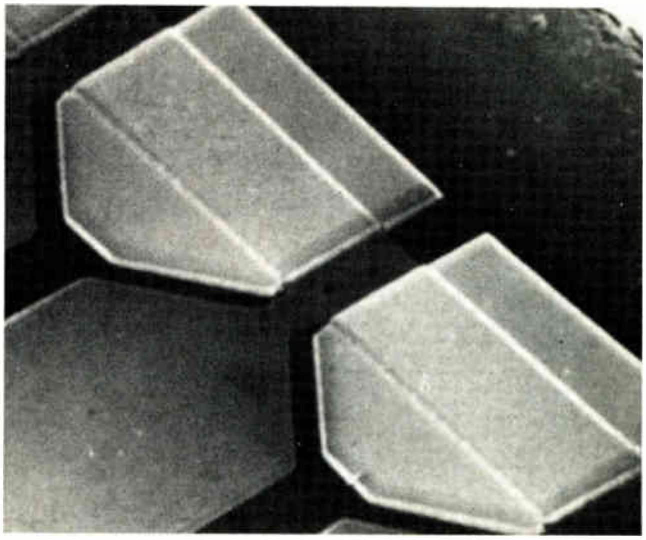
The Pedro transducer is a two-pole vertical type made of materials chosen for compatible thermal expansion coefficients and etching characteristics, as well as the obvious magnetic or electrical properties. An insulated design was chosen in which the metallic layers are separated by insulating layers.

Since the larger the number of transducers on a head, the lower the cost per track, it's important to reduce the number and complexity of transducer connections. As shown in Figs. 3, 4, 5, and 6, two adjacent transducers share a connecting pad. An alternative configuration would be to connect one side of each transducer to a common bus bar. With either configuration the number of leads from a head is one more than the number of transducers, permitting a flexible, flat multiconductor strip-lead to be used for a simple connection to the transducers. But the shared-terminal construction has better thermal performance because it maximizes the conductor area and cross section between transducers, while also maximizing track width for a given track density.

Ideally, the write field produced by a transducer would affect a magnetic storage medium of indefinite thickness only directly under the transducer gap. But ideal conditions are never realized; one departure is in the use of the flying head, which is necessary to reduce wear and tear on the recording surface. This separation



4. Worm's-eye view. Microphotograph shows 10 transducers on a common substrate, before excess at bottom has been ground away. Gray bands, connected to vertical pads, are the transducers.



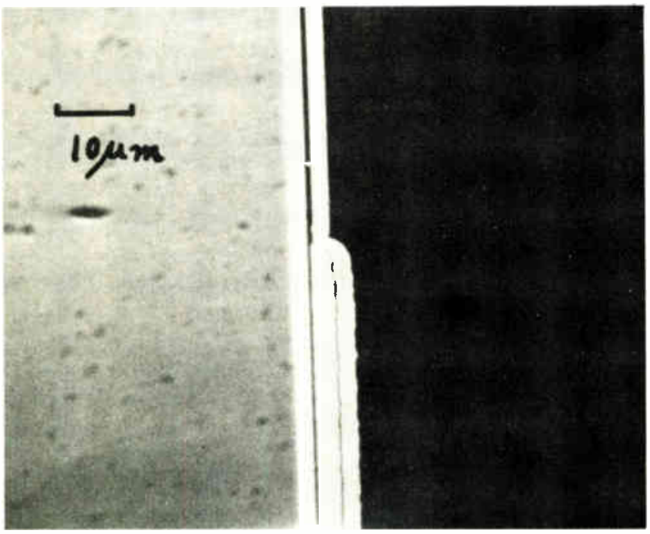
5. Detail. This photo, made with a scanning electron microscope, clearly shows how the nickel-iron deposition overlies the conductive gold layer, which extends leftward toward top of transducer.

of the recording surface from the transducer gap combines with the fringes of the write field (always found outside the gap) and the finite thickness of the magnetic medium to affect the medium at a distance from the gap. As a result, an isolated magnetic pulse spreads out, and closely packed pulses are reduced in amplitude—a phenomenon called pulse crowding.

Recent analyses of thin-film transducers have shown that the write field is less than that of a conventional transducer at distances greater than one gap length from the center of the gap, in a direction parallel to the recording surface, and may even become opposite in sign. This difference significantly improves resolution and reduces the problems of pulse crowding found with conventional transducers.

Likewise, the reading performance of a vertical thin-film transducer differs from that of a conventional transducer because of the thinness of the poles and the "turn-in-gap" configuration. In any transducer the voltage across the output terminals is generated by the sum of two changing flux patterns: a high-resolution part carried by the poles and linking the entire winding, and a low-resolution part carried through the air and linking at most only part of the winding. In conventional transducers, the winding has many turns and is remote from the gap, so that the airborne part generates a voltage that is only a negligible fraction of the total. But in thin-film transducers, with a one-turn "winding," the airborne flux is a much larger proportion of the total, and creates a more variable output.

Furthermore, the small uniform cross section of the film transducer and the limited permeability of materials such as nickel-iron and iron-cobalt, of which the transducer poles are made, results in leakage between the poles. Therefore not all of the flux entering the pole tips from the recording passes around the conductor. The ratio of the flux passing around the conductor to the total flux entering the pole tips can be calculated. It is greater than 0.95 for a permeability in excess of 500 and a 20-μm conductor height (Fig. 3). Because the mathematical expression for the ratio involves the square root of the permeability but the direct height of the conductor, the effect of the height is greater than that of the permeability. The ratio drops off quickly for a permeability below 200; it also decreases more or less linearly for taller conductors.



6. Actual scale. In another view, this microphotograph shows the nickel-iron layer "dropping off" the top of the gold layer. It also indicates true scale of the cross section shown in Fig. 3.

Because the transducers are very small while the write currents are relatively large, the current density in the conductor can reach 3×10^6 amperes/cm^2, dissipating as much as 0.25 watts and corresponding to a power density of over 20 megawatts/cm^3. These are orders of magnitude higher than in conventional transducers. To keep the temperature low enough for reliable operation, heat must flow readily along the path from the current-carrying conductor through the intervening layers of metal and insulation to the substrate.

Thermal characteristics

A theoretical thermal analysis under write conditions shows that the transducer's thermal and electrical conductances deteriorate rapidly above approximately 2.45 A (Fig. 7). However, the normal operating range is well below this nonlinear region. Theoretical analysis also predicts a temperature rise of 29°C in the conductor for a current of 1.5 A.

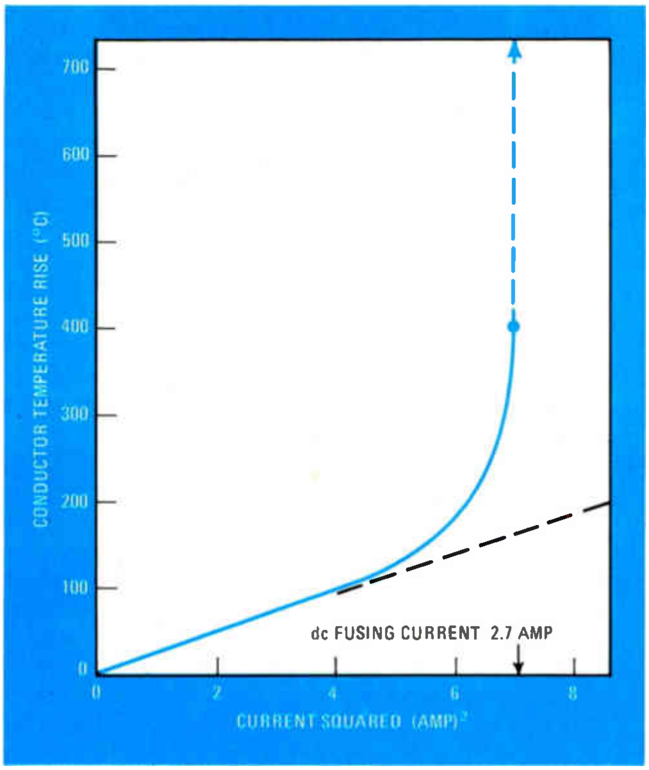
This has been experimentally verified, using the gold conductor in the transducer as a resistance thermometer. With the shared-terminal design a four-point-probe resistance measurement is possible. As shown in Fig. 8, if a current is passed through any one transducer, the actual voltage across that transducer can be measured with a high-impedance voltmeter connected to any pair of leads that have both current leads between them. Thus if the current through the conductor, which is made of gold, is accurately known, the conductor resistance can be calculated, and converted to temperature using the known relationship of resistivity to temperature for a thin film of gold.

Such measurements as these indicate that a temperature rise of 25°C, which is 4° below the predicted rise, is typical for these dimensions at a peak operating current of 1.5 A. Other measurements with pulsed currents up to 2.0 A showed that the thermal rise time is less than 60 microseconds. The turn-on time constant increases dramatically as the thermal nonlinearities come into play—but again, these are found well above the operating range. Such time constants are much shorter than ordinary data block periods in a disk file, and the demonstrated temperature rises are small. Thus reliability degradation caused by thermal cycling will not be a problem in storage systems using thin-film heads at the flying height in this model.

Head fabrication

The transducer is a five-layer, photoetched, thin-film structure, batch-fabricated on a thermally oxidized 1-0-0 silicon substrate. The silicon wafer is inexpensive, flat, smooth, and a good thermal conductor. Long rows of transducers extend right across the wafer, which can be readily scribed and broken into chips of any desired size. The long rows provide maximum flexibility in this regard, while the 1-0-0 crystal orientation simplifies the scribe-and-break step.

Standard sputtering and photo-fabrication tech-



7. Thermal response. Theoretical analysis, confirmed by experiment, shows reduced conductance and sharp temperature rise at high current, ending in destruction where curve becomes vertical. Normal operation is well down in linear part of curve.

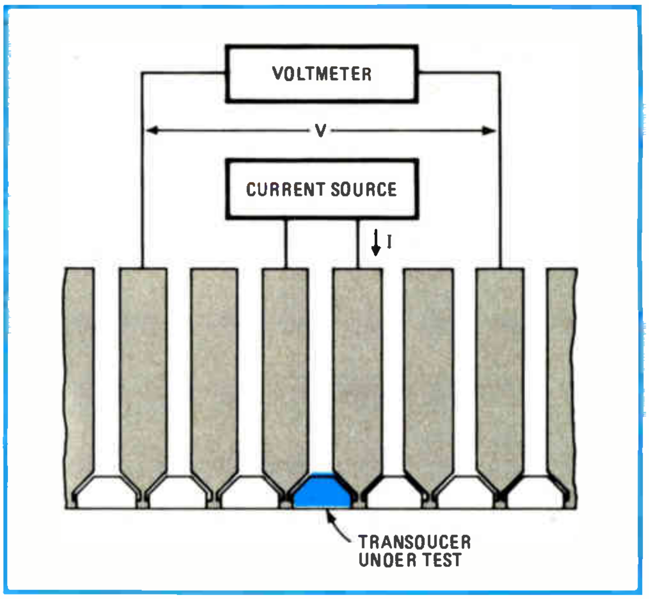
niques are used in depositing the five thin-film layers. These are, in order, the bottom magnetic pole material, the bottom insulation layer, the conductor layer (actually a three-part layer—.015 μm of chrome for adhesion, 13 μm of sputtered gold, followed by an electroplated layer of gold of the required thickness), the top insulation layer, and finally the top magnetic pole. All but the bottom insulation layer are also either etched or masked to align their respective patterns.

The thin-film transducer seems well adapted to a multi-track head for a disk file. The most convenient assembly locates the chip on the rear end of a standard slider, riding on the air cushion between it and the recording surface. A protective cover glass should be cemented over the row of transducers. This configuration is used in the present engineering model.

To connect the transducer chip to the circuit board, a flexible multilead cable is required. A suitable cable can be made by photoetching a multiconductor pattern on copper-clad Kapton, which is flexible, yet can stand the reflow soldering temperature without distortion. The strip-lead fans out from the 0.010-in. spacing of the chip connection pads to the 0.025- or 0.05-in. spacing at the circuit board.

Transducer/electronics interface

As described previously, at a nominal flying height of about 80 μin, the transducer requires drive currents of 1.0 A or more to produce the required magnetic fields for recording on standard disks. But the single-turn transducer has a resistance of about 0.2 ohm, and the combined impedance of transducer and associated



8. Resistance measurement. When current is passed through any one transducer in an array, voltage drop can be measured from any two other leads that have both current leads between them. Resistance and temperature are calculated from the voltage and current.

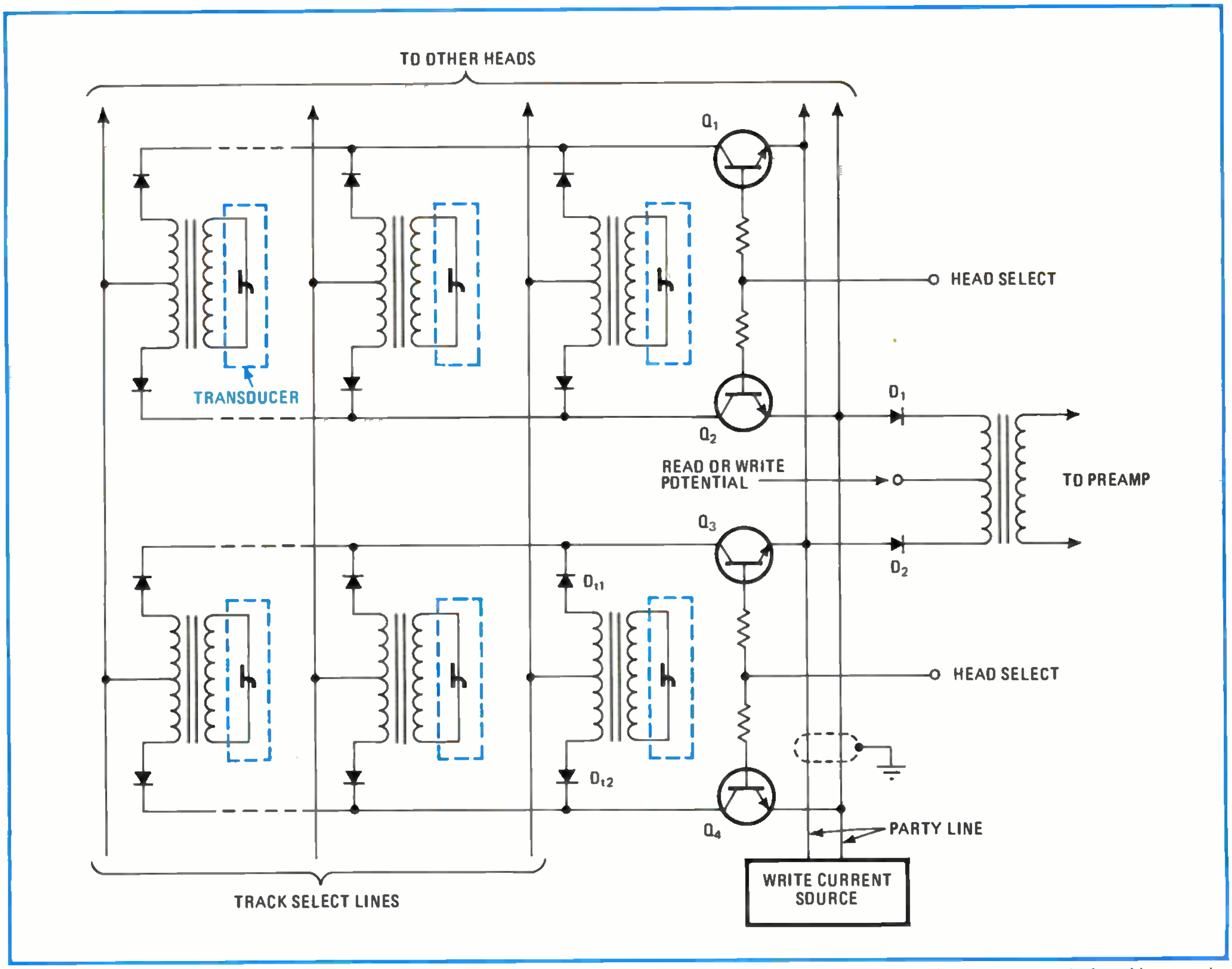
strip-leads is about 1 ohm at 2.5 megahertz. Meanwhile, the single-turn transducer produces a peak-to-peak read signal of about 120 microvolts at a recording density of 4,400 flux reversals per inch.

To drive and sense the single-turn transducer directly with integrated circuits is difficult with such a high drive current and low signal level. Thus discrete-component circuits have been used in the present model. The circuits use a single transformer for both read and write, to reduce the drive circuit's current requirements for writing and to increase the signal level for reading. Each transducer has a separate transformer, and the secondary winding of the transformer is center-tapped. The transformer has a turns ratio of 1:8 for write and 1:16 for read, through this center tap, thus reducing the required drive current by a factor of nearly 8 and increasing the sense signal to more than 1 millivolt.

To keep the transducer-transformer connection short, the transformer must be close to the head. Since transformers for all the transducers must fit in this limited space, they must be very small. To meet these constraints, the transformers are wound on pot cores, which are small cup-shaped pieces of magnetic material with a single post in the center of the cup.

In pot cores the windings go on the posts; the flux path closes through a cover or another pot core inverted over the first one. This arrangement shields the windings from external electrical interference and physical damage, while closing the magnetic path around the windings in three dimensions. But in the experimental disk file using the thin-film heads, the cores are used singly, stacked one on top of another so that the magnetic path of each one closes through the back of the next.

The presence of a transformer imposes some constraints upon the recording code. Normally the magnetic transducer is directly coupled to the write driver, thus responding to direct current. But the transformer



9. Transducer selection matrix. Combination of track-select and head-select lines picks one transducer, hence one track, for either read or write. Transformers (pot cores) increase write current and step up read signal. The h-shaped symbol represents the transducer (Fig. 3).

used with the thin-film transducer has a low-frequency cutoff of about 50 kilohertz. These characteristics would be unsatisfactory with the non-return-to-zero-inverted code, in which writing a continuous string of 0s requires the passage of a direct current. Likewise, any code that allows an unbalanced write-current sequence to be repeated indefinitely has a net dc requirement, which again won't pass the transformer.

But with certain codes—for example, the double-frequency and phase-modulation codes, or codes that permit only certain allowed sequences—a repetitive unbalanced write current sequence cannot occur. These codes therefore have no long-term dc bias and hence are suitable for use with a transformer.

The presence of a transformer causes no such problems in the read mode because sensing through rate of change of flux eliminates the need to detect direct current. However, the transformer's low-frequency cutoff may cause an undesired phase shift.

Transducer selection

Since every track has its own read/write transducer, selecting the transducer selects the track. The selection circuits must not significantly degrade the write current or the read signals. They must also be low in cost, so that they do not negate the cost advantages of batch-fabricated thin-film transducers. Low cost is achievable if each flying head carries at least 20 transducers, which can be done easily with the Pedro structure. The engineering model, which uses standard disks with 374 tracks, has 12 flying heads with 32 transducers on each head.

The selection circuits form a matrix (Fig. 9) in which the track select lines are the columns and head select lines form the rows. The selection transistors are drivers when writing and saturated switches when reading. One track-select line addresses, say, the innermost track served by each of several flying heads, while selection of one of those heads isolates the selection to one transducer and the track it serves. A double "party line" interconnects all selection transistor pairs with the write current source and with the read preamplifier. ☐

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Processor adds to computer power

High-speed signal analyzer provides host machine with capabilities for fast-Fourier-transform and other types of signal and data analysis

by Gail Farrell, Boston field editor

Digital signal processors can be costly, but CSP Inc. of Burlington, Mass. says its new line of macro arithmetic processors (MAP) allows minicomputers and large scientific computer systems to perform complex mathematical operations in real time, while still acquiring data, for as little as $5,000 in extra cost. The programable MAP can provide the host computer with the capability of a fast-Fourier-transform processor, array processor, display processor, image processor, voice processor, convolver box, or data-acquisition system.

But the main advantage of MAP, the company says, is its speed. CSPI claims it is among the fastest, most powerful signal processors available, in terms both of memory and of input/output capacity. It is available with multiported memory having cycle times of 125 or 500 nanoseconds and optimally addressed in 8-, 16-, or 32-bit words. Both memories are available with all three versions of MAP. At $5,000 the MAP 100 is the slowest unit; it can perform a 1,024-point complex FFT in floating point in 60 milliseconds. The MAP 200 for $10,000 can do the same operation in 10 ms, while the $15,000 MAP can do it in 3.5 ms.

A multiprocessor, MAP consists of up to four arithmetic processors, a control processor, up to four multiported memories, up to 64 input/output devices, and the host computer. The control processor is a stripped-down version of CSPI's CSP-30 computer [*Electronics*, March 2, 1970, p. 159]. It has some arithmetic capacity but no memory of its own, since it is used to set up I/O operations and calculate addresses and address patterns.

The arithmetic processor, in the same unit as the control processor, contains a 32-bit floating-point arithmetic section and does the real arithmetic work. It is data driven; its memory holds macro-instructions that enable it to perform one task repeatedly with only one instruction from the controller. Its 256-word memory also contains about 50 microprogramed routines, such as complex multiply, which are used as building blocks to set up "macro" arithmetic operations, such as FFT.

Maximum memory is 1,048,576 bytes, contained in a total of four memories. All four may be relatively slow, storing 262,144 bytes each on 4,096-bit MOS RAM chips with a 500-nanosecond cycle time. Alternatively, one or two of the four may be faster, storing 65,536 bytes each on 1,024-bit bipolar RAM chips with a cycle time of 125 ns. There can be up to four buses to transfer data, and in addition each memory has 16 ports.

Block transfer. Because the memory is ported, CSPI can provide an I/O system with MAP, called the I/O Scroll. Up to 24 Scrolls, one per port, each of which can handle one peripheral device, can be hung on the bus. High data rates can use up most of a computer's busing capacity, but the I/O Scroll data can handle the I/O by block transfer directly to and from memory. One command from the control processor initiates a full series of transfers, freeing the MAP computer from the need to carry out transfer programs running into hundreds of memory cycles. The Scroll can handle transfer rates of 32 megabytes per second in a single memory.

MAP can be used for signal processing in seismic and geophysical applications, communications, sonar, radar, and other areas. Application program packages are available, and new functions or algorithms can be added by programing the arithmetic and control processors. MAP is both macro- and microprogramable through the host operating system or higher-order languages such as Fortran.

Host interface, memory, and I/O Scroll are available as options.

CSP Inc., 209 Middlesex Turnpike, Burlington, Mass. 01803 [338]

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Processor analyzes 1,024 signal points in 2 milliseconds

Real time, fast-Fourier-transform (FFT) analysis of complex signals is being used more and more as the electronics and data-processing industries tackle more sophisticated problems. Jobs that would formerly have been assigned to huge, off-line computers are increasingly being done by portable or lower-budget equipment. This in part is possible because of the high speed of small, relatively inexpensive fast-Fourier transform processors, such as the new Datawest processor used in its Real Time signal-anslysis systems.

The processor module, developed for Datawest's voice-identification system, is now offered for sale separately, both as a "box" and as part of a system. The same processor, in combination with suitable accessories, such as a minicomputer and peripherals, can be used in seismic exploration and to analyze engines, vibration, acoustics, and speech. It's also suitable for communications tests, underwater sound analysis, automatic testing, pattern recognition, image processing, and shock, biomedical, and nuclear analysis.

The Real Time I is a 16-bit floating-point system priced at $40,000. Datawest claims the fastest speeds in the industry, with a transformation on 1,024 points performed in only 2 milliseconds. The units have a typical multiply time of 125 nanoseconds, and memory access time is 50 nanoseconds.

The system, depending on its specific configuration, permits on-line or off-line stand-alone or computer-augmented analysis of periodic, random and transient signals in either the frequency or time domain or both. The high speed provides the capability of analyzing multiple channels, even in real time (with sufficient displays, which could be the limitation).

The signal analyzers perform the following functions: FFT, inverse FFT, power spectrum, cross-spectrum, transfer, coherence, autocorrelation, cross-correlation, convolution, spectrum analysis, and ensemble averaging of any or all of these functions. Speed is 500,000 samples per second on each of two channels. Throughput rate depends on such factors as configuration, number of channels, and functions.

The system is available as a stand-alone or with an Interdata 7/32 computer. It can be interfaced to a customer's PDP-11 Nova, or Varian 620 or V73.

Datawest will also have 32-bit versions in the future.

Datawest Corp., 7333 E. Helm Dr., Scottsdale, Ariz. 85260 [361]

Controller links IBM printer with non-IBM computers

The IBM model 1403, although widely accepted as a printer, is designed only to be used on-line with IBM computers. Users who would like to use the printer with the DEC PDP-10 or Xerox Sigma computers can now do just that with a printer-controller developed by Spur Products. The firm had earlier developed controllers for off-line use and for CDC, General Automation and DEC PDP-8 computers. Spur's controller, the S1403, is an updated version of IBM's model 2821—smaller because it takes advantage of improvements in technology in the last 10 years, says Spur president Ray Lorenz. Unlike some printers, the 1403 comes stripped, without power supplies, hammer drivers, and logic, for example, so the controller includes these. The controller interfaced to a large computer such as the PDP-10 or Xerox Sigma series is priced at about $17,000. The company has other controllers under development and will develop custom adapters for other applications.

Spur Products, 2928 Santa Monica Blvd., Santa Monica, Calif. 90404 [341]

Versatile modem transmits 4,800 bits per second

Designed for data communications at 4,800 bits per second over dial facilities as well as dedicated lines, a modem designated the IBM 3874 provides broad flexibility in teleprocessing systems. It can be equipped, for example, to answer incoming signals automatically and to allow automatic calling of a remote location during operation over dial networks. In dedicated systems, the 3874 can allow transmission between two modems on a single line or between a control modem and as many as six locations on one line. The device can be shared by as many as three terminals or three multiplexers at one location. Rental fees range from $155 to $282 per month, and purchase prices from $4,650 to $7,200.

IBM, Data Processing Division, 1133 Westchester Ave., White Plains, N.Y. 10604 [340]

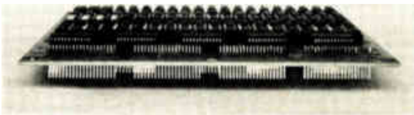
Add-on core memory offers up to 65,000 words

An add-on core memory, completely transparent to IBM 1800 System programs, can be used with both the 2-microsecond and 4-μs models. Up to 65,000 words are available in increments of 8,000 words, with an optional 8,000-word backup for service restoration. The model CH1-1106 attaches to the host system through slip-on connectors, which are attached to the pin side of the IBM logic gates. Connections are not permanent and can be easily installed or removed.

Computer Hardware Inc., P.O. Box 4496, Sacramento, Calif. 95825 [364]

Microprocessors allow user to design custom system

The DL-8 and DL-16 8- and 16-bit microprocessor computer systems provide users with custom design capability for specific computer applications. Data Logic DL-8 and DL-16 systems each comprise four major elements: central processor, power supply, control panels with displays, and finished cabinet. Both systems can be ordered without mi-

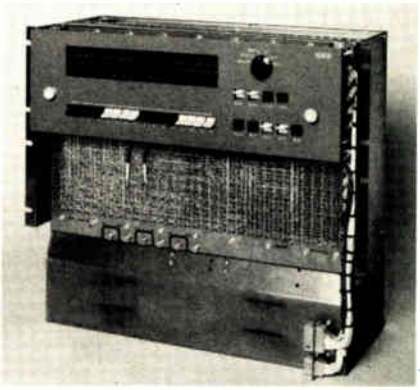


croprocessor chips or other IC elements, but are wired and tested so that customers can insert their own ICs. The microcomputers provide up to 128 input and output ports, each of 4, 8 or 16 bits. Prices start at $395.00 for a completely wired central processor.

Data Numerics Inc., 141-A Central Ave., Farmingdale, N.Y. 11735 [363]

Controller provides fast response to interrupts

A microprogramable controller with a throughput rate of 2,860,000 16-bit words per second is designed to provide response to fast interrupts in 350 nanoseconds, while multiplexed interrupt response is as fast as 1.05 microseconds. The SCU model's capabilities include input/output controller and/or preprocessor for a host computer, device controller for peripherals, communications system controller, special algorithmic processor, computer emulation system, remote intelligent processor, video display controller, and a stand-alone processor. A TriBus architecture, orga-



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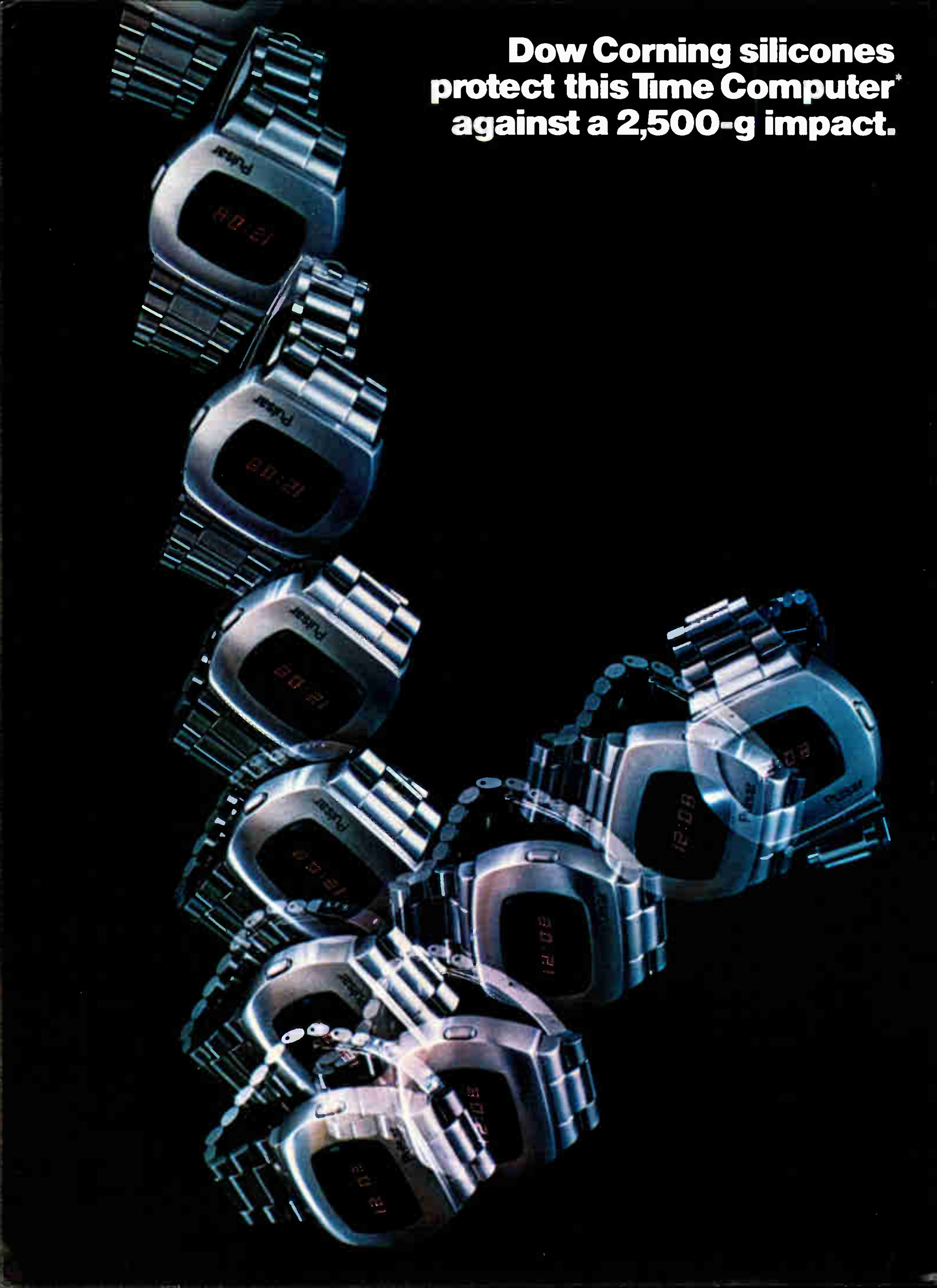
EUROPE: 14, AVENUE VILLARDIN, 1009 PULLY, SUISSE

Circle 135 on reader service card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nized around three 16-bit parallel buses, permits up to three data transfers to take place concurrently within a single microinstruction. Data may be intermixed combinations of bytes and 16-bit words. Price for a single unit is $4,500, with volume discounts available.

Xerox Corp., 701 S. Aviation Blvd., El Segundo, Calif. 90245 [365]

OCR page reader scans 1,000 characters a second

Designed for text editing and for photocomposition at 10,000 words per minute, the model OCR/COMP optical character page reader reads documents having 10 pitch fonts at rates up to 1,000 characters per second. The system is built to accept a

single font, but can have up to three fonts resident at any time. The standard, full alphanumeric fonts plus special symbols are Courier 12, OCR A and OCR B; other fonts are optional. The basic model OCR/COMP is priced at $29,900, with OEM prices available.

Dest Data Corp., 1285 Forgewood Ave., Sunnyvale, Calif. 94086 [366]

Disk storage unit holds 25 million words

A disk storage unit for use with any of the Prime small to medium-scale computers has a capacity of 25 million words. Up to four disks can be attached to a controller, which in turn can be attached to a Prime 100, 200, or 300 central processor. The disk units utilize 20-surface (11-

disk) packs. Information can be recorded in IBM-compatible format or any user-specified recording mode. Price for the 25-million-word disk storage unit is $20,000. The controller unit, which handles up to four disk pack units as well as one fixed-head disk, sells for $5,000.

Prime Computer Inc., Box 2600, 145 Pennsylvania Ave., Framingham, Mass. 01701 [367]

Data-acquisition system takes 60 samples/second

Dataquire IV, a 10- to 100-channel data-acquisition system, includes high-speed autoranging that allows automatic capture and recording of data varying from 1 microvolt to ±10 V dc, at speeds up to 60 samples per second. The unit provides a real-time nine-digit clock and multi-range timer, as well as 10 constant data switches for reader informa-

tion. Channel selection can be either sequential or random, determined by a front-panel pin-board programer. An optional printer is provided for setup and calibration, and a high-speed computer-compatible magnetic tape deck records the information for later processing on a computer. Prices start at $4,100.

Data Graphics Corp., 8402 Speedway, San Antonio, Tex. [368]

Ruggedized minicomputer's memory is expandable

The model 1603 is a conductively cooled ruggedized minicomputer that includes a four-card CPU, 8,000 words of memory expandable to 32,000 words and a 47–440-Hz power supply. Core memory is available in 8,000 word increments, and up to two semiconductor memory modules can be installed in the chassis. All memory in the 1603 provides typical cycle time of 1.2 μs. Direct memory access is standard. A one-card extended arithmetic unit providing 7.7-microsecond hardware multiply/divide is optional. Price of a unit with 8,000 words of memory is $9,950.

Rolm Corp., 18922 Forge Dr., Cupertino, Calif. 95014 [369]

Flexible-disk system can handle million bytes

A flexible-disk system, called Flexi-File 52, includes two disk drives, a built-in controller with formatting electronics, and a power supply. On-line capacity is 524,288 8-bit bytes in a 16-sector, 64-track format with a data transfer rate of 31,000 bytes. The unit accommodates an additional two-disk slave system which increases the total capacity to one million bytes. Access time is 10 milliseconds, track to track. All assemblies and electronics, including the disk drives, operate in an extended position to simplify maintenance.

Tri-Data, 800 Maude Ave., Mountain View, Calif. 94040 [370]

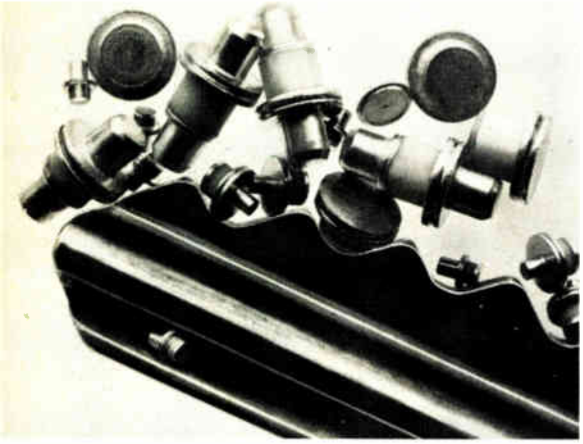
Microwave

Varactor diodes have high Q

Capacitance of tuning devices also increased by liquid-phase epitaxy process

Liquid-phase epitaxy is called the key to producing more uniform gallium-arsenide varactor diodes by engineers at Varian, Palo Alto, Calif. The company has a new line of high-Q tuning diodes, suitable for tuning Gunn and Impatt oscillators to frequencies as high as 50 gigahertz. Q values are almost double those of previous devices, while capacitance values have been increased between 10% and 25%. Other typical applications include wide-tuning range vhf and uhf oscillators, tunable filters, and tunable microwave transistor oscillators.

Varian's liquid-phase epitaxy process gives a uniform junction and avoids "spiking" in the doping profile, an effect often noted in devices made with vapor-phase epitaxy, claim the company's engineers. (Spiking limits the effective abruptness of the pn junction, and an abrupt junction is necessary for high tuning ratios.) Varian says it can grow an entire pn structure with its process, in only one heat cycle. The company contrasts its process with that used in most other varactors, which it says are made with zinc-diffused junctions in a vapor-phase epitaxial layer. Multiple heat cycles involved in such diffusions can lead to extreme spiking. The company says the liquid-phase epitaxy process is based on its work with gallium-arsenide Gunn diodes.



Q values range from 2,400 to 5,000, depending on capacitance and breakdown voltage. Total capacitance values can be specified from 0.5 picofarad to 5 pF with ±10% tolerance. Additional values and tighter tolerances are available on special order. More than 15 package styles are available, with package capacitances ranging from less than 0.1 pF to 0.25 pF. Breakdown voltages are selectable—from 15 V to greater than 60 V.

Prices in small quantities begin at $75 each.

Varian, Solid-State West Division, 611 Hansen Way, Palo Alto, Calif. 94303 [401]

Stabilized oscillator tunes over 100-MHz bands

A cavity-stabilized oscillator with automatic-frequency control within ±0.1% and low fm noise, is mechanically tunable over any 100-megahertz band from 3 to 4 gigahertz at up to 500 milliwatts. The afc option allows voltage tuning across ±0.1% of the band at typically 1 MHz/V and tuning rates to 10 MHz. Operation into all phases of a 1.5:1 mismatch is typically ±1 dB power variation and ±1 MHz frequency pulling.

Frequency Sources Inc., 166 Middlesex St., North Chelmsford, Mass. 01863 [404]

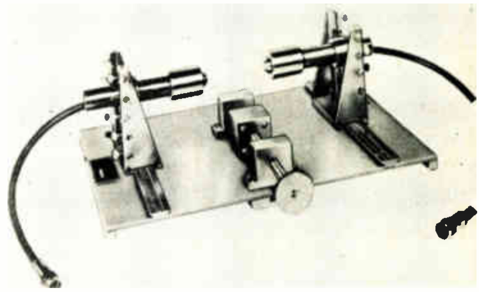
Diode switches cover 0.5-to-18-GHz range

A line of p-i-n diode switches—single-pole double-throw types, offers a wide variety of options for high-speed channel-selection or pulse-modulation applications. The models MT3580 and MT3581 have integrated TTL-compatible drivers and the models MT3680 and MT3681 are without drivers. Small size, low weight, and rugged construction make the switches suitable for electronic-countermeasures applications. Frequency is 0.5 to 18 gigahertz. Other specifications include a switching speed of 20 to 700 nanoseconds and a maximum insertion loss of 2.2 decibels at 18 gigahertz.

Alpha Industries Inc., 20 Sylvan Rd., Woburn, Mass. 01801 [402]

Coupling adapter measures filter-insertion loss

A universal coupling adapter for frequencies ranging from dc to 10 gigahertz is designated the model M-240B and is designed to measure filter insertion loss as specified in MIL-STD-220A. This enables engineers working with electromagnetic-interference problems to check filter circuitry for compatibility. Interference pollution, which is espe-



cially encountered in aerospace applications, can then be controlled within specification limits, according to the company. The M-240A is furnished with two coaxial cables and coupler heads to accommodate various types of terminal configurations. Accessories available include an isolation attenuator, a buffer network assembly, and coaxial switches.

Filtron Co. Inc., 200 Shames Dr., Westbury, N.Y. 11590 [339]

Electromagnetic-compatibility tester covers 1–18 GHz

For testing microwave electromagnetic compatibility, the model FSS-500, EMC system is designed to provide automated measurements at

Our new Series-500 Logic-Circuit Testers say so. Loud and clear. They are: fully portable, fully automatic, with both random and programmable patterns, at quantity prices as low as $5,950!

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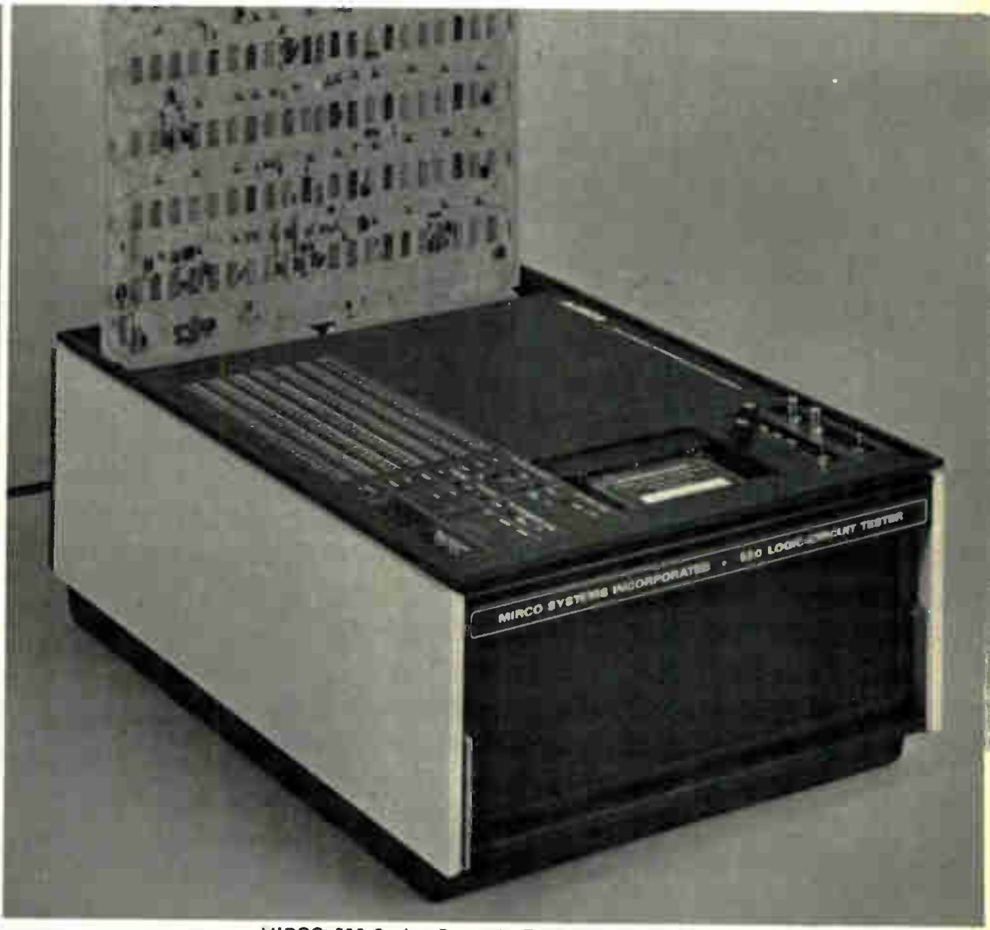

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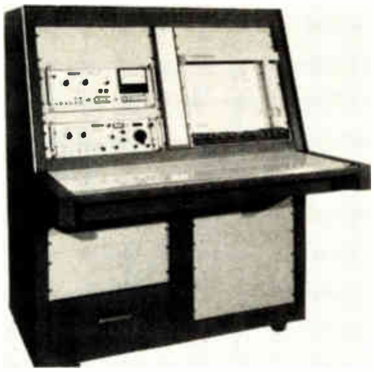
Circle 141 on reader service card

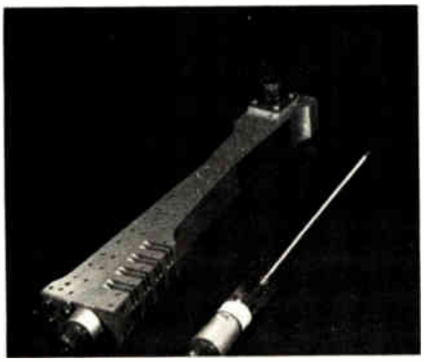


frequencies of 1 through 18 gigahertz. Designed as a companion unit to the model FSS-250, which measures lower frequencies, FSS-500 is normally installed in a matching dual-bay rack. However, to provide additional flexibility, the FSS-500 microwave system is operated independently of the lower-frequency system. One module in the system is the microwave receiver, model EMC-50, which covers 1 to 12.4 GHz and can provide optional coverage to 18.0 GHz. The EMC-50 receiver can be operated separately from the FSS-500 system. When calibrated measurement is required, the EMC-50 is operated with the other components in the system. Price of the system is about $45,000.

Penril Corp. Electro-Metrics Division, 5520 Randolph Rd., Rockville, Maryland 20852 [403]

Noise sources offered in millimeter range

Noise sources, available in nine waveguide sizes, cover the range from 18 to 170 gigahertz. Low VSWR is obtained by using a 7° insertion angle for the alumina ceramic noise

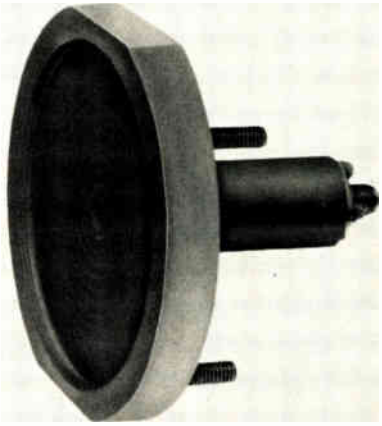


tube and by using a higher-than-normal pressure of argon gas along with a Kr85 additive. The models WR15, WR19, WR28, and WR42 have noise tubes that are replaceable in the field, and test data indicates that actual measurement values will be below a maximum cold VSWR of 1.30 and a maximum hot VSWR of 1.20. Pricing is in the $1,000 range, depending on the frequency specified.

Signalite, 1933 Heck Ave. Neptune, N.J. [405]

Spiral antenna operates from 2 to 8 gigahertz

The model ASO-1498A cavity-backed spiral antenna operates within the range of 2 to 8 gigahertz. The unit is designed to improve normally encountered low-end gain by 3 decibels at 2 GHz in a restricted-size envelope for applications in sur-



veillance and reconnaissance. Typical characteristics include a VSWR of 2:1, gain of 5 dB ±2 dB, and a beamwidth of 70°.

American Electronic Laboratories Inc., MS/1123, P.O. Box 552, Lansdale, Pa. 19446 [407]

Signal-source frequency is stable to ±5 ppm

Low-noise microwave signal sources covering from 1 gigahertz to 12.6 GHz in both free-running and crys-

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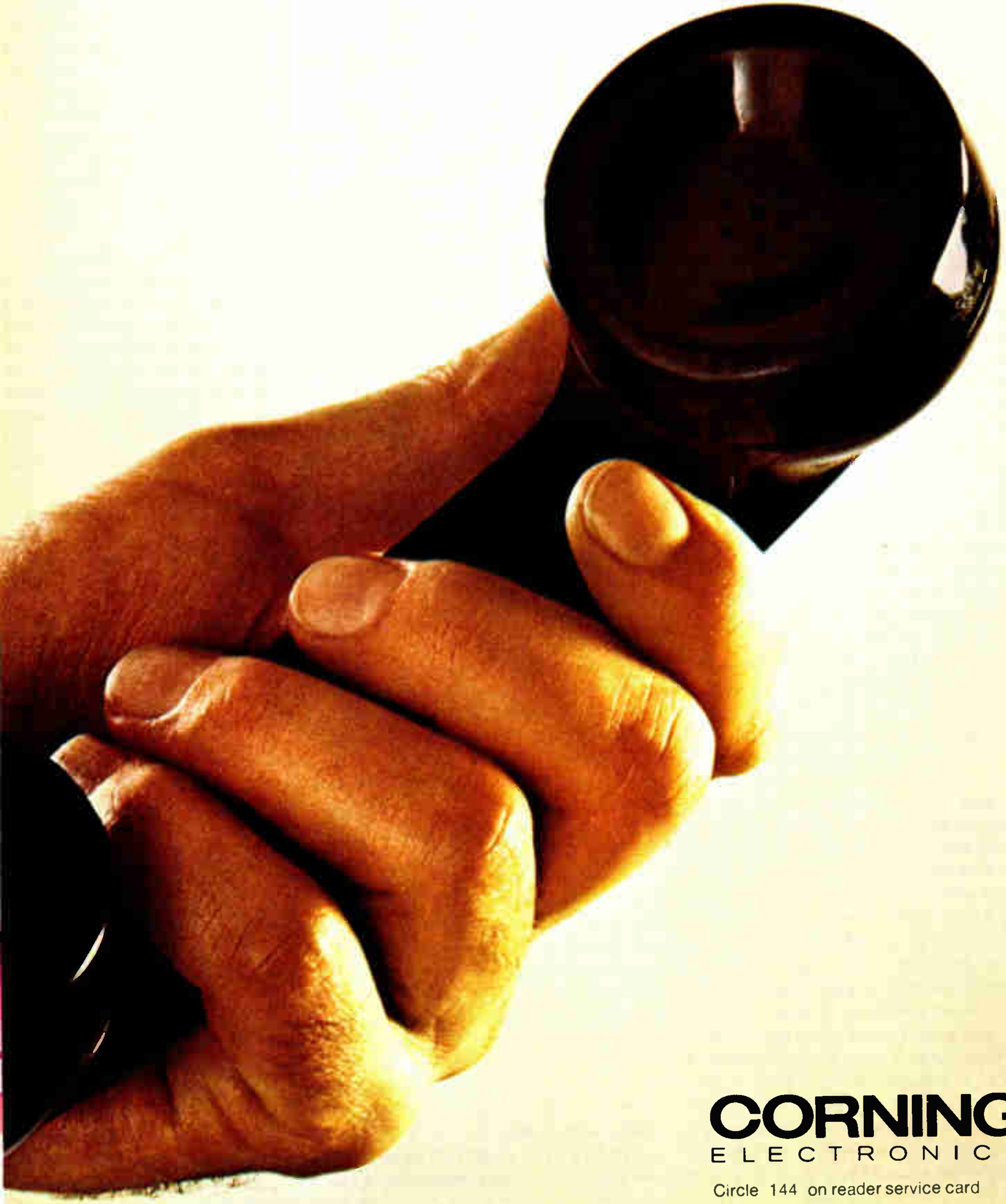
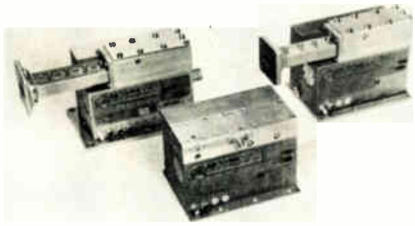


CORNING
ELECTRONICS

Circle 144 on reader service card

tal-controlled models are designated the 28450 series. Frequencies are stable to ±5 ppm in the standard package, which, as an option, can be operated from an external frequency standard. Typical applications include transmitter-exciters, frequency references for doppler radars, stable local oscillators for receivers in communications systems, and reference standards for laboratory experiments. Stability ranges from ±0.5% for free-running oscillators to ±.0005% for phase-locked sources with ovens. Power levels of 10 milliwatts, 50 MW and 250 MW

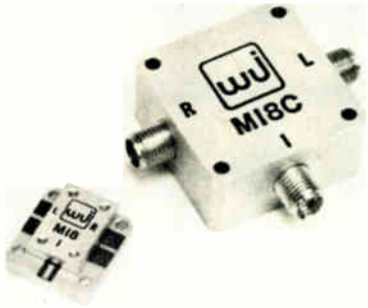


are standard. All units come in a 22-cubic-inch package, which is compatible with point-to-point communications equipment.

Micromega, 12575 Beatrice St., Los Angeles, Calif. 90066 [408]

Double-balanced mixers 'drop into' IC assembly

Because of miniaturization in the microwave industry, it is necessary to eliminate connectors and semirigid cable. Thus, a line of miniature "drop-in" double-balanced mixers, designated WJ-M15, -M16, -M17, and -M18 has been developed for direct integration into IC assemblies. Gold-plated 50-ohm microstrip transmission lines are provided at all three ports for integration with microwave IC amplifiers, hybrids, filters and circulators. Interconnection between modules is accomplished with gold ribbon. These models are also supplied in a hermetic SMA connector housing for breadboarding with semirigid cables which can then be removed for incorporation directly into an MIC or strip-line subassembly. Noise fig-



ures of typically 5.5 dB are available up to 13 GHz, and 7.5 dB at 18 GHz. Price ranges from $250 to $575.

Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. 94304 [406]

Signal sources deliver 5, 10, or 50 milliwatts

A series of free-running and phase-locked microwave-signal sources, which provides a minimum of 5, 10, or 50 milliwatts of output power over broad tuning ranges, also provides low residual fm noise—typically less than 16 Hz rms—in a 3-kilohertz bandwidth. Free-running models feature single-screw tuning and offer both afc/fm and phase-lock options. Twenty-one models of free-running and crystal-controlled sources provide output frequencies ranging from 3.60 to 8.50 gigahertz.

Frequency West, 3140 Alfred St., Santa Clara, Calif. 95050 [409]

Coax power dividers cover up to 18 GHz

The model 2532 coaxial power divider covers from dc to 12.4 gigahertz, and the model 2533 covers from dc to 18.0 GHz. Both devices, which are 6-dB resistive power dividers, exhibit good tracking across their frequency ranges (typically better than 0.25 dB). The maximum VSWR is 1.25:1 from dc to 10 GHz and less than 1.35:1 from 10 to 18 GHz. The model 2532 is priced at $142, and the 2533 is $165.

Midwest Microwave, 3800 Packard Rd., Ann Arbor, Mich. 48104 [410]

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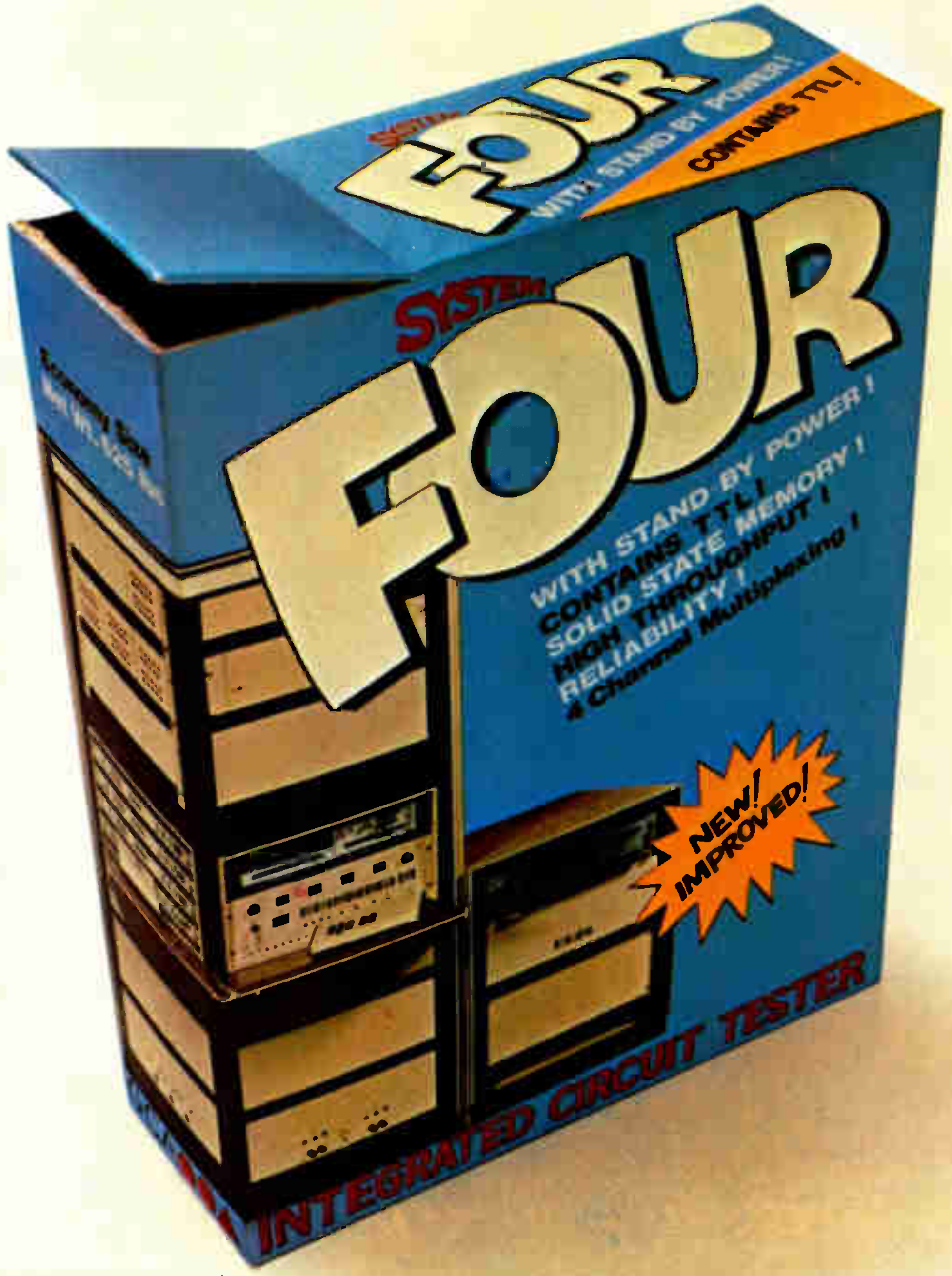


Circle 146 on reader service card

Semiconductor

Third calculator chip adds power

Array lets scientific unit compute complex functions in a few keystrokes

Solving advanced mathematical, statistical, or scientific problems becomes elementary with any hand-held scientific calculator designed around a new three-chip set from MOS Technology Inc. Basic calculating features plus a 14-digit display are handled by two chips, while the third extends the computational power of the system to include advanced functions.

Designated the Senior Scientist, the set operates in conjunction with a 40-key keyboard. On these keys, factorials, binomial coefficients, probability integrals and other advanced functions are represented in the "upper-case" position, actuated by a shift key.

All three chips are involved in handling series expansions, vector manipulation, permutations and combinations, coordinate conversions, complicated statistical equations, and complex mathematical problems in general. But the first two chips of the Senior Scientist may also be used alone to provide a basic 40-key scientific calculator.

This unusual option is provided by a system architecture common to all scientific-calculator array sets from MOS Technology: the master array of the system is programed to recognize the presence or absence of the third chip, and no electrical change is required to change the functional level.

Included within the three chips of the set are 12 data memories and 2,560 words of program storage. The memories are allocated in such a way that three are directly usable by the operator with separate store/recall keys. An additional four memories are internally accessed for storage of statistical group data, prior result data, and prior parentheses data. The remaining five are used by the system as working registers.

A minimum number of external components is required for integration of the set into finished calculator designs, the company says, and power dissipation is kept at minimum levels, less than 300 milliwatts average.

Price of the set is $50 in quantities of 100,000.

MOS Technology Inc., Valley Forge Corporate Center, 950 Rittenhouse Rd., Norristown, Penn. 19401 [411]

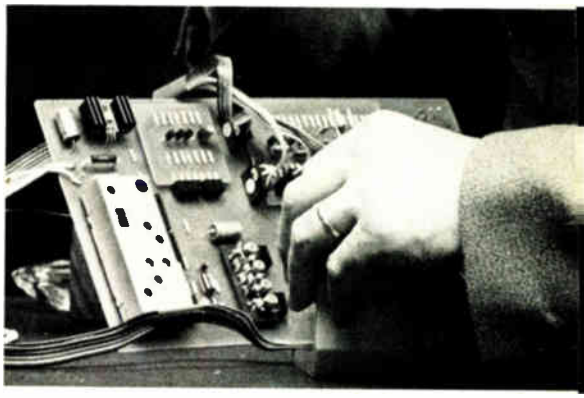
Philips launches 10 ICs for radio/audio functions

Though widely used in television sets, integrated circuits turn up in radio and audio equipment only sporadically. The limited number of rather simple active functions in such equipment could be handled quite economically with discrete components—at least, before consumers began clamoring for better sound reproduction in high-fidelity equipment, for quadraphonic systems, and for car radios with fm stereo, cassette player capability and easier control. Since all of this demands more circuitry, manufacturers see a need to extend the boundaries of integration.

One company responding to this need is Philips Gloeilampenfabrieken in the Netherlands. Together with 16 ICs for television applications [*Electronics International,* June 27, p. 9E], the Dutch electronics firm is launching 10 devices for the radio and audio sector.

Aimed at world markets, "our new range handles functions that haven't been integrated before," says Ted Van Moorsel, product manager for linear ICs at Philips' Eindhoven-based electronic components and materials division.

In addition to economic advantages, the new devices offer better equipment performance, Van Moorsel says. In hi-fi systems, for example (see photo), the circuits allow electronic pre-selection and search



tuning as well as AGC muting and improved stability. Volume production of the 10 ICs will start next year.

One device that should do well on U.S. markets is an 8-watt power amplifier, the TDA1004. Developed primarily for car radios, but also for use in record players, the TDA1004 consists of a preamplifier and a power amplifier, both stabilized against temperature drift and supply-voltage variations up to 18 volts.

Another is the TDA1001, also for car radios where it provides interference suppression in the audio stages of four mono or stereo channels.

For use in record/playback systems there are the TDA1002 and TDA1003, the former incorporating all amplifier circuits (except for the playback power output stage) needed in such systems, and the latter comprising a capstan motor speed control, a stop circuit, and an automatic bias/erase oscillator.

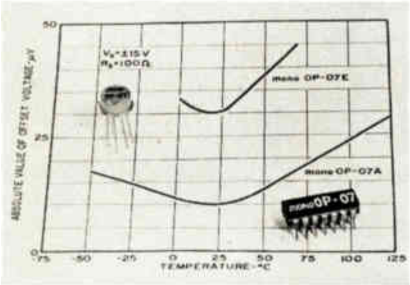
Philips Gloeilampenfabrieken N.V., Elcoma Division, P.O. Box 523, Eindhoven, The Netherlands [412]

Monolithic op amp challenges choppers

The mono OP-07, a monolithic operational amplifier, which has a bipolar-input, is designed to replace chopper amplifiers in microvolt and high-stability applications. An on-chip trimming technique reduces the cost of providing this level of performance, including input offset voltages of 10 microvolts, offset drift vs temperature of 0.2μV/°C, and

New products

long-term offset drift averages of 0.2 μV per month. The bipolar input circuit provides a high-impedance, fully differential input with a common-mode input-voltage range of ±14.0 V and common-mode rejection ratio of 126 dB. Applications for the mono OP-07 ultra-stable op



amps include precision buffers, thermocouple and strain-gage amplifiers, precision integrators and comparators, low-noise audio and medical amplifiers, and output amplifiers in high-resolution digital-to-analog converters. Price starts at $9.95.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050 [413]

Isoplanar FIFO memory offers 1.5-MHz data rate

A 40-word-by-9-bit first-in, first-out memory, the 3351, is the second MOS product made by Fairchild's Isoplanar technique. The circuit offers a low-cost solution to many problems associated with interfacing digital systems that have different data rates. Typically, the FIFO memory serves as an input or output buffer between a keyboard and a central-processing unit or between a CPU and a printer. Information can be entered into the FIFO at keyboard speed, saving computer time. Similarly, data can be fed from the CPU to the FIFO at computer speed and then transferred to a printer at the slower print-out speed. The model 3351 operates at data rates from dc to 1.5 MHz, has independent asynchronous inputs and outputs, and is compatible with TTL circuitry. It also can be expanded in width or length to accommodate other data formats. Price is $15.60 each in lots of 100.

MOS Products Division, Fairchild Camera & Instrument Corp., 464 Ellis Street, Mountain View, Calif. 94042 [415]

Bus drivers operate in 4 nanoseconds

Four current-mode bus drivers, forming a single integrated circuit, operate in 4 nanoseconds. Inputs of the model 10192 are compatible with all other devices in the ECL 10,000 series. Outputs are 16-milliampere, open-collector, switched-current sources. The complementary outputs can be switched to one of three logic states—"11," "01," and "10"—which provides the user with party-line capability in differential and single-ended modes. The open-collector outputs can also accept voltages ranging from +5.5 V to −1.6 V, permitting the designer to use a variety of termination and level-translation approaches to solving interface problems. Price is $6.27 in lots of 100.

Signetics Corp., 811 East Arques Ave., Sunnyvale, Calif. 94086

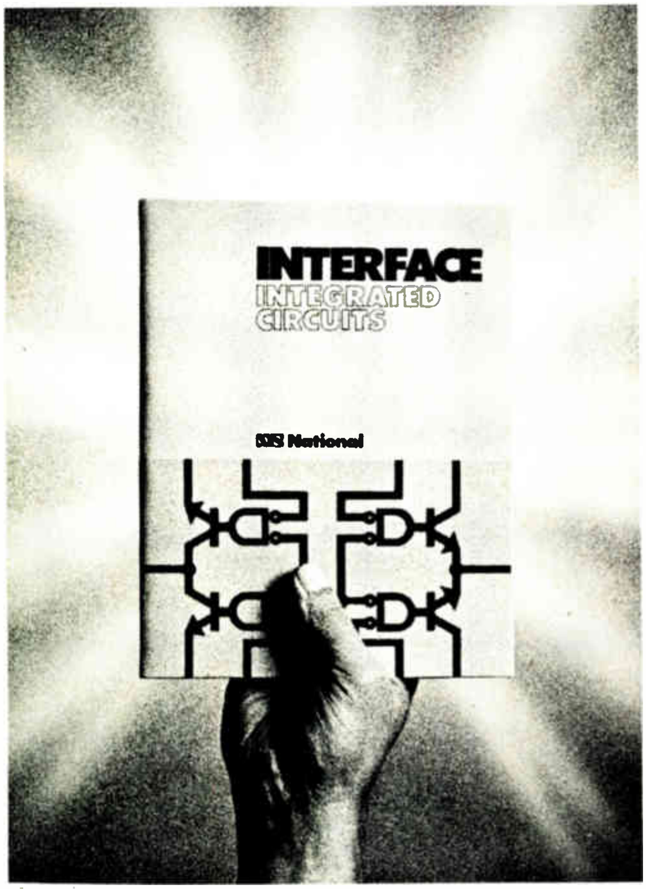
Darlington transistors handle up to 15 amperes

A family of 5-ampere, 10-A, and 15-A fast-switching industrial npn Darlington power transistors is packaged in steel-version TO-3 cases. The 5-A series is called the SDM 20301-04; the 10-A series, SDM 20311-14; and the 15-A series, the SDM 20321-24. All feature collector-emitter sustaining voltage from 40 to 100 volts, continuous collector current of 10 A, peak of 20 A, and thermal resistance from 1.75°C per watt. The SDM 20301-04 and SDM 20311-14 have a minimum current gain (h_{FE}) of 1,000 at 10 A; and the SDM 20321-24, 750 at 15 A. The 5-A series is priced at $2 each in quantities of 100; the 10-A series, $2.12; and the 15-A series, $2.32.

Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404 [416]

TA DA!

No more going from this catalog to that for different types of interface devices.



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In addition to our industry-standard LM 111 we've got this new one with high impedance due to a FET input, which is unique in the comparator field. On a monolithic chip.

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Half the input offset voltage of any other comparator: 2mv. And truly compatible with CMOS because—alone among all comparators—it offers the same advantage that CMOS offers.

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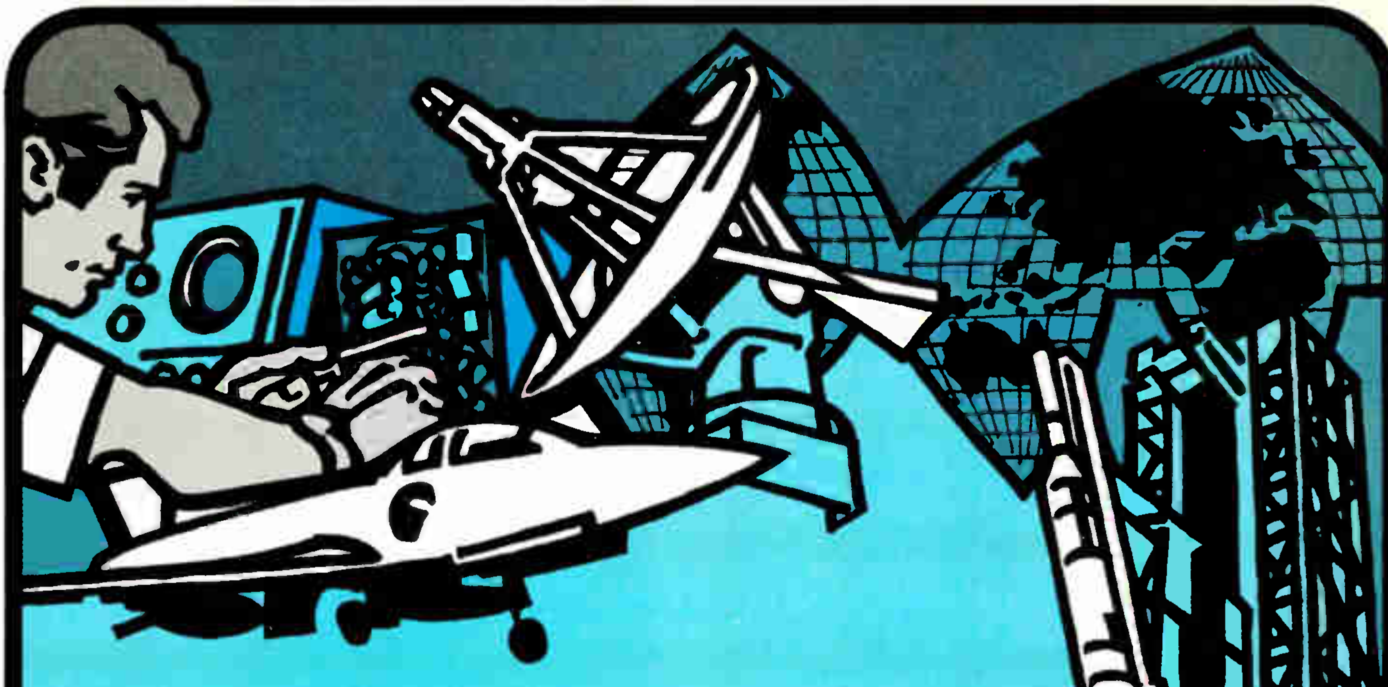
National Semiconductor Corp. 2900 Semiconductor Drive, Santa Clara, Calif 95051. Scottsdale, Ariz (602) 945-8473, Mountain View, Calif (415) 961-4740, Sherman Oaks, Calif (213) 783-8272, Tustin, Calif (714) 832-8113, Miami, Fla (305) 446-8309, Chicago, Ill (312) 693-2660, Indianapolis, Ind (317) 255-5822, Lenexa, Kan, (816) 358-8102, Glen Burnie, Md (301) 760-5220, Burlington, Mass (617) 273-1350; Farmington, Mich (313) 477-0400, Minneapolis, Minn (612) 888-4666; Englewood Cliffs, N.J. (201) 871-4410; Syracuse, N Y (315) 455-5858, Dayton, Ohio (513) 434-0097, Dallas, Tex (214) 233-6801



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Japan Space Program . . .

By 1976, the Japanese National Space Development Agency expects to launch a variety of communication and scientific satellites. EMR will supply both frequency and time division multiplex ground stations for use at several stages of the program: for experimenters to check out their scientific and communications packages; for functional tests of each stage of the rocket boosters; and for a complete checkout and monitoring system in the blockhouse at the launch site.

India Aircraft Flight Test Program . . .

The India Aeronautical Development Establishment is using an EMR ground telemetry Data Readout Station consisting of a quick-look, van-mounted, checkout system coupled with a large FM-PAM/PDM and PCM computerized telemetry system. Real-time flight testing of aircraft will be accomplished with this facility.

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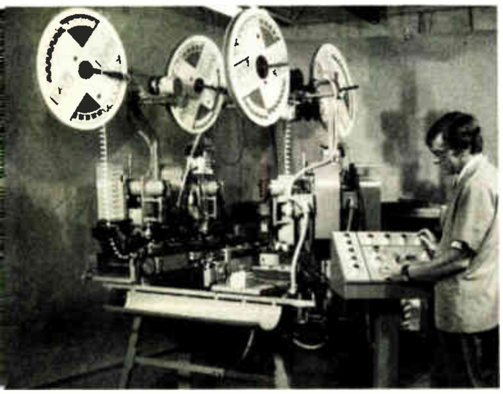
Packaging & production

Plug assembled, crimped to cable

Machine applies connector pin, ring and shell, then terminates ends of cable

Most push-on phono plugs used for radio, TV, and stereo are manufactured in several steps— some automated, some manual. But AMP Inc., Harrisburg, Pa., has developed a new three-piece connector for terminating coaxial cable that is designed to be assembled on an automated line that AMP is marketing.

Consisting of an outer shell and center pin of tin-plated steel, both supplied on reels, and a polyvinylchloride dielectric ring that can be hopper-fed, the AMP Coaxion phone



plug or connector is designed for use with RG-58 and RG-59 type coaxial cable. The connector shell and pins come in a variety of sizes. Insulation resistance between the pin and outer shell is at least 100 megohms; operating voltage is 350 volts rms; withdrawal force averages three pounds.

Two parallel series of applicator machines terminate each end of the cable in a three-step operation. Accepting cable cut to lengths down to 7½ inches, the system first strips cable jacket, braid, and dielectric for crimp termination, using a rotary coaxial wire stripper with preset blades. A pair of chain conveyors then carries each end of the stripped cable through the application of the connector's inner pin, insulator ring, and outer shell.

Although the inner pin is crimped onto the wire's center conductor, the crimp is behind the contact, providing for a smooth center plug. The phono plug's outer shell is crimped in the cable braid, around the rigid dielectric ring, using a "braid-pick" technique instead of the conventional pressure crimp. Four V-shaped lances on the outer shell's wire-barrel penetrate the braid, separating it from the cable dielectric, to provide a redundant electrical contact as well as additional mechanical strength.

Pricing depends on the number of connector components purchased and other factors.

AMP Inc., Harrisburg, Pa. 17105 [391]

Vertical etcher built for wafers and substrates

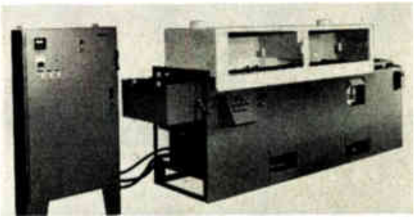
The model 1212 vertical etcher is designed for chemical machining to close tolerances and precision etching of circuit boards. The etcher is especially suited for the fine line and space resolutions required in the processing of semiconductor wafers and substrates. Its vertical, rotating work holder is synchronized with oscillating spray nozzles on each side, and either single-sided or double-sided work can be handled. The holder is adjustable to work from 2 by 2 inches up to 12 by 12 in., while etching periods are controlled by means of an automatic re-

set timer, which assures uniform etching over the entire surface, the company says.

Chemcut Corp., 500 Science Park, State College, Pa. 16801 [394]

Wave-soldering system processes 18 feet a minute

Designed to meet applicable operational and safety standards, a wave-soldering system is available



for board widths of 12, 15, 18, and 24 inches, with either pallet or finger conveyor. Both versions are inclinable from the horizontal to a maximum 8° angle, and individual stations can be customized to meet any production requirement. The standard system, which processes boards at a capacity of 18 feet per minute, includes foam-fluxing, preheating and wave-soldering with an integrated vent system. Sliding, heat-tempered glass panels on the front of the vent system permit observation and access. Price starts at $15,450.

Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N. Y. 10553 [393]

Connector links miniature devices by pressure alone

An elastomate micrometalized connector provides interconnection of microminiature devices by pressure alone. The connector, which eliminates large connector housings and associated hardware, is useful with liquid-crystal displays in electronic watches and in calculators where maximum packaging density is required. The connector consists of a nonconducting elastomeric core wrapped with parallel lines of gold-plated conductors on thin flexible

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More features.
For less money.

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With a 6 month basic DC accuracy of ±0.007% of reading ±0.001% of full scale ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 megohms resistance, 20% overranging, DC Ratio, isolated BCD output, remote triggering and remote ranging, it represents the most sophisticated lab-quality multimeter you can buy for less than $1000.

$995. complete

MODEL 3500 features the industry's most reliable, field proven circuit technology packaged behind a big, bright and easy-to-read ½ inch planar gaseous display. And none of the bugs of an unproven design.

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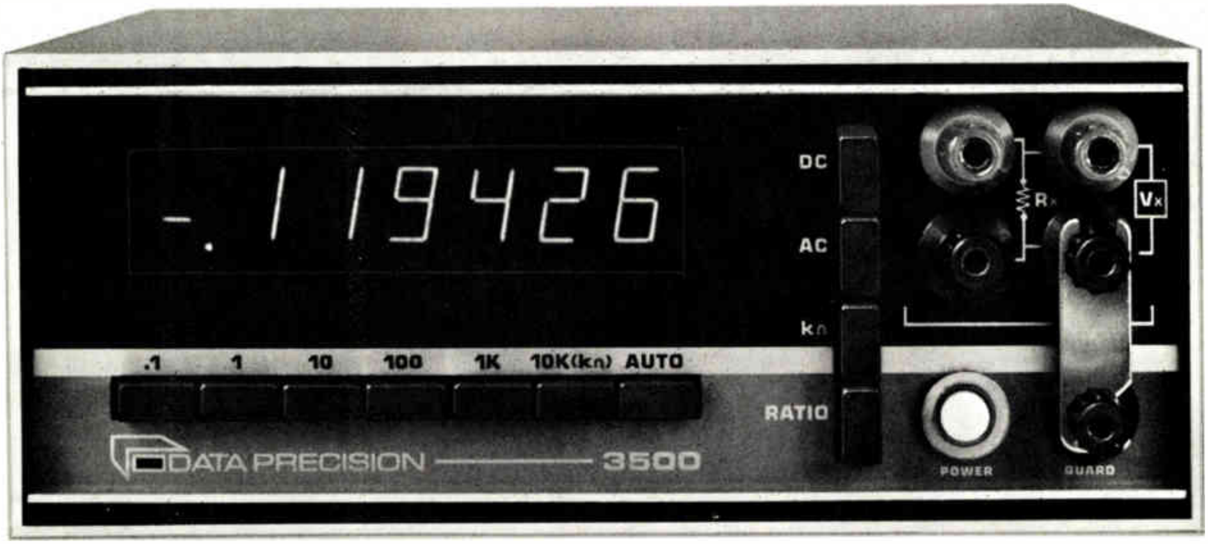


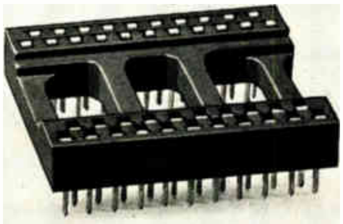
film. When compressed between two parallel planes, the metalized lines around the circumference interconnect the circuitry on each plane with assured contact redundancy. Standard connector conductors are 0.003-inch wide on 0.007-inch centers, but a variety of configurations is available.
AMP Inc., Harrisburg, Pa. 17105 [398]

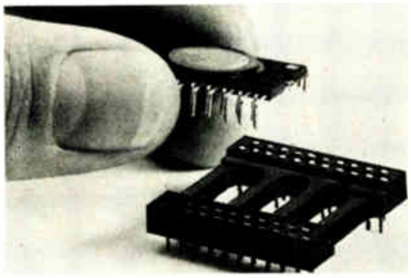
Drafting system eliminates registration problems

A new drafting system is designed to eliminate the major registration problems engineers and draftsmen encounter in preparing circuit diagrams for two-sided printed-circuit boards. The Nopan model drafting system has amber- and magenta-colored pressure-sensitive drafting tapes which, when used with Wratten filters, eliminate the need to use panchromatic film in the photographic reproduction of original printed-circuit diagrams. The system, instead, uses orthochromatic film, which is processed under normal red-light darkroom conditions instead of the complete darkness needed with panchromatic film for color separation of magenta and amber. Both magenta and amber negatives can be developed simultaneously in normal darkroom red light by standard developing procedures.
W. H. Brady Co., Computer and Drafting Products, 727 W. Glendale Ave., Milwaukee, Wis. 53201 [399]

42-pin socket staggers rows on 0.050-inch centers

A 42-pin socket, designed specially for flat-pack calculator chips, staggers four rows of pins on 0.050-inch centers. The sockets are furnished with tin-plated pins, and when required, gold-over-nickel plating can be provided. Pin material is a copper-alloy leaf spring. A low-profile, open-design insulator body reduces component height. Although developed for high-volume, commercial

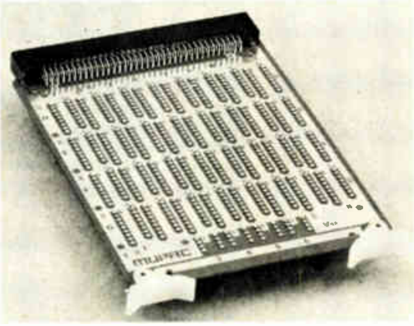




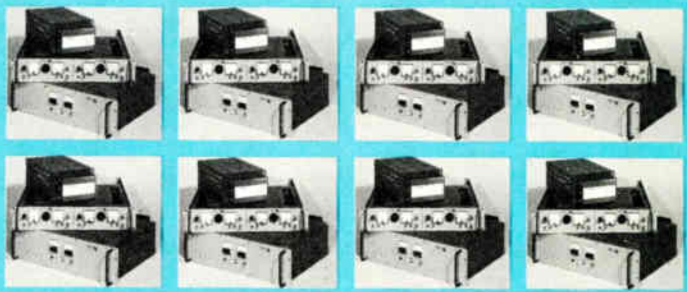
use, the socket can also be used for low-quantity experimental or research work.
Circuit Assembly Corp., 3169 Red Hill Ave., Costa Mesa, Calif. 92626 [397]

Wire-wrap panels built for three-voltage ICs

A family of wire-wrapping panels is designed for use with dual in-line integrated circuits that require two voltages and a ground, or three voltages. The panels are intended to aid the designer in the packaging of random-access memories, read-only memories, and other medium-scale and large-scale integrated digital and linear devices. A family of three voltage backplanes is also offered, along with 108-pin two-piece wire-wrap-to-wire-wrap connectors. The panels are priced at $61.50 each in quantities of 10.
Mupac Corp., 646 Summer St., Brockton, Mass. 02402 [400]



Whether you buy one's, two's... or multitudes–



North delivers power reliability!

MODEL	11000	12000	13000	14000	15000	16000	17000	18000
VDC	AMPERES							
5.0	3.9	5.3	11.3	13.0	20.0	32.5	49.0	82.0
12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.7	7.5	9.5	14.0	20.5	27.0	47.0
18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
36.0	1.2	2.2	3.1	5.6	8.0	11.0	14.0	23.0
48.0	.95	1.8	2.6	4.2	6.0	8.0	10.0	18.0

Listed here are the more popular models–many other voltages are available.

MODEL	10000
VDC	AMPS
0–7.5	2.10
0–16	1.25
0–25	0.85
0–33	0.68

DUAL OUTPUT SUPPLIES	
MODEL	N03052
VDC	AMPS
±15 12	400MA
MODEL	N60052
VDC	AMPS
±15 12	1.0A

Many O.E.M's agree that it just doesn't make sense to risk the reputation of a major piece of equipment over a minor component–especially, when the cost difference is so little.

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SP-16

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$349

Who else but FLUKE could bring you this new multi-counter at such an attractive price? A multi-counter that measures frequency or period — and totalizes too. Model 1900A from Fluke "The Counter House" has a dynamic range of 5 Hz to 80 MHz . . . advanced LSI/MOS circuitry . . . autoranging . . . and autoreset on all functions, gate times, filter and attenuator. And of course the 1900A incorporates all the traditional Fluke quality, and comes with a full 12-month guarantee plus a 15-day money-back policy.

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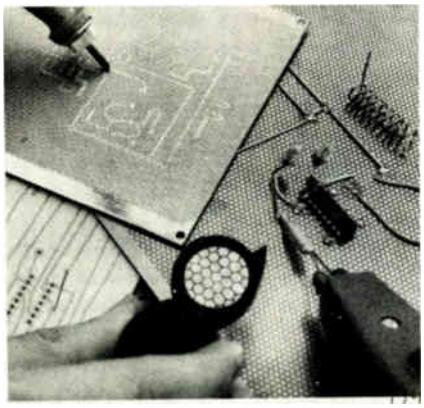


A nonconducting metal sheet, for pc applications, allows circuits to be drawn or scribed directly onto the metal sheet. Pressure is all that is necessary, and circuits may be erased for new designs. For mass production, a letter press may be used. A more economical version for direct-wiring purposes, rather than printed circuitry, is available. Spot-soldering may be done at random without spoiling adjacent areas of the board, since the sheet is nonconducting.

Metal Circuit Systems Corp., P.O. Drawer 2226, Houston, Texas 77001 [476]

An inexpensive package lid for semiconductors, made from an alloy of readily available metals and called Foballoy, takes the place of gold/tin preforms. Generally, clad lids are made of Kovar or Alloy 42, but the new lid is clad with a thin layer of Foballoy, which has a melting point of 235°C and therefore seals at a lower temperature than gold/tin. At current gold prices, Foballoy can provide a saving of $40 per thousand lids over gold/tin, the company says.

Plessey Inc., Materials Division, Melville, N.Y. [478]

A family of optical coatings, offered in thicknesses of 100 to 3,000 Å, is available on a broad line of fiber-optic face-plates. The coatings, which have applications in a variety of electro-optical systems, are available in many materials, including nickel, tin, chrome, inconel, gold, quartz, and magnesium fluoride.

Galileo Electro-Optics Corp., Galileo Park, Sturbridge, Mass. 01518 [480]

New literature

Dc-to-ac inverters. ATR Electronics Inc., 300 E. Fourth St., St. Paul, Minn. 55101, has issued a catalog covering dc-to-ac inverters in solid-state and vibrator models, as well as battery eliminators, Shav-paks, vibrators, and standby-power systems for emergency lighting and power. Circle 421 on reader service card.

Load cells. Sensotec Inc., 1400 Holly Ave., Columbus, Ohio 43212, is offering an eight-page catalog featuring eight series of strain-gage load cells. Technical descriptions and applications are provided. [422]

Pc-board cleaning. A brochure on Scotch Brite products for cleaning printed-circuit boards is available from the 3M Co., Box 33600, St. Paul, Minn. 55133. Information on cleaning brushes and deburring wheels for pc boards is given, along with information on finishing flap brushes for pc-board finger-cleaning. [423]

Product catalog. A short-form catalog summarizes the specifications, applications, and physical characteristics of products manufactured by Analogic Corp., Audubon Rd., Wakefield, Mass. 01880. These include analog-to digital and digital-to-analog converters, digital panel instruments, and industrial digiizing equipment. Additions to the lines are also discussed, and these include high-speed and low-price converters. [424]

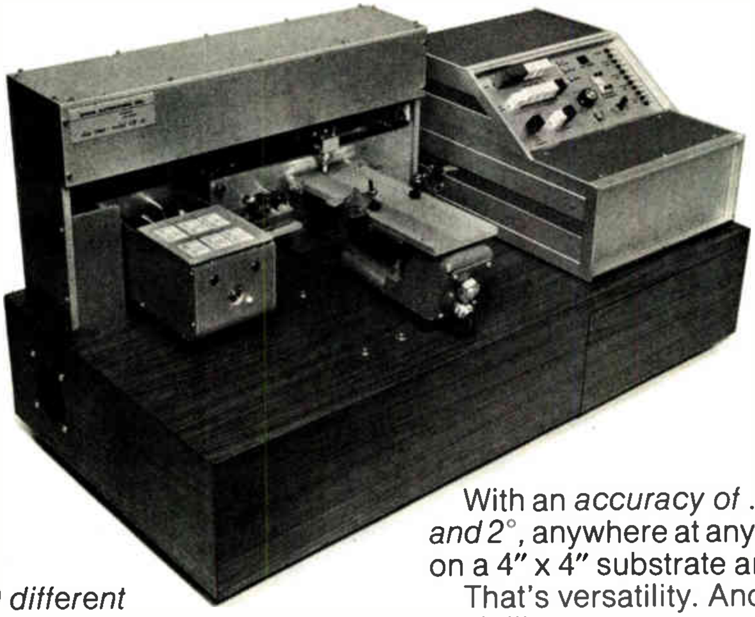
Optoelectronic components. Monsanto Commercial Products Co., 3400 Hillview Ave., Palo Alto, Calif. 94304. A short-form catalog describes the company's line of LED displays, discrete indicators, opto-isolators, and solid-state relays. [425]

Programable controllers. FX Systems Corp., Mt. Marion Rd., Saugerties, N.Y. 12477, has issued a four-page brochure that describes the MC-16 programable controller, which is especially designed for small machines or short processes requiring only a limited number of control inputs and outputs. [426]

Solving a major problem in hybrid circuit chip assembly...

The DIXON Robot.©

It solder-dips and places 800 chips per hour!



Our Model CR-10 Chip Assembly Robot... a precision machine that automatically places and solder-dips chip capacitors, IC's and resistors onto one or more substrates.

It can handle *mixed sizes* of square or rectangular chips from .080″ to .500″ in the same set-up. Up to *30 different chips per substrate.*

At a rate of 800 an hour... placing a metered amount of solder paste or epoxy on both ends of the chip. Or 1400 an hour if solder-dipping isn't required.

With an *accuracy of .002″ and 2°*, anywhere at any angle, on a 4″ x 4″ substrate area.

That's versatility. And flexibility.

Programming is a simple "walk-thru"... up to 60 chips placed per program. Programs can be permanently stored on a cassette for retrieval and later use.

The Robot does the work of many assemblers and with consistent quality. Without fatigue and coffee-breaks.

That's economy. And efficiency.

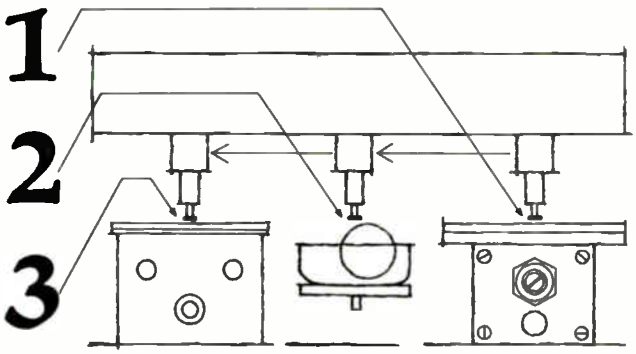
For more details and/or a demonstration of the Chip Assembly Robot, call Ken Dixon at (213) 325-0410. Or write him at the address below.

How the simple, versatile Robot works.

1 Vacuum chuck picks up chip capacitor from vibratory feeder.

2 Chip capacitor is solder-dipped on both ends. Solder amount can be precisely metered.

3 Placement is accurate to .002″ & 2° on 4″ x 4″ area. At the rate of 800 or 1400 an hour.



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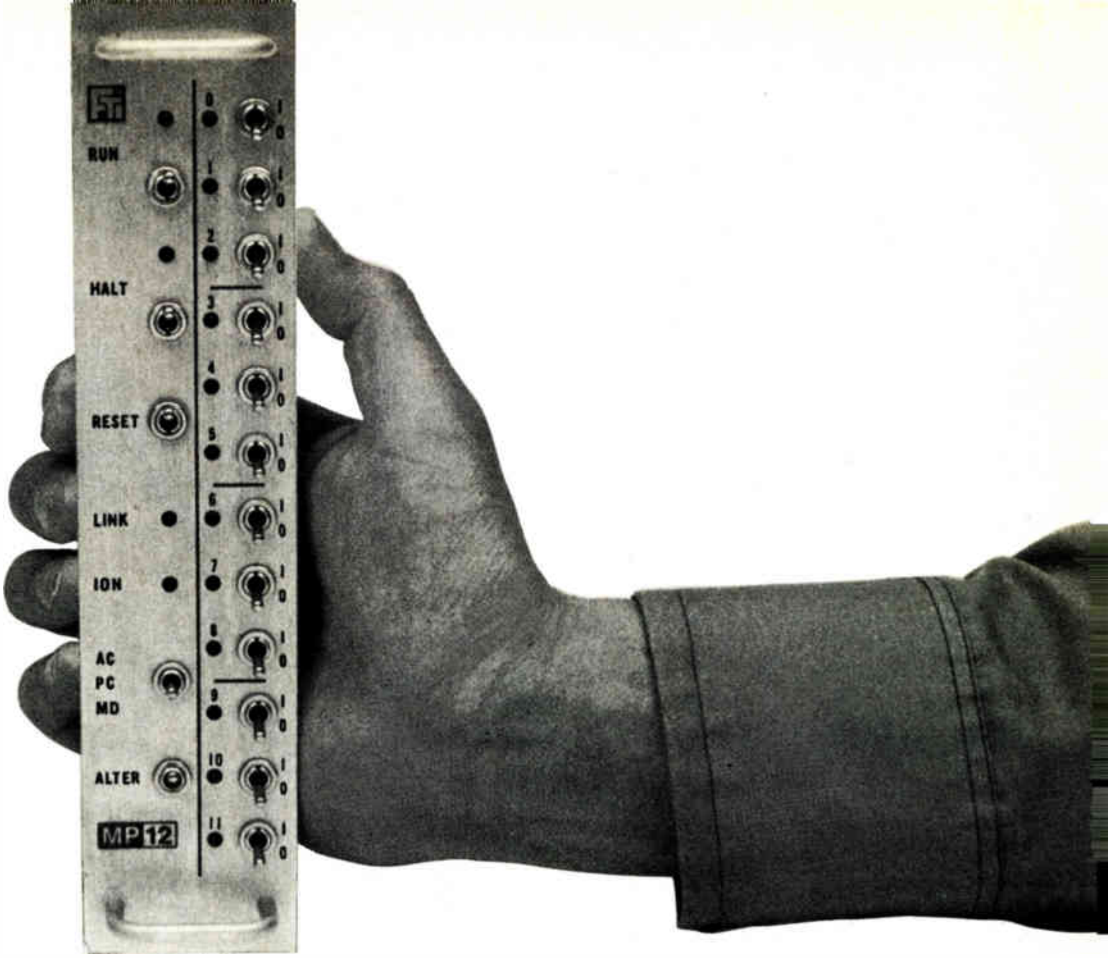

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It's the MP12 . . . Fabri-Tek's new microprocessor that performs like a minicomputer. The MP12 helps you get your application system up and running faster, easier and with more capability than ever before. No MOS microprocessor can match its performance in data acquisition, automated assembly, point-of-sale and other dedicated digital control applications.

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Easy Interfacing—You never had a processor so easy to interface. In fact, it's plug-in easy. The MP12 comes with all the timing and control necessary to interface with almost any peripheral. And it has enough power to drive up to 64 peripherals . . . printers, teletypes, CRT's, card equipment, on and off-line storage devices.

Quick Delivery, Low Price—There's a lot more you'll like about Fabri-Tek's MP12. Delivery and price, for instance. It's available for off-the-shelf delivery for as little as $990 in quantities of 100. It can actually help you cut your overall manufacturing costs.

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Electronics advertisers

July 25, 1974

Classified & Employment Advertising

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Advertising Sales Staff

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London 01-493-1451
Director of Marketing

Atlanta, Ga. 30309: Joseph Lane
100 Colony Square, 1175 Peachtree St., N.E.
[404] 892-2868

Boston, Mass. 02116: James R. Pierce
607 Boylston St. [617] 262-1160

Chicago, Ill. 60611:
645 North Michigan Avenue
Robert W. Bartlett (312) 751-3739
Paul W. Reiss (312) 751-3738

Cleveland, Ohio 44113: William J. Boyle
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Dallas, Texas 75201: Charles G. Hubbard
2001 Bryant Tower, Suite 1070
[214] 742-1747

Denver, Colo. 80202: Harry B. Doyle, Jr.
Tower Bldg., 1700 Broadway
[303] 266-3863

Detroit, Michigan 48202: Robert W. Bartlett
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Tel: 32-35-63

United Kingdom & Scandinavia: Keith Mantle
Tel: 01-493-1451, 34 Dover Street, London W1

Milan: Robert Saidel
1 via Baracchini, Italy Phone 87-90-656

Brussels: Alain Offergeld
23 Chaussee de Wavre
Brussels 1040, Belgium
Tel: 13-73-95

Frankfurt/Main: Fritz Krusebecker
Liebigstrasse 27c, Germany
Phone 72 01 81

Tokyo: Tatsumi Katagiri, McGraw-Hill Publications Overseas Corporation, Kasumigaseki Building 2-5, 3-chome, Kasumigaseki, Chiyoda-Ku, Tokyo, Japan
[581] 9811

Osaka: Ryji Kobayashi, McGraw-Hill Publications Overseas Corporation, Kondo Bldg., 163, Umegae-cho Kita-ku, Japan [362] 8771

Australasia: Warren E. Ball, IPO Box 5106, Tokyo, Japan

Business Department

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[212] 997-2044

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Electronics Buyers' Guide

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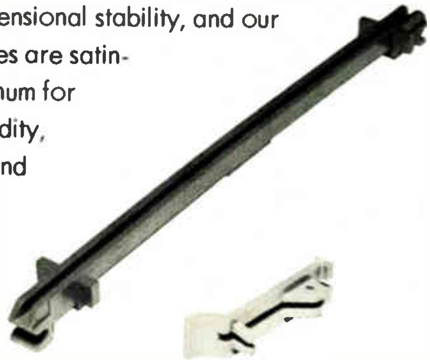
Card-Pak is our new card filing system that comes to you in four parts that takes (in most cases) just eight screws to put together. And we supply the screws.

The four parts are dimensioned to your order exactly, for card height, depth, spacing, and total number. Right from stock.

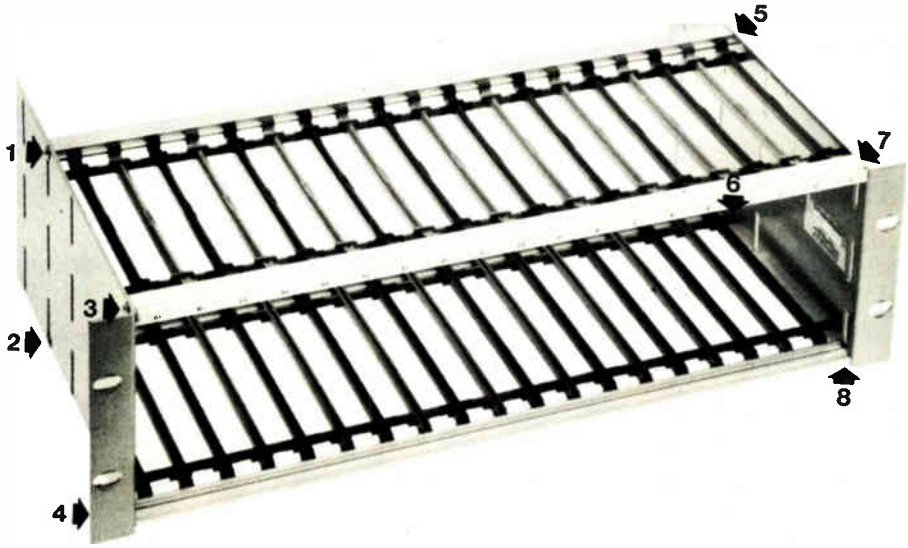
If you want to get fancy, we can give you double-tiered Card-Paks, single-double combos, card identification strips and markers, connector supports, and card handles and ejectors. All from stock.

Our card guides are made of Noryl, not nylon, for dimensional stability, and our metal structures are satin-finished aluminum for durability, rigidity, light weight, and beauty.



Card-Pak is a choice, not an echo. And we'll gladly send you our catalog. Or telephone (toll free) any G. S. Marshall Co. office nationwide.

Card-Pak. From EECO.



Eight screws and you've got it all together.

CARD-PAK from EECO

1441 East Chestnut Avenue
Santa Ana, California 92701
Phone 714/835-6000
Also from G. S. Marshall Company nationwide.

FREE CARD-PAK CATALOG

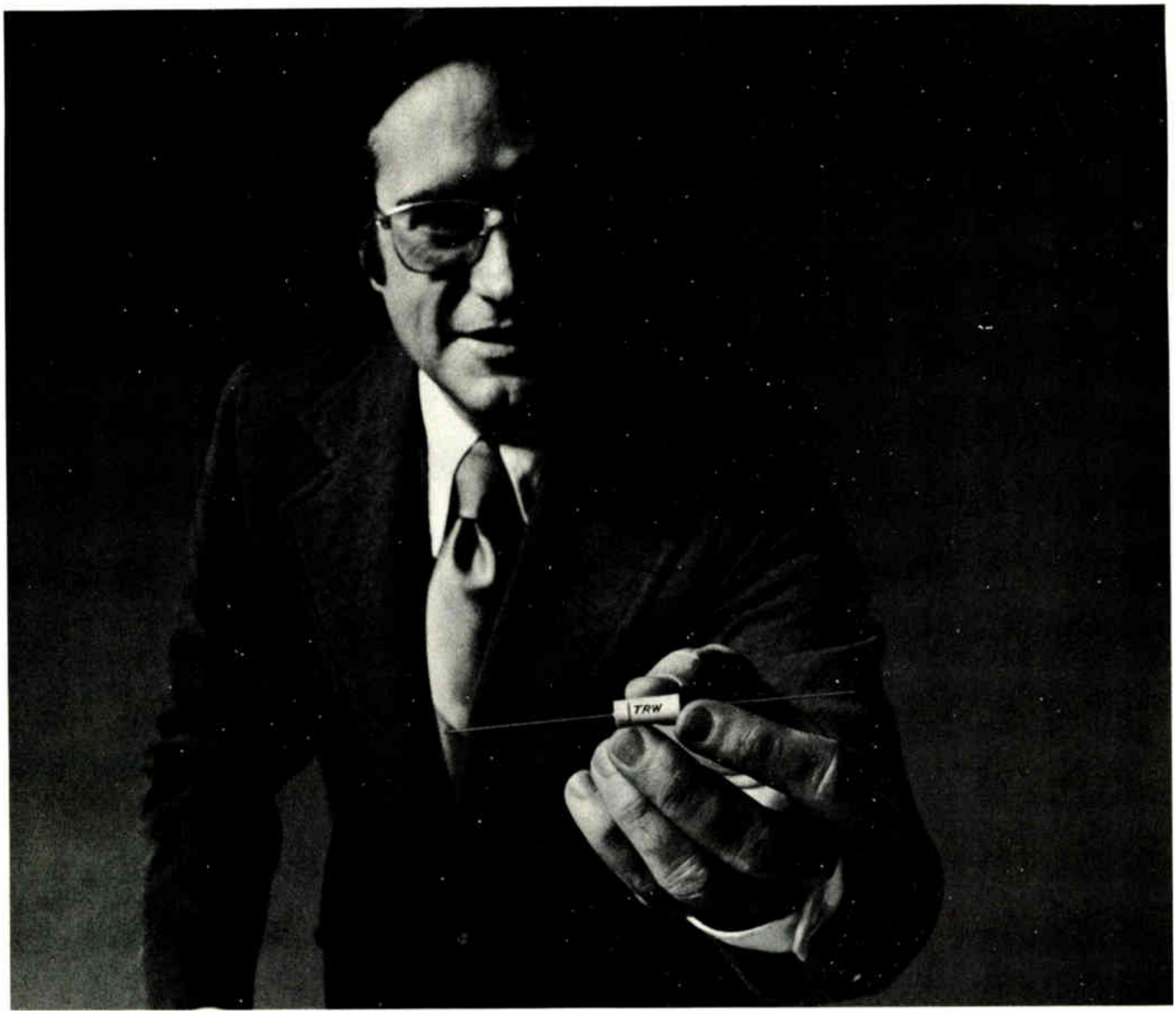
We'll send it to you if you'll send us the information below.

Name ____________________

Position ____________________

Company ____________________

Address ____________________



Tell you what we're <u>not</u> going to do.

Sure, we know *how* to make cheaper capacitors. But not with "TRW" stamped on them. No way. Because we figure you can't make quality capacitors and me-too capacitors under the same roof. Not without one operation eventually goofing the other one up.

So if it's marked "TRW," you *know* you're getting the top technology in wound—both metallized and film foil—and solid tantalum capacitors.

You're also getting a pipeline to some of the best minds in capacitor R&D, design, QC, and application engineering—ready to help you with *any* capacitance problem. From TV to aerospace.

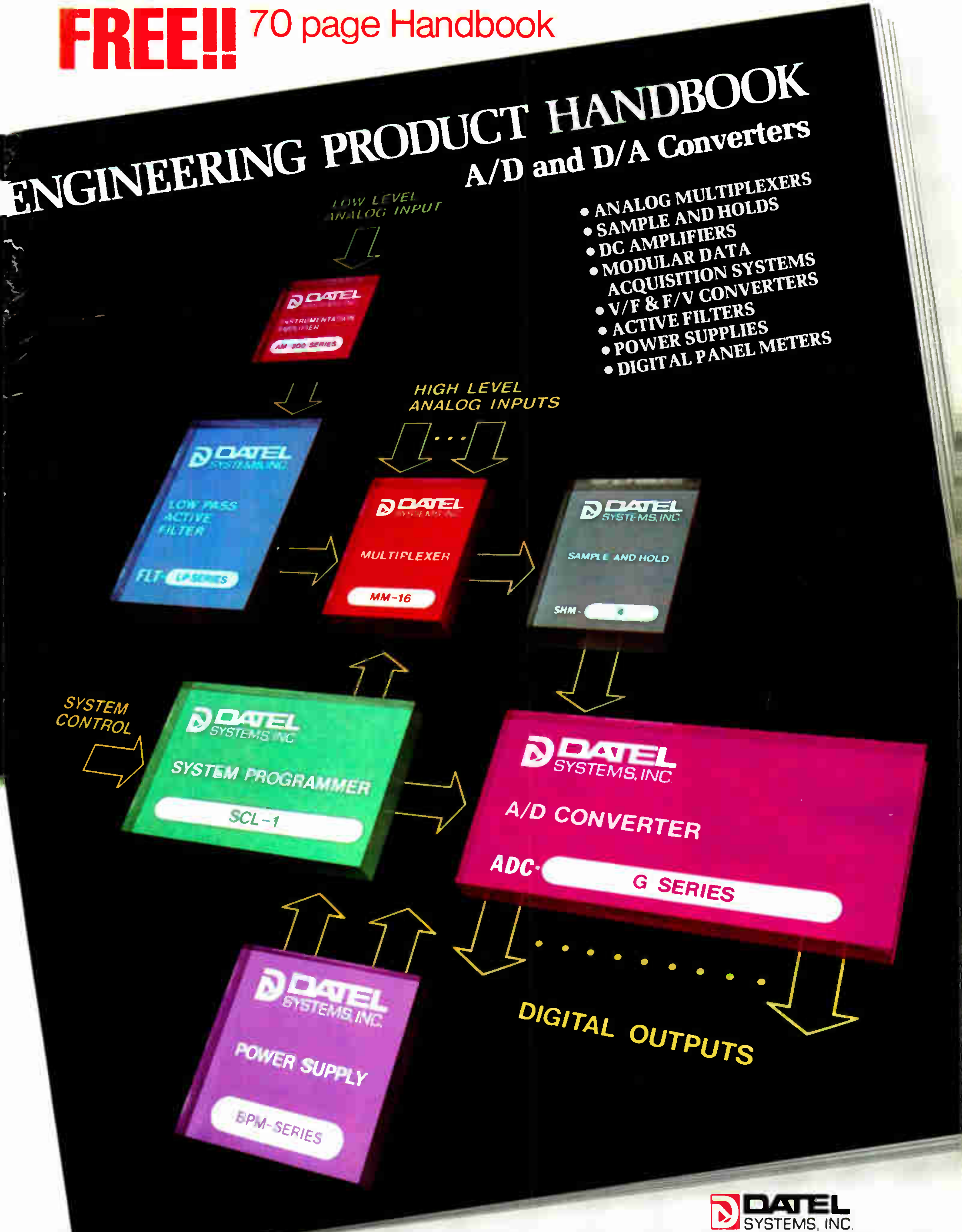
All this will cost you a little more per capacitor. In return, it can help *your* product earn a reputation for "no headaches, no surprises." What better edge in today's marketplace?

TRW Capacitors, an Electronic Components Division of TRW, Inc., Box 1000, Ogallala, Nebraska 69153.

THE WORLD'S BIGGEST "LITTLE BLACK BOX"
TRW
IS COMING YOUR WAY.

TRW® CAPACITORS

FREE!! 70 page Handbook



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DATEL SYSTEMS, INC.
1020 Turnpike Street, Canton, Ma 02021
• TEL. (617) 828-8000
• TELEX 924461 • TWX 710-348-0135

Circle 901 on reader service card

How to cut the cost of special resistors

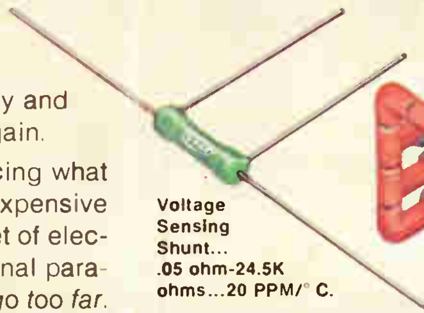
(even if you don't know what you want)

Project costs don't have to escalate when you find you can't use a standard resistor. There are positive ways you can save money and time—and even come out ahead in the bargain.

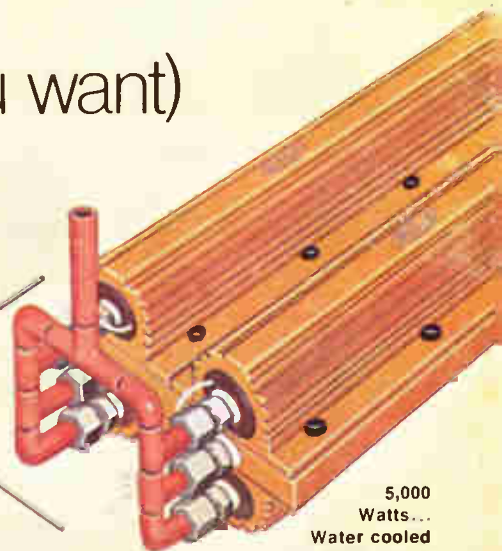
You can start cutting project costs by reducing what we call "visualization loss". This is the expensive extra time required to figure out an exact set of electrical, physical, environmental and dimensional parameters for the special part you need. *Don't go too far.* Especially don't wait until you're completely bogged down before you ask Dale for help. In electrical terms, we've long since figured out practical ways to deliver resistance as low as .001 ohm... tolerance as low as .01%...TC as low as ±5 ppm and power just as high and as stable as you want it to be. And we can put your non-standard electrical parameters in unique packages that are one part sophistication and one part midwestern ingenuity. Every day we're showing companies how they can bend, squeeze, mill, tap, bury and interconnect resistors for special purposes. We even put in plumbing, when required.

Your non-standard resistor may only need a different kind of lead or it may look like a Rube Goldberg nightmare. Either way, you'll find Dale is unique among resistor suppliers in the ability to help you quickly visualize what you need...and to deliver a prototype with a minimum of design lag. We've already designed and built nearly 5,000 special resistors—so it's quite possible we've already blueprinted the design you need.

Call us. You'll be glad to find someone is working to make the basics better.



Voltage Sensing Shunt... .05 ohm-24.5K ohms...20 PPM/°C.

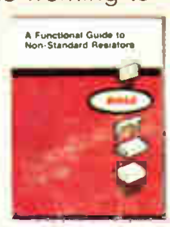


5,000 Watts... Water cooled .1 ohm-500K ohms, 0.5%-5% tol.

Space-saving P.C. board module containing 3 non-inductive resistors. (Far left)

◄ Network with 16 quick couple connections containing 12 resistors from .025 ohm 50 watts to .1 ohm 10 watts.

High Pulse Wattage ► railway safety resistor. Special housing for underground use.



Send for our free **Functional Guide to Non-Standard Resistors.**

DALE ELECTRONICS, INC.
1300 28th Avenue, Columbus, Nebraska 68601
A subsidiary of The Lionel Corporation
In Canada: Dale Electronics Canada Ltd.
In Europe: Dale Electronics GMBH, 8 Munchen 60, Falkweg 51, West Germany

DEPENDABLE DALE

Circle 902 on reader service card

European 1974 equipment markets

Factory prices in millions of dollars

Note: Estimates in this chart are based on market data supplied by some 180 companies, trade associations, and government agencies. The estimates are for equipment consumed in a country whether manufactured there or not. Imports are valued at cost-insurance-freight.

Participants were asked to value markets in local currency or to specify the exchange rate used for estimates in dollars. All estimates were first calculated in local currency, then converted into dollars at the exchange rates shown below. Because of the substantial changes in exchange rates over the past two years, estimates in this chart can be compared with those published in previous years only after correcting for currency changes.

The rates for this chart (per U.S. $1):

Belgium, 37 francs
Denmark, 5.7 crowns
Finland, 3.7 marks
France, 4.3 francs
Italy, 565 lire
Netherlands, 2.45 florins
Norway, 5.4 crowns
Spain, 57 pesetas
Sweden, 4.2 crowns
Switzerland, 3.05 francs
United Kingdom, 41 pence (£1 = $2.45)
West Germany, 2.45 marks

	Belgium		Denmark		Finland		France		Italy		Netherlands		Norway		Spain		Sweden		Switzerland		United Kingdom		West Germany		Total	
	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974
Consumer products, total	148.3	174.5	129.8	139.3	48.2	65.4	839.5	942.3	259.2	280.6	303.2	345.1	55.7	64.4	178.4	208.5	285.9	301.2	133.3	144.4	1,475.1	1,590.6	1,982.3	2,159.1	5,838.9	6,415.4
Audio tape recorders and players	7.8	8.1	15.8	17.4	7.5	9.0	94.2	113.5	21.1	23.0	22.4	23.3	5.2	5.7	14.9	18.0	20.2	21.4	13.8	15.0	110.3	137.8	122.4	124.5	455.6	516.7
Hi-fi equipment	14.9	15.9	21.4	23.5	6.0	9.0	68.6	81.4	7.2	7.9	30.6	35.5	7.4	8.3	4.4	5.4	35.7	42.8	11.5	13.8	36.8	49.0	127.3	159.2	371.8	451.7
Phonographs and radio-phone combinations	5.0	4.9	4.4	4.4	2.5	2.7	53.5	57.2	29.2	33.6	16.3	17.5	3.1	3.2	11.4	12.3	15.5	15.5	8.8	9.2	171.5	196.0	61.2	67.3	382.4	423.8
Radio (including car radios)	12.4	16.2	14.2	14.2	2.2	2.7	133.7	132.5	46.2	49.6	34.7	38.4	6.4	6.3	21.0	22.3	19.0	19.0	19.0	20.0	115.2	122.5	346.9	355.1	770.9	798.8
Radio recorders	4.1	5.1	2.1	2.4	–	–	26.7	29.8	8.8	9.0	4.1	4.7	1.2	1.4	4.0	4.9	3.8	4.3	3.9	4.4	41.7	56.3	89.8	100.0	190.2	222.3
TV sets, black-and-white	20.3	18.9	10.5	8.8	8.0	7.0	160.5	155.8	144.8	154.9	31.8	29.8	6.5	5.8	121.1	122.8	15.5	14.0	12.4	11.5	142.1	122.5	310.2	291.8	983.7	943.6
TV sets, color	83.8	105.4	61.4	68.6	22.0	35.0	302.3	372.1	1.9	2.6	163.3	195.9	25.9	33.7	1.6	22.8	176.2	184.2	63.9	70.5	857.5	906.5	924.5	1,061.2	2,684.3	3,058.5
Computers and related equipment,[1] total	135.2	152.3	78.8	92.4	46.9	61.1	964.7	1,122.5	451.3	539.6	212.8	262.4	54.3	62.0	199.1	263.3	138.4	174.8	155.1	175.7	612.2	715.2	1,847.0	2,045.9	4,895.8	5,667.2
Digital computers, central processors	63.8	70.2	41.2	47.4	23.0	30.0	488.3	551.2	238.9	286.7	114.3	134.7	33.3	37.0	96.5	119.3	62.4	71.4	67.2	76.0	306.2	343.0	898.0	980.0	2,433.1	2,746.9
Digital computers, local peripherals	50.3	57.3	31.6	37.9	16.4	21.9	372.1	441.9	136.3	166.2	72.6	90.6	12.0	13.9	75.4	101.8	46.2	65.5	55.7	62.3	215.6	257.2	693.9	775.0	1,778.1	2,091.5
Remote terminal equipment	12.2	14.6	3.2	3.9	3.5	4.9	46.1	58.1	16.8	18.5	10.4	16.3	4.6	5.6	19.3	31.6	16.6	23.8	11.5	13.8	46.5	61.2	79.6	91.6	270.3	343.9
Analog and hybrid computers	1.6	1.6	0.4	0.4	0.2	0.2	7.0	7.4	1.8	1.8	2.4	2.4	1.1	0.9	1.5	2.2	1.3	1.3	5.9	5.9	2.2	2.4	14.3	16.3	39.7	42.8
Electronic calculators	7.3	8.6	2.4	2.8	3.8	4.1	51.2	63.9	57.5	66.4	13.1	18.4	3.3	4.6	6.4	8.4	11.9	12.8	14.8	17.7	41.7	51.4	161.2	183.0	374.6	442.1
Communications equipment, total	121.6	141.3	63.5	67.3	28.9	32.4	756.9	884.4	230.2	267.6	83.8	112.4	63.5	62.8	156.5	173.3	99.9	108.4	66.6	68.8	578.8	619.0	837.6	925.3	3,087.8	3,463.0
Broadcast	3.6	3.6	1.8	2.1	0.9	1.0	34.9	34.9	5.1	5.1	1.6	1.8	5.6	3.7	14.9	14.4	3.6	4.3	1.3	1.6	15.7	16.4	10.2	12.2	99.2	101.1
Cable TV	0.8	1.0	0.5	1.0	0.2	0.4	–	0.6	0.1	0.1	–	–	0.6	0.9	*	*	*	0.2	0.5	0.5	7.4	7.4	51.0	57.1	61.1	69.2
Closed-circuit TV	3.7	4.3	1.0	1.0	0.6	0.7	12.1	13.2	13.3	16.8	2.7	3.2	0.8	0.9	3.1	3.6	0.6	0.6	2.4	2.5	4.9	4.9	17.8	20.4	63.0	72.1
Intercoms and intercom systems	7.3	8.5	10.7	11.4	0.5	0.5	46.5	62.8	4.8	5.1	9.2	10.2	2.6	3.0	3.8	4.3	10.0	11.0	4.4	4.6	9.8	11.3	26.5	30.6	136.1	163.3
Microwave relay systems	1.9	2.2	2.1	2.3	3.5	3.8	64.0	74.7	19.5	23.0	3.3	3.7	5.0	5.5	21.9	25.1	3.8	5.2	2.3	2.5	4.9	4.9	61.2	67.3	193.4	220.2
Navigation aids (except radar)	1.8	1.9	12.8	13.0	3.3	3.3	69.8	74.0	40.7	44.2	12.2	13.1	12.4	11.6	12.1	13.2	19.0	19.0	5.2	4.6	93.1	98.0	79.6	83.7	362.0	379.6
Radar	10.8	11.4	6.7	7.0	2.7	3.3	151.2	155.8	19.5	23.9	22.4	22.4	13.3	13.0	13.9	15.4	19.0	19.5	6.5	6.5	109.0	112.7	102.0	104.1	477.0	495.0
Radio communications (except broadcast)	8.5	9.7	14.0	14.4	4.3	4.8	116.3	127.9	21.2	24.8	16.9	18.4	6.7	6.3	13.1	15.2	16.7	17.8	11.5	11.5	142.1	153.1	155.1	153.1	526.4	557.0
Telephone switching, private (PABX)[2]	1.6	1.8	0.2	0.2	3.3	4.1	6.3	9.8	5.3	8.8	2.2	2.7	0.3	0.4	3.6	3.7	1.0	1.4	1.2	1.5	–	–	5.2	5.9	30.2	40.3
Telephone switching, public[2]	54.1	64.9	1.6	1.6	2.2	2.7	9.3	17.4	8.8	15.0	3.7	26.5	0.6	0.7	*	1.7	1.2	1.8	0.5	0.5	48.8	55.0	2.5	3.2	133.3	191.0
Telephone and telegraph carrier	23.0	27.0	6.0	6.8	5.2	5.2	220.9	280.7	88.5	97.3	4.9	5.6	11.6	12.6	62.9	68.0	16.7	18.3	19.7	19.7	93.1	98.0	249.0	277.5	801.5	916.7
Wire message	4.5	5.0	6.1	6.5	2.2	2.6	25.6	32.6	3.5	3.5	4.7	4.8	4.0	4.2	7.2	8.7	8.3	9.3	11.1	12.8	50.0	57.3	77.5	110.2	204.7	257.5
Industrial equipment, total	61.6	66.5	33.0	35.7	24.9	31.5	153.3	175.1	104.3	114.0	78.8	81.0	28.0	31.5	29.9	36.6	66.4	73.2	42.9	46.2	168.0	192.7	436.5	470.2	1,227.6	1,354.2
Industrial X-ray gauging and inspection	1.0	1.1	1.6	1.7	1.0	1.1	8.1	9.2	2.6	2.9	3.3	3.4	0.8	1.0	1.0	1.1	2.7	2.8	1.1	1.1	6.8	7.4	21.8	23.3	51.8	56.1
Infrared gauging and inspection	3.9	4.1	1.3	1.4	0.5	0.6	10.5	11.9	6.5	7.2	4.6	4.7	1.0	1.1	1.3	1.5	1.0	1.0	2.1	2.3	14.7	16.9	43.7	46.9	91.1	99.6
Machine-tool controls	1.6	1.8	1.5	1.6	0.6	0.8	8.8	10.5	6.2	7.1	1.6	1.7	1.3	1.8	2.2	2.5	2.2	2.4	4.4	4.8	11.0	13.2	21.2	22.9	62.6	71.1
Motor speed controls	6.0	6.4	3.2	3.4	4.1	5.5	5.8	6.6	5.8	6.5	8.6	8.8	1.8	2.1	4.6	5.1	6.2	6.7	5.2	5.6	13.7	15.7	25.7	27.8	90.7	100.2
Photoelectric controls	0.4	0.4	0.5	0.5	0.2	0.2	3.0	3.4	1.3	1.6	1.1	1.1	0.9	1.0	0.8	0.9	1.2	1.3	1.0	1.3	4.9	5.4	11.4	12.2	26.7	29.3
Power electronics	2.1	2.2	0.8	0.8	8.2	9.6	9.3	10.7	5.0	5.4	3.3	3.5	0.9	1.3	1.7	2.1	2.5	2.7	1.6	1.8	6.1	7.2	16.3	17.8	57.8	65.1
Process controls	45.9	49.6	23.6	25.8	8.2	11.0	96.5	110.5	74.3	80.4	50.7	52.0	20.4	22.2	14.0	18.4	49.3	54.8	26.2	28.0	102.9	118.3	273.5	295.0	785.5	866.0
Ultrasonic cleaning and inspection	0.2	0.3	0.1	0.1	0.5	0.5	3.7	4.2	0.7	0.8	3.5	3.6	0.4	0.4	0.5	0.6	0.3	0.4	0.3	0.3	1.5	1.7	4.1	4.3	15.8	17.2
Welding (with electronic control)	0.5	0.6	0.4	0.4	1.6	2.2	7.6	8.1	1.9	2.1	2.1	2.2	0.5	0.6	3.8	4.4	1.0	1.1	1.0	1.0	6.4	6.9	18.8	20.0	45.6	49.6
Test and measuring instruments, total	19.0	20.8	13.5	14.7	6.0	7.4	109.4	120.0	39.8	45.9	50.2	55.2	11.0	12.3	13.2	15.5	20.6	22.1	21.0	22.6	83.4	90.0	131.6	139.0	518.7	565.5
Amplifiers, laboratory type	0.2	0.2	0.1	0.1	0.1	0.1	2.8	2.8	0.2	0.2	1.1	1.1	0.1	0.1	0.1	0.1	0.3	0.3	0.6	0.6	1.2	1.2	2.6	2.4	9.4	9.2
Calibrators and standards, active and passive	0.7	0.7	0.2	0.2	0.1	0.1	4.1	4.1	0.6	0.7	3.1	3.1	0.5	0.5	0.4	0.5	0.3	0.4	1.0	1.0	3.3	3.4	4.6	5.1	18.9	19.8
Components testers	1.8	1.9	1.3	1.5	0.1	0.2	8.7	10.5	2.6	3.0	3.8	4.5	0.7	0.8	0.7	1.0	2.5	2.7	0.8	0.8	2.0	2.2	5.1	5.5	30.1	34.6
Counters and timers	3.2	3.6	1.4	1.3	0.4	0.5	7.0	7.7	2.7	3.1	3.5	3.7	0.6	0.7	0.8	0.9	2.5	2.5	1.1	1.3	6.1	6.6	8.8	9.2	38.1	41.1
Electronic meters, analog	2.0	1.8	0.6	0.6	0.4	0.4	3.9	4.1	1.0	0.8	2.2	2.0	0.6	0.6	1.6	1.8	0.6	0.6	0.3	0.3	4.9	5.1	3.7	3.8	21.8	21.9
Electronic meters, digital	1.0	1.5	1.3	1.5	0.4	0.5	6.4	7.0	2.5	3.3	2.4	2.7	0.4	0.6	1.8	2.0	1.2	1.4	1.1	1.2	7.4	7.8	6.5	6.9	32.4	36.4
Electronic meters, all panel types	–	–	1.4	1.5	0.4	0.4	3.2	3.6	2.6	2.8	0.8	1.0	0.2	0.2	1.5	1.8	2.1	2.3	2.6	2.6	3.4	3.6	6.9	7.4	25.1	27.2
Generators and synthesizers (to 1 GHz)	1.8	1.9	1.2	1.4	0.9	1.1	9.3	10.2	2.5	3.0	4.1	4.7	0.7	0.8	1.2	1.4	2.8	3.1	2.1	2.2	4.9	5.5	9.0	9.7	40.5	45.0
Microwave test and measuring (above 1 GHz)	0.8	0.9	1.3	1.5	0.4	0.5	8.4	9.3	6.0	6.5	10.2	12.2	2.0	2.3	0.8	1.0	0.9	0.7	0.6	0.7	6.4	6.8	13.7	14.1	51.5	56.5
Oscillators	0.7	0.8	0.2	0.2	0.1	0.1	6.9	7.6	1.0	1.0	1.6	1.6	0.4	0.4	0.4	0.5	0.3	0.3	0.7	0.7	3.4	3.7	5.3	5.7	21.0	22.6
Oscilloscopes and accessories	3.0	3.3	1.6	1.7	1.5	1.7	23.3	25.8	8.6	9.6	6.1	6.7	1.5	1.6	1.3	1.5	4.3	4.8	4.1	4.4	17.6	19.2	26.5	29.4	99.4	109.7
Power supplies, laboratory type	1.2	1.3	0.5	0.5	0.1	0.2	6.3	6.7	1.6	3.0	1.6	1.7	0.6	0.7	0.5	0.6	0.7	0.7	0.6	0.7	3.9	4.2	8.2	8.4	25.8	28.7
Recorders	1.8	1.9	2.2	2.4	0.9	1.3	16.3	17.2	7.0	7.8	7.3	7.6	1.6	1.8	1.4	1.6	1.1	1.2	4.3	4.8	14.7	15.9	28.9	29.4	87.5	92.9
Spectrum analyzers	0.8	1.0	0.2	0.3	0.2	0.3	2.8	3.4	0.9	1.1	2.4	2.6	1.1	1.2	0.7	0.8	1.0	1.1	1.1	1.3	4.2	4.8	1.8	2.0	17.2	19.9
Medical electronics equipment, total	13.1	14.2	7.8	8.8	13.0	16.2	83.2	92.1	35.5	40.3	20.7	22.1	5.9	6.8	26.7	32.0	27.4	27.6	13.3	14.1	23.4	26.4	186.4	219.0	456.4	519.6
Diagnostic (except X-ray)	2.2	2.4	3.2	3.6	4.4	5.5	16.5	18.1	7.4	8.5	3.7	3.8	2.3	2.6	7.5	9.2	6.0	6.0	2.6	2.9	2.9	3.2	17.1	19.6	75.8	85.4
Patient-monitoring	1.2	1.4	0.8	0.9	1.9	2.5	8.1	9.3	4.2	5.0	3.5	3.6	0.7	0.8	2.1	2.5	0.5	0.7	0.9	1.0	0.2	1.2	18.0	22.4	42.1	51.3
Therapeutic (except X-ray)	1.2	1.3	0.6	0.8	1.7	1.9	3.8	4.2	1.8	2.0	1.7	1.9	0.7	0.8	1.5	1.8	1.9	1.9	0.8	0.9	0.7	0.7	10.5	12.1	26.9	30.3
X-ray, diagnostic and therapeutic	8.5	9.1	3.2	3.5	5.0	6.3	54.8	60.5	22.1	24.8	11.8	12.8	2.2	2.6	15.6	18.5	19.0	19.0	9.0	9.3	19.6	21.3	140.8	164.9	311.6	352.6
Total equipment consumption	498.8	569.6	326.4	358.2	167.9	214.0	2,907.0	3,336.4	1,120.3	1,288.0	749.5	878.2	218.4	239.8	603.8	729.2	638.6	707.3	432.2	471.8	2,940.9	3,233.9	5,421.4	5,958.5	16,025.2	17,984.9

[1] Includes stand-alone minicomputers but not computers that are integral parts of process-control and like systems.
[2] Electronic or semi-electronic

*Less than $75,000

European 1974 components markets

	Belgium 1973	Belgium 1974	Denmark 1973	Denmark 1974	Finland 1973	Finland 1974	France 1973	France 1974	Italy 1973	Italy 1974	Netherlands 1973	Netherlands 1974
Passive and electromechanical, total	85.0	100.2	64.7	69.1	26.1	32.3	639.8	706.0	168.3	185.8	135.5	142.2
Antennas and antenna hardware	2.4	2.8	6.0	6.6	0.9	1.1	36.0	43.2	6.8	7.4	5.3	6.0
Capacitors, fixed	12.0	13.6	11.0	11.0	5.3	6.5	86.0	94.6	35.4	37.9	17.3	17.8
Capacitors, variable	2.7	3.1	1.0	1.1	0.4	0.5	5.1	5.3	5.1	5.5	2.0	2.1
Connectors, plugs, and sockets	4.3	4.9	3.0	3.3	2.0	2.7	75.6	82.1	15.0	16.8	6.9	7.5
Crystals and crystal filters	1.9	2.1	1.1	1.2	0.4	0.5	7.0	7.4	2.6	3.0	2.2	2.4
Delay lines	1.8	1.6	1.5	1.5	0.6	0.8	3.5	4.0	0.5	0.6	2.4	2.0
Displays (except solid-state devices)	0.3	0.4	0.2	0.3	0.4	0.5	6.3	6.7	0.8	0.9	1.1	1.2
Ferrite devices (except TV yokes and flybacks)	3.2	3.4	0.8	1.0	0.6	0.6	14.0	14.9	5.7	6.9	5.3	5.9
Filters and networks (except crystal)	1.2	1.4	1.4	1.4	0.1	0.1	7.4	8.0	2.2	2.4	1.7	1.5
Loudspeakers, OEM type	4.7	5.2	7.0	7.6	1.9	2.7	10.5	11.8	6.3	6.8	7.9	6.5
Microphones, OEM type	1.1	1.2	1.4	1.4	0.1	0.1	2.3	2.6	0.4	0.4	1.7	1.8
Potentiometers, composition	3.2	3.8	3.4	3.6	1.0	1.2	11.2	12.8	8.8	11.1	5.3	5.5
Potentiometers, wirewound	0.7	0.8	0.8	0.9	0.6	0.8	8.1	9.5	1.1	1.2	1.2	1.3
Power supplies, OEM type	3.9	4.4	2.2	2.4	1.6	1.8	32.6	35.3	4.2	4.4	6.6	7.1
Printed circuits	9.4	12.8	2.8	3.0	1.4	1.6	57.7	62.8	16.9	18.8	14.5	16.0
Relays	6.0	7.0	4.2	4.5	0.4	0.4	48.8	55.8	12.9	13.8	12.5	14.0
Resistors, fixed	6.8	9.5	3.8	4.1	1.7	2.0	41.9	46.0	9.7	9.9	10.5	11.4
Resistors, nonlinear	0.7	0.8	0.4	0.4	0.3	0.4	5.6	6.5	0.4	0.5	0.8	0.9
Servos, synchros, resolvers	0.9	1.0	0.5	0.6	0.1	0.1	8.1	8.8	2.5	2.6	1.6	1.9
Solenoids and fhp motors	4.4	4.8	2.6	2.9	1.4	1.5	100.0	108.8	11.8	12.6	11.2	12.3
Switches (for communications and electronics)	4.4	5.0	2.4	2.6	1.9	2.4	20.9	22.8	4.2	4.6	5.3	5.7
Transformers, chokes, coils, TV yokes, and flybacks	9.0	10.6	7.0	7.7	3.0	4.0	51.2	56.3	15.0	17.7	12.2	11.4
Semiconductors, discrete, total	14.8	18.6	14.5	16.8	7.5	9.5	117.7	126.5	49.5	56.3	18.1	20.3
Microwave diodes, all types	0.4	0.4	0.3	0.3	0.1	0.7	2.1	2.2	1.1	1.6	0.7	0.7
Rectifiers (including diodes rated more than 100 mA)	1.7	2.4	2.9	3.3	2.0	2.2	20.2	22.1	8.3	9.8	2.7	2.9
Signal diodes (rated less than 100mA, including arrays)	2.0	2.8	1.7	1.9	0.5	0.7	8.6	9.3	3.1	3.2	2.5	2.9
Thyristors (SCRs, four-layer diodes, etc.)	1.6	1.9	1.4	1.6	0.4	0.6	11.2	11.6	4.1	4.5	2.5	2.9
Transistors, power (more than 1-W dissipation)	3.0	3.5	2.6	2.9	1.5	2.2	23.3	24.4	10.7	13.4	3.5	4.1
Transistors, small-signal (including FETs and duals)	5.5	7.0	5.5	5.9	2.7	2.7	42.3	44.2	17.7	18.8	5.5	6.1
Tuner varactor diodes	0.3	0.3	*	*	0.1	0.1	3.0	4.6	1.9	2.2	0.4	0.3
Zener diodes	0.3	0.3	0.1	0.9	0.2	0.3	7.0	8.1	2.6	2.8	0.3	0.4
Semiconductors, integrated circuits, total	8.1	13.2	3.7	5.2	2.0	3.8	60.6	79.0	25.2	32.6	12.7	15.7
Hybrid ICs, all types	0.7	1.0	0.6	0.7	0.1	1.4	8.1	8.9	2.6	3.2	2.7	3.3
Digital logic circuits, bipolar	2.6	4.3	0.8	0.9	0.2	0.4	23.0	26.0	9.2	9.5	4.9	6.1
Digital logic circuits, MOS and C-MDS	0.8	1.2	0.4	0.5	*	0.1	5.0	7.4	1.8	2.5	0.4	0.7
Digital memory circuits, bipolar	0.3	0.5	0.2	0.2	*	0.1	1.9	3.3	0.9	1.7	0.2	0.4
Digital memory circuits, MOS and C-MOS	0.7	1.1	0.3	0.4	0.2	0.3	4.9	8.4	2.3	4.6	0.7	1.1
Digital special circuits, bipolar and MOS	0.9	1.8	0.5	0.9	—	—	3.7	6.4	0.7	0.9	—	—
Linear ICs (except op amps)	1.2	2.0	0.5	1.2	1.1	1.1	9.3	12.8	6.4	8.8	2.0	2.1
Op amps, monolithic only	0.9	1.3	0.4	0.4	0.4	0.4	4.7	5.8	1.3	1.4	1.8	2.0
Semiconductors, optoelectronic, total	1.0	1.0	0.7	0.8	0.6	0.8	4.1	6.1	2.4	2.8	1.0	1.2
Circuit elements (photoconductive cells, photodiodes, phototransistors, isolators, etc.)	0.8	0.8	0.2	0.2	0.1	0.2	2.3	3.3	1.9	2.2	0.5	0.6
Display devices (light-emitting diodes, LED arrays)	0.2	0.2	0.4	0.5	0.4	0.5	1.4	2.3	0.5	0.6	0.4	0.5
Photovoltaic (solar) cells	*	*	0.1	0.1	0.1	0.1	0.4	0.5	—	—	0.1	0.1
Tubes, total	51.4	69.2	22.2	24.7	17.1	22.9	212.5	236.5	91.7	103.9	24.0	23.2
Tubes, cathode-ray (except for TV)	0.1	0.1	0.4	0.4	0.3	0.4	11.4	12.6	2.0	3.4	1.8	2.1
Tubes, optoelectronic	0.8	0.9	3.4	3.4	1.2	1.4	13.2	14.2	3.0	3.6	0.6	0.7
Tubes, power types (including microwave)	3.8	4.6	1.9	1.6	0.6	0.7	38.4	40.5	16.8	17.9	6.5	7.3
Tubes, receiving types	3.5	2.8	0.5	0.5	1.4	1.4	19.8	18.1	8.5	7.5	6.1	4.1
TV picture tubes, black-and-white	10.8	9.4	7.8	7.8	1.4	1.4	25.1	23.2	38.9	40.0	9.0	9.0
TV picture tubes, color	32.4	51.4	8.2	11.0	12.2	17.6	104.6	127.9	22.5	31.5	—	—
Total components consumption	160.3	202.2	105.8	116.6	53.3	69.3	1,034.7	1,154.1	337.1	381.4	191.3	202.6

	Norway 1973	Norway 1974	Spain 1973	Spain 1974	Sweden 1973	Sweden 1974	Switzerland 1973	Switzerland 1974	United Kingdom 1973	United Kingdom 1974	West Germany 1973	West Germany 1974	Total 1973	Total 1974
Passive and electromechanical, total	34.0	37.3	59.1	66.2	117.1	125.8	83.3	92.5	617.5	673.0	1,174.6	1,263.7	3,205.0	3,494.1
Antennas and antenna hardware	1.7	1.9	4.4	4.9	4.2	4.6	4.3	4.7	39.2	43.0	61.6	64.0	172.8	190.2
Capacitors, fixed	5.6	5.9	14.9	16.9	22.6	25.0	12.4	13.7	109.0	120.1	200.0	216.3	531.5	579.3
Capacitors, variable	0.5	0.5	3.3	3.0	5.0	5.2	0.8	0.9	6.4	6.6	15.5	17.3	47.8	51.1
Connectors, plugs, and sockets	2.2	2.6	4.0	4.2	6.2	6.9	5.8	7.0	68.6	71.1	38.6	41.4	232.2	250.5
Crystals and crystal filters	0.7	0.9	0.8	1.0	2.6	2.7	2.1	2.5	11.0	12.1	14.3	15.9	46.7	51.7
Delay lines	0.4	0.5	0.1	0.3	0.9	1.0	0.8	0.8	5.4	6.1	6.9	6.9	24.8	26.1
Displays (except solid-state devices)	0.1	0.1	0.1	0.2	0.3	0.4	0.3	0.3	2.4	2.7	9.4	10.4	21.7	24.1
Ferrite devices (except TV yokes and flybacks)	1.0	1.1	2.1	2.8	1.3	1.4	3.6	3.9	11.0	12.7	32.7	34.9	81.5	89.5
Filters and networks (except crystal)	1.0	1.1	0.8	1.0	3.6	3.9	0.7	0.7	4.2	4.4	8.2	9.0	32.5	34.9
Loudspeakers, OEM type	2.0	2.1	2.2	2.2	5.8	6.1	1.5	1.6	17.6	19.4	25.3	26.6	92.7	98.6
Microphones, OEM type	0.1	0.1	0.3	0.5	1.4	1.5	0.4	0.4	4.6	4.9	17.1	18.8	30.9	33.7
Potentiometers, composition	1.6	1.7	3.5	4.0	2.9	3.2	2.1	2.5	16.6	19.4	69.7	75.8	129.3	144.6
Potentiometers, wirewound	0.4	0.4	0.6	0.7	1.4	1.6	0.6	0.6	12.7	14.7	16.3	18.3	44.5	50.9
Power supplies, OEM type	1.9	2.0	2.0	2.2	4.3	4.6	2.6	3.0	28.4	30.3	35.1	37.6	125.4	135.1
Printed circuits	2.4	2.6	1.7	1.9	5.7	6.4	8.1	10.4	30.6	34.3	80.0	86.0	231.2	256.6
Relays	3.0	3.4	4.5	5.0	15.4	14.9	5.7	6.1	51.5	57.6	71.4	77.6	236.3	260.1
Resistors, fixed	2.1	2.3	2.9	3.1	7.1	7.8	5.7	6.1	40.9	44.1	69.4	75.8	202.5	222.1
Resistors, nonlinear	0.3	0.3	1.1	1.2	0.6	0.6	0.6	0.6	5.6	6.1	10.0	11.0	26.4	29.3
Servos, synchros, resolvers	0.3	0.4	1.0	1.0	1.1	1.2	2.1	2.3	15.7	17.6	28.6	31.4	62.5	68.9
Solenoids and fhp motors	0.6	0.6	3.4	4.0	6.0	6.5	10.7	11.4	79.6	86.7	249.0	263.9	480.7	516.0
Switches (for communications and electronics)	2.0	2.2	1.4	1.6	6.9	7.7	3.3	3.6	17.3	18.7	42.0	45.8	112.0	122.7
Transformers, chokes, coils, TV yokes, and flybacks	4.1	4.6	4.0	4.5	11.8	12.6	9.1	9.4	39.2	40.4	73.5	79.0	239.1	258.2
Semiconductors, discrete, total	8.3	8.9	16.1	17.2	13.7	14.5	14.9	17.9	135.8	152.5	272.4	296.7	683.3	755.7
Microwave diodes, all types	0.2	0.3	0.2	0.2	0.3	0.3	0.5	0.5	2.4	3.0	3.1	3.6	11.4	13.8
Rectifiers (including diodes rated more than 100 mA)	1.1	1.2	3.6	3.9	2.0	2.0	1.5	1.7	20.1	22.8	37.6	43.2	103.7	117.5
Signal diodes (rated less than 100mA, including arrays)	0.8	0.8	2.1	2.3	1.7	1.9	2.5	2.8	11.0	11.8	30.6	32.4	67.1	72.8
Thyristors (SCRs, four-layer diodes, etc.)	0.6	0.6	1.2	1.3	1.5	1.5	2.0	2.2	10.5	11.0	26.5	28.6	63.5	68.3
Transistors, power (more than 1-W dissipation)	1.5	1.7	1.5	1.6	2.5	2.8	3.8	4.6	29.4	34.3	44.9	49.4	128.2	144.9
Transistors, small-signal (including FETs and duals)	3.4	3.5	6.0	6.2	4.5	4.8	3.8	5.3	52.2	57.1	102.0	107.1	251.1	268.7
Tuner varactor diodes	0.2	0.2	0.5	0.6	0.5	0.5	*	*	2.4	3.4	10.8	12.4	20.1	24.6
Zener diodes	0.5	0.6	1.0	1.1	0.7	0.7	0.8	0.8	7.8	9.1	16.9	20.0	38.2	45.1
Semiconductors, integrated circuits, total	3.7	4.9	4.2	6.0	8.8	12.8	10.3	13.0	79.5	100.0	135.2	175.3	354.0	461.5
Hybrid ICs, all types	0.3	0.4	0.8	1.2	0.6	1.2	1.3	1.6	12.2	14.7	15.1	17.3	45.1	54.9
Digital logic circuits, bipolar	1.1	1.5	1.2	1.5	4.0	5.0	3.6	4.3	24.5	27.0	48.2	53.0	123.3	139.5
Digital logic circuits, MOS and C-MDS	0.6	0.7	0.3	0.4	0.3	0.6	1.1	1.6	6.9	9.6	10.6	14.8	28.2	40.1
Digital memory circuits, bipolar	0.4	0.5	0.5	0.7	0.5	0.7	0.5	0.8	1.4	2.0	3.3	5.9	10.1	16.8
Digital memory circuits, MOS and C-MOS	0.2	0.4	0.3	0.4	1.2	2.4	0.8	1.2	4.4	6.1	6.5	10.8	22.5	37.2
Digital special circuits, bipolar and MOS	0.1	0.1	0.2	0.3	0.5	1.0	0.4	0.5	5.6	8.3	7.3	14.0	19.9	34.2
Linear ICs (except op amps)	0.8	1.0	0.7	1.2	1.1	1.3	2.2	2.5	18.4	24.5	35.5	49.7	79.2	108.2
Op amps, monolithic only	0.2	0.3	0.2	0.3	0.6	0.6	0.4	0.5	6.1	7.8	8.7	9.8	25.7	30.6
Semiconductors, optoelectronic, total	0.2	0.2	*	0.3	0.4	0.6	0.4	0.6	9.5	13.4	10.2	14.3	30.5	42.1
Circuit elements (photoconductive cells, photodiodes, phototransistors, isolators, etc.)	0.1	0.1	*	0.2	0.2	0.3	0.2	0.3	2.9	4.2	5.9	8.3	15.1	20.7
Display devices (light-emitting diodes, LED arrays)	0.1	0.1	*	0.1	0.2	0.3	0.2	0.3	6.1	8.6	3.7	5.3	13.6	19.3
Photovoltaic (solar) cells	*	*	*	*	*	*	*	*	0.5	0.6	0.6	0.7	1.8	2.1
Tubes, total	12.3	14.9	20.9	24.0	40.6	43.1	14.1	15.0	306.6	311.4	405.9	415.0	1,219.3	1,303.8
Tubes, cathode-ray (except for TV)	0.1	0.2	0.5	0.6	0.6	0.7	0.5	0.6	11.8	13.0	5.1	5.6	34.6	39.7
Tubes, optoelectronic	*	0.1	0.2	0.2	0.6	0.7	3.2	3.5	14.7	17.1	7.1	7.5	48.0	53.3
Tubes, power types (including microwave)	1.3	1.4	2.6	2.8	6.2	6.6	3.9	4.1	32.1	33.6	28.8	30.1	142.9	151.2
Tubes, receiving types	1.2	1.1	6.1	5.8	2.0	1.8	2.6	2.6	27.0	23.8	24.1	19.6	102.8	89.1
TV picture tubes, black-and-white	0.8	0.6	11.5	12.1	1.2	1.2	0.6	0.3	25.0	15.9	34.7	30.8	166.8	151.7
TV picture tubes, color	8.9	11.5	*	2.5	30.0	32.1	3.3	3.9	196.0	208.0	306.1	321.4	724.2	818.8
Total components consumption	58.5	66.2	100.3	113.7	180.6	196.8	123.0	139.0	1,148.9	1,250.3	1,998.3	2,165.0	5,497.1	6,057.2

Factory prices in millions of dollars

Note: Estimates in this chart are based on market data supplied to Electronics by more than 180 companies, trade associations, and government agencies. The figures show consensus forecasts for consumption of components used to produce equipment destined for both home and export markets.

Participants were asked to value markets at factory prices (or cost-insurance-freight for imports) in local currency or to specify the exchange rate used for estimates in dollars. All forecasts were first calculated in local currency, than converted into dollars at the exchange rates shown below. Because of the substantial changes in exchange rates over the past two years, estimates in this chart can be compared with those published in previous years only after correcting for currency changes.

The rates for this chart (per U.S. $1):

Belgium, 37 francs
Denmark, 5.7 crowns
Finland, 3.7 marks
France, 4.3 francs
Italy, 565 lire
Netherlands, 2.45 florins
Norway, 5.4 crowns
Spain, 57 pesetas
Sweden, 4.2 crowns
Switzerland, 3.05 francs
United Kingdom, 41 pence (1£ = $2.45)
West Germany, 2.45 marks

*Less than $75,000

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Package		TO-66	TO-66	¼" stud	TO-48	TO-48
I_{RMS}		5 amps	5 amps	10 amps	35 amps	35 amps
T_{OFF} (Microseconds)		2-6	6-10	5-10	10-15	6-10
1K Price:	200V	1.67	.90	3.00	7.24	7.89
	600V	2.89	1.30	12.20	15.60	17.20

Fast Recovery Rectifiers		TA7895	44938	43884	43894	43904	40960
Package		DO-26	DO-15	DO-4	DO-4	DO-5	DO-5
I_{AV}		1 amp	1 amp	6 amps	12 amps	20 amps	40 amps
T_{RR} (Nanoseconds)		50-500	150-500	150-350	150-350	150-350	150-350
1K Price:	200V	.44	.42	1.79	2.42	3.20	3.40
	600V	.72	.66	3.13	4.37	6.00	6.70

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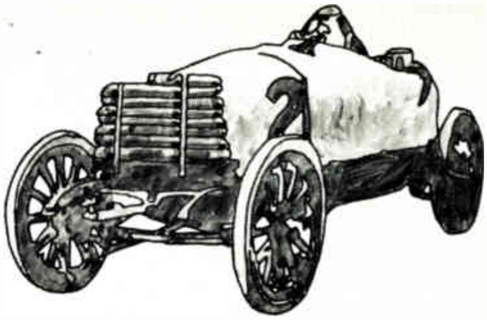

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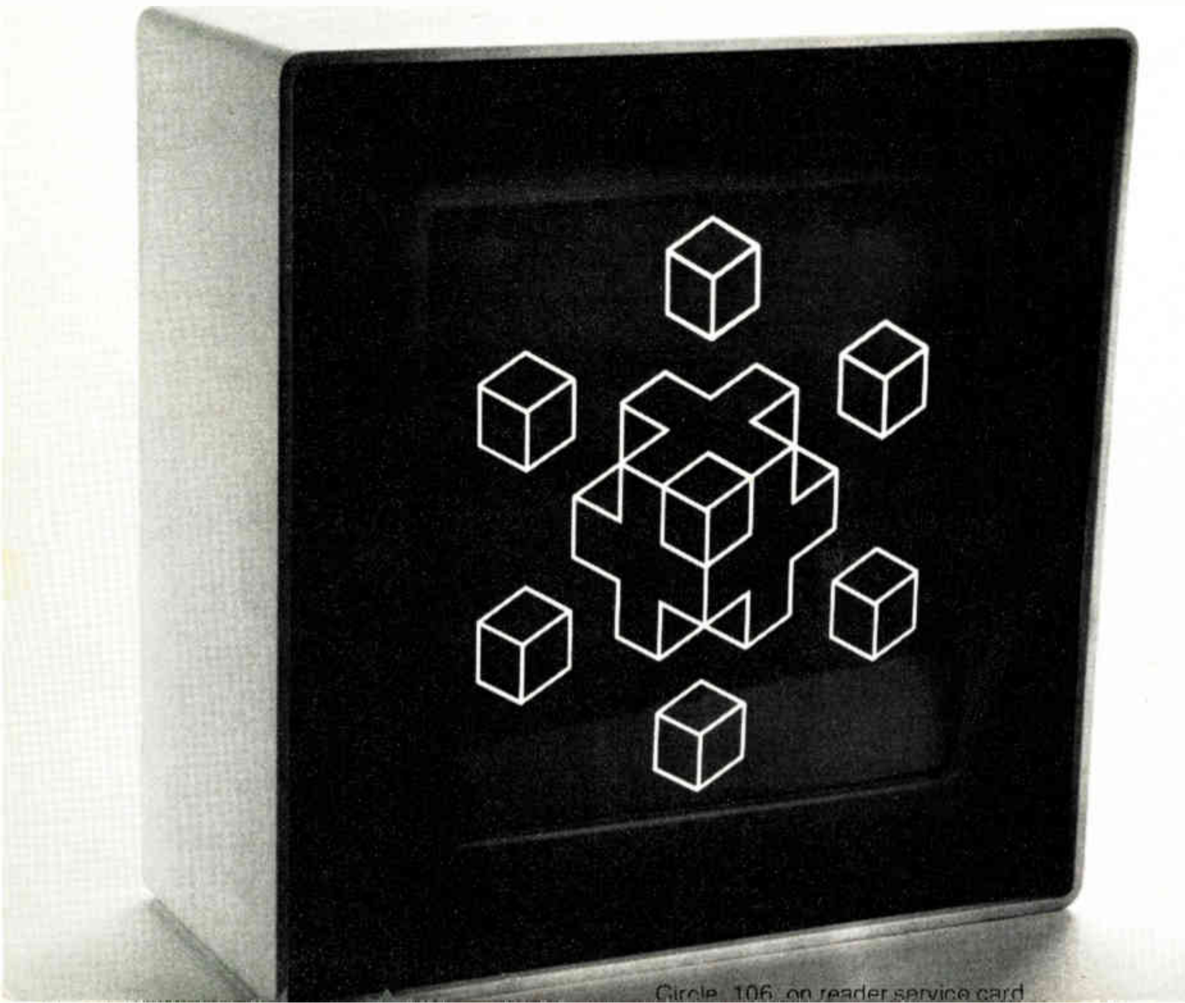


Circle 106 on reader service card

Simulated graphics on screen.

Digital-IC models for computer-aided design

Part 2: TTL flip-flops

When based on functionally equivalent circuits, computer models for a D-type flip-flop and a multiple-input J-K master/slave device need not be complicated

by John R. Greenbaum and Wayne A. Miller, *General Electric Co., Syracuse, N.Y.*

☐ Flip-flops are medium-scale integrated curcuits that can be modeled very simply, just like NAND gates [*Electronics*, Dec. 6, p.121], by developing a black-box equivalent circuit. The model given here for a D-type flip-flop is based on the TTL 9774 dual flip-flop, and the model for a J-K master slave device is based on another TTL unit, the radiation-hardened RSN54L72 flip-flop.

Modeling the D-type flip-flop

The 9774 D-type flip-flop (Fig. 1) is an edge-triggered device that accepts independent preset (SET) and clear (CRS) inputs, as well as clock (CK) and data (D) signal inputs. Information is transferred to its complementary outputs (Q and QB) on the positive-going edge of the clock pulse. Clock triggering occurs at a certain voltage level of the clock pulse (approximately 1.5 volts) and is not directly related to the transition time of this pulse's leading edge. After the clock threshold voltage is reached, any change in the input data is locked out until the next clock pulse.

The truth table in Fig. 1 defines the input/output relationships for the flip-flop when its clear and preset signals are high (logic 1) and, therefore, not controlling the device's performance. The table of electrical characteristics lists those specifications that are significant to the computer model. The flip-flop's propagation-time-delay relationships for the clock and data signals, as well as those for the clear and preset signals, are also given in the figure.

The computer model for the D-type flip-flop is shown in Fig. 2, along with the model descriptions for the Sceptre (System for Circuit Evaluation and Prediction of Transient Radiation Effects) analysis program and the Circus-2 (CIRCUit Simulator) analysis program. The subprograms for establishing the proper logic output signal levels and delay characteristics are also shown. The clock (CK), preset (SET), clear (RS), and data (D) voltages are defined as the input signals to the model. The required device propagation delays are controlled by time constants R1-C1 and R2-C2 for outputs Q and QB, respectively.

In the model, the signal input impedances are represented as zero-valued current sources (JD, JRS, JS, JCK), implying that the input signal terminals have infinite impedances, which is a reasonable first-order approximation. For better accuracy, the input current sources can be modeled in diode-equation format or as tables of functions of current versus applied voltage.

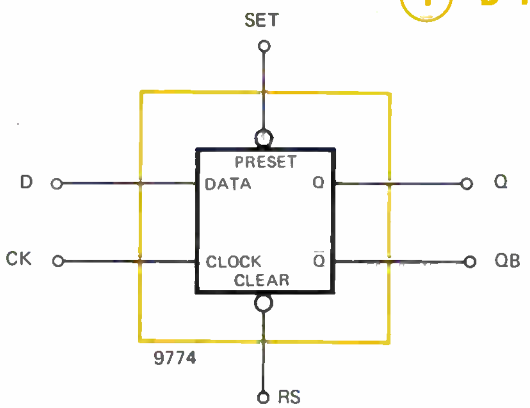
The voltage associated with dependent source E1 is determined by the subprogram for function FEI, which establishes the value of E1 to agree with the truth table in Fig. 1. If either the set or reset input signal is logic 0, all other performance conditions are overridden—voltage E1 is made equal to logic 1 for a logic 0 set input or equal to logic 1 for a logic 0 reset input. But if either the set or reset signal is logic 1, the function FEI then controls all other performance conditions.

To assure that the flip-flop triggers on the leading (positive-going) edge of the clock pulse, the function FEI monitors the clock signal. When the clock signal voltage is less than or equal to the preceding observation, the signal level associated with voltage E1 is not changed. When the clock signal voltage is greater than its preceding value, it is tested to determine whether it lies between a logic 0 level of 0.8 V and a logic 1 level of 2.0 V (since the clock pulse is effective only within this voltage range). If the clock level falls between these limits, the signal at the data input terminal is transferred to the output stage of the model.

Once it has been determined that the clock voltage is a positive-going signal and within the prescribed range, the subprogram for function FEI evaluates the voltage level of input signal D. If this input is logic 1, voltage E1

This article is the second in a five-part series on simplified, but accurate, computer models for common digital ICs. The models are developed on the basis of device terminal behavior, instead of by the classical method of modeling every transistor and diode junction in the IC. The NAND gate was covered in Part 1 in the Dec. 6 issue, the flip-flop is dealt with here, and the monostable multivibrator, the AND/OR inverter, and the shift register will be in upcoming issues.

1 D-TYPE FLIP-FLOP



TRUTH TABLE		
t_n	t_{n+1}	
INPUT D	OUTPUT	
	Q	$\bar{Q}$
0	0	1
1	1	0

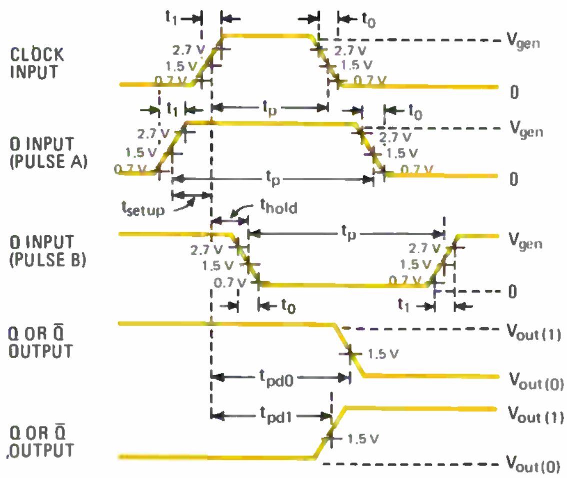
t_n = bit time before clock pulse
t_{n+1} = bit time after clock pulse

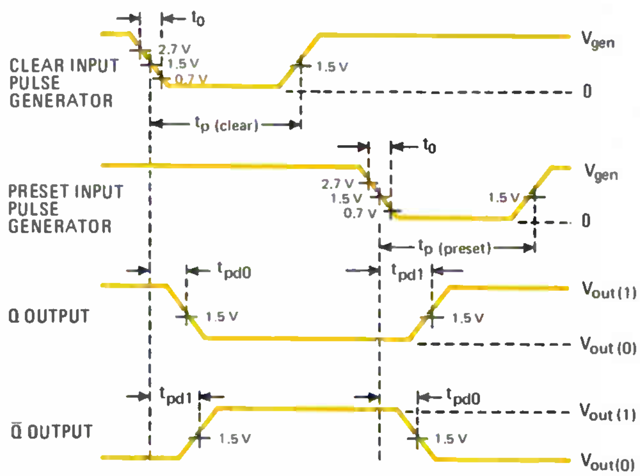
ELECTRICAL CHARACTERISTICS

	Parameter	Minimum	Typical*	Maximum
$V_{in(1)}$	Input voltage required to ensure logic 1 at any input terminal	2.0 V		
$V_{in(0)}$	Input voltage required to ensure logic 0 at any input terminal			0.8 V
$V_{out(1)}$	Logic 1 output voltage	2.4 V	3.5 V	
$V_{out(0)}$	Logic 0 output voltage		0.1 V	0.4 V
f_{clock}	Maximum clock frequency	15.0 MHz	25.0 MHz	
t_{setup}	Minimum input setup time		15.0 ns	20.0 ns
t_{hold}	Minimum input hold time		2.0 ns	5.0 ns
t_{pd1}	Propagation delay time to logic 1 level from clear or preset to output			25.0 ns
t_{pd0}	Propagation delay time to logic 0 level from clear or preset to output			40.0 ns
t_{pd1}	Propagation delay time to logic 1 level from clock to output	10.0 ns	14.0 ns	25.0 ns
t_{pd0}	Propagation delay time to logic 0 level from clock to output	10.0 ns	20.0 ns	40.0 ns

Positive logic: Low input to preset sets Q to logic 1.
Low input to clear sets Q to logic 0.
Preset and clear are independent of clock.

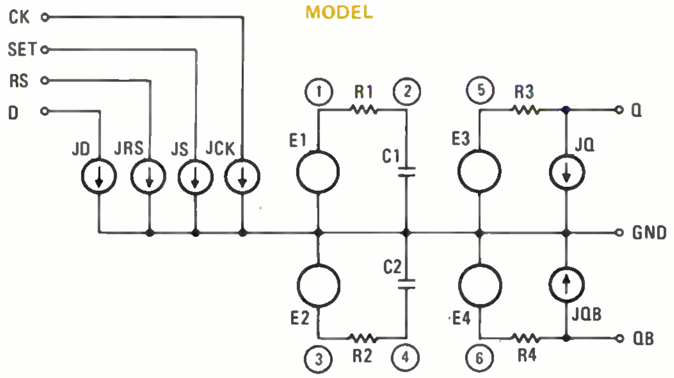
*All typical values are at V_{CC} = 5 V, t_a = 25°C.





2 D-TYPE FLIP-FLOP

MODEL



FOR SCEPTRE: E1 = f(FEI), C1 = f(FCAP1), E3 = f(VC1)
E2 = f(EI), C2 = f(FCAP1), E4 = f(VC2)
FOR CIRCUS-2: V1 = f(FEI), R1 = f(RR72), V3 = f(V.C1)
V2 = f(V1), R2 = f(RR72), V4 = f(V.C2)

SCEPTRE DESCRIPTION

```
MODEL 9774     (CK–D–SET–RS–Q–QB–GND)
               D FLIP FLOP
  ELEMENTS
  JCK,CK–GND = 0.
  JS,SET–GND = 0.
  JRS,RS–GND = 0.
  JD,D–GND = 0.
  JQ,Q–GND = 0.
  JQB,QB–GND = 0.
  E1,GND–1 = Q1(VJS,VJRS,VJCK,VJD,TIME)
  R1,1–2 = 100.
  C1,2–GND = Q2(E1,VC1,250.E–12,300.E–12)
  E2,GND–3 = X1(3.1–E1)
  R2,3–4 = 100.
  C2,4–GND = Q2(E2,VC2,250.E–12,300.E–12)
  E3,GND–5 = X2(VC1)
  R3,5–Q = 100.
  E4,GND–6 = X3(VC2)
  R4,6–QB = 100.
  FUNCTIONS
  Q1(A,B,C,D,E) = (FEI(A,B,C,D,E))
  Q2(A,B,C,D) = (FCAP1(A,B,C,D))
  OUTPUTS
  VJQ,VJQB.PLOT
```

CIRCUS-2 DESCRIPTION

```
MODELS
MODEL NAME = D FLIP FLOP
EXTERNAL NODES = (CK,D,SET,RS,Q,QB,GND)
TOPOLOGY
JCK,CK,GND
JS,SET,GND
JRS,RS,GND
JD,D,GND
JQ,Q,GND
JQB,QB,GND
V1,1,GND
R1,1,2
C1,2,GND
V2,3,GND
R2,3,4
C2,4,GND
V3,5,GND
R3,5,Q
V4,6,GND
R4,6,QB
EQUATIONS
    A1 = AA1
    A2 = AA2
    R1 = RR72(V1,V.C1,A1,A2)
    V1 = FEI(V.JS,V.JRS,V.JCK,V.JD,T)
    D(V1,T) = 0.
    V3 = V.C1
    D(V3,V.C1) = 1.
    V2 = (3.1 – V1)
    D(V2,T) = 0.
    V4 = V.C2
    D(V4,V.C2) = 1.
    R2 = RR72(V2,V.C2,A1,A2)
    RETURN
    END
END OF INPUT

DEVICES
DEVICE NAME = 9774, MODEL NAME = D FLIP FLOP
SINGLE VALUED PARAMETERS
JS=0, JRS=0, JCK=0, JD=0, JQ=0, JQB=0,
C1=100, E–12, C2=100.E–12, AA1=250, AA2=300
R3=100, R4=100
END OF INPUT
```

MODEL SUBPROGRAMS

```
CFEI                 D FLIP FLOP
      FUNCTION FEI(VSET,VRESET,VCLOCK,VDRIVE,TIME)
C-------------------------------------------------------------
C     FOR USE WITH D FLIP FLOP
C   VSET = VOLTAGE AT SET INPUT
C   VRESET = VOLTAGE AT RESET INPUT
C   VCLOCK = VOLTAGE AT CLOCK INPUT
C   VDRIVE = VOLTAGE AT D-INPUT
C   XCLOCK = VOLTAGE AT CLOCK INPUT DURING LAST COMPUTATION
C   XGEN = VOLTAGE AT GATE(E1) DURING LAST COMPUTATION
C-------------------------------------------------------------
      IF(TIME.LE.0.) XCLOCK = VCLOCK
      IF(TIME.LE.0.) XGEN = 3.0
      IF(VSET.LE.1.2) GO TO 1
      IF(VRESET.LE.1.2) GO TO 2
      GO TO 3
3     IF(TIME.LE.0.) XGEN = 3.0
      IF(VCLOCK.LE.XCLOCK) GO TO 9
      IF(VCLOCK.GE.0.8.AND.VCLOCK.LE.2.0) GO TO 4
9     FEI = XGEN
      GO TO 10
4     IF(VDRIVE.GE.1.5)FEI = 3.0
      IF(VDRIVE.LT.1.5) FEI = 0.1
      GO TO 10
1     FEI = 3.0
      GO TO 10
2     FEI = 0.1
10    XCLOCK = VCLOCK
      XGEN = FEI
      RETURN
      END
```

```
CFCAP1          DIGITAL IC CAPACITOR SELECT
      FUNCTION FCAP1(A,B,C,D)
CFCAP1 TO ESTABLISH CAPACITOR VALUE OF DIGITAL IC
      FCAP1 = C
      IF(A.GE.B) FCAP1 = D
      RETURN
      END
```

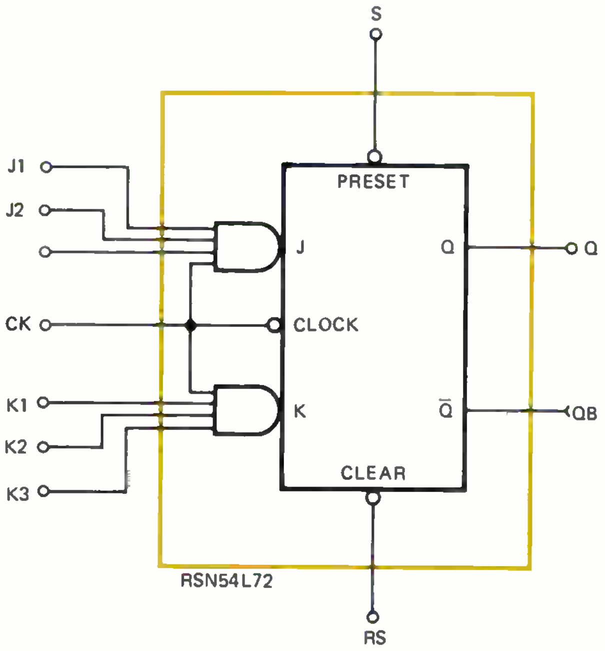
is set equal to 3.0 v, which represents a compromise between the typical and minimum values for a logic 1. If, on the other hand, the D input is logic 0, voltage E1 is set equal to 0.1 v.

The voltage across capacitor C1 (VC1) is established by voltage E1 and is directly related to output voltage Q through dependent source E3. The model, then, transmits data input signals to its outputs in a normal fashion, while maintaining isolation between its input and output terminals.

Since output QB is the complement of output Q, dependent voltage source E2, which establishes the signal level for QB, is computed to be 3.1 v minus the value of voltage E1. Therefore, when voltage E1 is set to 3.0 v (logic 1) by function FEI, voltage E2 is made 0.1 v (logic 0); and when E1 is 0.1 v, E2 is then 3.0 v. Likewise, as the Q output signal is related to the voltage across capacitor C1 and voltage E3, the QB output signal is related to the voltage across capacitor C2 (VC2) and voltage E4.

To obtain the time delays associated with the various controlling signals, the time constants R1-C1 and R2-C2 are used. Since the time delay (t_{pd1}) for an increase in the levels of outputs Q and QB is different from the time delay (t_{pd0}) for a decrease in these levels, the values of capacitors C1 and C2 must be changed appro-

3 J-K FLIP-FLOP



TRUTH TABLE

Inputs at t_n		Outputs at t_{n+1}	
J	K	Q	$\bar{Q}$
0	0	Q_n	$\bar{Q}_n$
0	1	0	0
1	0	1	0
1	1	$\bar{Q}_n$	Q_n

J = J1 · J2 · J3

K = K1 · K2 · K3

t_n = Bit time before clock pulse

t_{n+1} = Bit time after clock pulse

Q_n = Level of output Q at t_n

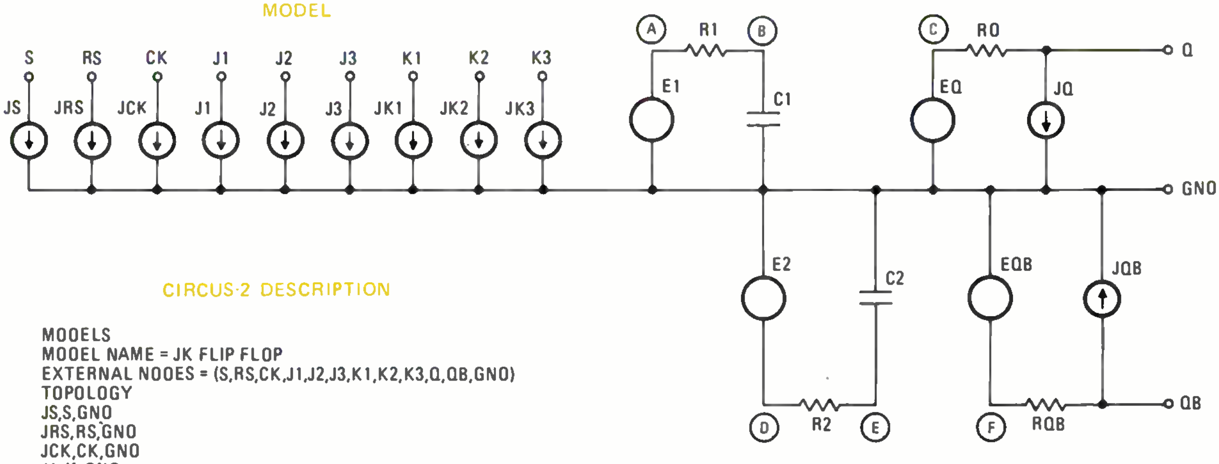
$\bar{Q}_n$ = Level of output $\bar{Q}$ at t_n

ELECTRICAL CHARACTERISTICS

Parameter		Minimum	Typical	Maximum
$V_{in(1)}$	Input voltage required to ensure logic 1 at any input terminal	1.9 V		
$V_{in(0)}$	Input voltage required to ensure logic 0 at any input terminal			0.8 V
$V_{out(1)}$	Logic 1 output voltage	2.4 V		
f_{clock}	Maximum clock frequency		3 MHz	
t_{pd1}	Propagation delay time to logic 1 level from clear or preset to output			75.0 ns
t_{pd0}	Propagation delay time to logic 0 level from clear or preset to output			150.0 ns
t_{pd1}	Propagation delay time to logic 1 level from clock to output	10.0 ns		75.0 ns
t_{pd0}	Propagation delay time to logic 0 level from clock to output	10.0 ns		150.0 ns

4 J-K FLIP-FLOP

MODEL



FOR SCEPTRE: E1 = f(F01), C1 = f(FCAP1), EQ = f(VC1)
E2 = f(F02), C2 = f(FCAP1), EQB = f(VC2)

FOR CIRCUS-2: V1 = f(F01), R1 = f(RR72), VQ = f(V.C1)
V2 = f(F02), R2 = f(RR72), VQB = f(V.C2)

CIRCUS-2 DESCRIPTION

```
MODELS
MODEL NAME = JK FLIP FLOP
EXTERNAL NODES = (S,RS,CK,J1,J2,J3,K1,K2,K3,Q,QB,GND)
TOPOLOGY
JS,S,GND
JRS,RS,GND
JCK,CK,GND
J1,J1,GND
J2,J2,GND
J3,J3,GND
JK1,K1,GND
JK2,K2,GND
JK3,K3,GND
V1,A,GND
R1,A,B
C1,B,GND
VQ,C,GND
RQ,C,Q
V2,D,GND
R2,D,E
C2,E,GND
VQB,F,GND
RQB,F,QB
JQ,Q,GND
JQB,QB,GND
EQUATIONS
      A1 = AA1
      A2 = AA2
      P01 = F01(P03,V.JRS,V.J1,V.J2,V.J3,V.JQB,V.JRS,V.JCK)
      P02 = F02(V.JQB,P01,V.JS,V.JQB,V.JS,V.JCK)
      P03 = F01(P01,V.JS,V.JK1,V.JK2,V.JK3,V.JQ,V.JS,V.JCK)
      P04 = F02(V.JQ,P03,V.JRS,V.JQ,V.JRS,V.JCK)
      V1 = P02
      D(V1,T) = 0.
      R1 = RR72(V1,V.C1,A1,A2)
      VQ = V.C1
      D(VQ,V.C1) = 1.
      V2 = P04
      D(V2,T) = 0.
      R2 = RR72(V2,V.C2,A1,A2)
      VQB = V.C2
      D(VQB,V.C2) = 1.
      RETURN
      END
END OF INPUT

DEVICES
DEVICE NAME = RSN54L72, MODEL NAME = JK FLIP FLOP
SINGLE VALUED PARAMETERS
JS = 0, JRS = 0, JCK = 0, J1 = 0, J2 = 0, J3 = 0,
JK1 = 0, JK2 = 0, JK3 = 0, JQ = 0, JQB = 0,
AA1 = 600, AA2 = 475, C1 = 100E-12, C2 = 100E-12,
RQ = 100, RQB = 100
END OF INPUT
```

SCEPTRE DESCRIPTION

```
      MODEL RSN54L72 (S-RS-CK-J1-J2-J3-K1-K2-K3-Q-QB-GND)
JK FLIP FLOP RSN54L72
      ELEMENTS
JS,S-GND = 0.
JRS,RS-GND = 0.
JCK,CK-GND = 0.
J1,J1-GND = 0.
J2,J2-GND = 0.
J3,J3-GND = 0.
JK1,K1-GND = 0.
JK2,K2-GND = 0.
JK3,K3-GND = 0.
E1,GND-A = P02
R1,A-B = 100.
C1,B-GND = Q3(E1,VC1,600.E-12,475.E-12)
EQ,GND-C = X1(VC1)
RQ,C-Q = 100.
JQ,Q-GND = 0.
E2,GND-D = P04
R2,D-E = 100.
C2,E-GND = Q3(E2,VC2,600.E-12,475.E-12)
EQB,GND-F = X2(VC2)
RQB,F-QB = 100.
JQB,QB-GND = 0.
DEFINED PARAMETERS
P1 = 0.
P01 = Q1(P03,VJRS,VJ1,VJ2,VJ3,VJQB,VJRS,VJCK)
P02 = Q2(VJQB,P01,VJS,VJQB,VJS,VJCK)
P03 = Q1(P01,VJS,VJK1,VJK2,VJK3,VJQ,VJS,VJCK)
P04 = Q2(VJQ,P03,VJRS,VJQ,VJRS,VJCK)
FUNCTIONS
Q1(A,B,C,D,E,F,G,H) = (F01(A,B,C,D,E,F,G,H))
Q2(A,B,C,D,E,F) = (F02(A,B,C,D,E,F))
Q3(A,B,C,D) = (FCAP1(A,B,C,D))
      OUTPUTS
VJQ(Q OUT),VJQB(QB OUT),PLOT
```

priately. Accordingly, if voltage E1 or E2 is greater than or equal to its respective Q or QB output level, the subprogram for function FCAP1 respectively sets the values of capacitors C1 and/or C2 equal to 300 picofarads. When E1 or E2 is less than its respective output signal, the capacitors are set equal to 250 pF.

In the Circus-2 program, the model's time delays are adjusted by varying resistors R1 and R2, rather than capacitors C1 and C2. This is why the Circus-2 listing calls for subprogram RR72, instead of subprogram FCAP1, which is used in conjunction with the Sceptre listing to vary capacitance.

The output impedances associated with the flip-flop's Q and QB terminals are fixed at 100 ohms. Although this is not an accurate impedance representation for all voltage and load conditions, it does provide first-order accuracy. Zero-valued current sources JQ and JQB are dummy elements that are included in the model to per-

4 J-K FLIP-FLOP

MODEL SUBPROGRAMS

```
CFD1                SUBPRDGRAM FDR JK FLIP FLDP
          FUNCTIDN FD1(A,B,C,D,E,F,G,H)
C         SUBPRDGRAM FDR JK FLIP FLOP
          X = 1.5
          NPART1 = 1
          IF(A.GE.X.AND.B.GE.X) NPART1 = 2
          NPART2 = 1
          IF(C.GE.X.AND.D.GE.X.AND.E.GE.X) NPART2 = 2
          NPART3 = 1
          IF(F.GE.X.AND.G.GE.X.AND.H.GE.X) NPART3 = 2
          NPART4 = 1
          IF(NPART2.EQ.2.AND.NPART3.EQ.2) NPART4 = 2
          FD1 = 0.1
          IF(NPART1.EQ.1.AND.NPART4.EQ.1) FD1 = 3.0
          RETURN
          END
```

```
CFD2                FDR USE WITH JK FLIP FLDP
          FUNCTION FO2(A,B,C,O,E,F)
C         FOR USE WITH JK FLIP FLDP
          X = 1.5
          FD2 = 0.1
          NPART1 = 1
          IF(A.GE.X.AND.B.GE.X.AND.C.GE.X) NPART1 = 2
          NPART2 = 1
          IF(D.GE.X.AND.E.GE.X.AND.F.GE.X) NPART2 = 2
          IF(NPART1.EQ.1.AND.NPART2.EQ.1) FO2 = 3.0
          RETURN
          END
```

mit computer monitoring of the output signals under varying performance conditions.

Modeling the J-K flip-flop

The RSN54L72 master/slave flip-flop changes state on the negative-going edge of the clock pulse. As indicated in Fig. 3, it features multiple J and K inputs with direct preset (S) and clear (RS) capability for asynchronous operation. Logic information present on the J and K inputs, plus information fed back from the complementary Q and QB outputs, sets the flip-flop's master section. With the clock input at logic 0, the master section is isolated from the slave section. As soon as the clock pulse rises and reaches its threshold level of 1.5 v, the logic information on the J and K inputs is entered into the master section. When the clock is at logic 1, the master and slave sections remain isolated. But, once the clock pulse falls to its threshold level, the logic information at the output of the master section is transferred to the slave section, which controls the flip-flop's output.

Provided that the signals on the J and K inputs remain stable during the clock transitions, the flip-flop's performance will agree with its truth table whenever the clock goes from logic 1 to logic 0. Because the flip-flop operates on dc levels rather than dynamic signal changes, maximum rise and fall times are not imposed on the clock signal or the J and K signals. The asynchronous preset and clear inputs, which are active when they are low (logic 0), may be applied at any time and will override the effect of the clock input pulse.

The truth table given in Fig. 3 for the J-K flip-flop applies for high (logic 1) preset and clear signals. The device's significant electrical characteristics are also given in this figure. (The device's propagation delay characteristics look the same as those drawn in Fig. 1 for the D-type flip-flop.)

The computer model for the J-K flip-flop, the Sceptre and Circus-2 model descriptions, and the subprograms needed to establish the flip-flop's output signal levels are shown in Fig. 4. Again, as for the D-type flip-flop, all input impedance levels are taken to be infinite as a first-order approximation.

The voltages associated with dependent sources E1 and E2 are determined by the functions FO1 and FO2, which simulate the flip-flop's master and slave sections, respectively. The output signals for the master and slave sections are saved as DEFINED PARAMETERS to avoid confusion if multiple flip-flops are called for as part of a network description. DEFINED PARAMETERS PO1 and PO3 are the output signals of the master section, while DEFINED PARAMETERS PO2 and PO4 are the output signals of the slave gates. These DEFINED PARAMETERS are also used in the latching function—a signal greater than or equal to 1.5 v is a logic 1, and a signal less than 1.5 v is a logic 0.

Since the flip-flop triggers on the negative edge of the clock pulse, the model senses the level of the clock signal and transfers input information in two steps. As the clock signal rises above 1.5 v, input signals are transferred to DEFINED PARAMETERS PO1 and PO3 as determined by function FO1 (the master section of the flip-flop). When the clock signal falls below 1.5 v, the data stored in DEFINED PARAMETERS PO1 and PO3 is transferred to DEFINED PARAMETERS PO2 and PO4 as determined by function FO2 (the slave section of the flip-flop). Input signals, therefore, enter the flip-flop's master section during a high clock signal and are transferred to the slave section during a high-to-low clock transition (the negative edge).

The delay times, t_{pd1} and t_{pd0}, for the model are established by time constants R1-C1 and R2-C2. These are adjusted by varying the values of capacitors C1 and C2, depending upon whether a logic 1 or logic 0 is the output signal. Capacitor values are determined by the same subprogram used for the D-type flip-flop, FCAP1 in Fig. 2. Again, for the Circus-2 program, the values of resistors R1 and R2 are varied by means of routine RR72 to adjust the model's time-delay characteristics.

Capacitor C1 is set equal to 600 pF, unless voltage E1 is greater than or equal to the voltage across C1 (VC1); then C1 assumes the value of 475 pF. Capacitor C2 is found similarly. Since output voltage EQ and EQB are equal to capacitor voltages VC1 and VC2, respectively, a relationship between input-signal and output-voltage levels is readily established.

Output impedances RQ and RQB are fixed at 100 ohms each, which provides good first-order accuracy for output signal level. To duplicate actual impedance variations, resistors RQ and RQB can be made variable and expressed as functions of the load voltage and currents. And, as noted for the D-type flip-flop, the zero-valued output current sources, JQ and JQB, are dummy elements that permit monitoring the J-K flip-flop's output signal under varying conditions. □

No-ladder d-a converter works from one 5-V supply

by E. Insam
Chelsea College, University of London, London, England

An 8-bit digital-to-analog converter that operates from a single positive 5-volt supply can be built without the usual front-end ladder network. This is done by creating a pseudo-random binary generator that is driven by a free-running multivibrator at a nominal clock frequency of approximately 5 megahertz. The multivibrator also provides the -5-V supply line for the converter's operational amplifier.

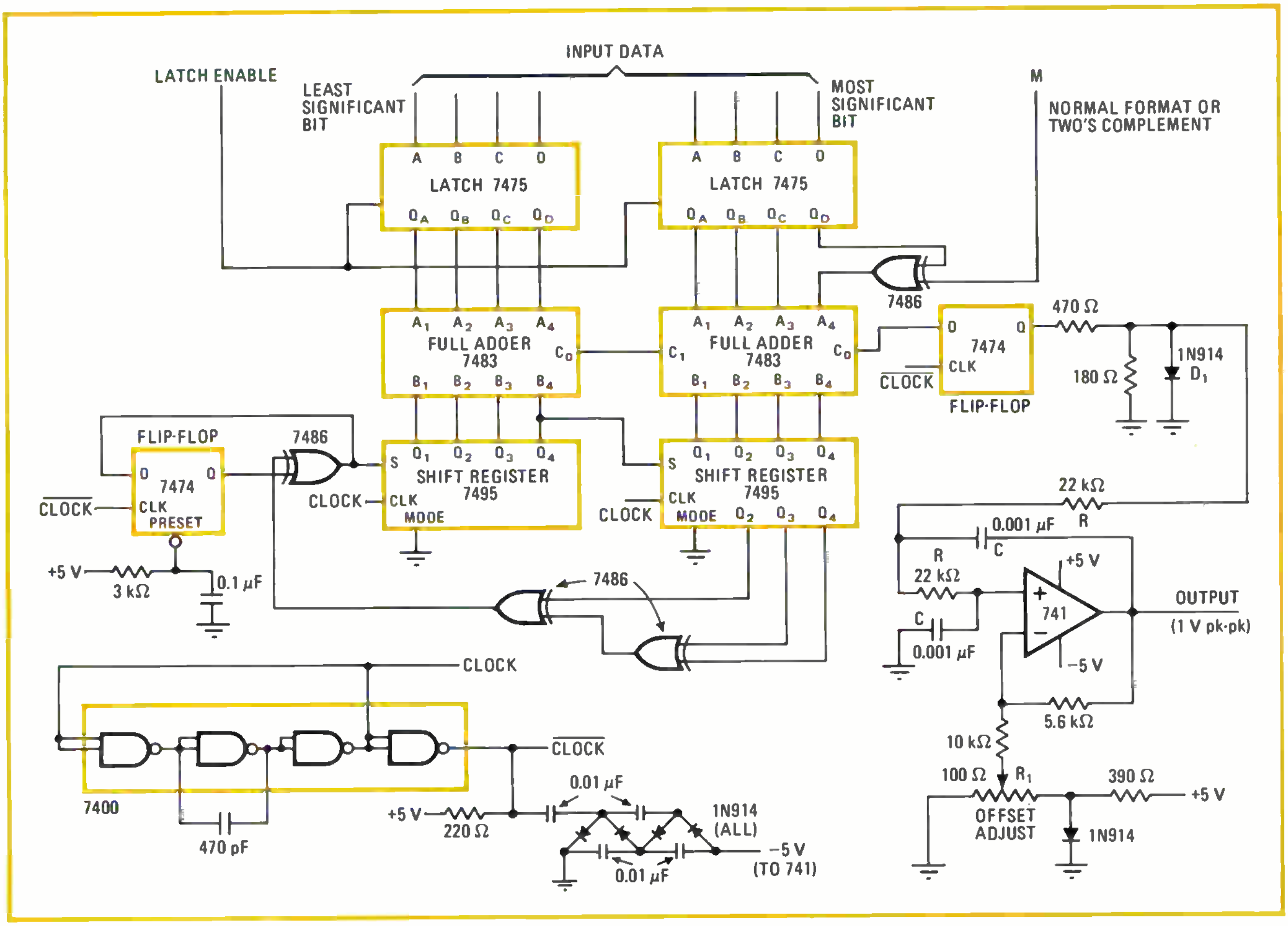
The output from the binary generator is compared (by subtraction) with the 8 input data bits. These can be in either a normal format or a two's-complement format, depending on the control input M. The carry output from the full adders is a pulse train whose mean value is proportional to the input data and is clamped to about 0.6 V by diode D_1.

This pulse train is then fed to an active Butterworth low-pass filter formed by the op amp and its associated components. In the circuit given here, the gain of this stage is set at 1.59 to give the necessary filter-pole positions and to bring the peak-to-peak output amplitude of the converter to 1 V. Potentiometer R_1 controls the dc shift of the analog output.

The quantizing noise consists of harmonic multiples of the clock frequency divided by 255. In this case, the lowest harmonic occurs at around 20 kilohertz, which is beyond audibility. The cutoff frequency ($\omega = 1/RC$) of the Butterworth filter is around 7 kHz. The circuit's gain accuracy, which is not a major concern for audio work, depends only on diode D_1 and the closed-loop gain of the op amp.

The transistor-transistor-logic version of this d-a converter consumes around 300 milliamperes. If low power drain is an important design factor, complementary-MOS devices can readily be substituted, reducing the current consumption to around 40 mA. □

From digital to analog. Instead of the conventional ladder network followed by an op amp, this d-a converter employs a pseudo-random binary generator and an active low-pass filter. The generator's outputs and the 8 input data bits are subtracted in the full adders, resulting in a "carry" pulse train that drives the filter. Only one positive 5-volt supply is needed to power the entire circuit.



Dc restorer for video use offers ultra-stability

by Roland J. Turner
AEL Communications Corp., Lansdale, Pa.

A sample-and-hold technique, along with strong degenerative feedback, permits an active dc restorer to operate with very high stability over a wide temperature range. Restoration stability can be maintained to within 30 microvolts, even in the presence of a dc offset voltage as large as 100 millivolts.

The circuit is useful in radar applications, where it is often essential to peak-detect or integrate video signals relative to a stable dc reference. This is especially true if the video sensor contains diodes that have a temperature-dependent offset voltage.

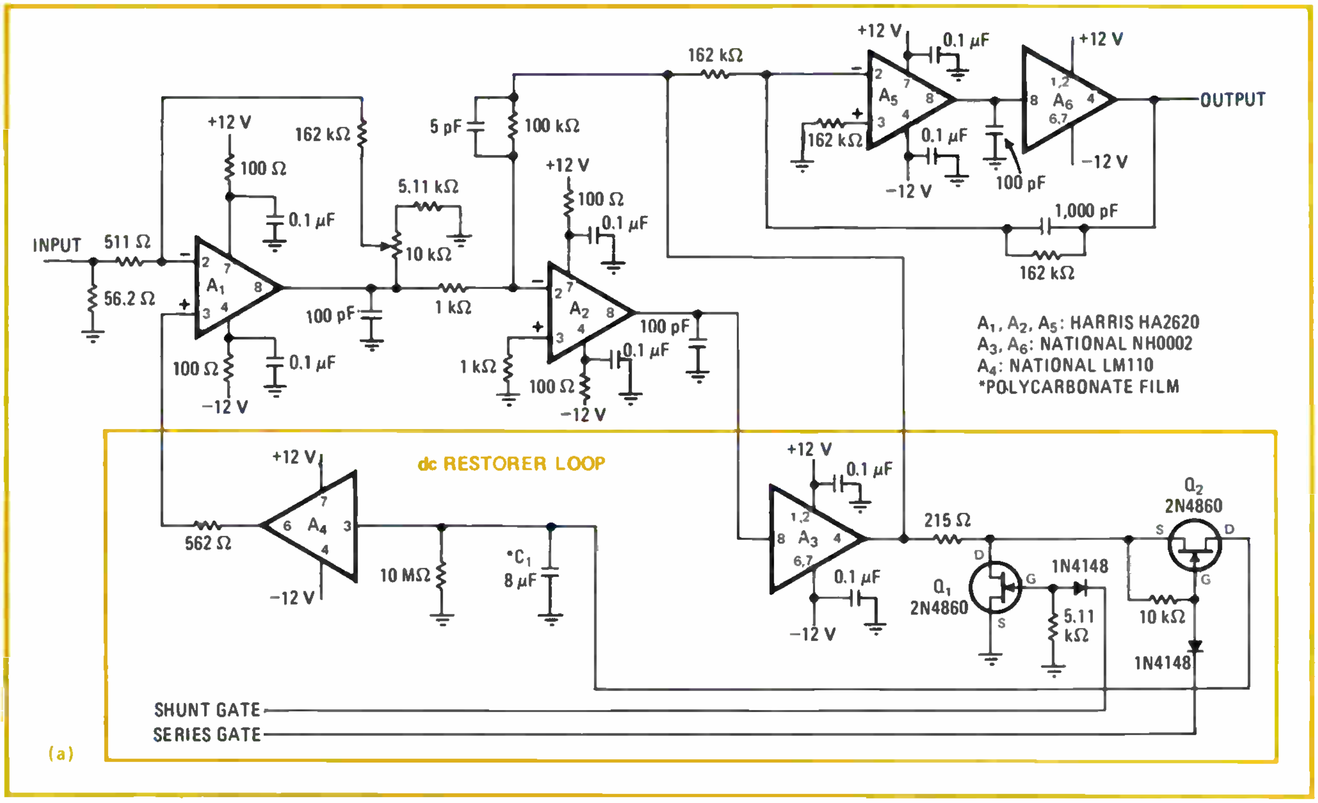
The dc restoration must be performed without any temperature-induced offset voltage, since dc coupling must be preserved in the video processing (peak detection or integration) following dc restoration. Accurate signal detection, then, heavily depends on providing a stabilized dc restoration level. The video output signals must be independent of any thermal variations that may occur in the video detector and dc restorer.

Conventionally, a dc restorer operates at relatively high signal levels and requires considerable video gain prior to dc restoration. Moreover, a dc restorer generally employs a temperature-compensated zener diode, and two matched diodes to keep the dc restored level relatively constant over a wide temperature range. But even with the best matched diodes and the most stable temperature-compensated zener, the dc restored level cannot be made more stable than ±10 mv over a 100°C temperature range. With the dc restorer shown here, however, stabilities of 30 μV can be established at extremely low video levels.

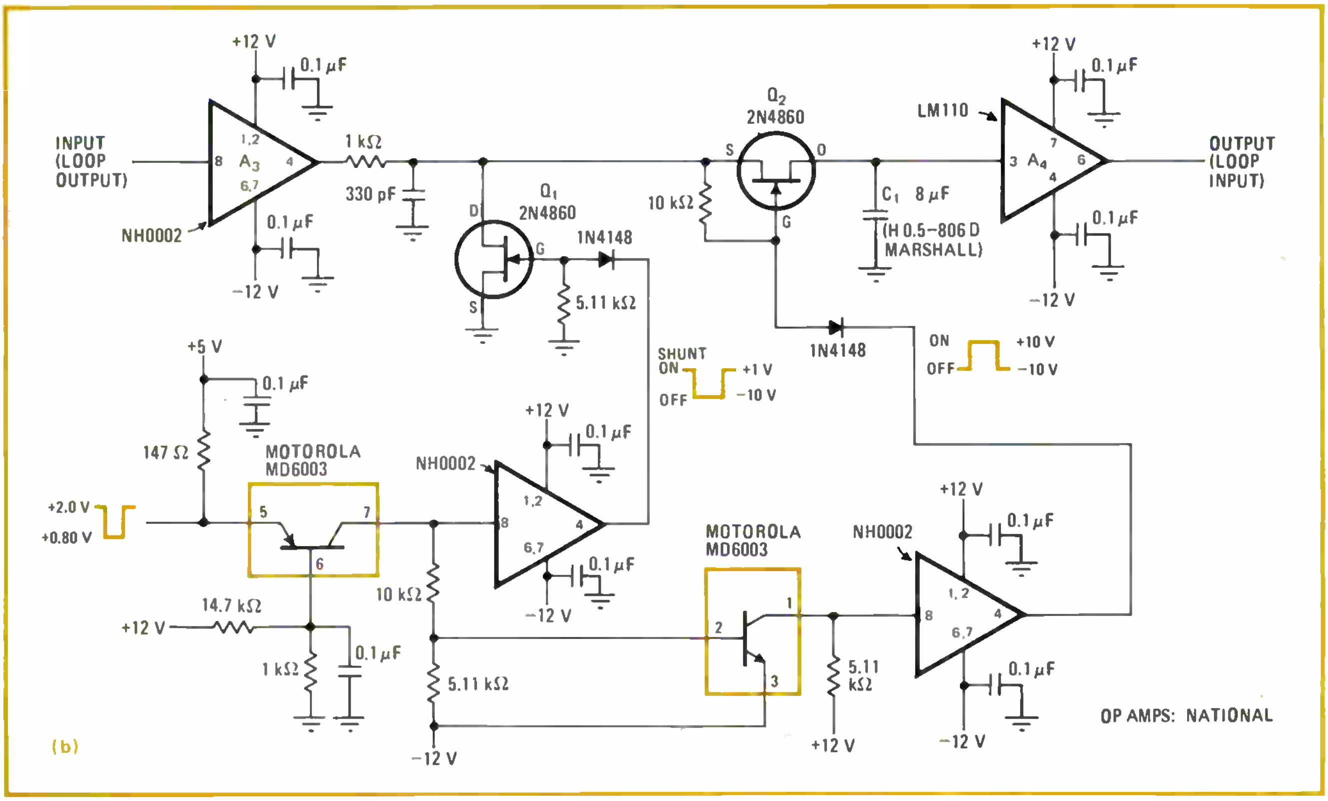
A complete video amplifier employing this improved dc restoration technique is drawn in (a). In this circuit's sample-and-hold scheme, the dc output of a dc-coupled amplifier is sampled over a 50-microsecond gating interval. It should be noted that dc coupling must be maintained from the input (sensor) through to the output integrator or peak detector. As a result, dc signal changes longer than the sensor's thermal time constant, which is typically less than 10 milliseconds, can be recognized as a valid signal/target by the peak detector or integrator.

The full schematic of the dc-restorer section of the video amplifier is given in (b). During the dc-restoration interval, the FET shunt gate, Q_1, is open, while the FET series gate, Q_2, is closed. During the gating interval, sampling capacitor C_1, which is a highly temperature-stable polycarbonate-film capacitor, charges to the average noise level present at the output of amplifier A.

When the sampling gate is closed, the circuit's sampling process activates a degenerative-feedback loop that forces the average signal value at A_3's output to approach the signal-noise level. In effect, the dc level at the noninverting terminal of input amplifier A_1 is forced to match the dc level at A_1's inverting terminal to



Emphasizing stability. Dc restoration loop of video amplifier (a) allows the amplifier to match dc input levels to within 30 microvolts, in spite of widely varying temperatures. The sample-and-hold circuitry of the dc restorer loop is shown in (b). During the gating interval, which is 50 microseconds long, FET shunt gate Q_1 is off, FET series gate Q_2 is on, and capacitor C_1 (a temperature-stable unit) charges.



within 30 μV. During the signal processing interval, when shunt FET gate Q_1 is on and series FET gate Q_2 is off, the voltage across capacitor C_1 establishes an ultra-stable dc-restored level at the positive input to amplifier A_1 as a reference for detecting whatever video signals may be present at the negative input of A_1.

To realize a high degree of dc-restoration stability within the gating aperture, it is essential to select op amps for amplifiers A_1 and A_2 that have fast slew rates. This is why Harris' type HA2620 op amp, which has a gain-bandwidth product of greater than 30 megahertz, is used for both A_1 and A_2. Amplifier A_4 is a high-stability buffer that serves as a high-input-impedance load for the sampling capacitor, C_1.

This active dc restorer can reduce a 100-mV dc offset at the sensor to an equivalent dc offset of less than 30 μV. And because of the low leakage of the sampling gate, the stored charge on capacitor C_1 is not disturbed during the hold interval, even if a 10-V signal is present at the gate input.

The forward gains (80 decibels) of amplifiers A_1, A_2, and A_3 contribute to the degenerative-feedback loop during the dc restoration interval, forcing A_1's positive input to follow the dc offset present at A_1's negative (sensor) input. The circuit's integrating stage containing amplifiers A_5 and A_6 must be placed outside the dc-restoration loop, since the fast slew rate of the forward-control loop must be preserved during the dc restoration interval.

For the circuit to operate properly, the input-signal condition must be known during the dc-restoration interval. In radar systems, this time occurs between pulse transmission and signal reception; for television signals, this time occurs during the sync tip transmission. □

Regulator for standby supply handles large load currents

by James Allen
Honeywell Inc., Aerospace Division, St. Petersburg, Fla.

A simple voltage regulator for a standby-power source can supply amperes of current at whatever voltage is required. Additionally, the circuit, which includes current-limiting and short-circuit protection (current foldback), can produce large current pulses.

There are many systems that require noninterruptible power sources—for example: gyro test stands involving long test sequences, volatile semiconductor memories, and computer systems or test systems where a power failure cannot be tolerated because it may destroy components or mean going through long start-up sequences.

If the primary dc supply fails, either because of internal malfunctions or because of some line disturbance that momentarily causes an interruption in its ac source, the standby power supply cuts in and continues to supply the necessary load current. Usually, the power source for this standby or backup supply is a bank of storage batteries. However, the voltage level provided by these storage batteries is not normally the voltage level needed by the backup supply for the system.

The regulator in the figure offers ample voltage and current capability. And it can be conveniently and easily tailored to suit a specific application. (The figure also contains plots of the regulator's dc-output characteristic and pulse-current performance.)

The zener voltage of the zener diode determines the output voltage at which the regulator begins to conduct. Current limiting is provided by the combination of control transistor Q_1 and field-effect transistor Q_2, which acts as a voltage-variable resistor. The current-limit level is set by the ratio of resistor R_1 to resistor R_2:

$$I_{max} = 3.1[1 + (R_1/R_2] \text{ amperes}$$

The current foldback of the regulator is obtained through transistor Q_3 and resistor R_3. The voltage level (V_f) at which foldback begins is determined by the ratio of resistor R_4 to resistor R_5:

$$V_f = [R_5/(R_4+R_5)](V_B - V_Z - 2V_{BE3} \text{ volts}$$

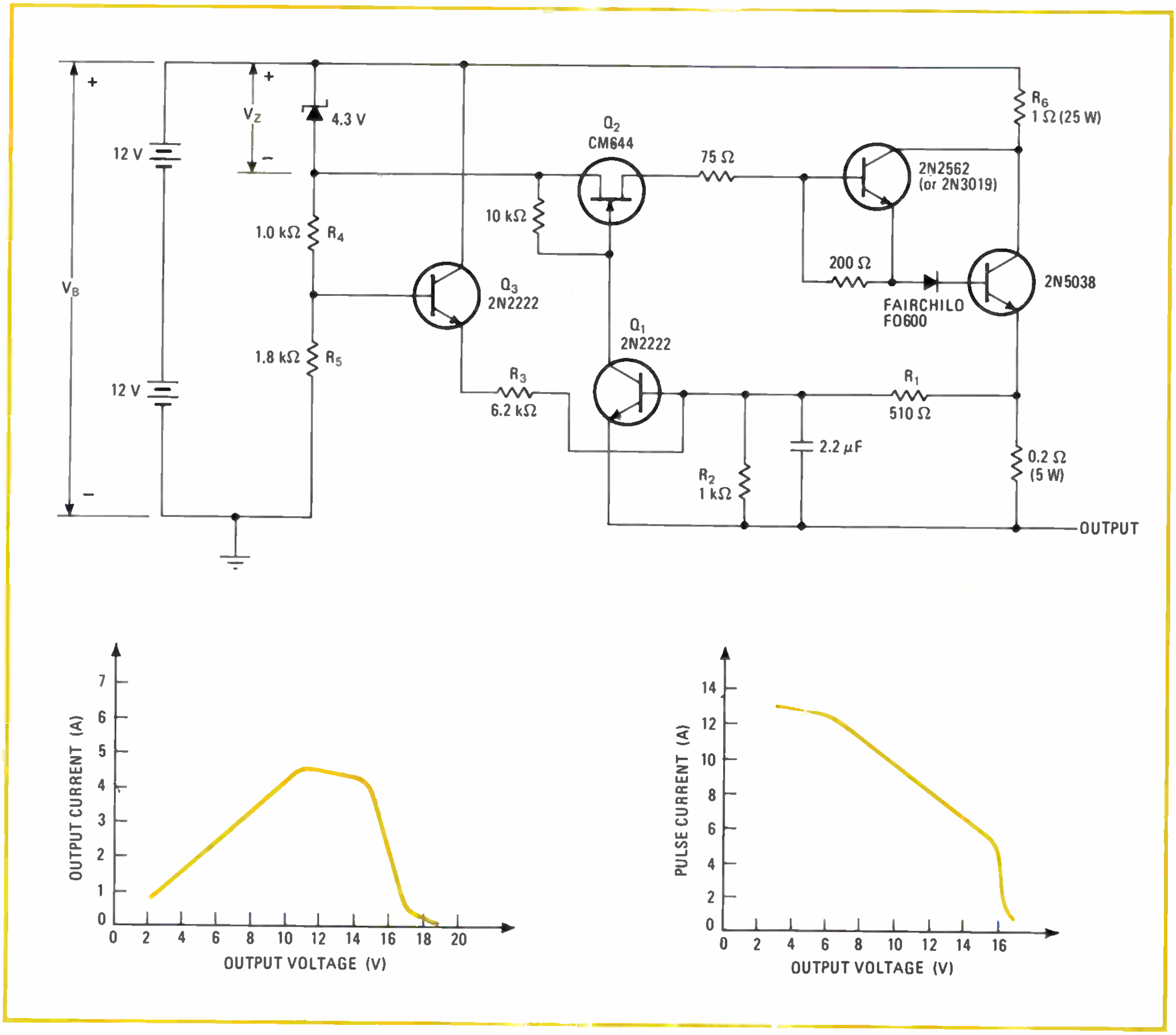
where V_B is battery voltage, V_Z is zener voltage, and V_{BE3} is base-emitter voltage of Q_3. The slope of the current foldback curve is set by the ratio of R_1 and R_3.

$$\Delta V/\Delta I = 0.2R_3/R_1 \text{ V/A}$$

Since the regulator will normally be operating into a large-capacity load that will probably exhibit large dv/dt variations initially, it should be able to supply a significantly larger amount of charge during turn-on. This pulse current capability is provided by the capacitor, which delays the feedback current so that transistor Q_1 does not conduct for several hundred microseconds. The magnitude of this pulse current is determined by the value of resistor R_6. □

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.

Watchdog backup power source. Readily adaptable regulated standby-power supply can produce several amperes of current at the desired voltage level, as shown by its output characteristic. The circuit's pulse-current capability (also plotted) is ample and able to satisfy large initial turn-on load current demands. Both current limiting and current foldback are included to protect the regulator circuit.



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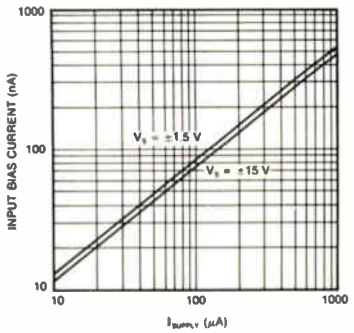
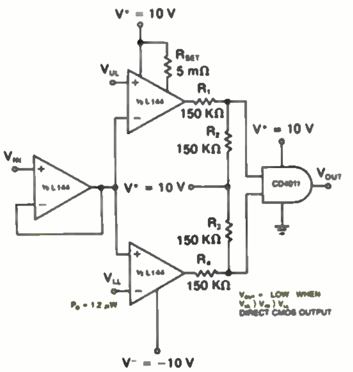
[1] L144CJ 100-piece price



Applications examples:



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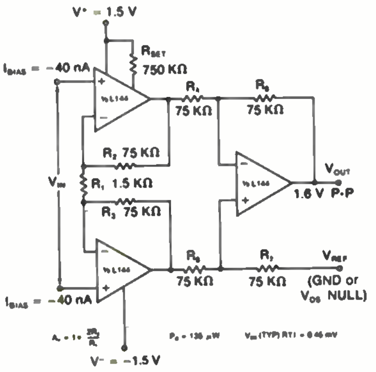

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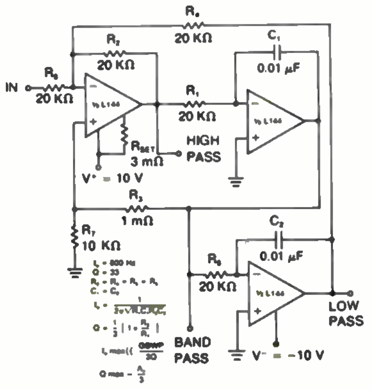

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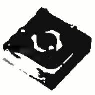

Even though this multipurpose device features a small case (.75x.75x.50 inches), it can handle an average rectified current of 5A at 55°C case temperature. Single cycle surge rating of 50A and available in PIV from 50 to 600V.

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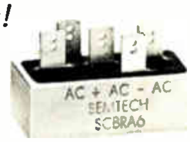

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Digital logic circuit reads phase difference

by Demetrios K. Kostopoulos
Dalmo Victor Co., Belmont, Calif.

The phase difference between two sinusoidal waves of the same frequency can be measured digitally if the phase difference is converted into a time difference and the time difference is converted into a number of pulses. A count of these pulses then serves as a numerical representation of the phase difference between the two input wave forms.

The basic outline for this simple and inexpensive digital phase meter is shown in the diagram. Signal A is the reference sinusoidal waveform, while signal B is the sinusoidal waveform whose phase (relative to signal A) is to be determined. Both signals must have the same frequency, but they may differ in amplitude. The waveforms are converted into square waves by means of the voltage comparators, and two square waves are then ANDed together.

The output of comparator $COMP_A$ is low when signal A is positive and high when signal A is negative. The opposite is true for the output of comparator $COMP_B$. This makes it possible to detect any phase difference between the two waveforms. When they do not overlap, both comparator outputs are high for a length of time that is proportional to the phase difference between signal A and signal B.

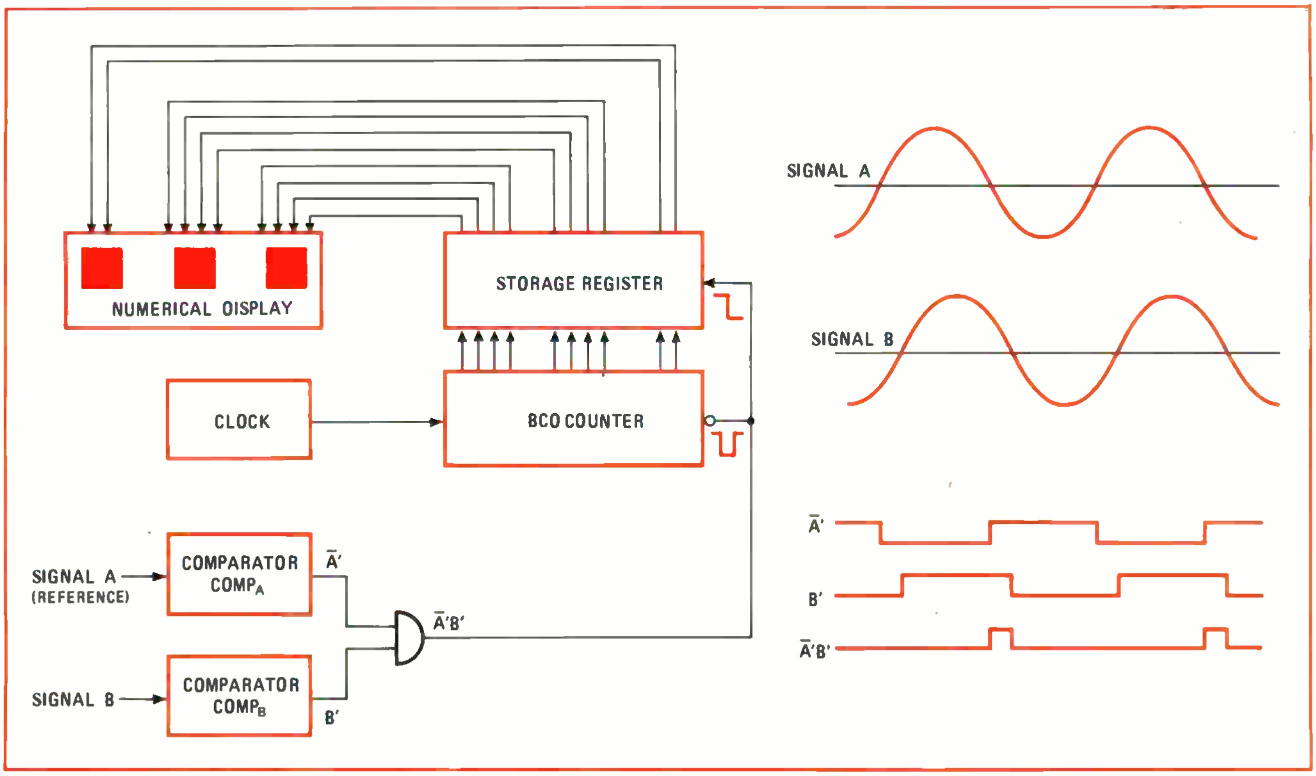
The function of the AND gate is to clear and enable the binary-coded-decimal counter. When both gate inputs are high, the gate output is also high, and the counter is enabled. The counter is cleared when the gate output goes low. The number of gate-output pulses logged by the counter is directly proportional to the time that the gate output is high. Therefore, the final number in the counter is directly proportional to the phase difference between input wave form A and input waveform B.

During the high-to-low transition of the gate output, the counter output is stored in the register. This storage register drives a set of numerical readouts that display the phase difference. The phase weight of the least-significant digit in the display is:

$$\Delta\phi = 360°(f_s/f_c)$$

where f_s is the signal frequency, and f_c is the clock frequency. If $f_c = 360 f_s$, then the units of the displayed number are whole degrees; and if $f_c = 3{,}600 f_s$, the units become tenths of a degree. □

Determining phase digitally. Straightforward approach permits standard logic ICs to be used for measuring phase—the phase difference between sinusoidal inputs A and B is converted into a time difference. When the square-wave outputs from the comparators overlap, a phase difference exists, and the AND-gate output goes high, enabling the counter. The final count is stored in the register for display.



Liquid crystals isolate electrical short circuits

by Roger Anderson
Honeywell Information Systems, San Liego, Calif.

Isolating a short circuit on a circuit board or back panel is relatively simple when only single-circuit paths are involved. But it grows progressively more difficult as the number of common voltage and ground paths is increased.

Surprisingly, encapsulated liquid crystals can greatly simplify finding short circuits in this situation. Besides saving money and parts, testing with liquid crystals can also significantly reduce trouble-shooting time. Other techniques for isolating electrical shorts call for unsoldering or clipping component leads, or increasing the current through the unit being tested until a hot spot or smoke is detected.

Sheets of encapsulated liquid crystals have been used successfully to detect: solder bridges on printed-circuit and wire-wrapped boards; wire shorts on wire-wrapped boards and back panels; internal shorts of such components as capacitors and delay lines; and internal shorts on multilayer boards from a pin to an etch, from a pin to a voltage or ground bus, and from one etch to another etch. Encapsulated liquid crystals can also be used for detecting shorts in cables or harnesses, or wherever multiple- or common-circuit paths exist.

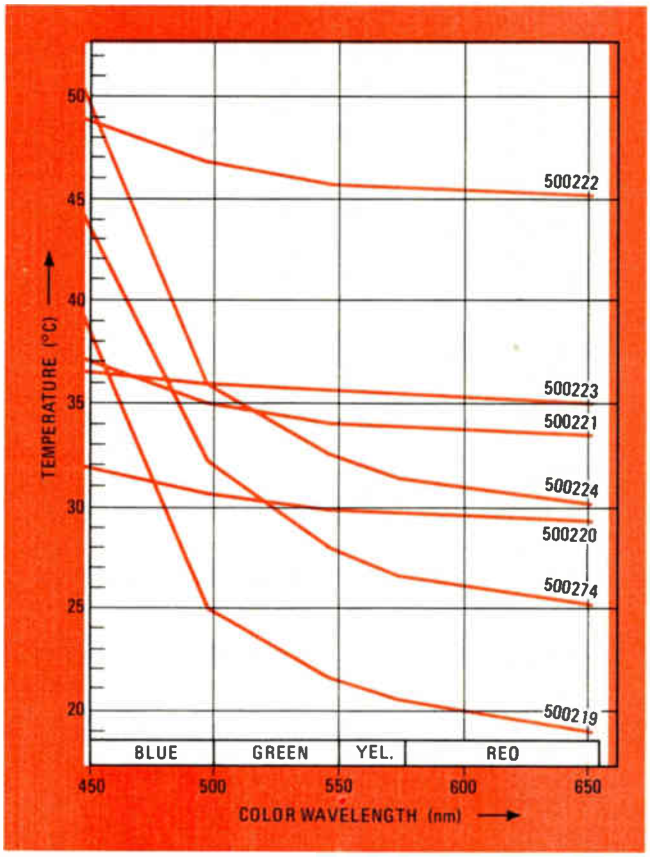
Liquid crystals are usually derivatives of cholesterol that exhibit the mechanical properties of a liquid and certain optical properties of a solid. They have a rather unusual characteristic—the capacity to reflect different wavelengths of light with variations in temperature so that they visibly change color. Liquid crystals have a reproducible color range within specified temperature limits.

Since the colors are derived from scattered incident light, they are most visible when observed against a dark background, like black ink. The black ink can absorb any light transmitted through the liquid crystals and allows the selectively (determined by temperature) reflected light to be viewed.

Encapsulated liquid crystals can be supplied as Mylar sheets, and the colors can be seen through the Mylar. (The capsules containing the liquid crystals are actually too small, between 20 and 40 micrometers in diameter, to be seen with the naked eye.)

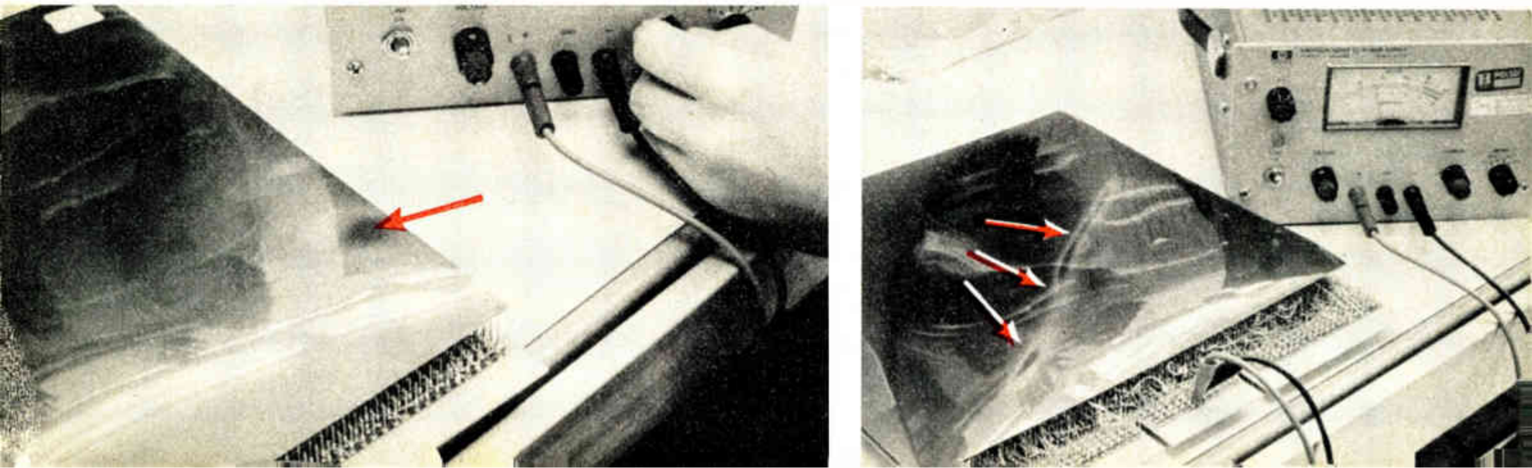
The sheets have very definite temperature and color ranges, as shown by the graph in the figure. These particular sheets can be bought from Edmund Scientific Co., Barrington, N.J.

All the liquid-crystal sheets exhibit the total spectrum of colors as temperature changes. Blue colors are associated with warmer temperatures, reds with cooler. Because the colors result from scattered (reflected) incident light, they will be more intense if a bright light source is used. The number 500274 sheet is best for indicating electrical shorts because it produces a bright



Sample lot. Every sheet of encapsulated liquid crystals has its own color response over a given temperature range. The sheets shown here are sold by Edmund Scientific. The one numbered 500274 is a good choice for isolating electrical short circuits.

Making shorts colorful. In left photo, a bright blue spot of the liquid-crystal sheet pinpoints a shorted capacitor on a wire-wrapped circuit board. In the right-hand picture, a shorted wire traces its own path as a blue streak of color across the liquid crystals.



blue spot that shows up well against a dark brown background at the start.

The liquid-crystal sheet must be placed directly on the circuit under test. The closer the liquid crystals are to the faulty part, the more readily the short will be detected. To locate faults in hard-to-reach places, the sheet can be cut into narrow strips that are laid directly on the suspect components.

By carefully controlling the amount of current applied to the circuit, it's possible to locate the short without damaging wires or good components. The current flow is concentrated through the shorted device and/or path, and the liquid-crystal sheet changes color precisely at the location of the short because of the heat the short generates, as shown by the left photograph.

As little as 12 milliwatts of dissipated power at a shorted junction will cause a color change in the sheet. The greater the current that can be safely applied, the easier it will be to find the short because of the increased heat generated. Even a shorted wire on a back panel is generally easy to identify, since its position is traced in color across the entire sheet, as the other photograph indicates. Special care should be taken not to exceed the rated current capacities of the wires. □

Regular stereo amplifier can be variable ac source

by M.J. Salvati
Sony Corp. of America, Long Island City, N.Y.

Here's how to turn an ordinary hi-fi stereo amplifier into the power supply for a variable-frequency power source. The setup produces a regulated ac output voltage that typically contains less than 0.2% distortion and that is adjustable from 0 to 130 volts root-mean-square at any frequency between 50 and 400 hertz.

The two channels of the stereo amplifier are driven 180° out of phase with each other so that the load can be connected differentially across the amplifier's "hot" output terminals. This technique avoids the inherent danger of paralleling the outputs of a transistorized power amplifier.

The output power available depends primarily on the particular power amplifier used. (About 220 watts can be obtained from an amplifier like the Sony TA-3200F.) Naturally, the amplifier's power bandwidth characteristics must satisfy the application. Usually, any oscillator that has an rms output of 5 V with less than 0.05% distortion will be adequate. If the precise operating frequency matters, then the oscillator's frequency accuracy and stability also are important. In some applications, a frequency counter might be a useful addition.

Variable-frequency power sources are available commercially as single-package systems costing from $700 to $1,100 for a 250-W unit. But all the equipment required for the setup shown in the diagram can be purchased new for less than $600. And even greater saving can normally be realized, since a suitable oscillator is generally available in most laboratories. If a suitable hi-fi amplifier can also be "found," the cost of the complete setup can be pared to a mere $35.

Transformer T_1 provides two equal-amplitude but opposite-phase drive signals for the power amplifier. Since most hi-fi power amplifiers have an input impedance of around 50 kilohms, impedance matching need not be considered. Transformer T_1 must have a good low-frequency response and a turns ratio that provides the proper drive level for the power amplifier. Generally, a turns ratio (from primary to each half of the secondary) of 1:1 or 2:1 is suitable for most oscillator/amplifier combinations.

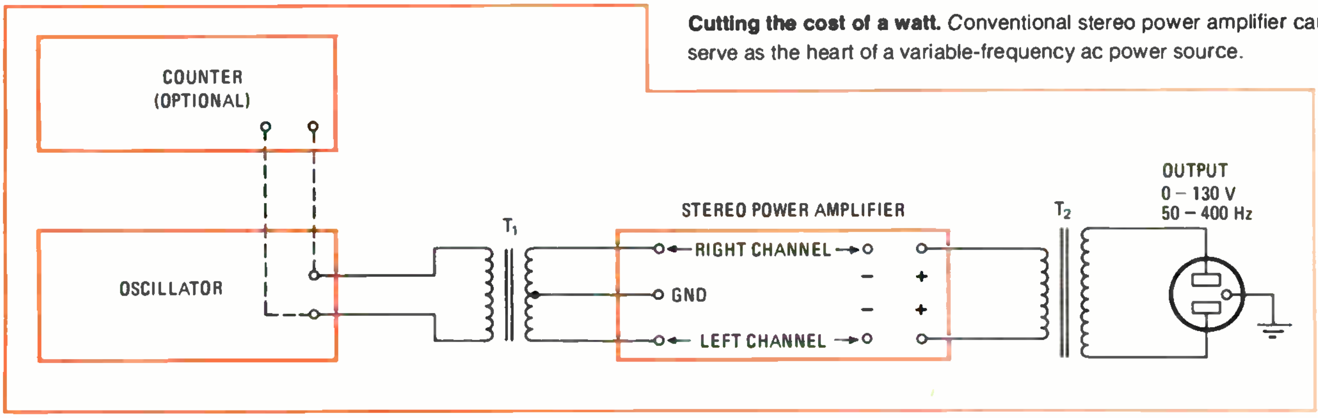
A good frequency response from 50 to 400 Hz is also essential for transformer T_2. The turns ratio required for T_2 depends on the power-output rating and load characteristics of the power amplifier. To determine T_2's turns ratio, it's necessary to compute the amplifier output voltage (per channel) appearing across the specified load impedance (which is usually 8 ohms) at the maximum rated power output:

$$E = \sqrt{P_{out}R_{load}}$$

Since transformer T_2 is operated "backwards," select a 120-V power transformer with a secondary voltage rating that is twice this calculated amplifier voltage. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

Cutting the cost of a watt. Conventional stereo power amplifier can serve as the heart of a variable-frequency ac power source.



Engineer's newsletter

Connectors are not guilty of pulse degradation

Digital designers who'd like to blame their connectors for the trouble they have with pulse shapes and pulse degradation in high-speed logic systems had better forget it. According to Paul Messinger of ITT's Cannon Electric Co., **the common technique of testing the pulse-conducting properties of connectors by wiring them all in series and observing the pulse for degradation is not valid.** More often than not, he says, any trouble observed is a transmission-line effect, arising from the length of line over which the signal is transmitted.

In an award-winning paper presented at the recent IEEE Connector Conference in Chicago, Messinger showed that **even the smallest connector discontinuity would produce a pulse discontinuity greater than 10 microseconds—and the pulse discontinuities encountered in practice are usually no larger than 1 ns.** "Look to your circuit designs for the trouble, and not to the connectors," suggests Messinger.

Optical isolators save power . . .

In these days of power shortages and fluctuating line voltages, optical isolators deserve another look. **They can be used to isolate digital logic from the ac power line**—for instance, power can be conserved in control applications by substituting one for the reed relay that's normally inserted between the digital control circuit and the triac or SCR output of a solid-state relay. **In data transmission applications, an opto-isolator can serve as a line receiver;** having no ground return, the isolator eliminates ground-loop noise between a remote terminal and a central processor. Tips are courtesy of application specialists Stu Harris of Fairchild and Bob Farrall of Clairex.

. . . and FETs can handle more power

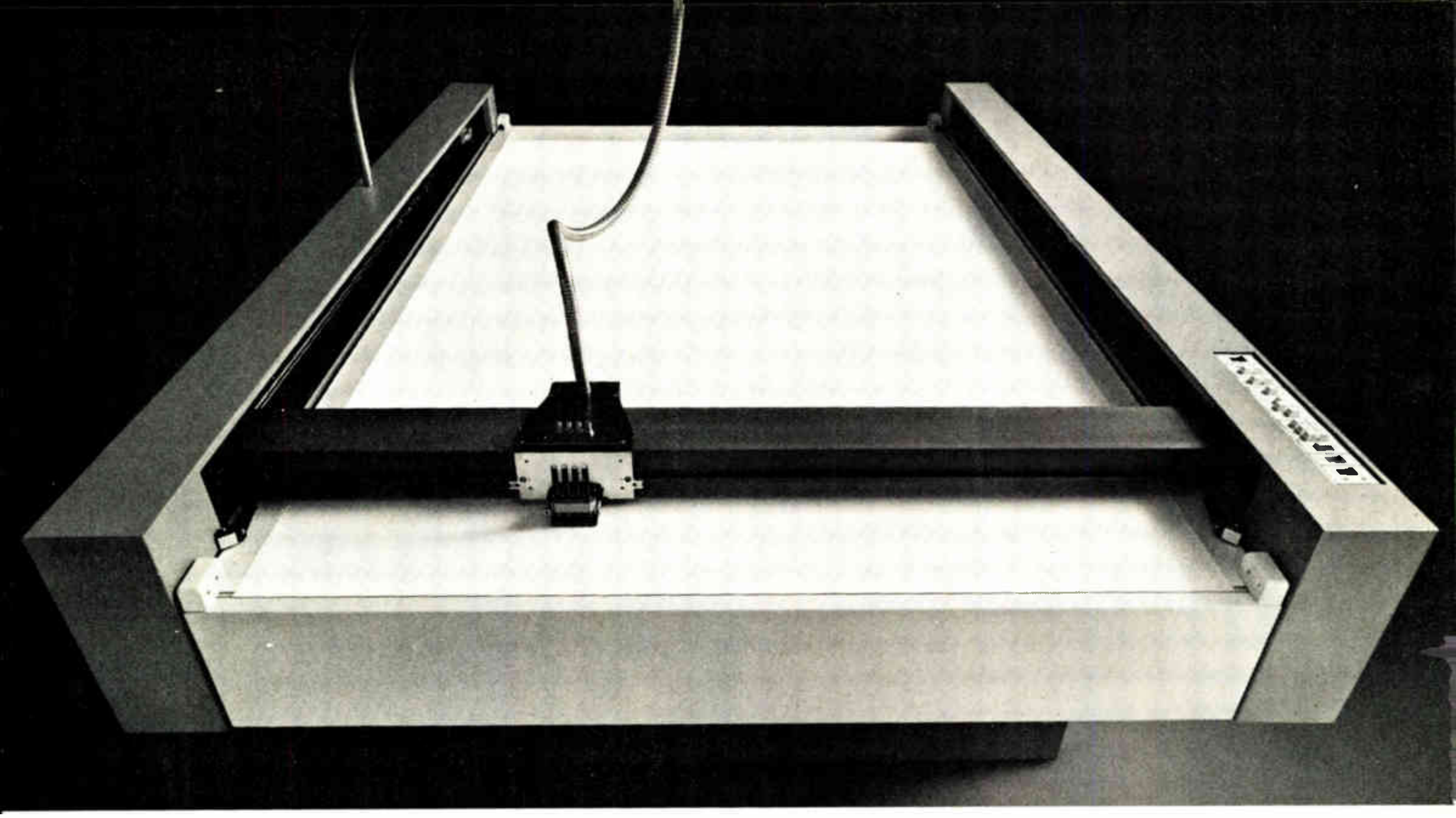
Now that microwave field-effect transistors are beginning to rival bipolar power transistors, it's time to start considering them for microwave power amplifier designs. **A 6-gigahertz FET delivering 0.63 watt with 1-decibel gain compression** was reported at the recent National Telecommunications Conference by engineers at RCA Laboratories, Princeton, N.J. **Other power devices operating up to 1 watt at S band** are being developed at Westinghouse Research Laboratories, Pittsburgh, Penn.

How to replace a selenium with a silicon rectifier

Have you ever needed to replace a selenium rectifier? A silicon rectifier would, of course, be ideal—if you knew what ratings it needed. Well, **a selenium rectifier can be its own data sheet,** says Richard W. Adams, a senior technician at Burroughs Corp. in Hollywood, Fla. **To determine the reverse-voltage rating,** count the plates in the selenium rectifier and multiply this number by 75 V. Then find the area of one plate (in centimeters) and multiply it by 0.07 ampere **to obtain the maximum current the rectifier can handle at 75% efficiency.** (Remember that efficiency decreases with age.) For safety and added reliability, choose a device with ratings that exceed these computed values.

Items wanted

If you've run into a tricky design problem recently and found a neat solution, or if you've any other design tips, we'd be glad to hear about them. Send them in to the attention of Senior Editor Laurence Altman. Any item used will be credited to you and your affiliation.



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Logic scope handles 50-MHz data rate

Asynchronous instrument has dual-threshold detectors; CRT displays all control settings, as well as timing diagram of circuit under test

by Michael J. Riezenman, Instrumentation Editor

In the instrumentation field, 1973 will be remembered as the year of the logic scope—that new class of instruments that displays sequences of logic states in much the same way that oscilloscopes display voltage waveforms. Accustomed as one may be to the speed of developments in electronics, it is nevertheless remarkable that since their introduction last spring, logic scopes have already evolved to their second generation.

The first of these second-generation instruments is the AMC 1320 Digiscope made by E-H Research Laboratories of Oakland, Calif. Unlike its predecessors, which are all 10-megahertz instruments, the Digiscope has a maximum resolution of 20 nanoseconds per bit, allowing it to handle data rates as high as 50 MHz.

More significant than its increased speed, however, is the Digiscope's use of dual-threshold detectors. These detectors, which have separate thresholds for the logic 1 and logic 0 states, allow the instrument to detect low-amplitude 1s, high-amplitude 0s, slow rise and fall times, ringing, and the presence of spikes.

Unlike most earlier logic scopes, the Digiscope is an asynchronous instrument that runs off its own internal crystal-controlled clock. Thus it can easily be used to test asynchronous, as well as synchronous, logic systems.

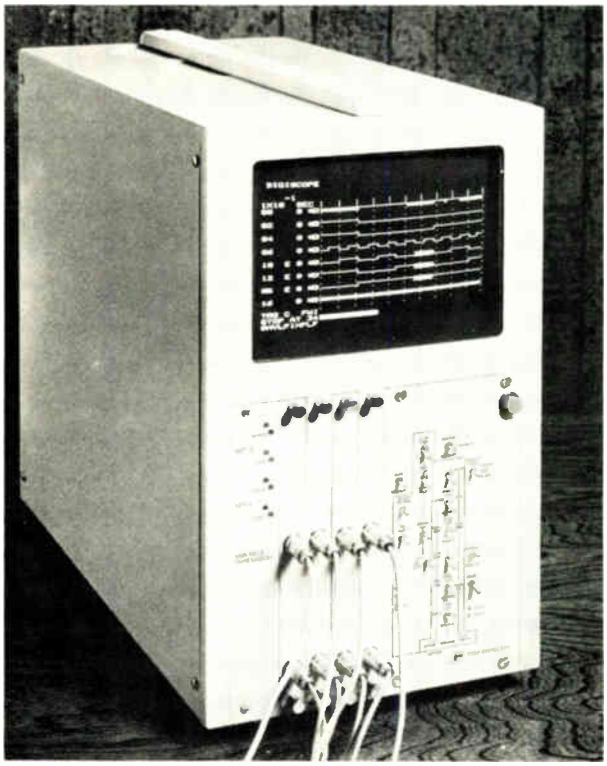
Finally, the Digiscope uses a cathode-ray-tube display on which are shown not only the logic sequences being measured but all of the control settings for the instrument, as well. Thus, a photograph of the screen contains all of the data needed to interpret the display correctly; no notes need be scribbled on the back of the photo.

The CRT display looks like a logic timing diagram. A maximum of eight channels of input data can be stacked vertically. And since all eight inputs are sampled simultaneously by the instrument's internal clock, the time relationships implied by the relative horizontal positions of the various traces are valid to within one (internal) clock interval. In testing synchronous systems, the Digiscope's internal clock can be set to run several times faster than the clock of the system under test (up to a maximum of 50 MHz). This makes it possible to reduce the timing uncertainty to a small fraction of a system-clock interval.

All logic scopes differ from ordinary oscilloscopes principally in that their data-acquisition circuitry is completely independent of their display circuitry. Their front ends are digital circuits that can capture and store sequences of digital data—whether repetitive or single-shot. The display circuitry has no need to be able to keep up with the front end; it needs merely to be capable of handling a refresh rate that is high enough to eliminate annoying flicker: a simple video monitor could do the job.

Looking backwards. Since logic scopes are storage devices, they have the extremely valuable ability to look back in time. That is, their trigger signals can be used to stop the collection of data, as well as to start it. When negative delay is desired, the logic scope is set up to record and dump data continuously until a trigger signal is received. At that time, it stops acquiring new information and displays the previously stored data. Consequently, a history of the logic sequence imme-

Digiscope. 50-MHz logic scope displays 100 bits on each of up to eight channels. All control settings are shown on CRT.



diately preceding the trigger event can be studied—an obvious boon to troubleshooters who know what went wrong, but don't know what caused it.

The Digiscope can store up to 100 bits on each of its eight channels. Thus it can look back as far as 100 bits before a trigger event. An adjustable amount of positive delay can be added to the basic 100-bit negative delay of the trigger signal, making it possible to vary the instrument's hindsight from 0 to 100 bits. One could, for example, display and examine the 45 bits preceding a trigger event and the 55 bits following it, with the trigger point clearly shown on the screen both as a two-digit number and as the length of a horizontal bar.

The Digiscope is triggered by programing it to recognize a specific logic combination of its inputs. Anywhere from one to all eight inputs, some of which may be inverted (complemented), are ANDed together to define the trigger event. To add to its flexibility, the Digiscope can be made to trigger on either the leading edge or the trailing edge of the trigger event.

A free-running mode of operation is also available. In this mode, the instrument simply acquires 100 bits of data and displays them for a selectable length of time (0.2 second, 1.0 s, or 16 s), and then repeats the process. An inhibit switch can be activated at any time to freeze the display if an event of particular interest is discovered.

Flexibility. Although all existing logic scopes have adjustable thresholds, and thus can be used to test many different types of logic circuitry, the Digiscope can handle two different types of logic at the same time. Two pairs of logic thresholds can be set into the machine, and then each input channel can be programed to use either pair.

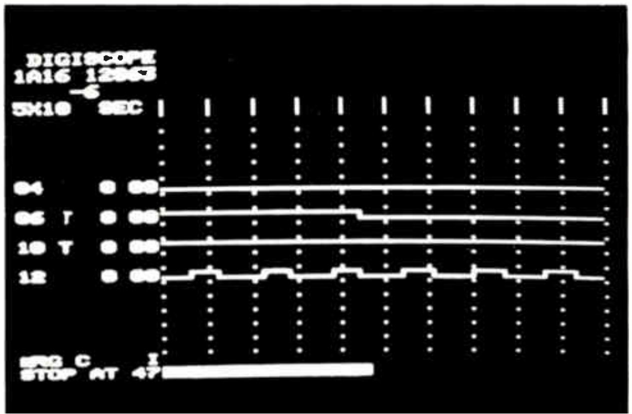
In addition to these so-called "fixed" thresholds which the user sets from the rear of the instrument on a more or less permanent basis, each input channel can also be referred to two pairs of "variable" threshold levels, which are adjustable from the front panel.

All of the operational flexibility in the world isn't worth very much if the instrument that has it causes aberrations in the circuit under test because of excessive circuit loading. To minimize the possibility of this occurring, the Digiscope's designers chose to use active probes for the input channels. Each probe has an input impedance of more than 1 megohm in parallel with less than 6 picofarads. Probe bandwidth is 100 MHz. In addition to minimizing circuit loading, the active probes make it possible to operate the instrument at a considerable distance from the circuit under test.

The Digiscope's controls are as unusual as the rest of the instrument. Momentary-contact switches are used instead of multiposition rotary switches. To change the time per bit, for example, one simply holds a switch up (or down, depending upon whether the time is to be increased or decreased) and watches the numbers change on the CRT.

The Digiscope weighs 55 pounds and measures 15 in. by 9 in. by 16 in. Power consumption is 250 watts, and screen size is 5 in. high by 7 in. wide. Price is $6,300 for a complete eight-channel unit. If fewer channels are desired, the cost breaks down as follows: $2,700 for the mainframe and $900 for each two-channel plug-in module. Deliveries will begin in March.

E-H Research Laboratories Inc., P. O. Box 1289, Oakland, Calif. 94604 [338]



Self-explanatory. Display has all information needed to interpret the timing diagram. Channels marked by letter T, for example, define the trigger event.

Process yields low-cost FET op amp

Selective diode-shorting, done at a standard wafer-probe station, rapidly and inexpensively reduces input-offset voltage

by Joel DuBow, Components Editor

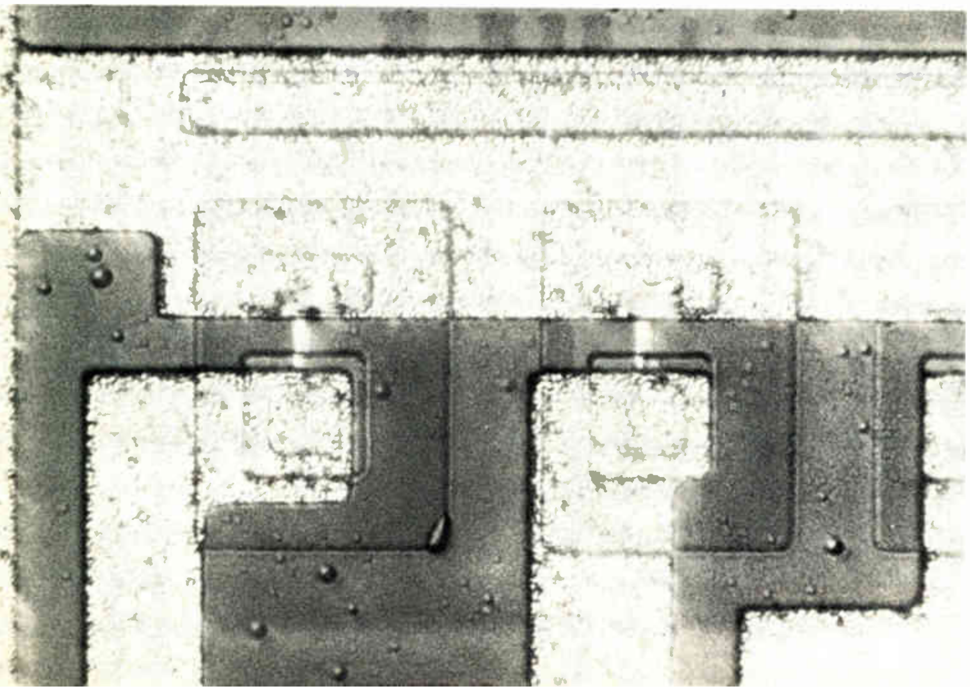
The performance of nearly all linear circuits can be improved by trimming, or matching certain characteristics, of the circuit. For operational amplifiers, the most frequently trimmed parameter is the input-offset voltage, which is applied between the input terminals through two equal resistances to obtain zero output.

Most trimming processes are costly and time-consuming, but now Intersil has adapted a technique used in its programable memories, applied it to a slightly modified 8007 op-amp chip, and developed a new high-performance FET-input op amp—one that the company says will eventually sell at a low price. Initial price is relatively high, about $20, but volume production will bring this down significantly.

The new units, designated the 8007 series, feature very low input current (1 picoampere for the 8007A), very low offset voltage (2 millivolts for the 8007-1), a high input impedance of 10^{12} ohms, and internal frequency-compensation. They are also low-noise devices, with input spot noise below 600 nanovolts per root hertz at 10 Hz and wideband input noise of about 5 μV for a 1-kilohm source resistance. Monolithic op amps rarely achieve spot noise of less than 1 μV per root hertz.

The new method of trimming involves selectively connecting a number of on-chip resistors by short-circuiting reverse-biased diodes, which are in series with the resistors. High-resistance (10^{10} ohms) reverse-biased diodes are changed into low-resistance (10 ohms) shorting elements by means of avalanche-induced migration. This technique was pioneered by Intersil three years ago for use on electrically programable memories. The company claims that its reliability data shows this technique to be superior to other methods, such as fusing links of a thin-film material, for obtaining the same results. Since the die may be trimmed at a standard probe station at the wafer-sort stage of production, the time required to trim and test each die is only slightly greater than that required to test an untrimmed die of the same type.

Avalanche path. Two diodes shown in center are short-circuited by high reverse-biased voltage. Further magnification reveals no damage to adjoining silicon and aluminum.



Previously, high-performance FET op amps were either costly monolithics or hybrid discrete-monolithic modules. An external potentiometer can be used to trim performance on less expensive units, but pots take up space, require time-consuming adjustment, especially if components have to be replaced, and have different temperature coefficients of change than the semiconductor chips. Laser trimming requires a costly ($100,000) setup and complex alignment to scan the entire wafer and maintain accuracy to hit a few-mils-wide line, Intersil points out.

In operation, the sequence of trimming events at the sorter consists of checking out the amplifier electrically with the given offset-voltage specification, automatically determining the resistor combination that gives the minimum offset-voltage reading, connecting the appropriate resistors into the circuit by avalanching their respective diodes, and performing a final electrical check.

The 8007 series includes a broad range of both general-purpose and special devices for military and other applications. It is available in TO-99 packages, but dual in-lines are also being considered.

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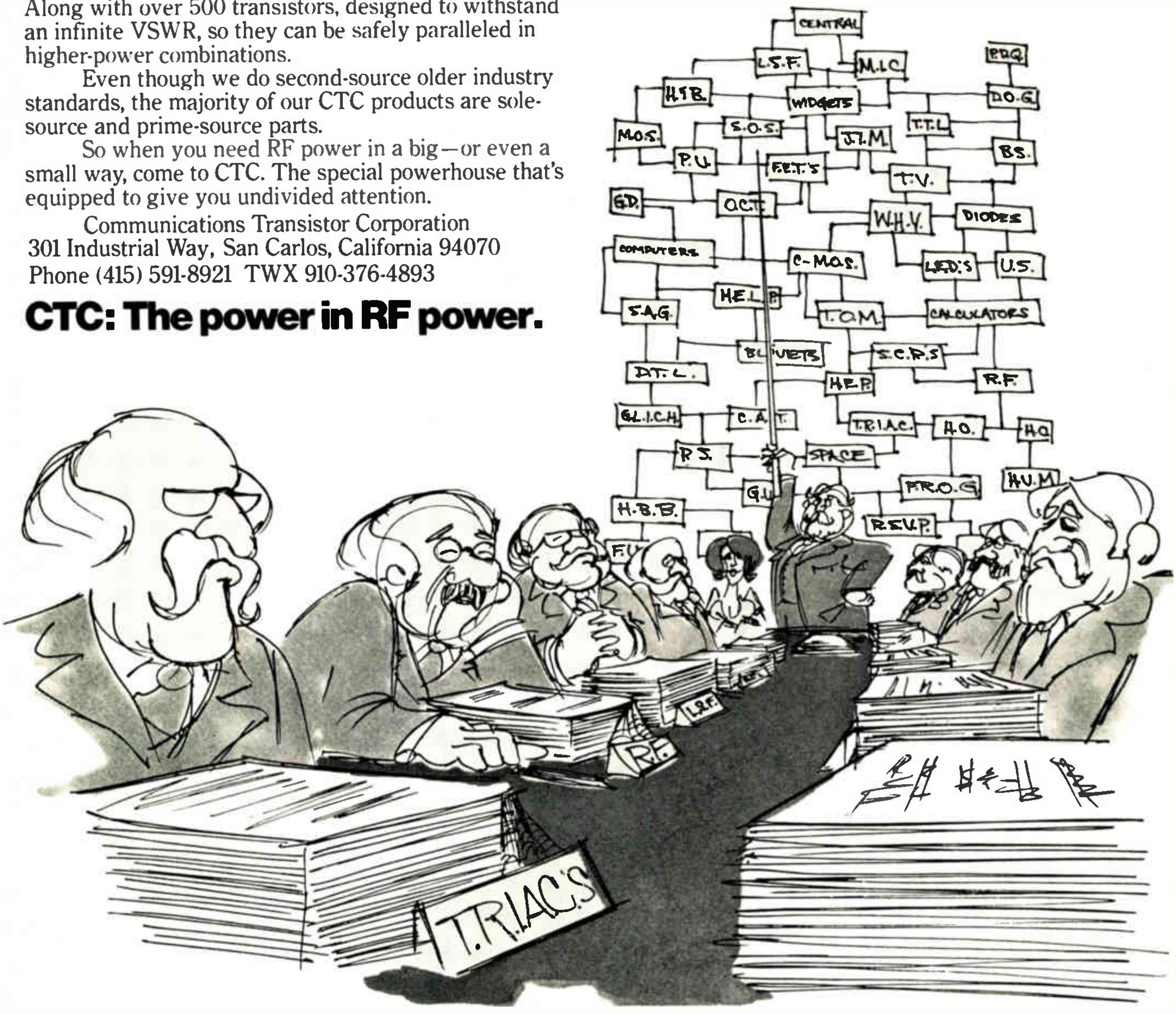

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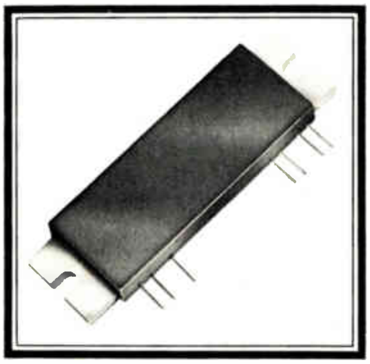

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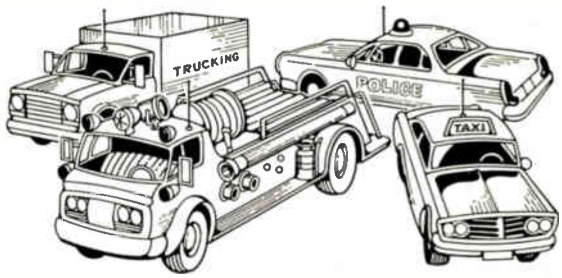

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Frequency Range (MHz)	395-440	395-440	395-440	440-470	440-470	440-470	470-512	470-512
Power Output, Min. (W)	10	13	15	10	13	15	10	12
Supply Voltage, Nom.	12.5	12 5	12.5	12.5	12 5	12.5	12.5	12.5
Power Gain, Min. (dB)	20	20	20	20	20	20	20	20
Overall Efficiency, Min. (%)	35	35	35	35	35	35	35	35

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Data handling

Tape-deck line aimed at OEMs

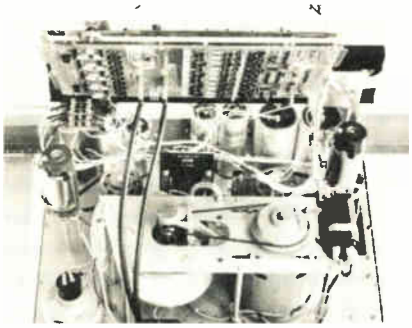
Parts commonality built in to accommodate tension-arm and vacuum-column drives

Original-equipment manufacturers are buying digital tape decks now in such large quantities that they command 80% of the market, compared with 30% three years ago, asserts Norman P. Gruczelak, president of Bright Industries, a subsidiary of Data Disc Inc.

Many of the OEM systems use both tension-arm and vacuum-column drives, and that's why parts commonality has been extended to 80% in a new family of low-cost digital tape decks built by Bright Industries for minicomputers, midicomputers, and for intelligent terminals. The decks were designed to reduce OEM inventory and service costs and to make both types of drive look alike during loading and control operations, thus reducing loading times and operator errors when both types are used in a system. With commonality, an OEM can service both types, and, if customer preferences change, the decks can be retrofitted.

If retrofits are made, Gruczelak says, they'll mainly involve upgrading from tension-arm to vacuum drives. Until now, tension-arm drives have dominated the market because of the higher cost of the vacuum-column equipment, but Gruczelak predicts that the latter will win an increasing market share—up to 25%—in the next few years. He points out that the vacuum-column drives cause less tape wear and experience fewer start-stop errors in such operations as merging and sorting separate reels in the application of minicomputers and intelligent terminals as front-end processors.

Compared with the price of as much as $3,300 for older tension-arm models in quantities of 100 and more, Bright's new model 2730 is priced at $2,800. And the previous range of $5,000 to $6,000 for vacuum-column decks has dropped to $3,200 for the new model 2740 and $3,300 for the model 2750. The 2730 and 2740 operate at read-write speeds to 45 inches per second and the 2750 to 75 in./s.



All are IBM-compatible and available with the usual minicomputer-tape-memory options, such as seven or nine tracks, single and dual packing densities from 200 to 1,600 bits per inch, and the like. Data formatters, which the OEM normally builds into his systems, are also available at $1,300 for NRZI, $2,400 for phase-encoding and $3,300 for a dual NRZI/PE formatter.

Gruczelak says a lack of commonality was a major reason for the higher costs of older decks. Bright designed its new drives for maximum use of interchangeable parts so that it could invest heavily in value engineering of major parts and subassemblies, order them in volume, and build and test the decks on Detroit-style assembly and test lines. For example, the two printed-circuit cards carrying read, read/write, and drive/control circuits are identical, except for plug-in circuits that adapt each drive to options and data formats chosen by the OEM. The only major subassemblies not identical are the vacuum and tension-arm electromechanical assemblies—these go on a main deckplate with the same overall dimensions. In fact, an OEM may order the plate machined to accept either type of drive.

To make loading easier and faster, all models have similar one-hand tape-loading paths. Tension arms retract so that, as on the vacuum models, the operator simply runs the tape end around four guides and through a head cover that is shaped to guide the finders through the head threading steps.

Also added are several data- and tape-protection features. Under program control, the two normal read-threshold levels or a third, extra-high, level can be selected. The new level catches dropouts during read-while-write operation. Electronic skew-compensation cuts NRZI errors, automatic braking prevents the tape from flying loose if power fails during rewind, and a new tape sensor has been developed for the vacuum-column models.

The new sensor replaces conventional photoelectric cells. It cannot be thrown off by oxide accumulations, and, extending almost the entire length of the column, it allows linear adjustment of the drive servo instead of the usual "bang-bang" changes in drive speed, Gruczelak says. Among other refinements of the vacuum design is a three-step drive pulley. The steps keep vacuum pressure within specifications, whether the deck is used on 50-Hz or 60-Hz line power.

Bright Industries Inc., 683 W. Maude Ave., Sunnyvale, Calif. 94086 [361]

Terminals are designed for dispersed computer systems

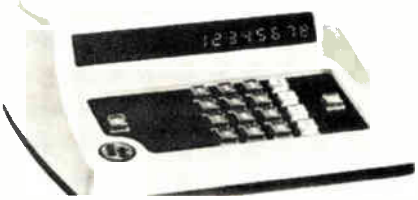
Two terminals, designated models 1100 and 5500, are intended to enhance Datapoint's current line of dispersed data-processing systems. The 1100 consists of a processor, a RAM with a capacity of 8,000 words, dual cassette drives, a display, and

ASCII keyboard. The terminals are for use in on- or off-line multi-location intelligent applications. The 5500 employs memory segmentation, hardware relocation, storing, and arithmetic instructions. Memory of up to 64,000 bytes is available. Price for 36-month lease of the 1100 is $138 per month.

Datapoint Corp., 9725 Datapoint Dr., San Antonio, Texas 78284 [364]

Interactive terminal offers data check

The model 735 interactive data-entry terminal offers buffered light-emitting-diode displays, which allow the operator to verify all data entered before it is transmitted to the computer. The unit has a 16-key keyboard with characters 0 through 9, a send key, a decimal point, and four function keys. Additional keys are available as options. The terminal is particularly suited to point-of-



sale and check-cashing operations, as well as inventory control, and it is compatible with most minicomputers.

Interface Technology Inc., 10500 Kahlmeyer Dr., St. Louis, Mo. [366]

Data controller couples collection, display system

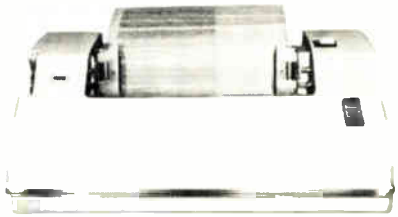
The model 4408-1 data-collection controller is an interactive coupler between the model 4400 data-collection system and the model 2409 keyboard-display system. Coupling of the two systems increases their capability for monitoring data in industrial applications. Functionally the controller polls the 4400 system input stations for source data and

transfers the gathered information to the 2409 system, where it is stored on disk as transaction records. The controller automatically adds the date and time of day to each data-collection record, plus other identifying information.

Mohawk Data Sciences Corp., Box 362, Utica, N.Y. [367]

Impact printer operates at 100 characters a second

Designated the model 700, a bidirectional serial impact printer operates at 100 characters per second across a full 132-character line; the unit uses a 7-by-9-dot matrix. The print head travels left to right on one line and reverses its direction on the next line. Also featured is an automatic line-length control. When the printer finishes the last character at the right end of the first line, the second line is loaded into a full 132-character buffer. The head then moves to a predetermined position to the right of the last character of the second line, performs a line-feed operation, reverses its direction, and

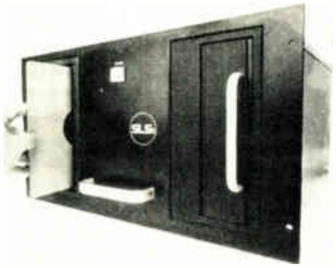


prints right to left. OEM prices start at less than $1,000.

Trivex Inc., 3181 Red Hill Ave., Costa Mesa, Calif. 92626 [369]

Disk system is built for Datapoint 2200 users

Manufactured specifically for users of the Datapoint 2200 processor, the MDP-8 disk system offers 2.5 to 20 megabytes of on-line storage. The unit also incorporates an interface,



formatter, and random-access, cartridge-loaded, disk drive. The interface contains an MOS memory-sector buffer, which holds up to four sectors of 256 bytes each. This is used to temporarily store information between the disk and the 2200. The unit is plug-to-plug-compatible with similar disk subsystems offered by Datapoint. Prices start at $9,750 for a single unit.

Standard Logic Systems Inc., 2215 S. Standard Ave., Santa Ana, Calif. 92707 [368]

Disk system designed for PDP-11 computer

The model 4091 disk system, built for use with the PDP-11 minicomputer, has a movable head and removable media. The system consists of a single- or dual-platter drive, an interface controller, interconnection cables, an I/O device, and diagnostic software. Formatted data-storage capacities of up to 9.6 million 16-bit words are available. Prices for a basic 1.2-million-word system start below $9,000.

Datum Inc., 1363 S. State College Blvd., Anaheim, Calif. 92806 [370]

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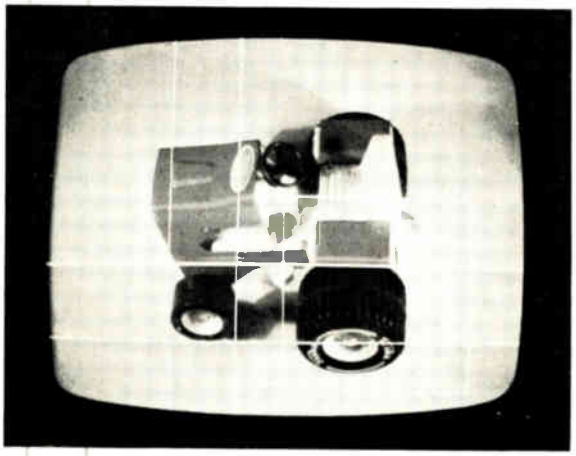

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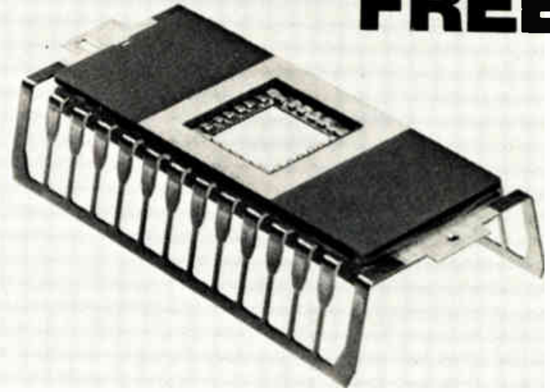

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Components

Capacitive keys are priced low

Contactless keyboards sell for $69, eliminate all wire connections

In their quest for contactless keyboards to improve reliability and last longer than mechanical key switches, manufacturers have turned to Hall-effect devices and to capacitive-switching systems. The Hall devices have gained a large segment of their market, but their complexity seems to restrict them to higher-price applications. Capacitive keyboards, on the other hand, have often suffered from unreliability brought about by inconsistent capacitance among the keys, fast wear, and susceptibility to particles between the active plates.

A new noncontact system from Controls Research seems to have overcome some of these problems, and company marketing vice president Jim Antrim says the new capacitive keyboard not only costs less than present contactless keyboards at $69 in 1,000-piece lots, but it offers the prospect of prices ranging from $30 to $40 by 1976. The company claims a life of 100 million operations per key.

The active switching element in the C-Scan keyboard consists of two half-moon segments etched on a circuit board. An insulated flexible moving plate provides a capacitance ratio of 6 to 1 as it is pressed against the fixed plates, which eliminates all wire connections under the keys for reliability. The flexible dielectric and metal plate, backed up by a special foam pad on the plunger, also provides return action. The flexible pad eliminates a common problem in systems using rigid plates—small dirt specks that prevent the plates from meeting, uneven wear, or differences that cause capacitance variations.

The key closure is converted to electrical output by a scanned technique for keyboard encoding. Although a few ICs are required for this operation, the number is comparable to that on a conventional electromechanical keyboard. Full encoding provides the standard TTL interface. Antrim expects part of the predicted price reduction in the keyboard to come from integration in MOS of the whole scanning and encoding function.

The standard SC-6000 keyboard, an ASR-33 type with "n" key rollover, uses standard ASCII coding. It includes 53 keys on ¾-inch centers. Key operating force is 3 ounces nominal, pretravel is 0.090 in., and total travel is 0.182 in.

Controls Research Corp., 2100 S. Fairview, Santa Ana, Calif. 92704 [341]

Liquid-crystal displays provide from 3½ to 8 digits

Three series of liquid-crystal displays are offered in reflective or transmissive versions. The 3400 series provides a 3½-digit clock-type readout and a character height of 1.12 inches. The 3500 series offers an eight-digit calculator display with a character height of 0.470 inch, while the series 3600 provides a 3½-digit instrumentation display with a character height of 0.500 inch. Rise time for all the displays is typically 100 milliseconds, and decay time is typically 150 ms.

Hamlin Inc., Lake and Grove Sts., Lake Mills, Wis. 53551 [345]

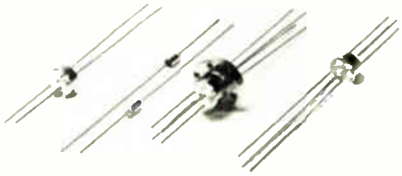
Active filters are programable

The 744 series of active filters, which are BCD-programable, four-pole, low-pass types, are designed for applications such as programable test equipment, computer-controlled signal processing, automated measurements, noise reduction, and analog-to-digital conversion. Four basic models cover the range from 0.1 hertz to 50 kilohertz with maximum cutoff frequencies of 50 Hz, 500 Hz, 5 kHz, and also 50 kHz.

Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01830 [346]

High-vacuum feedthroughs come in mini sizes

With adapter diameters of 0.247 and 0.747 inch, a family of miniature feedthrough assemblies are intended for ultrahigh-vacuum and high-pressure applications. The as-



semblies are high in alumina content and are of ceramic-metal construction. They are available with one, two, or four feedthroughs mounted in a weld adaptor. Each feedthrough is rated at 1,000 volts peak, and current ratings are 1, 5, or 15 amperes.

Cermaseal Inc., New Lebanon Center, N.Y. 12126 [347]

Metal-film resistors are combined with capacitors

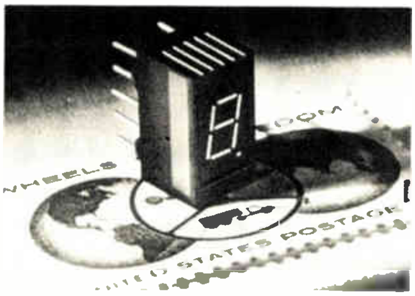
Metal-film resistors and ceramic capacitors have been combined on a single substrate to comprise the type 904C and 906C Multi-Comp family of resistor-capacitor networks. The networks, which are molded in dual in-line packages, are compatible with integrated circuits and offer mechanical protection during insertion into printed-wiring boards, as well as reliability under severe envi-

ronmental conditions. The units are designed as by-passed pull-up, speed-up, RC-coupling, and active terminator networks. The Metanet resistors are made from noble metals encased in protective glass, and are layer-built by alternating metallic electrodes and ceramic dielectrics. Capacitance values range from 100 picofarads to 0.05 microfarad, and resistance values are from 100 to 6,800 ohms. Delivery of the networks is from stock.

Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247 [343]

LED displays have built-in contrast-enhancing filters

A series of gallium-arsenide-phosphide LED numeric displays are about half the size of postage stamps, but are said to be readable from as far as 10 feet, even under

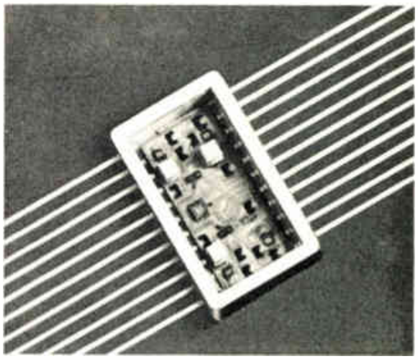


ambient-light conditions. Designated model 135-3870, the wide-angle displays are red seven-segment types that have large emitting surfaces plus built-in enhancing filters. They are compatible with low-power digital ICs.

Genisco Technology Corp., Eldema Division, 18435 Susana Rd., Compton, Calif. 90221 [348]

Ceramic-chip capacitors range from 1 pF to 3.7 μF

A series of ceramic chip capacitors are said to provide more capacitance in smaller packages for high volumetric efficiency. The capacitors have a 0.015-inch profile and are available in seven sizes, with the



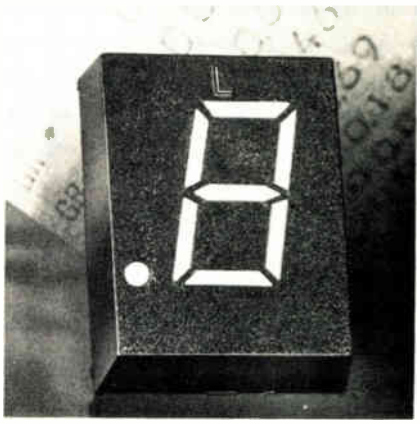
smallest version measuring 0.40 by 0.30 by 0.15 inch. Capacitance values extend from 1 picofarad to 3.7 microfarads. Price, which varies with model, is said to be about 10% higher than standard chip capacitors.

Johanson/Monolithic Dielectrics Division, Box 6456, Burbank, Calif. 91505 [349]

LED digit measures 0.6 inch in height

Industrial controls, point-of-sale systems, instrumentation, and other applications requiring readability to distances of 20 feet are applications for the model 747 light-emitting-diode digit. Measuring 0.6 inch in height, the LED is a common-anode, left-decimal-point digit with double-DIP pin-spacing. Brightness is 5 millicandelas at 20 milliamperes. Price is $5.15 each for 1 to 99 pieces, $4.30 for 100 to 999, and $3.60 in 1,000-lots.

Litronix Inc., 19000 Homestead Rd., Cupertino, Calif. 95014 [350]

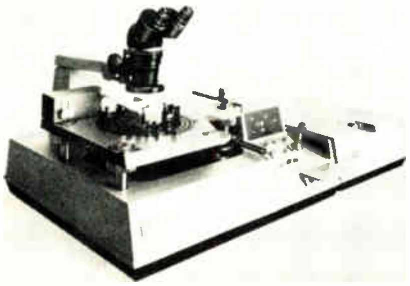


Packaging & Production

Wafer prober rides on air

Linear motor for indexing table increases machine speed, reduces down time

Trying to save wear and tear by eliminating rotating mechanical parts, Electroglas Inc., Menlo Park, Calif., has introduced an automatic wafer prober with an X-Y indexing table that rides on a bearing of air.



The company says that the machine, called the model 1034X, is 30% to 40% faster than wafer probers with the usual stepping-motor-and-lead-screw arrangement. Also, the 1034X requires "drastically reduced" maintenance time, the company says.

Basically, the performance features of Electroglas' earlier model 1034 are incorporated in the new 1034X. The stage on which a wafer is mounted can travel up to 5 inches, plus an additional 5 inches in the X axis for loading and unloading. Digitally controlled acceleration and deceleration speeds have been increased, but accuracy stays the same—within ±0.0005 inch over the full 5 inches of travel. Speed is 5 inches per second with an acceleration of 1 g. Indexing range is 0.005 to 4.999 inches with 0.5-mil resolution.

Other features include: alignment via automatic gross positioning, theta-alignment scanning, and a multifunction joystick; adjustable- or fixed-point probe cards that can be changed easily; and delayed inking, as well as conventional in-place inking. Options include optics for a TV-type display, and magnetic inking.

The new wafer prober relies on the so-called Sawyer principle to produce motion through the interaction of magnetic forces. Essentially, the action is that of a linear motor with an electromagnetic "forcer" block moving smoothly and silently on a cushion of air over a ferromagnetic platen.

The forcer consists of a permanent magnet with an electromagnet at each of its poles. The platen is a flat plate, cross-scored to form equidistant square islands in a pattern resembling a waffle. These scorings are filled with nonmagnetic material to provide a smooth surface.

Magnetic flux is developed in the forcer by the combination of the flux in the permanent magnet and the two electromagnets. The direction in which the forcer moves is controlled by the current in the electromagnets. Two separate forcers at right angles to each other control motion in the X and Y axes.

Electroglas' parent company, Xynetics Inc., originally applied the Sawyer principle to an X-Y plotter two years ago. Since then, Electroglas has also applied it to its model 1400X laser scriber for silicon wafers.

Price of the model 1034X is $14,950, compared to $12,950 for the earlier 1034. Delivery time is 10 to 12 weeks.

Electroglas Inc., 150 Constitution Drive, Menlo Park, Calif. 94025 [391]

Burn-in unit has memory tester, heat controller

An automated burn-in system, designated the model 1000, combines a memory exerciser with a temperature controller and a chamber to provide an efficient burn-in operation. The exerciser automatically performs a variety of tests on different memory types, and the test program can be adapted to most logic-board assemblies. The temperature controller maintains the chamber at +50°C, while circulating fans prevent hot spots. Power to each test connector is switched and fused, while individual indicators display burn-in times up to 99 hours.

Concept Development Inc., 2401 S. Broadway, Santa Ana, Calif. 92707 [393]

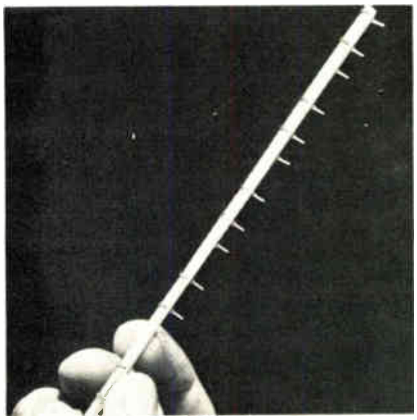
Waste-recovery system saves alkaline etchants

A waste-recovery system, designated the Reverse Osmosis system, operates on MacDermid Continuetch alkaline etchant. The unit eliminates the etchant-rinse water as a pollution source, and it provides a means of recovering etchant from the concentrate. Instead, 93% of the etchant feed is recycled as clean rinse water, and the concentrate is collected for recovery with the spent etchant.

Abcor Inc., 341 Vassar St., Cambridge, Mass. 02139 [395]

Pc-card bus bar mounts under DIPs or sockets

A three-layer printed-circuit-card bus bar is made to a 0.050-inch maximum measurement so that it will mount easily under standard DIPs or sockets. Called the M-827, the unit incorporates the third layer to provide a second voltage-distribution level. When used in conjunction with two-sided pc boards, the combination is equivalent to a five-layer board, consisting of two layers for signals, two for voltage, and one



for ground. Price is $2.95 each in 100-lots.

Rogers Corp., Box 700, Chandler, Ariz. 85224 [397]

Substrate-cutting system can handle liquid crystals

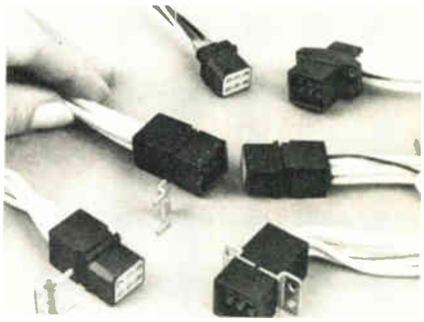
A substrate-cutting system has been adapted for slicing and dicing liquid-crystal-glass display material. Called the Accu-Cut 500, the unit provides void-free bonds between

the glass and its back-up plate to guarantee chip-free cuts. Multiple cutting of the glass plates is also offered, and the company says that about 5,000 substrates can be cut per day. Price of the system is $4,995 plus the cost of diamond cut-off wheels.

Aremco Products Inc., Box 429, Ossining, N.Y. 10562 [394]

Miniature connector is rated at 5 kV dc

Rated at 5 kilovolts dc at 70,000 feet and operating over the temperature range of −55 to +125°C, a subminiature high-voltage connector requires less than 0.6 square inch of



mounting surface and occupies less than 0.75 cubic inch per mated pair of six-position units. The fully polarized plug and receptacle are molded of flame-retardant glass-filled polyester, with a silicone-rubber insert to provide an interfacial seal. The recessed contacts are gold-plated and have a 5-ampere rating.

Capitron division, AMP Inc., 1595 S. Mount Joy St., Elizabethtown, Pa. 17022 [398]

Platform-type DIP aimed at hybrid work

A platform-type dual in-line package is made from hard alumina glass. The 14-pin hermetic packages can also be supplied with epoxy preforms for sealing. Applications are in hybrid-circuit manufacturing. Delivery is from stock.

Packaging Unlimited Inc., 10 Railroad St., Lawrence, Mass. 01841 [399]

Ribbon-cable assembly interconnects pc boards

A ribbon-cable assembly, designed to interconnect printed-circuit boards, is said to simplify the problem of busing and crossovers. Several varieties of wire sizes, conductor terminations, and stranding configurations are available to suit most applications. For example, the conductors may be round or flat, and the jumpers, which come in various sizes, may be made with any number of conductors from two to 100. They are available individually with pretinned leads and can be supplied in a continuous roll form with conductors stripped at desired intervals.

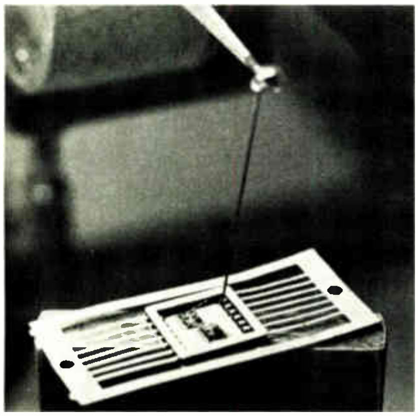
Spectra-Strip Corp., 7100 Lampson Ave., Garden Grove, Calif. 92642 [400]

Subassemblies

Hybrid drivers are shelf items

Units designed for switching bias current of p-i-n diodes are compatible with TTL, DTL

Microwave-equipment makers looking for switch drivers have usually had two choices—buying big discrete units off the shelf, or buying smaller hybrids on a custom basis. With the introduction of the UHC-



200 series of off-the-shelf hybrid switch drivers by Hybrid Systems Corp., the user can have the best of both worlds. The devices are the first in a line of standard products from Hybrid's new microelectronics division, recently bought from Sprague Electric Co. Hybrid Systems officials hope that the standard products will "lead Hybrid out of the woods from being errand boys" for companies who need custom items.

The UHC-200 series is designed for switching the bias current of p-i-n diodes in series and shunt-switching applications, and they can be used in coaxial, stripline, or microstrip circuits. Current is provided from either the positive or negative supply, and inputs are compatible with most TTL and DTL circuits.

Current spikes as large as 400 milliamperes are generated to inject and remove the diode-junction charges. Type UHC-201 has a steady-state output minimally set at 5 mA, but this is externally adjustable to ±30 mA. Several other output options are available, including complementary inverting designs. All types have output short-circuit protection.

Open-circuit output voltage is ±2 volts. Minimum logic 1 input voltage uses 2.0 V, while logic 0 input voltage is 0.8 V maximum. Logic 1 output is +5 mA, and logic 0 is -5 mA on the UHC-201. Delay time is 10 nanoseconds maximum. Supply voltage is ±5 to ±12 V dc. Operating-temperature range is -55°C to 125°C, and the units meet the requirements of MIL SPEC 883. The devices are hermetically sealed in a flatpack 0.5 by 0.5 inch, but they may also be ordered in a plug-in design.

The UHC 201 is priced at $48 each for 1 to 9, and $16 each in quantities of 1,000.

Hybrid Systems Corp., 87 Second Ave., Burlington, Mass. 01803 [381]

Rms-to-dc converter is priced at $62

Priced as low as $42 each in 100-lots and selling for $62 singly, the model 440 rms-to-dc converter measures 1.5 by 1.5 by 0.41 inch. In addition to performing as a converter, the unit can also measure true rms when it is hooked to a digital display. The 440 responds to the total effective dc-heating value of any waveform, and its maximum error is ±2 mV ±0.05%. This level of accuracy and the 3-dB bandwidth of 500 kilohertz enable the model 440 to process SCR waveforms and complex noise patterns.

Analog Devices Inc., Rte. 1 Industrial Park, P.O. Box 280, Norwood, Mass. 02062 [383]

Digital-to-resolver converter accepts 12-bit binary input

A modular digital-to-resolver converter accepts a binary 12-bit angle input and provides two ratiometric outputs proportional to the sine and cosine of the programed input angle. The converter can be used with frequencies down to dc. With a power-output module, it can be used in 400-hertz systems of either 11.8 or 90 volts with 1-VA power output.

Astrosystems Inc., 6 Nevada Dr., Lake Success, N.Y. 1140 [384]

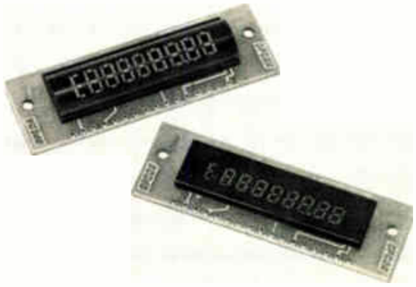
8-way power divider is compact, broadband

An eight-way power divider-combiner in a flatpack configuration, measuring 1¾ by 1 by 0.22 inch, offers a frequency response of 30 to 1,000 MHz. Designated the model FP8A-HJ-8-689, the unit also provides an insertion loss of 2.5 dB maximum, isolation of 25 dB minimum, and a nominal impedance of 50 ohms. Maximum VSWR is 1.4 to 1, and maximum power rating is 1 watt. Price is $250 each for one to four units.

Olektron Corp., 6 Chase Ave., Dudley, Mass. 01570 [385]

Multidigit LED display is available in green

A LED display with a height of 0.120 inch is offered in green. The gallium-phosphide device can directly replace equivalent red gallium-arse-



nide-phosphide displays in most circuits, solid-state calculators, timers, and counters. Luminous intensity is 30 microcandela typical at 1 milliampere average current per segment. The nine-digit version, called G-B125, is supplied on a pc board measuring ⅜ by 2⅜ inches. Other versions with fewer digits are available.

Opcoa Division, AVX Corp., 330 Talmadge Rd., Edison, N.J. 08817 [386]

Op amp operates over ±18 to ±125-V supply range

The model 1032 modular FET operational amplifer is offered either as a general-purpose problem solver

for new high-voltage applications or as a low-cost replacement for higher-priced amplifers used in existing designs. Price of the 1032 is $59. The unit operates over the range of ±18 to ±125 volts, and when used with ±120-V supplies, it provides ±112-V output at ±12.5 mA.

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, Mass. 02026 [387]

Operational amplifier gives 500-volt isolation

A maximum of 500 volts of continuous input/output isolation is a feature of the model 3450 operational amplifier, one of a series called Iso-op-amps. The unit is fabricated for use with low-level signals from low-impedance sources, such as strain gages and thermocouples. Input-voltage drift is less than ±1 microvolt/°C maximum, and gain nonlinearity is ±0.01% maximum. The FET-input version, model 3451, is designed for use with higher-level voltage sources or low-level current

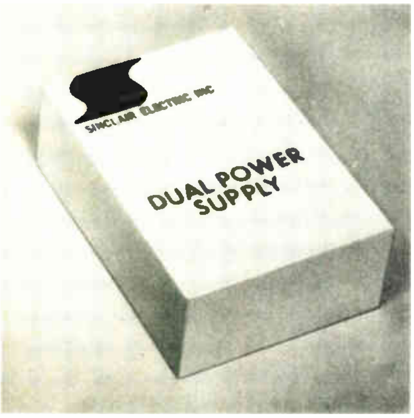
sources. Input impedance is 10^{11} ohms and bias current is -25 picoamperes maximum. Price of the 3450 is $165, and of the 3451, $105.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734 [388]

Dual power supply is priced at $9

Priced at $9 each for 1 to 99 units, the model S21 dual power supply provides ±15 volts at 100 milliamperes and 0.01% regulation to discrete and integrated-circuit operational amplifiers and function modules. The unit is an epoxy-encapsulated module suitable for printed-circuit-board mounting, and it can be supplied with fixed voltages from ±5 to ±100 volts.

Sinclair Electric Inc., 155 Brighton Rd., Clifton, N.J. 07012 [389]



Circle 230 on reader service card

Designated Galax GGG, a single-crystal gadolinium-gallium-garnet material is for use as an electronic substrate. Nonmagnetic GGG is used for the epitaxial growth of uniaxial magnetic garnet films applicable to bubble memories, shift registers, counters, and other devices. The material is available in boules, sawn blanks, polished wafers of various degrees of finish, and special shapes. Specifications include a melting point of 1,750°C and a lattice constant of 12.3832 ±0.0005 angstrom.

Allied Chemical Corp., Synthetic Crystal Products, Box 1021R, Morristown, N.J. 07960 [476]

A variety of sizes of glass-epoxy coil bobbins are available for use in solenoids and power supplies. Core sections are molded tubes of Fiberglas-laminated epoxy, sanded outside and cut to length. Flanges are wire-side-sanded and made for a drive fit over the core tube. Bonding is done with a 155°C epoxy adhesive.

Stevens Products Inc., 128 North Park St., East Orange, N.J. 07019 [477]

A mercaptan-terminated liquid polymer that provides rapid curing of epoxy resins, when used in combination with selected amines, is known as Dion Polymercaptan 3-800. The product is said to provide quick cures at low temperatures in thin films. Moreover, curing rates and properties of the formulation can be varied by small changes in the amine content or content of the Dion 3-800.

Nopco Chemical division, Diamond Shamrock Chemical Co., 350 Mt. Kemble Ave., Morristown, N.J. 07960 [478]

New literature

Components. A 12-page catalog from Brooks Instrument division, Emerson Electric Co., Hatfield, Pa. 19041, describes precision components for analytical instrumentation, including controllers, regulators, and flowmeters. Circle 421 on reader service card.

Instrumentation. A line of high-performance instrumentation is described in a 40-page catalog from Heath/Schlumberger Instruments, Benton Harbor, Mich. 49022. The booklet provides photos, general information and specifications for frequency counters, oscilloscopes, power supplies, digital multimeters, and other instruments. [422]

Impulse noise. Bowmar Instrument division, 531 Main St., Acton, Mass. 01720. A technical brochure provides information on the model 480A impulse-noise and level-measuring set. [423]

Temperature control. The Quantem, an 8.5-ampere proportional controller that comes equipped with set-point pot, dial plate, and sensor, is described in a bulletin from Heinemann Electric Co., Magnetic Dr., Trenton, N.J. 08602 [423]

Connector. Test and evaluation reports on the Mini-Wasp connector are available from Malco, a Microdot company, 5150 W. Roosevelt, Chicago, Ill. 60650. Three reports cover the low-insertion, medium-insertion and high-insertion versions.

Supplies and modules. Advanced High Voltage Co., 14532 Arminta St., Van Nuys, Calif. 91402. A four-page catalog describes the company's line of standard high-voltage supplies and modules. [425]

Thermistor probes. A 12-page catalog describing sizes, series, and types of thermistor probes is offered by the Keystone Carbon Co., St. Marys, Pa. 15857. A series of seven probe configurations is available in 20 styles. [426]

Resistor system. A brochure on the Rely-Ohm resistor system, which

New literature

provides resistor inks used in hybrid circuits for high stability and reproducibility, is available from Engelhard Industries, 430 Mountain Ave., Murray Hill, N.J. 07974 [427]

Capacitors. The line of capacitors and ceramic substrates available from Centralab Distributor Products, 5757 N. Green Bay Ave., Milwaukee, Wis. 53201, is described in a 36-page catalog. Electrical tests and specifications are given, along with applications data. [428]

MOS circuits. A revised product guide on a broad line of COS/MOS ICs for low-voltage digital applications in industrial, military and commercial fields is being offered by RCA Solid State division, Rte. 202, Somerville, N.J. 08876 [429]

Microwaves. A two-page bulletin containing a comparison chart and discussion of low-noise microwave front-end configurations for C and X bands is available from RHG Electronics Laboratory Inc., 161 East Industry Court, Deer Park, N.Y. 11729 [430]

Switching system. Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830. The mobile ESK crosspoint switching system is described in a four-page brochure. The system, mounted on a tractor-trailer, can be equipped with up to 2,000 lines. [431]

Ceramics. Three brochures have been published by The General Electric Co. Ltd., Hirst Research Centre, East Lane, Wembley, Middlesex, England, that describe a high-permittivity dielectric ceramic for microwave applications. [432]

Switches. Chicago Switch Inc., 2035 Wabansia, Chicago, Ill. 60647. Catalog 7309 is a 20-page handbook providing information on switching products. The booklet gives testing data and applications information. Products include subminiature switches in slide, push-button, and rotary configurations, in addition to rockers, leaf-types, and indicator lights. [433]

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December 20, 1973

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Brussels 1040, Belgium
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Liebigstrasse 27c, Germany
Phone 72 01 81

Tokyo: Tatsumi Katagiri, McGraw-Hill
Publications Overseas Corporation,
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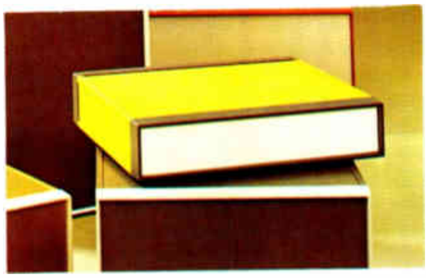

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