FEBRUARY 3, 1977

WHAT THE FINAL FORD BUDGET ADDS UP TO FOR ELECTRONICS/77

High-reliability semiconductors: are they worth the cost?/101

Low-cost scope option eases time measurements/113

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097/42

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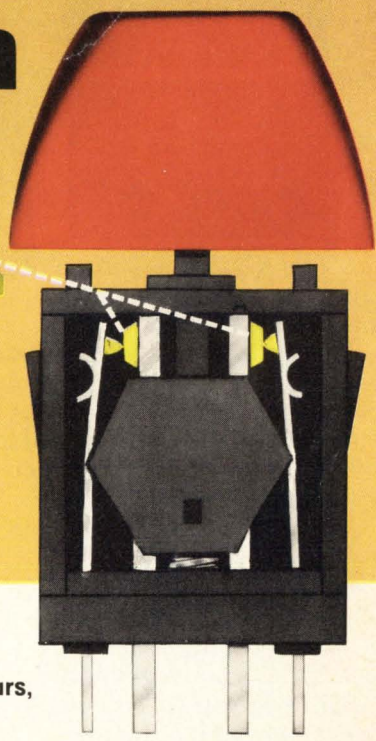

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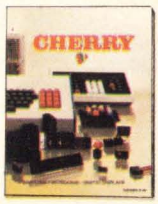

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*Substantial quantity discounts available.

Circle 2 on reader service card

Electronics

The International Magazine of Electronics Technology

Vol. 50, No. 3 • February 3, 1977

Highlights

Cover: ICs sway power-supply design, 91

One of the last bastions of discrete components, power supplies are yielding to integrated circuits. Already the field shows the kinds of changes that swept signal processing in the wake of circuit integration.

This special report details IC developments for the fast-developing switching-regulated power supplies and for the more popular series-regulated units. It also explores the role of ICs in making possible simple but ultrastable voltage references.

Mark David Smith illustrated the cover. The circuitry behind the faceplate is derived from an RCA Corp. IC voltage regulator.

Ford's last hurrah: the 1978 budget proposal, 77

Sharp increases in military spending and major new space programs mark President Ford's $440 billion fiscal 1978 budget proposal. Any changes President Carter suggests are unlikely to affect major electronics spending.

The budget proposal includes a record $123 billion for defense, up 12% over fiscal 1977, and $3.9 billion for space programs—only a 5.3% increase but leading to an 11% increase in fiscal 1979. Better than a third of the proposed civilian R&D outlays of $9.4 billion will go to energy-related projects.

High reliability can cost too much, 101

An 18-month test study of almost 190,000 high-reliability semiconductors suggests strongly that it is not worth paying extra for hi-rel integrated circuits. But for diodes and transistors, premium prices do guarantee lower failure rates most of the time.

And in the next issue . . .

Major new solid-state products bow at the International Solid State Circuits Conference: a special report . . . are plasma panels or cathode-ray tubes better for data terminals? . . . a chip that easily performs complex calculations.

Electronics

Publisher's letter

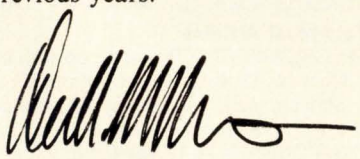
With integrated-circuit techniques fast finding their way into power supply design, there's good news for designers who have to come up with, say, yet another switching supply. As you'll find out in our special report on the impact of linear ICs on power supplies, which starts on page 91, the discrete component approach is giving ground ever more rapidly.

Based on lengthy traveling and interviewing by our components editor, Lucinda Mattera, and backed up by reporting by our field editors, the 10-page survey is a valuable status report on power-supply design trends today. Contributing to it were Larry Armstrong, Midwest bureau; Bruce LeBoss, New York; Bernard Cole, San Francisco; John Gosch, Frankfurt; William F. Arnold, London; and Arthur Erikson, Paris.

The annual Federal budget is an important document to us because its thousands of pages contain guideposts on the directions spending for electronic goods and research will take. So every year we devote a major chunk of pages to covering the budget (see page 77).

Our budget team, which included Washington bureau chief, Roy Connolly, and Associate Editor, Howard Wolff, went in mid-January to the usual prepublication briefings held in Washington for the press. A veteran of many such annual rounds of department-by-department briefings, Wolff is now something of a expert on the ways the bureaucracy deals with the public. Last year, for instance, President Ford, in a departure from the norm, attended, and the security was tight.

This year, though, things were different. Says Wolff: "I heard one official say it was more like the last day of school than a budget briefing. Security precautions were virtually nonexistent—because President Ford, with a week left in office, decided to not to attend. But the other lame-duck officials who had to attend—such as Alan Greenspan, head of the Council of Economic Advisers, and Frank Lynn, head of the Office of Management and Budget—were friendly, jocular, and somehow just not as serious as in previous years."



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Readers' comments

Why $7,800 a year?

To the Editor: In the Dec. 9 issue, you report that electrical engineers with 10 to 20 years' experience, some with Ph.D.s, were getting as little as $7,800 a year in 1974 ["IEEE lobbies for legislation to protect engineers working for service contracts," p. 16]. But would they relocate? Did they have one year's experience 20 times?

An engineer is quoted as saying Huntsville, Ala., is hard-hit. But industry there is even advertising on television to attract engineers and technicians.

My friend who used to be with the National Aeronautics and Space Administration says, "I went with one of those contract companies because they paid me a little more. They didn't tell me we would be the first to be laid off. Now the people I worked with are GS-14s, or at least -13s. Wish I could go back."

Rudy Holman
Chattanooga, Tenn.

Corrections

The proper identification of the curves in the illustration accompanying the analysis of the 1977 U.S. communications market [Jan. 6, p. 85] is "Market potential for digital signaling transmission and reception equipment." In addition, the last part of the accompanying caption should read: ". . . the market for digital signaling equipment could reach $3.6 billion by 1980 and climb to $6.1 billion by 1985, when electro-optic penetration could account for $1.28 billion."

The 100-picosecond bipolar large-scale-integrated logic [Jan. 6, p. 71] to be discussed at this month's International Solid State Circuits Conference comes from Musashino Electrical Communications Laboratory of the Nippon Telephone and Telegraph Public Corp.

1976 Index is available

The index of articles in *Electronics* in 1976 may be obtained by circling 340 on the reader service card.

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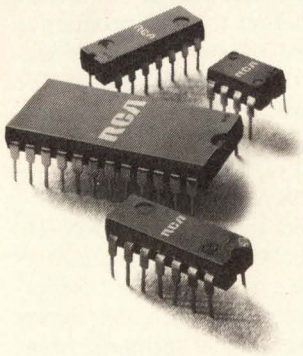

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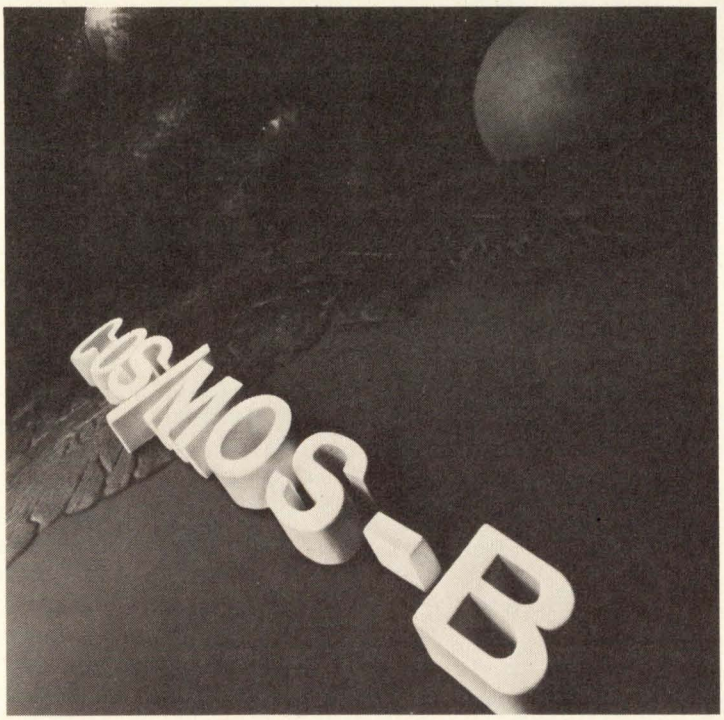

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News update

■ Lockheed Electronics Co. of Plainfield, N.J., has delivered to the Naval Electronics Systems Command an omnidirectional antenna system with radically new features to improve airspace coverage and shipboard control of aircraft.

The new system, the first of two to be delivered to the Navy under contracts totaling $835,000, uses an electronic-beam steering concept for 360° airspace coverage [*Electronics*, Feb. 5, 1976, p. 38]. The Navy plans to test the system on land, then conduct an evaluation at sea before deciding whether to enter production for shipboard and/or land-based tactical identification-friend-or-foe (IFF) systems. Tests are being conducted by the Test & Evaluation Detachment of the U.S. Naval Engineering Station, St. Inigoes, Md.

Designated the OE-120 (XN-2)/UPX, and better known as the AIMS antenna, the system has a 12.5-foot-diameter antenna with 64 beam radiators around its perimeter. Unlike conventional IFF systems, which radiate beams to only one airspace sector at a time, the AIMS unit can activate all its radiators at once to scan 360° about a ship, says a Lockheed Electronics spokesman. This capability, he adds, gives the radar operator improved coverage and faster and more accurate aircraft identification information.

The AIMS antenna can scan and hold on the radar presentation a specific area by energizing a group of radiators. And, notes the spokesman, AIMS operators can go from one sector to another or fluctuate the scan ±10° about an indicated bearing. Since no moving parts are involved, switching is said to be extremely fast: the beam can be steered from one position to the next in about 25 microseconds. This system flexibility and speed are achieved through a Lockheed-developed power distribution concept that integrates two 3-decibel couplers and two 6-bit phase shifters, which change the phase of energy applied to individual radiating elements. This permits the antenna's beam to bounce from one direction to another at 25 μs levels.

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Write or phone Advanced Micro Devices, The Buyer's Market.

Ours and Theirs.

(The 9080A & 8080A)

Specification	Intel	AMD
Minimum Instruction Cycle Time	1.3 microseconds	1 microsecond
Maximum Power Dissipation (at 1.3 microsec. 0-70°)	1307 milliwatts	829 milliwatts
Output Drive	1.9mA @ .45V	3.2mA @ .4V
Minimum Input High Voltage	3.3V	3.0V
MIL-STD-883	Special	Standard

Ours and Ours.

(Am9080A System Circuits)

AMD Part Number	Description	Availability
	CPU	
Am9080A/-2/-1/-4	0 to +70°C	Stock
Am9080A/-2/-1	-25 to +85°C	Stock
Am9080A/-2	-55 to +125°C	Stock
	STATIC READ/WRITE RANDOM ACCESS MEMORIES	
Am9101A/B/C/D	256 x 4, 22 Pin	Stock
Am91L01A/B/C	256 x 4, 22 Pin	Stock
Am9102A/B/C/D	1K x 1, 16 Pin	Stock
Am91L02A/B/C	1K x 1, 16 Pin	Stock
Am9111A/B/C/D	256 x 4, 18 Pin	Stock
Am91L11A/B/C	256 x 4, 18 Pin	Stock
Am9112A/B/C/D	256 x 4, 16 Pin	Stock
Am91L12A/B/C	256 x 4, 16 Pin	Stock
Am9131A/B/C/D/E	1K x 4, 22 Pin	Stock
Am91L31A/B/C/D	1K x 4, 22 Pin	Stock
Am9141A/B/C/D/E	4K x 1, 22 Pin	Stock
Am91L41A/B/C/D	4K x 1, 22 Pin	Stock
	DYNAMIC READ/WRITE RANDOM ACCESS MEMORIES	
Am9050C/D/E	4K x 1, 18 Pin	Stock
Am9060C/D/E	4K x 1, 22 Pin	Stock
	MASK PROGRAMMABLE READ-ONLY MEMORIES	
Am9208B/C/D	1K x 8, 250 nsec. max.	Stock
Am9216B/C	2K x 8, 300 nsec. max.	Stock
Am8316A	2K x 8, 850 nsec. max.	Stock
Am8316E	2K x 8, 550 nsec. max.	Stock
	ERASABLE READ-ONLY MEMORIES	
Am1702A	256 x 8, 1.0 μsec.	Stock
Am2708	1K x 8, 450 nsec.	1st Q. 1977

CPU: 9080A = 480 nsec. -2 = 380 nsec. -1 = 320 nsec. -4 = 250 nsec.
MEM: A = 500 nsec. B = 400 nsec. C = 300 nsec. D = 250 nsec. E = 200 nsec.

AMD Part Number	Description	Replaces	Availability
	SECOND SOURCE SUPPORT		
Am8212	8-bit I/O Port		Stock
Am8216	Non-Inverting Bus Transceiver		Stock
Am8224	Clock Generator		Stock
Am8226	Inverting Bus Transceiver		Stock
Am8228	System Controller		Stock
Am8238	Extended Write System Controller		Stock
Am8251	Prog. Communications Interface		Stock
Am8255	Prog. Peripheral Interface		Stock
Am8257	Direct Memory Access Controller		2nd Q. 1977
Am8259	Priority Interrupt Controller		2nd Q. 1977
	IMPROVED SUPPORT		
Am8238-4	High Speed System Controller	N/A	Stock
Am9511	Arithmetic Processing Unit	N/A	2nd Q. 1977
Am9517	Multi-mode DMA Controller	8257	2nd Q. 1977
Am9519	Universal Interrupt Controller	8259	2nd Q. 1977
Am9551/-4	Prog. Communications Interface	8251	Stock
Am9555/-4	Prog. Peripheral Interface	8255	Stock
Am25LS138	1-of-8 Decoder	8205	Stock
Am25LS139	Dual 1-of-4 Decoder	8205	Stock
***Am25LS273**	8-bit Common Clear Register	N/A	Stock
***Am25LS373**	8-bit Transparent Latch	8212	2nd Q. 1977
***Am25LS374**	8-bit 3-State Register	8212	1st Q. 1977
***Am25LS377**	8-bit Common Enable Register	8212	1st Q. 1977
***Am25LS2513**	Priority Encoder	8214 & 8212	Stock
***Am25LS2537**	1-of-10 3-State Decoder	8205 (2)	1st Q. 1977
***Am25LS2538**	1-of-8 3-State Decoder	N/A	1st Q. 1977
***Am25LS2539**	Dual 1-of-4 3-State Decoder	N/A	1st Q. 1977

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Editorial

Searching for IEEE's next general manager

The need to search for a new general manager of the Institute of Electrical and Electronics Engineers after the resignation of Herbert Schulke Jr. provides an excellent opportunity to review the definition of the job and the qualifications of the person to fill it. It also raises an important question: how best to organize the search.

In 1974, a committee that some felt had too many members to operate efficiently was appointed to find a replacement for Donald Fink, who was retiring from the position. The committee even drew up guidelines for screening applicants.

The fact that the man signed for the job did not work out and that he had to bring the situation to a head on his own is significant. Perhaps the committee did not function very well and did not follow its own guidelines, or perhaps the guidelines were faulty in not reflecting the job, or perhaps the entire search method was inappropriate. We think it was partly all three, with the last probably the weightiest.

Even in 1974 it was clear that professional activities were going to be an important adjunct to the general manager's job. Yet the search committee set out as though it was going to fill the job for 1965, not 1975. Granted no one could foresee just how disruptive, time-consuming, and politically volatile the whole area of professional activities would become. But there were ample signs that the members would not let this half of the institute's responsibilities fade away.

In fact, so much factionalism has emerged since 1974 that trying to form another search committee today to satisfy everyone would be futile. Instead, why not go to a professional head hunter with the assignment?

There is nothing so rare about the qualifications for IEEE's general manager that a top-notch recruiting firm could not handle. And the job is so important, it deserves the best talent to find the best talent. Defining the job would also be part of the recruiter's assignment, since these people can, in many cases, observe, analyze, and define a candidate's profile better than those who are too close to the situation.

In addition, politics can be kept to a minimum by this third party and if the selection did not pan out, no IEEE leader's reputation would be at stake, and therefore no face-saving would be needed. Finally, the management recruiter operates quietly behind the scenes and can be frank with job candidates.

As for the qualities required for the job, there are the obvious needs: leadership, commitment to member service, understanding of the EE's needs, and so forth. Obviously, too, the general manager has to be a good manager with technical background. Being both an employee and a spokesman for the IEEE, the general manager these days needs to be open constantly to member communication, tough-skinned when subjected to attack, and, above all, a canny politician in the upbeat sense of the word. A good sense of humor would help too.

A SIGNIFICANT ANNOUNCEMENT IF YOU'VE BEEN WAITING FOR A BREAKTHROUGH IN SMALL, PORTABLE DVM PERFORMANCE.

Until now, you haven't had much choice in a small, inexpensive but top-performing portable DVM.

The wait is over.

The Fluke 8040A, 4½-digit DVM has arrived. It's a handheld autoranging DVM, with the sophisticated performance of a benchtop instrument.

It has five measurement functions with a total of 26 ranges. True rms conversion techniques for all ac measurements. Autoranging and autozero. Extensive input overload protection. We made it truly portable, at a mere 2.5 pounds. And it's rugged enough to withstand the rigors of any field environment. We even designed a retractable hood, to make it easier to read in bright sunshine. It's been tested with transient overloads of 6 kV across the input with no damage.

DC voltage measurement from 10 μV to 1100V with basic accuracy of ±0.05%. AC voltage measurement from 100 μV to 750V rms with basic accuracy of ±0.5%. AC and dc current from 10 nA to 1.999A with basic dc accuracy of ±0.3% and basic ac accuracy of ±1%. Resistance measurement from 10 mΩ to 19.999 MΩ with basic accuracy of ±0.2%.

And true rms sensing means optimum accuracy—even when you've got noise or a distorted waveform.

Ranges can be manually selected or autoranged.

80T-150 Temperature Probe	
Sensitivity:	1 mV/°C or 1 mV/°F
Accuracy:	
+15°C to +35°C ambient:	±2°C(3.6°F) −25°C to +125°C ±3°C(5.8°F) −50°C to −25°C and +125°C to +150°C
0°C to 15°C, 35°C to 50°C ambient:	Add 1°C(1.8°F) to above

You can also get temperature measuring capabilities with the 8040A.

There are two battery options: a rechargeable NiCad for 8 hours of line-free operation, or disposable alkaline batteries. 100V, 115V or 230V ac line-powered battery eliminator/chargers are available. Accessories include measurement probes for rf voltages, high current ac, high voltage dc, temperature, and deluxe test leads. A carrying case is also available.

At last. A truly portable 4½-digit autoranging DVM that's got everything you need. And for only $425*.

Because we didn't think you should have to wait any longer.

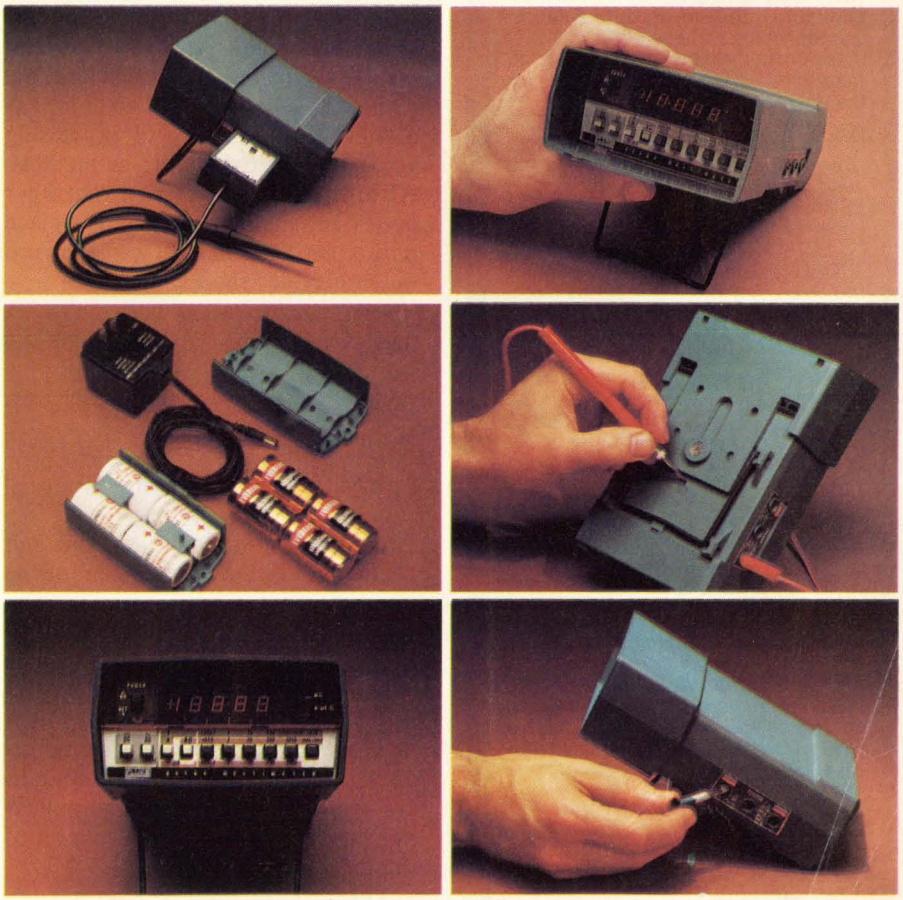
For data out today, dial our toll-free hotline, 800-426-0361.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043

Fluke (Nederland) B. V., P.O. Box 5053, Tilburg, The Netherlands.
Phone: (013) 673-973 Telex: 52237

**U.S. price only.*

There aren't many small, inexpensive and portable DVM's around that can perform like the 8040A.



FINALLY, A COMPLETE PORTABLE. 8040A DVM. FLUKE®

People

Maiman: making technology more useful at TRW

"This is a fantastic situation," says Theodore H. Maiman, bubbling with enthusiasm over his new job at TRW Inc., the aerospace giant. Named in December as assistant for advanced technology to J.S. Webb, head of the TRW Electronics Group in Los Angeles, Maiman is still sizing up what the company has to offer.

The range, he is happy to report, is indeed broad, running "from the tremendous microelectronics capability at the Systems group to our own booming data-communications business." A big part of Maiman's charter is to spur the transfer of state-of-the-art technology from the space and military-oriented Systems operation to the commercially oriented Electronics group. He'll also be developing new products in the Electronics group, which last year had sales of $400 million.

Digital data. Maiman known worldwide as the inventor of the ruby laser, plans to exploit several trends he believes are accelerating. "The whole country will go digital as a more efficient way of processing voice and video signals," he predicts. Also, there is no question that fiber optics for moving data is one place nature is on our side, since sand is so much cheaper than copper."

TRW is cultivating both fields. A digital-switching operation at its Vidar division, acquired in 1975, is growing, and the company has just completed a prototype 24-channel fiber-optics multiplexer for a communications systems. The firm, which made all the parts, including connectors and couplings, will demonstrate the optics system to officials of independent telephone companies later this month.

Maiman's move to the firm results from his friendship with corporate vice chairman Simon Ramo, whom he met in 1967 while receiving a science award at the White House. "Working with Si is always exhilarating," he observes.

Since 1968, when he left Korad Corp., the laser firm he founded with Union Carbide, he has been "entrepreneuring," his term for consulting. One wide-ranging assignment was at think-tank Rand Corp., where he looked at "unique tranportation ideas such as a levitated train that would travel in an evacuated tunnel." A multibillion-dollar price tag, and the lack of good tunneling equipment, stymied it.

As for progress of his laser brainchild, 17 years old in May, Maiman believes it has developed about on the schedule he foresaw. Although he then dubbed it a "solution looking for a problem," he notes now that "everybody else put communications uses at the top of the list, but I said it was 20 years away, and that, considering the interest now in fiber optics, is about right."

Simpler languages aiding penetration by small computers, says Data General's Foster

Although William Foster did not participate in the development of the interactive data-entry and access system that Data General introduced last summer, he thinks that its capabilities open up a new opportunity for minicomputers. The company's new director of software development maintains that such systems are increasingly penetrating applications once considered the domain of the large mainframe.

The system, built around a Data General Eclipse minicomputer, works with the company's English-like Idea language, which nonprogrammers can use to develop distributed business-data-processing programs. Since the minicomputer can serve many terminals and use the language, business managers can develop routines for data entry and access without the need for a knowledge of Fortran or Cobol.

"The trend is toward solving more problems with small computers,"

WHAT WE DID FOR DIGITAL VOLTMETERS, WE'RE DOING FOR COUNTERS.

O.K. Wake up out there.

Fluke has got a frequency counter design specifically for communications —the 1920A. It sells for $895.*

We wouldn't bother you if it wasn't worthwhile.

Let's face it. We've had to forge some new ground to get a good footing in the counters marketplace. When you're coming up fast on the leaders, like we are, you can't afford any ho-hum instruments. Each counter gets a little better. And, of course, the guy at the bench benefits.

That's how it is with the 1920A counter.

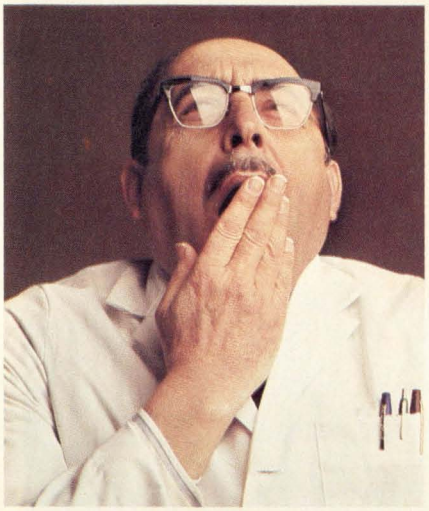
Some advanced LSI/MOS circuitry gives the unit exceptional specifications. And makes it a little more portable. There's a 9-digit LED display, sensitivity to 15 mV, AGC standard, and a frequency range of 5 Hz to 520 MHz. Optional internal prescalers to 1000 MHz and 1250 MHz cover the UHF television, 900 MHz telecommunications, and TACAN /DME bands.

Frequency Extension Options
1000 MHz Prescaler
Covers 50 to 1000 MHz using a scaling ratio of 8. Sensitivity is 15 mV rms, and maximum allowable input is 5 V rms (fuse protected). VSWR less than 2.5:1 50 ohms for levels less than 1 V rms.
1250 MHz Prescaler
Covers 50 to 1250 MHz using a scaling ratio of 8. Sensitivity is 20 mV to 1000 MHz, decreasing to 40 mV rms at 1250 MHz. Maximum input 5 V rms (fuse protected), and VSWR less than 2.5:1 for levels less than 1 V rms.

A few extras take you higher.

Direct and prescaled inputs are color-coded to match their corresponding function switches to facilitate operation. The display incorporates full leading zero suppression, automatic annunciation, overflow, and a self-check mode which lights all digit segments.

Then there are some features we're really proud of—exciting to find in an $895 unit.



But you knew that, anyway.

Measurement delays have been eliminated. A rapid-access gate free runs in the absence of input signals. It's in position to open the gate for the selected gate time as soon as a signal is sensed. An auto-reset circuit initiates a new measurement every time any front panel switch is activated. The first measurement obtained is always correct.

In addition to normal frequency measurements, there's a burst function. The unit measures RF bursts of greater duration than the selected gate time. To avoid erroneous reading, the display is automatically reset to zero if the burst width is less than the gate time selected.

An optional resolution multiplier coherently multiplies audio tone signals by 1000, providing a resolution of 0.001 Hz in 1 sec.

But now that we've got your attention, the 1920A really doesn't seem so surprising, does it? Really, it's something you sort of expect, when you come to think about it.

Another great instrument from Fluke.

As far as we can tell, it means two things. A promise to you that Fluke is giving their full attention to counters.

And a lot of worry for our competitors.

For data out today, dial our toll-free hotline, 800-426-0361.

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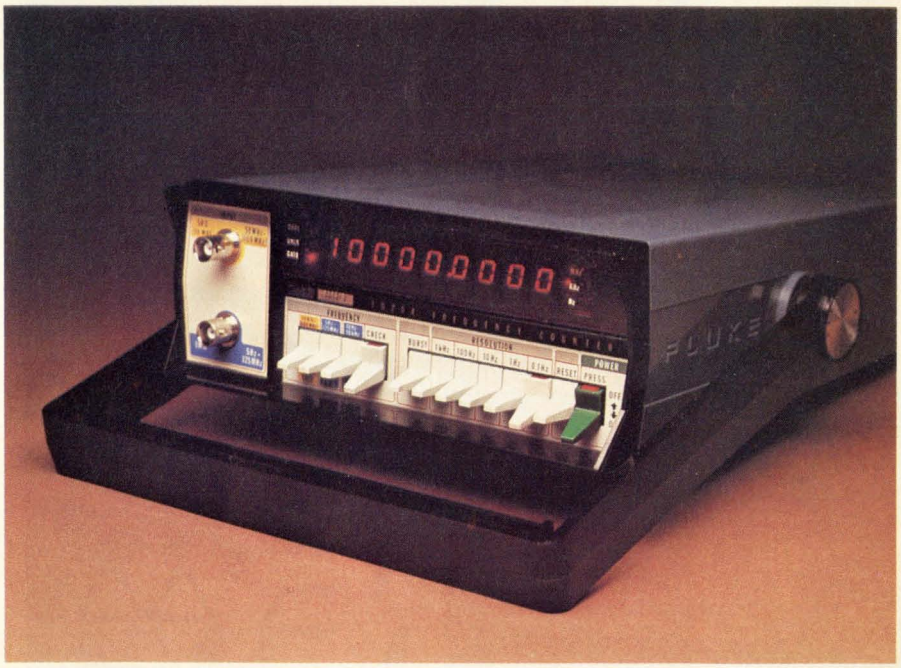
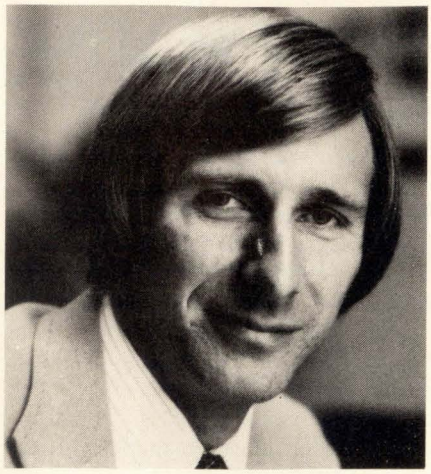
Phone: (013) 673-973 Telex: 52237

**Domestic price only.*



FOR COMMUNICATIONS. 1920A COUNTER. FLUKE®

People



Helper. William Foster is out to help the user do productive work sooner.

says the 32-year-old northern California native, who formerly headed hardware and software development at Hewlett-Packard Co.'s General Systems division. He indicates that more products like Idea can be expected from the Southboro, Mass., minicomputer manufacturer.

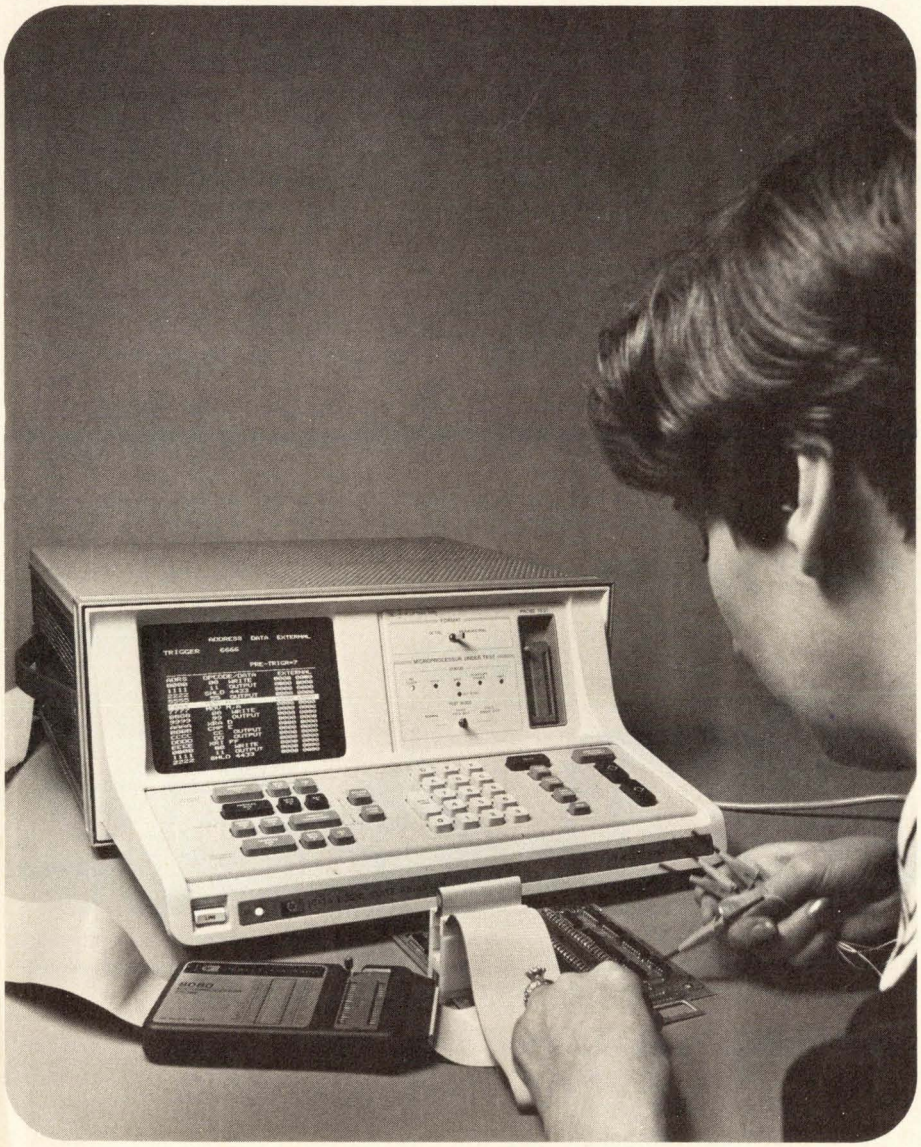
End-user software. Foster, who classifies small computer systems as those selling for about $100,000, says his group's charter is to develop software for the company's computer line and "assist in overall strategy whenever software plays a part." His job is to make sure that as Data General increasingly penetrates end-user markets, the software exists to support the application. "I've worked with end users before," he says, "and I can contribute here." He foresees the expansion of the use of high-level English-like languages on small machines "to the point where the user won't even have to know Fortran or Cobol."

In earlier days, when minicomputers were regarded strictly as original-equipment products, "engineers went off and developed a computer, and then told the software people to program it," he observes. "Now it is a team effort, with the software guys in on the planning from the start. But it is really the user who is pacing the development in our company, because we ask who is going to use a system and then optimize the hardware and software around the applications."

MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

FEBRUARY 1977



Direct connection is made to the microprocessor with the "clothespin" clip. The EXTERNAL connections are through separate leads. These may plug directly onto test pins, or they may be inserted in pincher-type miniature probes as shown. The display on the CRT is a probe test verifying internal operations of the logic analyzer.

in this issue

A new logic analyzer dedicated to debug microprocessor-based systems

As new applications for microprocessor-based systems proliferate, Hewlett-Packard recognized the need for an instrument that could handle the vast quantity and complexity of data during system debugging. This measurement need resulted in the development of the new HP 1611A logic state analyzer with powerful triggering capabilities, mnemonic display and time interval measurements, saving you a significant amount of time in debugging microprocessor-based systems.

An extremely important feature of

(continued on third page)

Economical counters

The 80 MHz 5381A and 1.3 GHz 5300B/5305B are two of the choices HP gives you in economical counters. Two of the eleven 5300B modules are at the right; the D/A converter and battery pack.

Many counter problems only require a simple, economical and dependable instrument. It is for this reason that the frequency-only 5380 family and the modular 5300 system were developed.

The 5381A, 5382A, and 5383A represent an inexpensive solution to a frequency only measurement problem up to the frequency ranges of 80 MHz, 225 MHz, and 520 MHz, respectively. All these counters feature direct counting capability (a resolution of 1 Hz in 1 second), as well as an optional TCXO for improved measurement accuracy.

For applications involving counter measurements other than just frequency, the modular 5300 system is an excellent and economical solution. Configurations can be changed to meet different needs by simply snapping on an appropriate module. For example, frequency extensions to 1.3 GHz, time interval measurements to 1 ns, battery operation, digital multimeter, and even "talk" capability on the H-P Interface Bus are just some of the possibilities with the expandable and economical 5300 system.

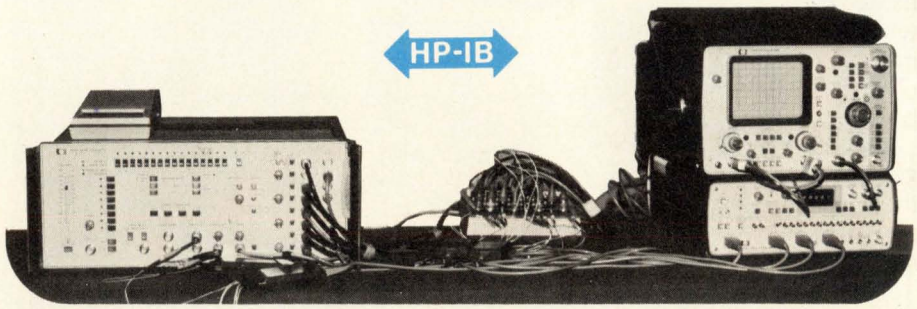
For the whole story, check K on the HP Reply Card.

HP-IB programmable word generator with pulse parameter control for thorough digital testing

Hewlett-Packard's 8016A word generator is a versatile 50 MHz data source ideal for digital testing applications. Using it, you first set up your test pattern in the generator's 9-channel by 32-bit memory. By adjusting clock and inter-channel delays, pulse widths and amplitudes, you can easily simulate worst case or other conditions.

Multi-channel parametric tests such as set-up times, hold times, propogation delay, critical timing, sensitivity and noise immunity tests, are now easy with the total capability of the 8016A.

Now, you can use the 8016's multi-channel capabilities in CMOS applications as well. A new accessory, the HP 15451A TTL to CMOS translator, amplifies 4 channels of TTL information to CMOS levels with pulse amplitudes determined by the CMOS power supply.



In combination with HP's 1600A logic analyzer, you have a practical stimulus-response combination for observing your logic circuits in action. Functional tests of your logic circuits, memories, microprocessors, etc. can be performed quickly with the 8016A/1600A combination.

A remote programming capability, (Option 001) allows fast loading of data to the instrument's memory with an HP Interface Bus compatible card reader, calculator, or minicomputer—a valuable option for on-line testing where speed and accuracy are important.

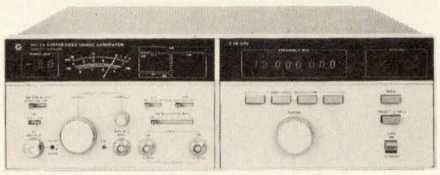
For details on this powerful word generator, check M on the HP Reply Card.

Microwave synthesizer application note now available

A new HP Application Note 218-1, *Applications and Performance of the HP 8671A/8672A*, details applications ranging from satellite communications testing to electronic warfare and component test. The 8672A (M/C News, May 1976) has AM/FM modulation and calibrated output usually associated only with signal generators but also resolution, spectral purity, stability and programmability of a high quality synthesizer.

A typical section of the note describes a technique to obtain finer frequency resolution of 1, 2, or 3 Hz at microwave frequencies from 2 to 18 GHz. Another section covers considerations and additional equipment required for microwave coverage to 36 GHz by use of external doublers.

Other sections provide detailed information on the actual operational performance of the 8672A, giving the user considerable help in getting the synthesizer applied to his job quickly. For example, specific synthesizer programming subroutines are listed and annotated to assist in writing application programs.



For precision signal simulation from 2 to 18 GHz, the HP 8672A provides +3 to −120 dBm signals with AM and FM modulation, and all front panel functions remotely programmable.

For your free copy, check R on the HP Reply Card.

Conversationally interactive programmable data logger also operates in unattended mode

A programmable data logger is a system to collect and analyze data, make decisions based on the data and interact with the test, process, experiment, instrument, or the system which generates the data.

The 3051A system can measure dc from 1 microvolt to 200 V with 1 μvolt resolution, ac from 10 μvolts to 200 V with 10 μvolt resolution, and ohms from 1 milliohm to 10 Megohms with 1 milliohm resolution. The system measures dc at five channels per second, ohms and ac at 4 channels per second.

System configuration includes the HP 3455A high accuracy/resolution 6½-digit DVM, a 3495A input multiplexer, a 9815A computing controller, and a 9815A HP-IB I/O card.

The *user* communicates with the system via an alphanumeric keyboard; the *system* communicates with the user by a numeric display and an alphanumeric thermal strip printer. This conversational interaction capability allows the system to be operated by personnel with no formal knowledge of programming or data logging. Auto start capability allows the system to operate unattended.

For more information, check D on the HP Reply Card.

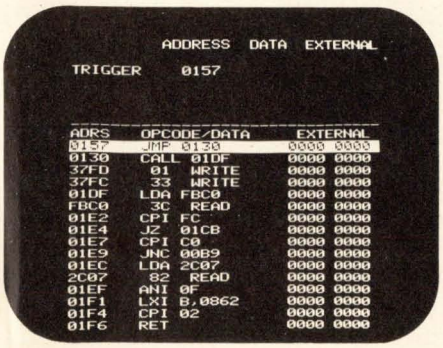
HP-IB

The Hewlett-Packard 3051A data logging system scans from 1 to 80 channels of analog data. A ten channel relay actuator card provides alarm and multiple switching functions.

Dedicated logic analyzer *(continued from first page)*

the 1611A is its ability to display the mnemonic set used by the microprocessor in the system. If cycle-by-cycle analysis is desired, the data can be displayed in the absolute mode where the display is in hex or octal machine language. Eight additional uncommitted probes allow you to relate activity elsewhere in the system.

With new highly sophisticated triggering capabilities, the 1611A permits the framing of a real-time data window around virtually any event, or set of related events or desired sequence of system operations. The 1611A also accurately measures execution time or counts selected events between two keyboard-selected events.



Mnemonic display has been made possible by the use of "personality" modules—consisting of special circuits and microprocessor probe—to monitor specific microprocessors. Presently, two options are available: Option 080 for the 8080 and Option 068 for the 6800. Additional optional modules will be available shortly. To reconfigure your analyzer, parts can be ordered as a kit and easily exchanged in about 15 minutes.

An internal 8-bit MOS microprocessor is used as a controller in this new keyboard controlled logic state analyzer. The CRT displays both the measurement conditions and results.

For detailed information, check B on the HP Reply Card.

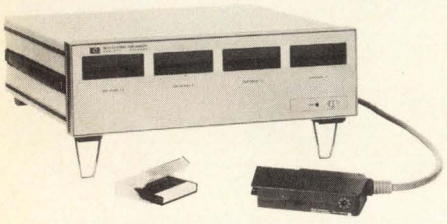
Easy tape duplication with expandable storage up to 1 Mbyte using new external memory unit

The HP 9877A External Tape Memory is a self-contained peripheral that can hold up to four cartridge drives to expand the capabilities of the HP 9825A desktop programmable calculator. Using the same cartridge unit, storage capacity from 250,000 to 1 Million bytes is now provided in increments of 250,000 bytes.

Each tape cartridge unit has a built-in two-track drive which provides rapid access to data and programs with automatic verification of all stored information. A 2,750 byte/second data transfer rate and a 228.6 cm/second search speed makes it a very fast and inexpensive method of storing, retrieving or duplicating data. An HP 9877A, fitted with four tape units, takes about six seconds to locate any file from any tape in the unit.

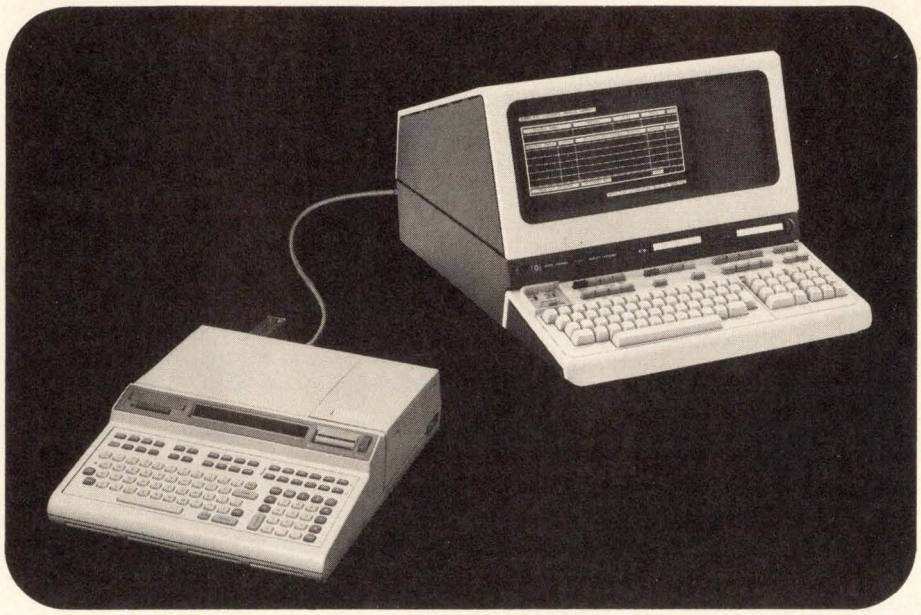
Using the duplicator program supplied with the 9877A, a full master cartridge can be copied and verified in about 16 minutes. Two copies, from the same master data tape, are sequentially copied and verified in 26 minutes and four copies in 50 minutes.

For more information on expanding tape storage capability, check P on the HP Reply Card.



External tape memory presents an inexpensive method of storing large volumes of data plus the convenience of duplicating cartridge tapes.

Now, interface your 9825A desktop to a teletype or a remote computer



Data can now be gathered from a remote terminal or computer, reduced and analyzed by the high speed processing of the 9825A desktop, and results returned to the remote location.

The HP 98036A bit serial interface opens new areas of application for the HP 9825A desktop computer. In addition to bit parallel, binary coded decimal, and HP-IB (Hewlett-Packard's implementation of IEEE Standard 488-1975) interface capability, the advent of the 98036A allows connection to such devices as teletypes, CRT terminals, and telephone modems.

Because of the flexibility of the 9825A desktop computer, the 98036A can be used to configure the 9825A as a timeshare terminal. This allows the keyboard of the 9825A to be used to send information to a remote computer. The 9825A display or an attached printer can be used for output information received from the remote computer eliminating the need for another terminal in a distributed system.

The vectored interrupt capability of the 9825A further enhances the usefulness of the 98036A. The desktop computer's buffered input/output scheme will allow multiple interfaces to communicate simultaneously with different remote devices while locally executing another program. Priority interrupts ensure that more important information can be dealt with quickly to maximize system throughput.

Configuration of the 98036A is accomplished via internal switches and by programming the 9825A. The number of bits per character, parity, internal/external data clocking, and bit rate are configured by the user. The 98036A operates in an asynchronous mode with data rates from 75 bits per second to 9600 bits per second.

For complete information, check E on the HP Reply Card.

Three more spectrum analyzer application notes

Three new application notes relating to spectrum analyzers have just been published. Subjects of these brief, informative notes are:

AN 150-9: Noise Figure Measurement
AN 150-10: Field Strength Measurement
AN 150-11: Distortion Measurement

In each case, the theory is reviewed, measurement procedures described, and examples of measurements presented. Advantages and tradeoffs that apply to using the spectrum analyzer are discussed.

For free copies of these new notes, just check Q on the HP Reply Card.

New display station handles both APL and ASCII data

Use the power of APL on a small general purpose computer

Hewlett-Packard designed the 2641A Display Station to complement the power and elegance of the APL language. Key to the secret of APL's capability is a distinctive set of characters, each one symbolizing a powerful operation.

The 2641A is a member of the 2640 family of HP terminals that pioneered internal mini-cartridge mass storage and offers features such as self-test and "soft keys". The 2641A has these family features, plus a versatile keyboard labeled with both the APL and standard ASCII characters.

The 2641A supports a full 128 APL character set, a 64 character overstrike set and a 64 character Roman set. These sets represent the special symbols used on IBM and Burroughs systems, and most symbols used by timeshare bureaus that support APL.

Overstruck characters, an APL innovation, are a combination of two existing characters and are produced by striking one key, backspacing, and striking a second key. Without the high resolution display of the 2640 family, overstrike characters would be difficult to read. The 2641A assures crisp, clear characters.

After a user inputs an overstrike character, a search and compare with the existing set in memory assures that the character is valid.

The full complement of display enhancements (inverse video, blinking, half-bright, etc.) are standard, and the optional line drawing set allows the creation of readable forms with visual prompts.

For more information on the 2641A, or other family members, check C on the HP Reply Card.

With the advent of APL\3000 in conjunction with the HP 3000 Series II computer and a new interactive terminal, the 2641A, designed especially for the language, APL is now more readily available as a new dimension in computational capability.

APL\3000 is the first APL software available on a low-cost general purpose computer. Patterned after APLSV, this enriched version from Hewlett-Packard is particularly useful for business, education, scientific and engineering applications involving the manipulation of large data arrays.

```
      ∇VR'NEWQUEENS'
 ANS←NEWQUEENS;NESW;NWSE;R;X;J;I;K
 NESW←NWSE←I↓X,X←R←8⍴0
 J←1 ◊ I←78
 CYCLE:→REGRESS×⍳8<K←¯1+I+(0=(I←1↓I×R≠8↑((J←1)↓R)∨(8-J)↑NWSE)×1
 X[J]←K ◊ PLACEQUEENS JTX
 →OUT×⍳8<J←J+P←1=1 ◊ I←1
 JOIN:R[K]←NWSE[8+K←(J-P)]←NESW[K+(J←P)-1]←P
 →CYCLE
 REGRESS:→NOSOL×⍳P←0=J←J-1
 I←1+K←X[J]
 →JOIN
 NOSOL:ANS←'NO SOLUTION'
 →0
 OUT:ANS←'SOLUTION IS ',⍕X

      ∇CR'PLACEQUEENS'
 PLACEQUEENS X;B
 X←8↑X
 B←,⍉X∘.=⍳8
 □←CR,ESC,"U",ESC,"H"
 □←B↓'■'
 □←ESC,"X"
```

APL, **A P**rogramming **L**anguage, has a large following of users, who embrace its use for its capacity to express complex mathematical applications in a concise manner; numerous computer operations can be compressed into just a few lines of code.

Because of its mathematical power, APL is of growing interest to those in the fields of statistics, finance, forecasting and modeling.

Hewlett-Packard's APL\3000 has the following enhancements:

Large workspaces. Since work spaces are virtual, they are effectively limited only by the on-line disk storage available. As code is needed and used, it is brought from disk into main memory. APL\3000 is infinitely more useable with this close-to-infinite workspace. Microcoding the "virtual workspace" scheme results in faster execution.

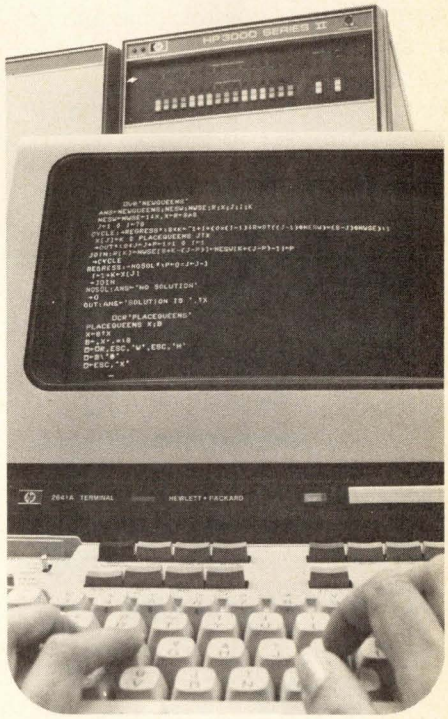
Dynamic compiler. APL is implemented as a dynamic, incremental compiler and not a simple interpreter; compiled code is preserved and when possible, used repeatably without recompiling. The result is faster execution of repetitive programs.

Powerful easy-to-use editor. The APL\3000 editor is a full text editor as well as a function editor. Commands are given in English-like words. Anyone who has made a mistake in editing will appreciate "UNDO" which allows quick recovery from an editing error avoiding long, complex recovery edits typical of most editors today.

Use of microcode. The most time consuming aspects of the subsystem have been microcoded to speed operation.

The 3000 Series II computer treats APL\3000 as a standard language subsystem. *When* APL is executing, up to 16 terminals may be operating either in batch or interactive mode, with any of the 3000's other languages: FORTRAN, COBOL, RPG, BASIC and SPL.

For additional details, check A on the HP Reply Card.



A new interactive terminal designed especially for APL, provides a clear, sharp display. APL is a terse and concise language for describing processes and algorithms.

Multiprogrammer expands your testing capabilities

Test engineers can now plug off-the-shelf units together and assemble their own automatic test and measurement system quickly and economically. A calculator-based HP Interface Bus (HP-IB) multiprogrammer system is designed for ease in communicating bi-directionally with your device under test.

A basic system includes the controller, (a desktop programmable calculator HP 9825 or 9830) connected via the HP-IB to a multiprogrammer interface unit, a 6940B multiprogrammer, and from 1 to 15 randomly-addressable I/O cards that plug into the 6940B mainframe.

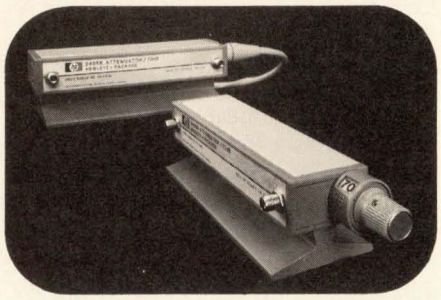
Up to 15 extender mainframes, each holding 15 plug-in cards, can be combined permitting system expansion up to 240 I/O channels controlled by a single calculator.

Input card functions include current or voltage monitoring, digital input, counting, and event sensing. Output functions cover stimulus and control including voltage, current, resistance, relay contacts, digital bit patterns, stepping motor control, time and frequency references.

For more details, check L on the HP Reply Card.

HP-IB multiprogrammer building-block components bring the power, economy, and ease of programming of HP desktop programmable calculators to your automated testing system.

Step attenuators now operate dc to 26.5 GHz



The APC-3.5 connectors used on these HP 8495D/K 70 dB step attenuators are fully compatible with the industry-standard SMA.

Considerable microwave activity is now focusing on coaxial designs above 18 GHz. Such diverse areas as satellite communications and electronic warfare require measurement components operating to 26.5 GHz and beyond.

The new HP-developed APC-3.5 coaxial connector provides a mode-free, beaded, air line for operation to 34 GHz (*Microwave Journal*, July '76). By use of this new connector, a step attenuator from the HP 8495 series is able to operate dc to 26.5 GHz.

HP 8495D manual step attenuator offers 70 dB range in 10 dB steps. HP 8495K is the programmable version with the same specifications. Solenoids operate from 20-30 volts at 110 mA. These attenuators are composed of four attenuator sections (one 10 dB card, and three 20 dB cards) connected in cascade. Each section consists of a precision thin-film attenuator card, a lossless thru line, and a ganged pair of gold plated center conductor contacts that switch the attenuation card in and out. This combination results in high accuracy and excellent repeatability (typically 0.03 dB).

For details, check N on the HP Reply Card.

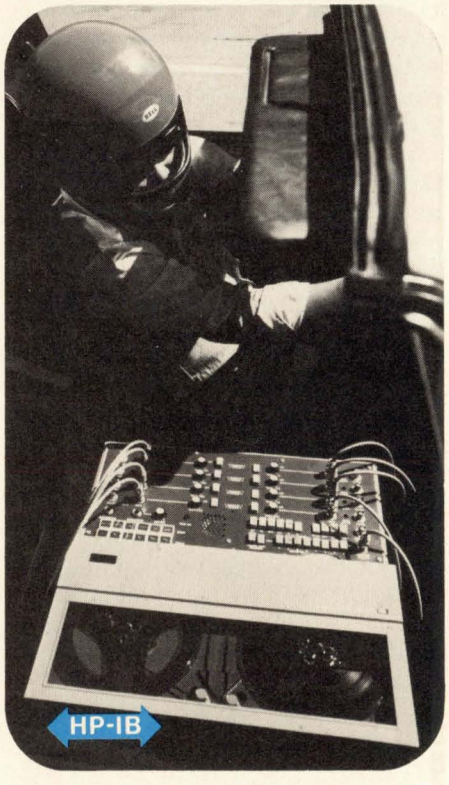
Take your instrumentation tape recorder with you

Now HP instrumentation tape recording quality is available to you in the field, where and when you need it. A dc to ac inverter, capable of operating your HP 3964A or 3968A instrumentation tape recorder, from either a 12 or 28 dc voltage source is now available as Option 021.

This new inverter option is included as part of the recorder itself and is specified as part of the original purchase. Total weight of the recorder with inverter is 31.3 kg (69 lbs).

If you have need for a rugged, portable tape recorder to be used in a variety of applications, send for data on the HP 3964A and 3968A recorders. *Please check F on the HP Reply Card.*

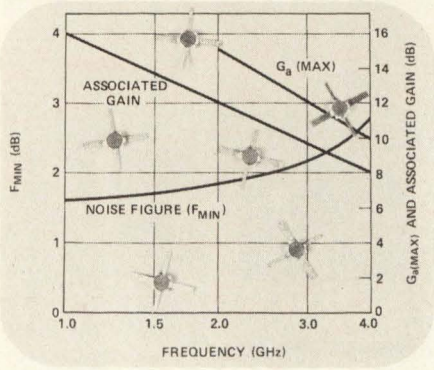
A 66-page catalog describing consumables available for HP plotters, x-y recorders, strip chart recorders, oscillographic recorders, and instrumentation tape recorders is available. *Check G on the HP Reply Card.*



Analysis of vibration is possible when you transport your instrumentation tape recorder with you. Shown above is a Hewlett-Packard ITR recording data 'live" on a speedway.

HEWLETT-PACKARD COMPONENT NEWS

Two new low-noise microwave transistors



Packaged in the hermetic HPAC-100, a rugged metal/ceramic package, both devices can meet the requirements of MIL-S-19500 and the test requirements of MIL-STD-750/883.

With only 1.6 dB maximum noise figure at 1.5 GHz, the HXTR-6104 is ideal for use in low-noise amplifiers, in communications equipment and radar preamps. Associated gain at NF bias conditions is 13 dB minimum.

The HXTR-6103 with 2.2 dB maximum NF at 2 GHz and 11 dB minimum associated gain is a replacement for the Fairchild FMT 4005.

Ion implantation techniques and titanium-platinum-gold metallization are used in both devices.

For details, check J on the HP Reply Card.

Two new technical notes

AN 967 describes the design of a single-stage state-of-the-art low noise amplifier at 4 GHz using the HXTR-6101 silicon bipolar transistor. Both the input and output matching networks are described. *For a copy of AN 967, check T on the HP Reply Card.*

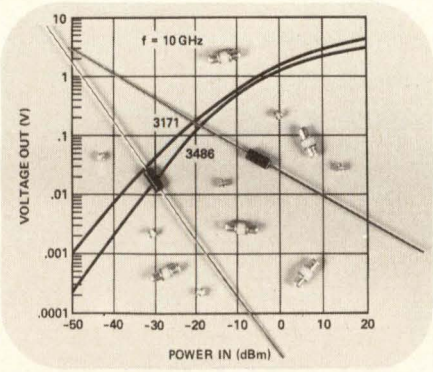
AN 968 discusses IMPATT amplifier design. A waveguide amplifier produced 2 watts of power with 10 dB gain at 11.2 GHz. Using a coaxial structure, similar performance was obtained at 8.4 GHz. *For a copy of AN 968, check U on the HP Reply Card.*

No dc bias needed with new Schottky detector diodes

These new zero bias Schottky diodes eliminate the problem of temperature compensation of the dc current required in sensitive detector circuits using conventional detector diodes. The high voltage sensitivity of these diodes makes them especially suitable for narrow-band video detectors in high-frequency receivers and measurement equipment.

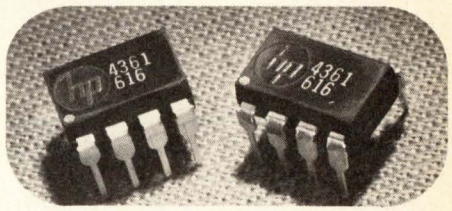
The HSCH-3000 series diodes have a typical voltage sensitivity of 10 to 50 millivolts of output per microwatt of input power (depending on device type) at 10 GHz. Conventional Schottky detector diodes with dc bias applied produce 5 to 10 mV/μW. Both low impedance (2000 to 8000 ohms) and high impedance (80,000 to 300,000 ohms) devices are available).

For a technical data sheet, check I on the HP Reply Card.



The HSCH-3000 series zero bias Schottky diodes are available in either ceramic or glass axial lead packages.

New isolator rejects 100X more common mode noise



Combining a GaAsP LED and an integrated high gain photon detector, this high speed gate provides maximum dc and ac circuit isolation while achieving TTL compatibility.

A design using an internal shield for high common-mode rejection (CMR) which guarantees common-mode transient immunity of 1000 volts/μsec minimum is the key feature of these new optically coupled isolators.

The 5082-4361 is designed for use in high-speed, high-noise line receiver applications, logic-to-logic isolation applications and high-noise power control related applications.

For details, check H on the HP Reply Card.

How to use optically coupled isolators in linear applications

Application Note 951-2 describes how isolators can be useful in applications where analog or DC signals need to be transferred from one module to another in the presence of a large potential difference or induced noise between the ground or common points of these modules.

Applications are those in which large transformers, expensive instrumentation amplifiers or complicated A/D conversion schemes are used.

The note covers the basics of optoisolator operation. Specific HP devices are recommended.

For your free copy, check S on the HP Reply Card.

High performance and precision PLUS wideband coverage—all in one RF sweeper

HP 86222B/8620C RF sweeper covering 10 MHz-2.4 GHz generates crystal markers that add frequency identification to wideband polar plots made with the HP 8410B Network Analyzer.

Hewlett-Packard's 10 MHz-2.4 GHz RF plug in (models 86222A and B) for the 8620C sweeper mainframe offers performance capabilities that make it a truly multi-purpose test signal source. It can cover the 10-2400 MHz range in one continuous sweep and deliver calibrated RF output from 0 to +13 dBm with full range flatness of ±0.25 dB. For each of its key performance characteristics—e.g. frequency accuracy, linearity, stability, residual FM, harmonics, spurious content—the 86222 matches or exceeds other wide-range RF sweepers. For *overall* performance specifications, the 86222 stands alone.

This excellence of performance also commends the 86222 for narrow-band sweep testing as well. In fact, many CW test requirements can be filled with this sweeper.

The 86222**B** version adds precision crystal-controlled "birdie" markers (1, 10, 50 MHz) for additional precision and convenience in setting or identifying frequencies. These digitally-processed markers are uniquely compatible with such analysis systems as the HP 8410B (vector) Network Analyzer and the HP 8755 (scalar) Frequency Response Test Set. An applications-oriented data sheet presents many ideas on how this sweeper contributes to better RF testing.

For all the details, check O on the HP Reply Card.

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Cost advantages increase potential applications.

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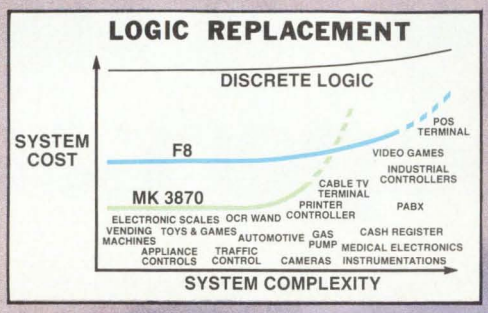

Full-capability on one chip.

The 3870 is the first single-chip microcomputer offering full compatibility with a multi-chip processor family. The device can execute the complete F8 instruction set of more than 70 commands, providing complete software compatibility with the versatile F8 multi-chip family. It features twice the program storage as other single-chip devices—2048 bytes of ROM, 64 bytes of scratchpad RAM, four 8-bit I/O ports and a single +5 volt power supply requirement. If more memory (RAM, ROM or PROM) or I/O is eventually required, the system can be simply upgraded to the expandable MK 3850 (F8 CPU).

Low-cost, development tools.

Development represents a significant investment in your program. Mostek offers one low cost

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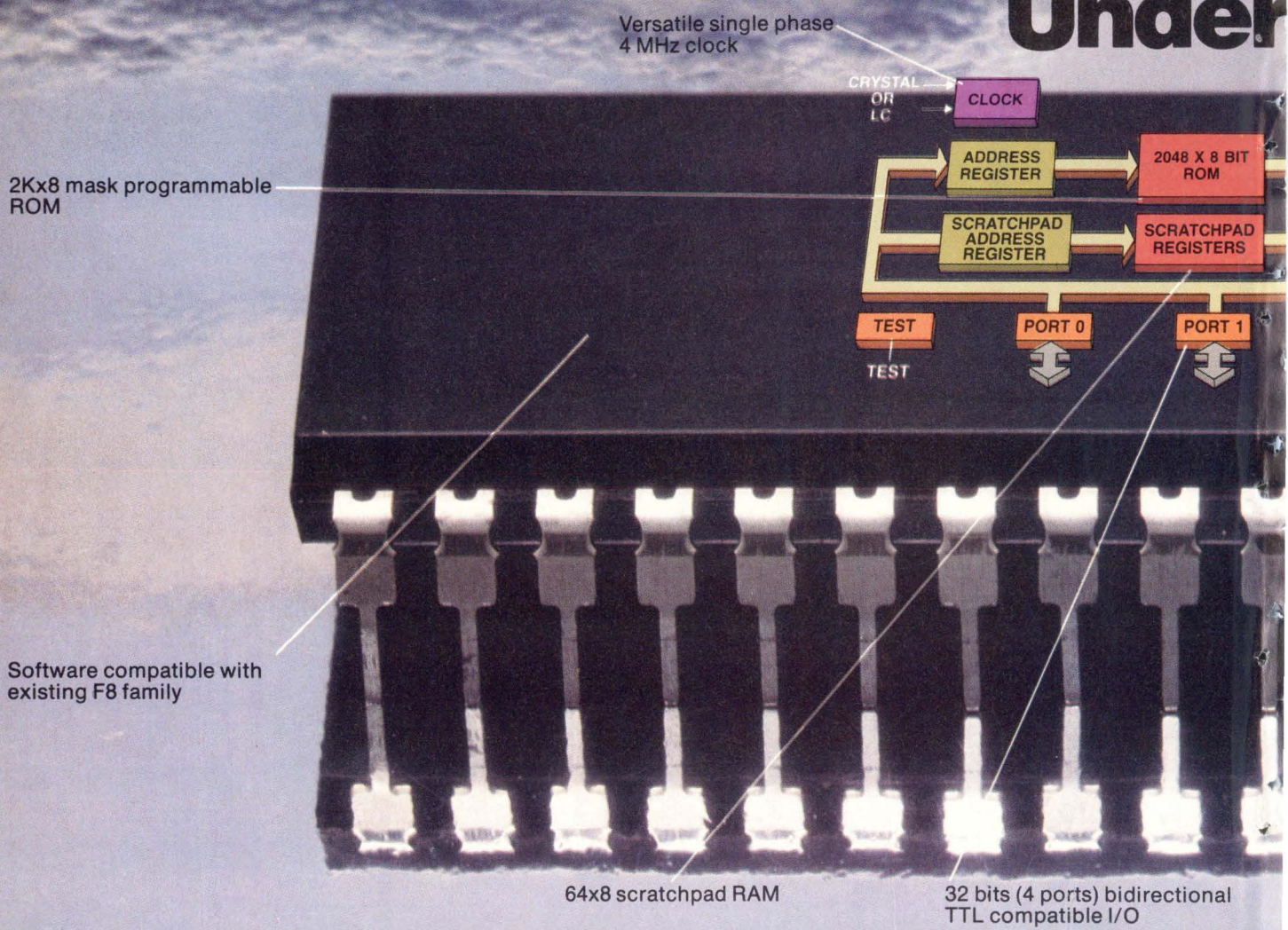

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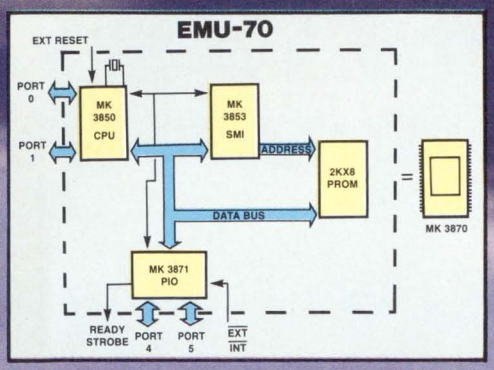

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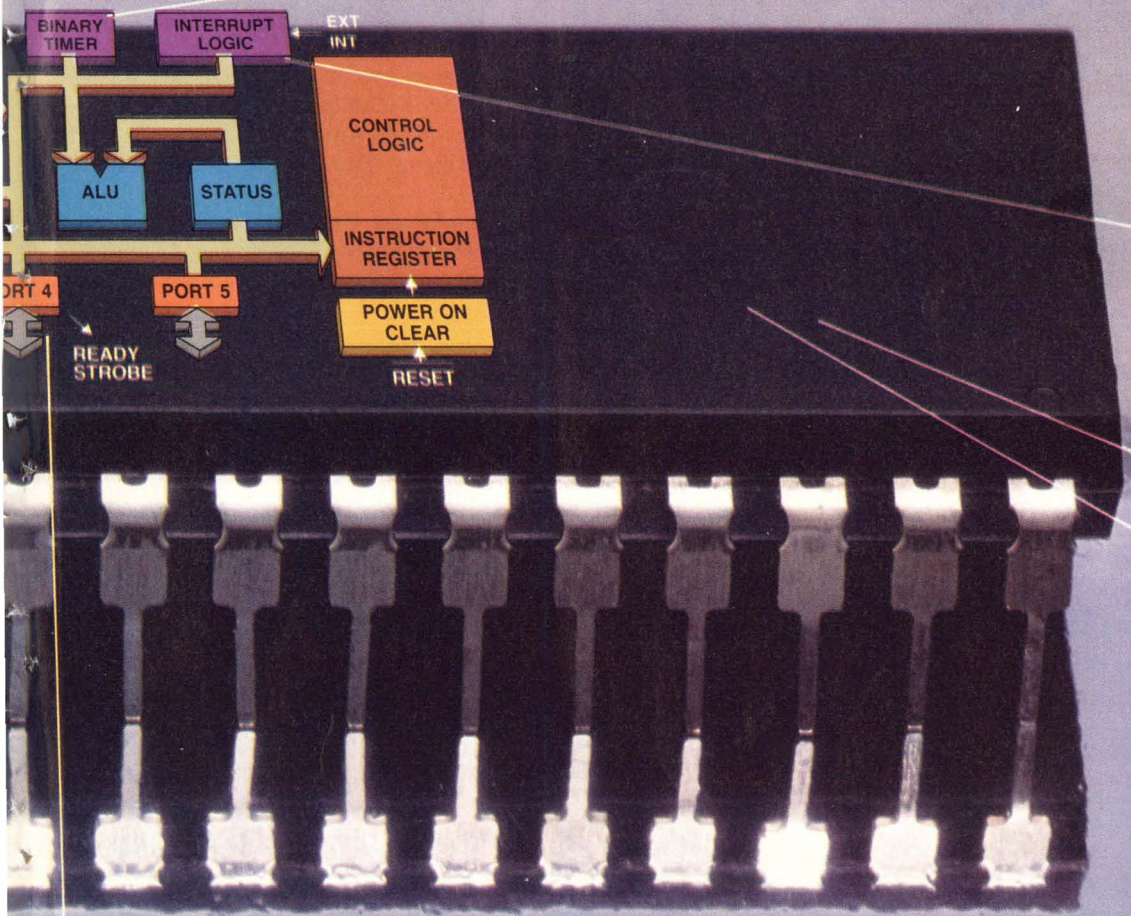

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1977 SAE International Automotive Engineering Congress and Exposition, Society of Automotive Engineers, Cobo Hall, Detroit, Feb. 28 – March 4.

Nepcon '77 West—National Electronic Packaging and Production Conference, Industrial and Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., March 1–3.

First Annual Joint Symposium on Ultrasound in Medicine, Ultrasonic Industry Association Inc. (New Rochelle, N.Y.), Hyatt-Regency Hotel, San Francisco, March 14.

Fourth Energy Technology Conference and Exposition, Government Institutes Inc. (Washington, D.C.), Sheraton-Park Hotel, Washington, D.C., March 14 – 16.

Symposium on Numerical and Asympotic Techniques for Electromagnetics and Antennas, University of Arizona, Tucson, March 14 – 18.

Southwest Printed Circuits and Microelectronics Exposition '77, Industrial and Scientific Conference Management Inc. (Chicago), Market Hall, Dallas, March 16 – 17.

Vehicular Technology Conference, IEEE, Orlando Hyatt House Hotel, Orlando, Fla., March 16 – 18.

IECI '77: Industrial Applications of Microprocessors, IEEE, Sheraton Hotel, Philadelphia, March 21 – 23.

Fourth Annual Computer Architecture Symposium, IEEE, Sheraton Silver Spring Motor Inn, Silver Spring, Md., March 23 – 25.

Data Processing Technology: 1977 – 1981, American Institute of Industrial Engineers (Santa Monica, Calif.), Americana Hotel, New York, March 23 – 25.

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Intel 8080 peripherals

Now you can get microcomputer based products out of the lab and into production faster than ever before. Intel® 8080 programmable LSI peripherals give you the competitive advantage by helping you reduce design time, component count and manufacturing and inventory costs. Most of all they'll help you get to market first.

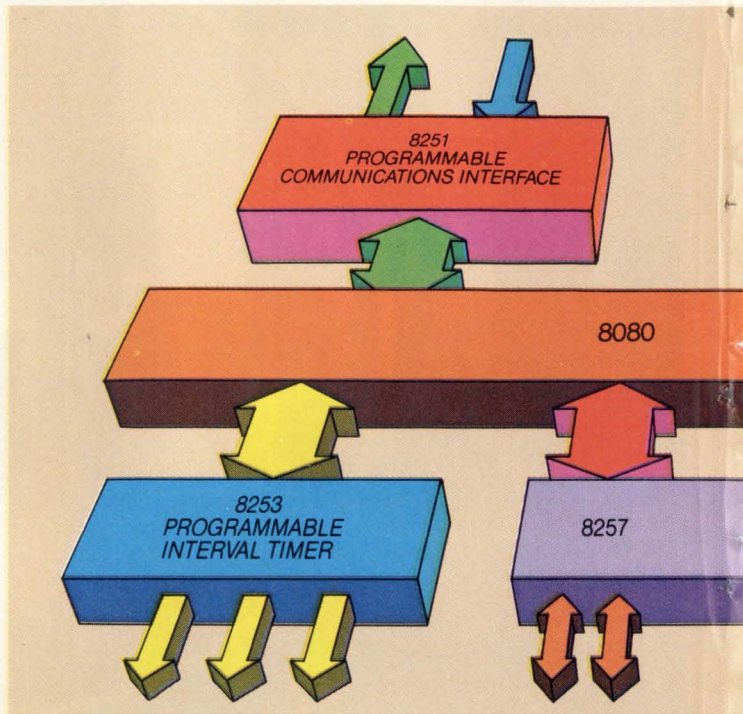
Intel 8080 programmable peripherals are software controlled LSI replacements for hardwired SSI/MSI logic assemblies. You simply attach the appropriate peripherals to the system bus and the +5V supply. Then, with system software, you personalize device operating configurations to suit your applications. Reconfiguration and design changes are made with software. No expensive and time consuming hardware redesigns are necessary.

One peripheral, the 8253 Programmable Interval Timer, is the first LSI solution to system timing problems. It counts out I/O servicing delays, eliminating software timing loops and increasing CPU throughput. It also saves hardware when you need event counters, rate generators or real-time clocks. Each 8253 contains three 16-bit timer/counters.

Our 8257 Programmable DMA Controller is the lowest cost way to handle applications that require high speed data transfer such as disks, magnetic tape, analog interfaces and high speed communication controllers. The four channel 8257 contains all the logic necessary for bus acquisition, cycle counting and priority resolving of the channel requests.

The 8259 Priority Interrupt Controller replaces complex TTL arrays and minimizes component costs. The CPU can change interrupt structure "on the fly" to suit changes in the operating environment, such as time of day or process control parameters. The 8259 handles up to eight vectored priority interrupts. Multiple 8259's can control up to 64 interrupt levels.

Use the 8251 Programmable Communication Controller for "serial I/O." The first true USART in a single chip, the 8251 implements all popular com-



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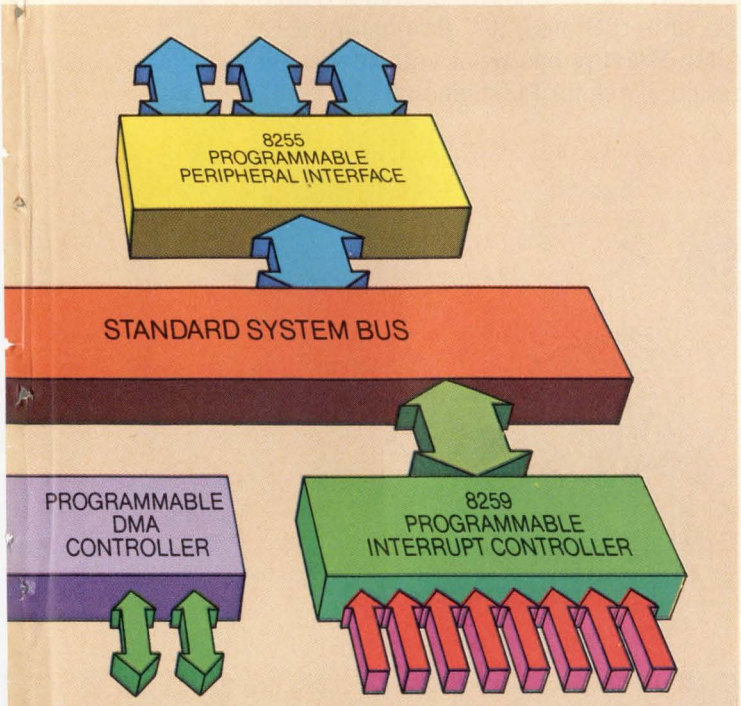

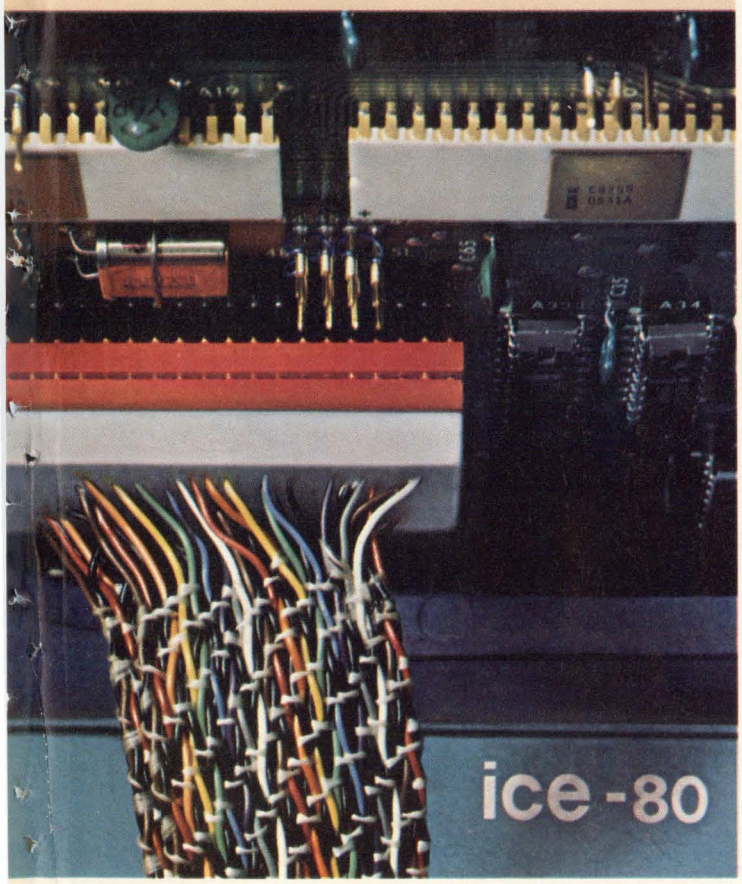

munication protocols, including IBM Bi-Sync. For "parallel I/O," each 8255 Programmable Peripheral Interface gives you 24 versatile I/O lines to interface relays, motor drives, printers, keyboard/display and other parallel equipment.

Once you've selected the peripherals to fit your application, use the Intellec® Microcomputer Development System for both software and hardware development. Using the Intellec CRT terminal, call up the resident text editor. Write the source program to initialize the peripheral and the subroutines for peripheral/system operation. Then you assemble or compile the source programs into an object file using resident macroassembler or resident PL/M compiler—and store the object file on the Intellec diskette. With the relocation and linkage capability of the Intellec ISIS II diskette operating system, these routines can be added to a system library and called from user programs as needed. Once the main system program is written, the new peripheral device routines are easily linked in. The entire program is now ready to be run on your prototype via the Intellec ICE-80™ in-circuit emulation module. ICE-80 lets you debug your software and hardware in your actual prototype environment. Move from system integration and debugging to production in a fraction of the time previously required.

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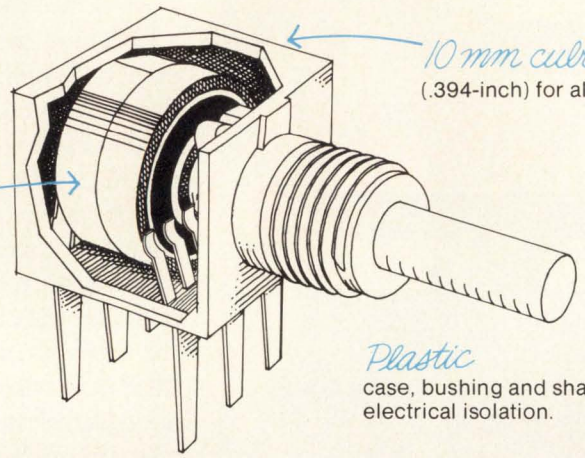
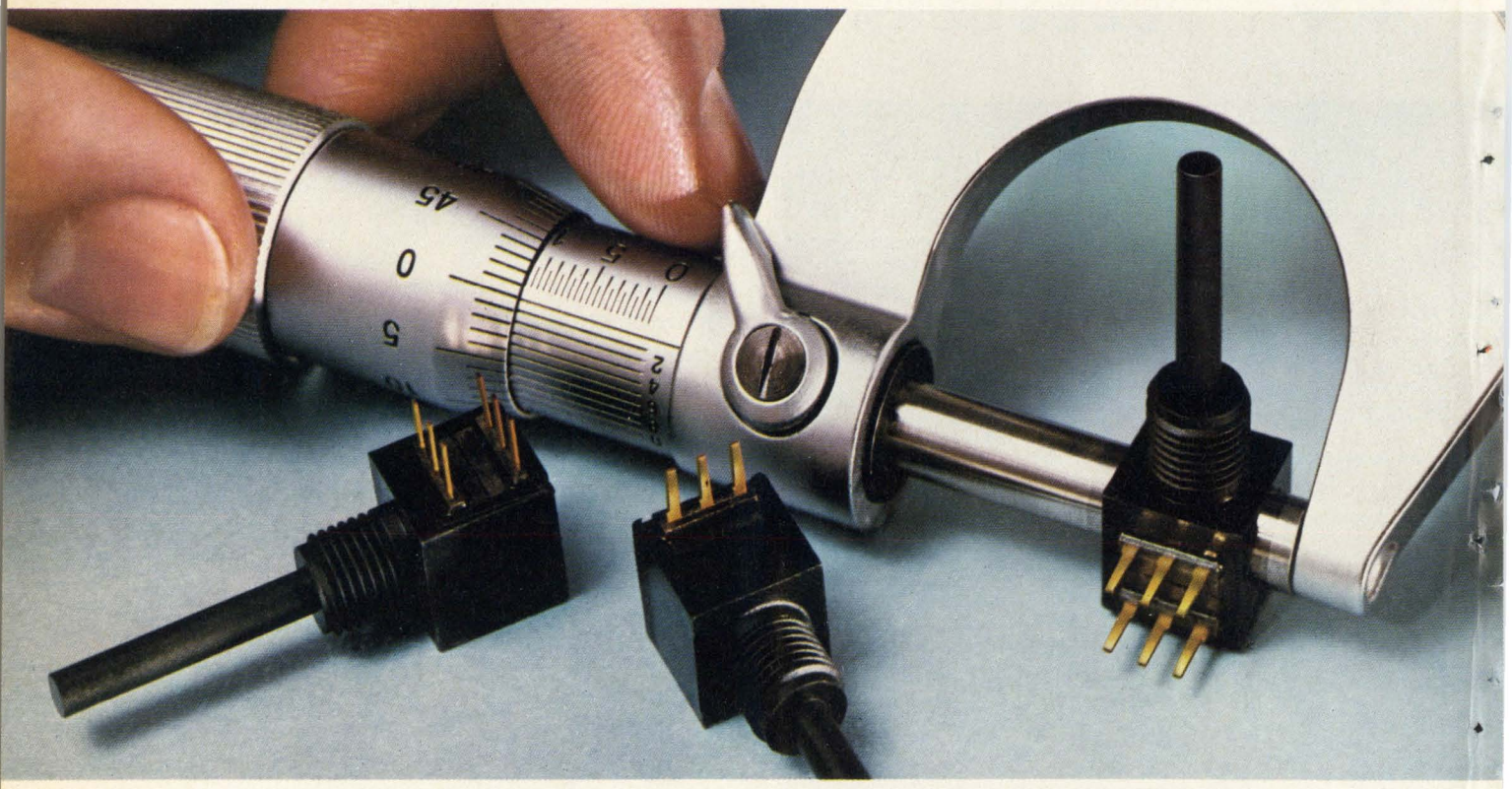


Plastic
case, bushing and shaft for electrical isolation.



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EC131

Electronics newsletter

RCA maps concerted push in SOS circuits . . .

A semiconductor industry that continues to view silicon on sapphire as exclusively a performance-oriented military technology, and not price-competitive, may be in for a surprise. This is the year that RCA's Solid State division, which sold nearly $250 million worth of semiconductors last year, will be putting its two years of commercial investment in SOS on the line with a host of digital C-MOS-on-sapphire circuits. Says Philip R. Thomas, division vice president and director of MOS operations, **"We are moving our sapphire line into full manufacturing status** at our LSI facilities in West Palm Beach."

In microprocessors, the company will have samples of a sapphire version of its 1802 C-MOS microprocessor, the 1802-S, which executes instructions typically in 1 microsecond, or two and a half times as fast as the bulk version. In random-access memories, the company will have eight static C-MOS-on-sapphire RAMs, priced to compete with n-MOS statics for microprocessor and peripheral applications. Two 4,096-bit static RAMs (4,096-by-1-bit and 1,024-by-4-bit) will operate in the 200-to-300-nanosecond range, dissipate a mere 10 milliwatts of power, and have a 28,000-mil-square chip that will make them smaller and potentially cheaper than some n-MOS equivalents. RCA engineers also are working on read-only memories, ultraviolet-erasable programable ROMs, timing circuits, watch chips, and analog-to-digital converters, all in sapphire.

. . . and prepares to sign processor second source

Meanwhile, RCA expects soon to pick up another domestic alternate source for its microprocessor line—Solid State Scientific Inc. of Montgomeryville, Pa. Leonard Kedson, president, confirms that the two companies are **about to complete a deal covering the 1800 microprocessor family,** (1802 central processor, RAMs, ROMs, and peripherals) in both the C^2L (closed C-MOS) version and, eventually, the sapphire version. Hughes Aircraft's MOS division is now a supplier of the 1800 bulk devices.

RCA itself is filling out its microprocessor family with a multitude of peripheral parts slated for 1977 entry: bus and data buffers, n-bit decoders, memory interface chips, computation extenders, and some programmable input output chips. The firm also is introducing a TV display chip, the 1861, that works with the 1802 and other processors. Its first application will be in microprocessor-based video games.

Univac jumps into business-computer arena

Convinced that small business computers form the "fastest-growing marketplace in the computer industry," Sperry Univac is preparing to deliver its first system, the BC/7, in April. The Sperry Rand Corp. division predicts that the demand for small machines in the U.S. **will grow 21% annually through 1981, nearly doubling to $6.1 billion from $3.27 billion.** The market is now dominated by IBM's System 32 and Burroughs Corp.'s B-80.

The wholesale/distribution and manufacturing markets, as well as general accounting applications, are the initial targets of the BC/7, which is riddled with microprocessors. Intel Corp.'s 8080 devices turn up in the control processor, operator console, work stations, and as a device controller, while Intel's 3000 series processor slices are used for direct-memory-access control and in a macro-instruction processor for improved program execution. Main storage, 32 to 64 kilobytes expandable in 16-kilobyte increments, uses 4,096-bit random-access memories, Intel's 2107 and its Texas Instruments counterpart, the 4060. Typical purchase prices

range from $43,725 to $57,434, or about $933 to $1,304 per month on a five-year lease.

Lloyd, National's MOS LSI chief, to start own firm

Robert Lloyd has left his job as group director of MOS LSI at National Semiconductor Corp. The 43-year-old Lloyd, who founded Advanced Memory Systems in 1968, says he is now forming a company that will cash in on **"applying microprocessor technology to the power-supply business."**

Lloyd was replaced quickly at National by Roy Thiels, who has been National's European technical director and managing director for its United Kingdom operations.

Participants hope solar program will heat up

"A feeling of anticipation" that changes are in the offing permeated late January's quarterly integration meeting in San Diego on the ERDA-JPL program to develop a low-cost silicon-solar array. "Nobody knows what to expect from the new Administration," admited one participant, but he noted a hopeful attitude that more impetus will be put behind all the photovoltaic-energy efforts sponsored by the Energy Research and Development Administration and the Jet Propulsion Laboratory. The low-cost program, **slow in getting started in 1975, has lagged even more since then.**

Speculation at the meeting also centered on which of the nine industry bidders will win the prime contract for Sandia Corp.'s 10-kW solar-cell concentrator array (see p. 44). Front-runners are said to be giants Westinghouse Electric, Martin-Marietta, and small Spectrolab Inc.

Microwave oven sales to soar another 38% in '77

Sales of microwave ovens leaped 60% in 1976 and will show another 38% gain this year, growing to 2.2 million units valued at $900 million retail. That is what William W. George predicts, president of Litton's Microwave Cooking division, America's largest manufacturer. What's more, models with electronic touch controls—first introduced last year—**will account for half of this year's sales.**

George pegs 1978 sales at $1.2 million, outstripping the combined markets for conventional gas and electric ranges, and figures that by 1985, half of all American homes will have microwave ovens.

Addenda

After a year of product refinement, Monroe Calculator Co. is bringing out a ledger-card computer manufactured in Sweden by the Datasaab division of Saab-Scania. Monroe is marketing the self-contained desktop computer, called the LCC/60, **in hopes of filling a gap it sees** in small- and medium-sized business-accounting systems, below expensive minicomputer systems. . . . IBM's Office Products division, which dominates the word-processing market, has caught on to the fast-growing competition for CRT-display text-editing terminals. With typical CRT systems running about $35,000. to $40,000, **IBM has introduced the Office System 6 priced at $31,850.** This package includes the display, diskette storage, magnetic card reader/recorder, high-speed ink-jet printer, and paper-handling equipment. The terminal without printer is $16,450. Also, a communication option is available for $4,270.

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For years now, we've recognized industrial cleaning as a vital link in maintaining component and system purity and reliability. And here's what we've done to make sure Miller-Stephenson aerosol cleaners can help achieve the system integrity you need.

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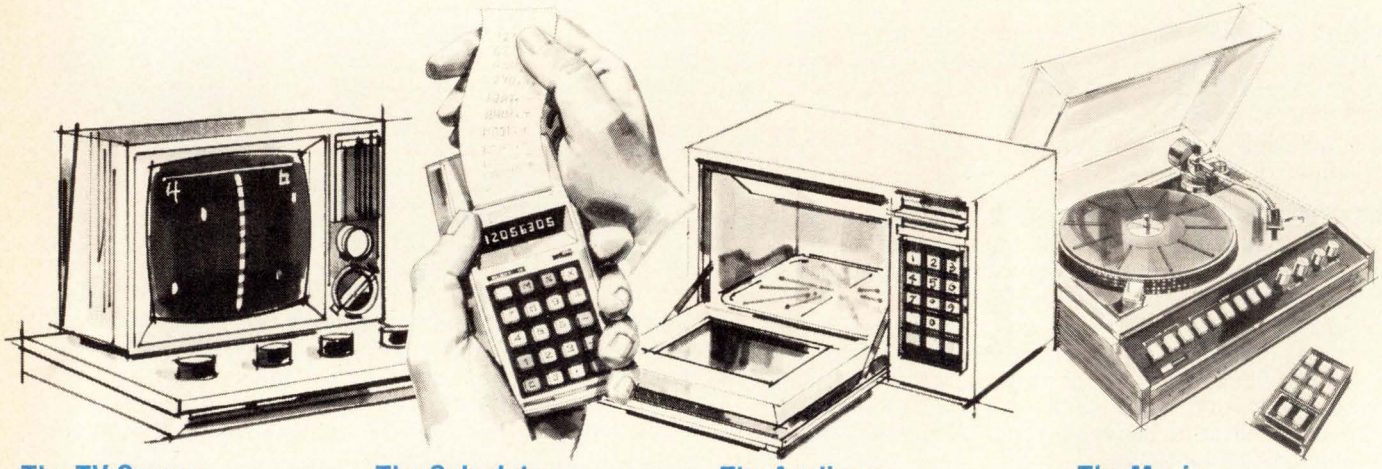
Circle 37 on reader service card

GI microprocessors "dedicated" to help you compete



The TV Games Microprocessor

Put your boss in the corner by challenging him to a TV game. Or two. Or maybe six. GI makes six-games-on-a-chip—tennis, squash, soccer, practice and two target shooting games. Plus microprocessors for many more games including two intriguing tank battle games. And advanced ball and paddle games. It's not surprising that we're the leader in TV game chips. After all, GI Microelectronics was the **first** to achieve high volume capability in microprocessors for TV games. Today, we make them in three types: dedicated home games, programmable "Interactive" games and custom arcade games . . . Tennis anyone?

The Calculator Microprocessor

For the record . . . our hand-held printing calculator circuits are making the revolution possible. General Instrument Microelectronics makes all kinds. From a simple 4/5 function chip to a full scientific microprocessor. Printout or display. Or printout and display. Hand-held or desktop. We've been a major supplier of MOS/LSI circuits for hand-held display calculators from Day One. Today, GI chips are compatible with a whole new generation of low-cost miniaturized print mechanisms . . . Any way you figure it, our calculator chips make you more competitive.

The Appliance Microprocessor

Things are really happening in the kitchen . . . thanks to GI microprocessors. A good example: the microwave oven. One of our circuits masterminds the entire operation. Cooking. Defrosting. Time display and timing. Reset. Right down to the beep. Our circuits can do the same for your products, too. Need a 24-hour programmable, repeatable on/off switch with 24-hour clock? How about a count-down timer? You name it . . . chances are we already make it. If not, we can "cook up" one just for your requirements . . . For the best in appliance microelectronics . . . come to the circuit "chefs".

The Music Microprocessor

Have you ever wished for a "smart" record player? That is, a turntable you could control to select any or all tracks on a long-playing record. Play them in order. Or skip and repeat. Today, the "intelligent" turntable is a reality . . . and a General Instrument Microprocessor controls the 25 commands you can give it, either by push buttons or remote control. We're big in other areas of the home music field, too. Our piano circuit makes almost anyone a pro. You'd swear the sound comes from a real piano. That goes for GI's electronic organ circuits, too.

General Instrument is dedicated to microprocessors and GI Microprocessors are dedicated.

GI Microprocessors are *optimized* for the application they serve. And GI *minimizes* the additional circuits needed to interface the microprocessor to your specific application. As a result, you pay only for the circuitry that's relative to the performance of your product.

For example, a standard microprocessor designed as a numbers cruncher isn't the optimum vehicle for appliance control. It requires too many external circuits to interface it with the appliance and it carries along overhead hardware you simply don't need. In contrast, the GI approach provides a dedicated microprocessor that permits you to program the functions your appliance requires for its own personality...The optimum cost solution to the application.

Here are a few examples of how GI's "dedicated" approach to microprocessors is working for customers whose applications call for high volume and minimum cost.

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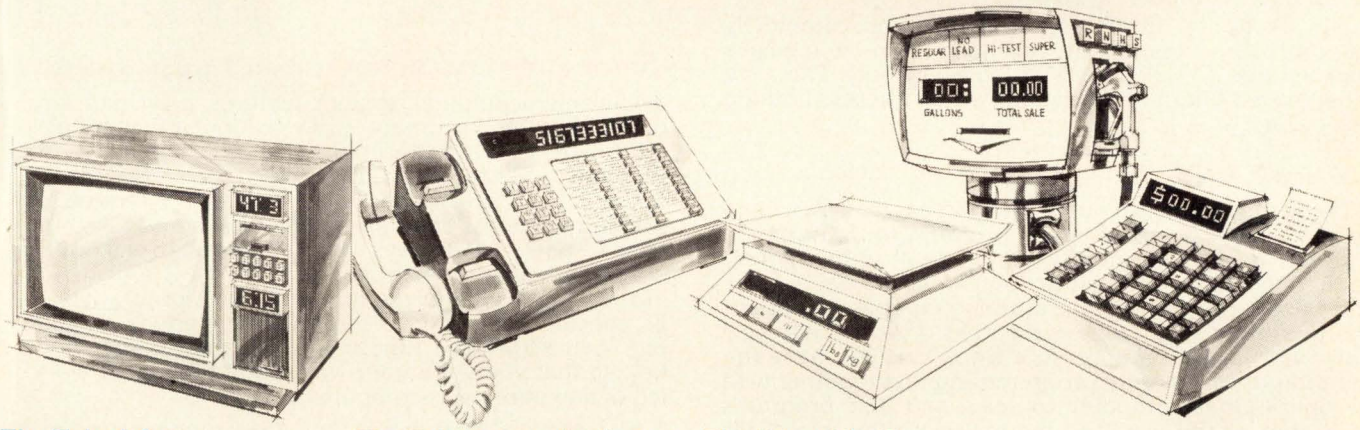


The Television Microprocessor

These TV circuits can turn on your sets... and turn on your customers. GI makes digital tuning systems for the most advanced sets on the market. Like yours. One microprocessor lets the user select 82 channels with on-screen channel display. It fine-tunes all channels independently and retains tuning data in its memory when power is off. Without CMOS and without a battery. It's remoteable, too. How about radio circuits? We make a radio receiver frequency circuit that counts and displays MW, SW and VHF. And another for AM/FM with a 12-hour clock... If it's TV/radio circuits you need, you need our "dedicated" microprocessor line.

The Telecommunications Microprocessor

GI microprocessors are opening the way to advanced telephone technology. Our MOS/LSI circuits make the telephone almost human. They're making possible today's third generation, solid-state phone. And tomorrow's "superphone". Take one-button dialing. Instead of dialing, you simply push a button. The phone dials for you. Instantly. Automatically. And if you get a busy signal, the phone will re-dial until you hang up. You can even change your phone into a data transmission center. And we have circuits that convert push button input to rotary dial pulses... and decode them... Making phoning easier is another job for GI Microelectronics.

The "Anything" Microprocessor

Our PIC1650 circuit exemplifies GI's most advanced dedicated microprocessor technology. To date, that is. It's a great little miracle worker—a microcomputer on a single chip. Other manufacturers have simply upgraded one of their calculator chips or merely combined an old multiple chip processor and called it a single-chip computer. But the PIC1650 is the genuine article. We designed it from the ground up with true computer architecture. Our PIC1650 chip contains a microprocessor. A 512x12-bit ROM. A 32x8-bit register file. Four sets of eight I/O lines. And more... including the software that lets you program it to do the things you want it to do. The PIC1650 can do wonders for vending machines. Automatic gasoline pumps. Commercial and consumer scales. Fast-food cash registers. Telephones. Appliances. Postage stamp meters... the possibilities are endless. You probably have a product right now that can use the PIC1650 to broaden its range of useful functions at less cost. Or you may prefer one of our other dedicated microprocessors.

We help you compete.

Microcomputer pro with the Iasis Co

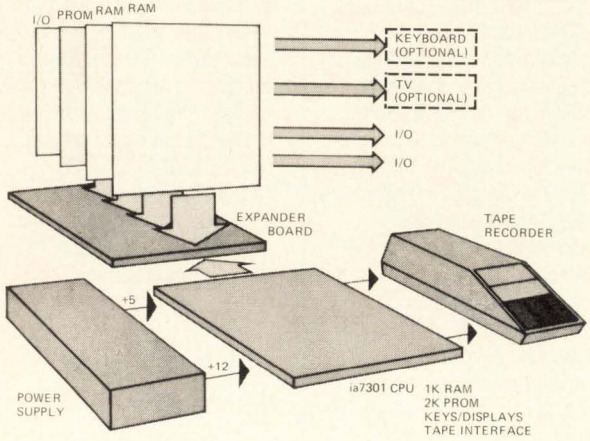
The fact is that right now microcomputer programming is a bear. Microprocessors are loaded with subtleties which make software development a long, arduous process. That's why we developed the ia7301 Computer in a Book.* It's a fully operational microcomputer system and a 250 page programming course all contained in a 3-ring binder. This is not a kit or a toy but a powerful, microcomputer system (based on the industry standard, the 8080) and a practical programming course specifically designed to quickly bring you up to a high level of understanding and proficiency in programming 8080 based microcomputer systems.

The Computer in a Book comes to you completely assembled and tested. All you need is an inexpensive dual voltage (+12V & +5V) power supply. The −5V is generated internally in the computer. There is nothing else to buy.

A super programming course

The programming course text is easy to follow and begins with a one instruction program to determine if a switch is open or closed. This is built upon and expanded through all 78 instructions until 250 pages later, you become adept at programming complex problems like multi-byte arithmetic and games of skill like Pong.™ Only with Iasis Computer in a Book can you have the advantages of a handy programming text together with an operational computer to load and test programs each step of the way and thereby learn the intricacies of microcomputer programming at a comfortable pace.

And since this microcomputer has a special built in monitor program which allows you to look into the operational parts of the system you'll never get bogged down in debugging or editing. The ia7301 Computer in a Book is the fastest way to learn everything about microcomputer programming.



*U.S. Patent Pending
Pong is a trademark of Atari, Inc.

Some great microcomputer features, too

The microcomputer system features a 24 pad keyboard, 8 seven segment LED readouts that display information in hexadecimal code which is far more versatile and advanced than binary or octal coded systems, and an onboard cassette tape interface for saving programs. The hexadecimal keyboard also contains 6 special mode keys which allow you to call up and change any data or instructions in the CPU registers or in the system's RAM memory. Likewise programs can be executed instantly or they can be stepped through one instruction at a time using the appropriate mode key, so that you learn your way around the inner working of an entire microcomputer system.

Also the write tape and read tape mode keys have been carefully designed for accurate and convenient operation with any home cassette tape recorder that has an earphone and remote microphone jack. Two LED indicator lamps tell how long it takes to dump or reload programs from the system's memory onto tape and back again. But in the reloading cycle, if any errors have occurred such as a lost piece of data or the volume knob is too low, the readout displays will indicate errors. This little feature prevents untold problems in debugging a reloaded program.

Upwards expandability from the start

We designed the Computer in a Book to be upwards expandable and not become a kluge in the process. The microcomputer contains 1K bytes of RAM memory, 1K bytes of PROM memory (containing the monitor program), and 2 I/O ports. The Computer in a Book is expandable to virtually any level you want, i.e. up to 65K bytes of memory and 256 I/O ports.

Optional expander boards are available and attach to the ia7301 computer at the top edge connector. A wide variety of standard interface boards can be plugged into the system to give add on memory, TV and teletype interface, and much more.

Thus what served as an educational system can now be upgraded for many new applications. We've included a machine language coding pad for writing and documenting programs, working out subroutines and pro-

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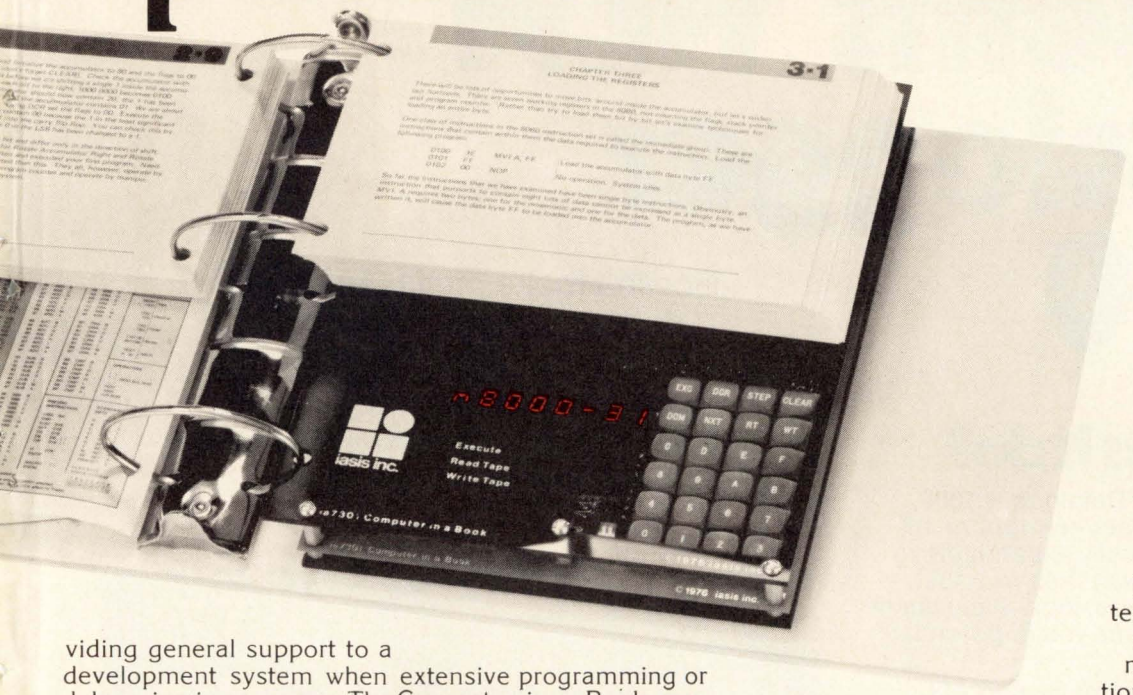
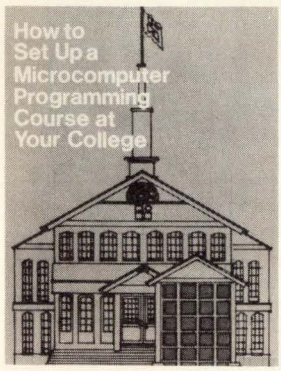
mputer in a Book



viding general support to a development system when extensive programming or debugging is necessary. The Computer in a Book may also be used to train field service technicians by putting verbal information and programs on cassette tapes. We are coming out with preprogrammed PROMs and extension tapes containing new application packages such as floating point arithmetic and micro-assembler programs. Our goal is simple. We want to provide microcomputers that are useful and practical.

A college assistance program



Educators interested in exposing their students to a comprehensive background in Microcomputer programming should look into the Iasis Microcomputer Instructional Courses for their college or university. Send for our free pamphlet which describes ways of setting up short microcomputer programming courses. It offers some advice on structuring a coordinated and comprehensive program, so your students can learn programming and get valuable hands-on experience with operational systems at very reasonable prices.

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The complete Computer in a Book which includes an operational 8080 based system, 250 page programming course, machine code pad, hexadecimal conversion card all in a 3-ring binder is offered for only $450. The Computer in a Book has a 90 day parts and service warranty. Iasis also provides a check out list and start up instructions with each system. Please allow 30 days for delivery.

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If you order your Computer in a Book before April 15, 1977, Iasis will give you an $8.00 Microcomputer Applications Handbook as a free bonus. It contains 144 pages of text, diagrams, and tables on hardware design and microcomputer applications. Order today. If the Computer in a Book isn't everything we say it is, then return it within 15 days for a full refund and keep the Applications Handbook as a gift. We're sure you'll find that microcomputer programming is a snap with the ia7301 Computer in a Book.

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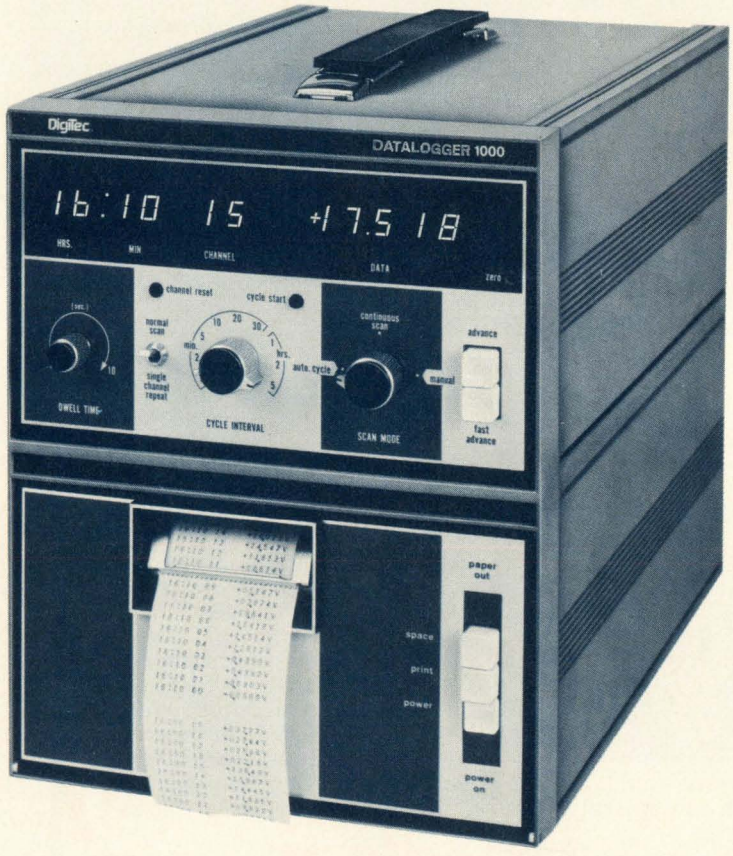

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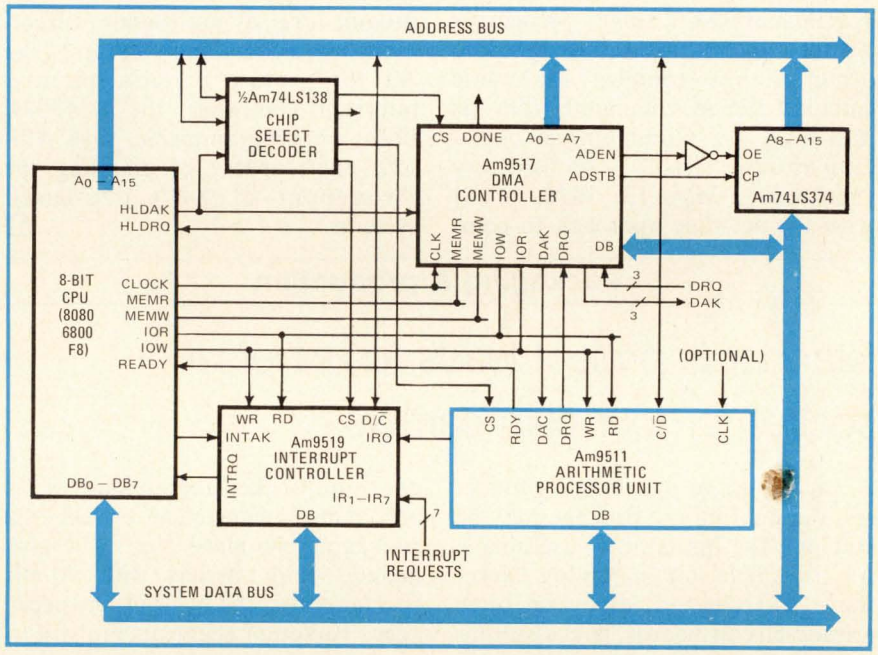
Peripheral circuits boost throughput of 8-bit microprocessors

Advanced Micro Devices adds arithmetic-processing unit to increase the performance of existing microprocessors



Boosters. Arithmetic-processor unit from Advanced Micro Devices is added as a peripheral device, along with direct-memory-access controller and interrupt controller in a family to boost performance of existing 8-bit microprocessors.

As other manufacturers move toward higher-speed second-generation 8-bit microcomputers, Advanced Micro Devices Inc. thinks it can make money by boosting the throughput of existing 8-bit microprocessors with a new family of programmable "super-peripheral" chips. "We believe there is considerable additional capability latent within existing microprocessors like the 8080A, the Fairchild F8, the Motorola 6800, and the Signetics 2750, for example," says Andrew Allison, MOS microprocessor-product manager at the Sunnyvale, Calif., semiconductor firm.

"The lower component count and the single, 5-volt supplies of advanced new systems like the Intel 8085 and the Zilog Z-80 are marginal advantages at this point," says Allison, "when compared to the much lower average selling price of existing microprocessor components." The advantage will be even slimmer, he continues, if users can increase both their system throughput and their range of applications with current central-processor-unit designs and avoid the hardware and software trauma of switching to new systems.

Fixed and floating. The most unusual member of the family is also the first, the AM9511, a 24-pin depletion-mode n-channel MOS arithmetic-processing unit, which the company expects to begin sampling in midsummer and place in limited production soon after. When combined with existing 8-bit CPUs, the speed with which the system can do complex arithmetic functions is increased 50 to 100 times. These functions include fixed-point single- and double-precision calculations plus floating-point single-precision addition, subtraction, multiplication, division, square roots, logarithms, and exponentials, as well as direct and inverse trigonometric operations.

This versatility opens up a whole new market for 8-bit microcomputers at the low end of such applications as machine-tool numerical control and distributed-intelligence process control, where real-time "number-crunching" is vital, Allison says. This market is dominated by 16- and 32-bit minicomputers.

In such applications, a 16- or 32-bit-oriented CPU takes about 20 to 30 microseconds to do a floating-point multiply, 150 to 200 μs for a square root, and about 150 to 300 μs for a sine function. Existing 8-bit MOS CPUs, which are basically data manipulators, rather than arithmetic processors, must be specially programmed for these calculations.

For the same operations, an 8080A requires 7 milliseconds, 77 ms, and 118 ms, respectively, through software. "And that's not even in the same ball park, as far as real-time numerical-control calculations are concerned," says Allison.

A 2-megahertz version of the

AM9511 APU, by comparison, enables an 8-bit CPU-based system, such as the 8080A, to do floating-point multiplication in about 200 μs, square roots in 400 μs, and sine functions in 2 ms. A faster 4-MHz version, designed to operate with AMD's 1-μs version of the Intel 8080A, the AM9080A-4, does the same operations in half the time.

Bit slice. Such an increase in throughput is achieved, Allison says, because the APU is essentially a special-purpose "slave" processor with an instruction set designed to perform such complex arithmetic calculations on command from its host 8-bit CPU. Combining its depletion-mode MOS technology [*Electronics*, May 13, 1976, p. 65] with the bit-slice approach to computer architecture of its 2900 bipolar bit-slice family, AMD has built a 16-bit arithmetic-oriented processor on the 200-by-200-mil AM9511. Included are a 16-bit arithmetic/logic unit, a microprogram-sequence controller, an 8-level operand stack register, a 10-level working-register stack, command and control registers, and a control read-only-memory array.

Also in the works, using the same special-purpose slave-processor approach are a multimode direct-memory-access controller, the AM9517, and a universal priority-interrupt controller, the AM9519. Both are programmable, says Allison, and capable of doubling the throughput of 8-bit CPU-based systems. □

Packaging & production

Standards project leads to universal socket for four chip carriers

For many large mainframe producers, the dual in-line package may be reaching the limits of its usefulness. As a vehicle for mounting large-scale integrated circuits onto printed-circuit boards, package limitations show up in the multileaded 40- and 64-pin versions, where excessive lead length adversely affects chip rise time.

It is no wonder, then, that many large users of LSI are seriously considering the use of chip carriers in their upcoming equipment. Chip carriers, which are small leadless ceramic or plastic reflow-solderable packages about a third the size of a comparable DIP, have nearly three times the upper-frequency capability of DIP packages.

Prodded by Sperry Univac and the IEEE Computer Packaging Committee, Jedec task group JC 11.3.1 of the Electronics Industries Association has written an unusually comprehensive standard for a family of 50-mil-spaced LSI chip carriers and sockets for pc-board use. This document, drawn up by the task group's computer, semiconductor, and package, and socket representatives, is only one segment of an overall LSI-packaging standard that will also include chip carriers with 40-mil spacing, DIPs, and quad in-line packages. The other segments are still in the planning stage, but an EIA meeting on DIPs is scheduled for Feb. 7 in Santa Clara, Calif.

Interchangeable. With the chip-carrier standard, a pc-board user may interchange four and possibly five types of chip carriers without having to redesign his board. Dan Amey, engineering manager of packaging techniques at Sperry Univac, Bluebell, Pa., and chairman of the task group says, "Our committee recognized quite early that a chip-carrier standard built around only one technique is not practical."

The standard, which has been mailed out for member approval, is designed around four different types of chip carriers, all of which have their contacts on 50-mil spacings. The first two types are single-layer and multilayer metalized ceramic carriers, both of which normally are reflow-soldered to ceramic substrates in hybrid applications. The multilayered type is similar to parts already commercially available. Since the temperature coefficients of the carriers' ceramic and the board's epoxy glass are not close, these two carriers require a socket.

The third type of package specified, now under development at Berg Electronics, is a small square ceramic carrier with edge clips on all sides. The compliant leads of these clips can be reflow-soldered to a board or plugged into a socket. The fourth package is a premolded plastic package with compliant leads being designed at AMP, Inc.

Fifth possibility. In addition, the footprint that holds the universal socket will take General Instrument Corp.'s Minipak, a low-cost glass-epoxy carrier too large for the proposed socket, giving a user a fifth possibility—a Minipak soldered directly to the board. The proposed carrier family would cover devices having 28 to 156 leads with square package sizes ranging from 0.450 to 2.050 inches on a side.

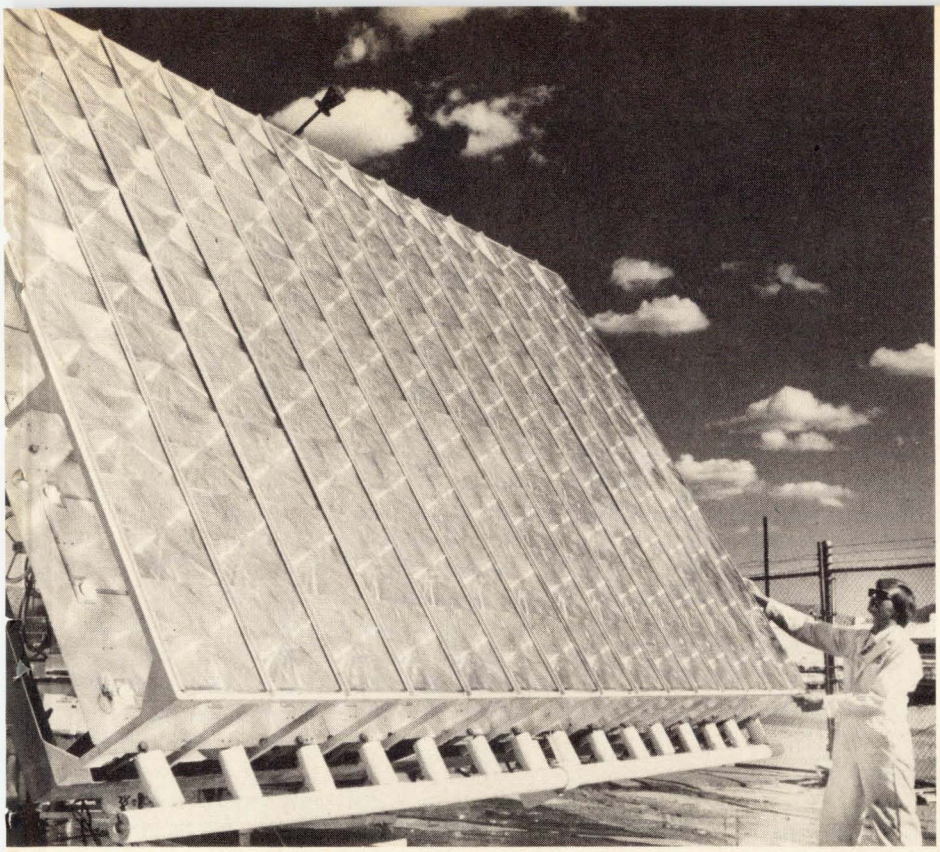
Sockets, which would be attached to the universal footprint on the board by reflow soldering, would have internal corner posts and locating features for positioning the various types of chip carriers. The socket is the subject of a concurrent effort under the EIA standard P5.2 committee. A meeting is scheduled March 2 at Nepcon West to set socket dimensions. □

Photovoltaics

Sandia to fund 10-kW array

January saw the startup of its 1-kilowatt photvoltaic optical concentrator array—and 1978 will see a 10-kW unit in operation, if plans at Sandia Corp. go well. While Sandia built the 1-kW array itself from its own solar cells, it will delegate the entire manufacture of the 10-kW unit to a prime contractor, to be picked from nine industry bidders.

"We'll be picking and announcing



Arrayed. Lenses in front of the 135 solar cells in Sandia Laboratories test concentrate sun's rays for 1-kilowatt output. Next step is 10-kW array.

the contractor within the next few weeks," predicts Donald G. Scheuler, supervisor of Sandia's Photovoltaic Systems Definition Projects division. He would not name the bidders, but he says they include all current cell producers like Spectrolab Inc. and Solarex Corp. Not included are any of the large semiconductor firms like Texas Instruments, Rockwell International, and Motorola Semiconductor, which have contracts in a separate project—the low-cost silicon-solar-array program administered by the Jet Propulsion Laboratory. Both programs are funded by the U.S. Energy Research and Development Administration [*Electronics*, Nov. 11, p. 86].

$2 a watt. The nine bidders for the 10-kW unit are being asked, in part, for "demonstrated technology to get the cost to $2 a watt in 1978 when the array will start operating," Scheuler says. This goal is at least several years ahead of JPL's program schedule. The lowest ERDA photovoltaic energy cost now contemplated is 50 cents a watt by 1986, and Sandia is increasingly confident that concentrator arrays can achieve that figure by the early 1980s. For that reason, they hope for an increase in their program funds, which now run at about a quarter of JPL's level.

The 1-kW concentrator array has 135 plastic Fresnel lenses that focus sunlight, with a 50 times greater intensity boost, on 135 silicon solar cells [*Electronics*, July 22, p. 41]. This concentration produces a peak output of 1 kW from 2.9 square feet of cell area. Scheuler says the 1-kW array is "a continuing test bed that will be repopulated with better next-generation cells and [will be used] to evaluate the lens lifetime and reliability of the system." It is cooled by circulating water that reaches temperatures of 90°C, producing energy that could be used for space heating and air conditioning. However, the proposed 10-kW array will be designed to operate passively without water or forced-air cooling. □

IEEE

Search begins for Schulke replacement

The surprise resignation late last month of Herbert A. Schulke Jr. as executive director and general manager of the Institute of Electrical and Electronics Engineers has started the organization's leadership on a forced march to find a replacement within the next six months. IEEE president Robert Saunders, professor of electrical engineering at the University of California—Irvine, is now in the process of organizing a search committee, which, he says, will be kept to a minimum size to ensure fast action.

On Feb. 18 and 19, Saunders plans for the executive committee and then the full board of directors to review and approve the search group. The institute might hire also an executive-search consultant.

"I'm not interested in politicizing the search committee," Saunders remarks. "In 1974, the last time there was a committee organized—when Donald Fink was retiring—there was too much attempt to get many voices, and the result was unwieldy. I think nothing is more effective than a small committee."

Duties questioned. The reason Schulke gave for his sudden resignation may cause some rethinking of the general manager's job description, as well as the management structure he directs. Schulke pointed out in his letter of resignation that attending to IEEE professional activities had taken more of his time than anticipated, to the detriment of the institute's technical and publishing activities. Along with the professional activities, of course, have come the politics, contested elections, and other internal struggles that apparently were not to Schulke's liking, nor fully appreciated when he was hired.

"When I looked at what I was doing and what I thought I would be doing, it didn't come close enough for me to deliver the performance required of the job," he explains. "In my case, professional activities didn't permit time for the technical activities I considered so essential. I have to stay close to technology or I'm not happy."

Although under fire a year ago during a staff shake-up and a budgetary crisis accompanied by a dues increase, Schulke appeared to have survived the internal battles

and was still in command for 1977. He leaves on something of a high note, with financial allocations and spending under better controls and the satellite offices in Washington, D.C., and Piscataway, N.J., running more smoothly than before.

"I certainly do feel a sense of satisfaction. The New Jersey service center is equal to that in any technical society. We have gone from a $1 million deficit in 1974–75 to meeting the target surplus budget in 1976. And we know where we stand for 1977," he says.

On the minus side, he has been criticized for his handling of staff cuts, turmoil in the IEEE standards operations, and general lack of accessability to members. Others have blamed the last search committee for misjudgment in recommending the former director of communications for the U.S. Joint Chiefs of Staff for the IEEE position in the first place. □

Memories

Half-size 16-k read-only memory may signal start of price break

Now that 32,768-bit read-only memories are becoming available, users should expect the price of 16-k devices to decrease rapidly. What may be the start of the trend is the pair of 16,384-bit entries being readied by General Instrument Corp.'s Microelectronics division, Hicksville, N.Y.

Later this month, the firm will offer samples of its n-channel, metal-oxide-semiconductor devices with maximum access times of 300 nanoseconds [*Electronics*, Jan. 6, p. 25], or at least as quick as the faster 16-k parts coming to market.

But speed is only half the story. The firm is giving the higher performance away for free by pricing the new parts, RO-3-9316C and RO-3-8316C, in the $8 range for 1,000 pieces, or as low as most suppliers charge for slower ROMs.

Perhaps more important for the rapidly expanding consumer market, where GI is seeing an increasing number of large-quantity ROM purchases, the firm plans even lower pricing. "We intend to get into the $4 or $5 range for 10,000 to 100,000 pieces," says Robert McDonald, manager for memory products. He will be relying on a tightened silicon-gate process that almost halves the chip area—under 19,000 square mils (115 by 165 mils)—from the current size of 36,000 mils^2 (180 by 200 mils) for GI's 9316B with a 450-ns access time.

Even more significantly, the firm's designers see their process as allowing them to build 32-k ROMs that will be introduced in the second quarter of the year. They also will undercut their competitors in price and size. "We'll be aiming the price of the 32-k ROM, in production, at the current level of 16-k ROMs," McDonald says.

At these prices, GI looks to replace many functions implemented with programmable and erasable programmable ROMs. For instance, many equipment makers using more costly PROMs early in systems development have been sticking with them into small-scale production. Such companies "will no longer be able to justify any production with PROMs because of the even lower cost per bit and fast [4-week] turnaround times we'll be offering," says McDonald.

Whether the firm's bold price move will start a trend for 16-k ROM parts is open to question. Dick Konrad, sales manager at Mostek Corp. in Carrollton, Texas, notes that certain factors, such as fast turnaround time transcend pricing. "The general marketplace for very large quantities—10,000 to 100,000 pieces—of 16-k ROMs seems to be in the $8 to $10 range, depending on the speed, number of patterns, and the quantity per pattern type" he says. As business improves, he sees prices firming up from the low figures quoted when the overall market became soft last October.

However, Harry Neil, product marketing manager for ROMs at Electronic Arrays Inc. of Mountain View, Calif., doesn't think GI's large-quantity pricing will be a hard target to hit. "At 100,000 pieces, I don't see why 16-k ROMs can't go for around $5," says Neil. "If we can get the equally-complex 4-k random-access memory down to the $3-to-$4 level in those quantities, I don't see why we can't get the 16-k ROM down to $5."

32-k ROMs coming. Paralleling GI's planned introduction of a 32-k ROM about the same size as the current B versions in the firm's 16-k ROM

A new ROM design

When General Instrument Corp.'s Microelectronics division in Hicksville, N.Y., enters volume production of its new 16,384-bit read-only memories in late March or early April, it will employ some new design techniques. The new ROMs are organized as 2,048 words by 8 bits, dissipate about 300 milliwatts, and are available in the usual 24-pin dual in-line package. One unit, 8316C, is a pin-for-pin replacement for Intel Corp.'s 8316A ROM (850-ns access time); the other unit, the 9316C, for Intel's 8316E (420 ns). Both are powered by a single +5-volt power supply.

According to GI's manager for memory products, Robert McDonald, the firm is able to shrink cell size about 35% by doing away with the dedicated ground column, usual for every two access columns. Instead, a logic-switching technique is used in which ground terminals are timeshared. The room opened up was used to add split-decoding circuits for the read-only access line, helping to lower the access time. Also, gate lengths were substantially reduced.

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family, Texas Instruments Inc., of Dallas, and Mostek have announced future availability of 32-k static ROMs. TI will have quantities of its TMS 4732 available late in the first quarter. Mostek's 32000 will be available in samples then, with volume available in the second quarter. TI hasn't disclosed prices for its 32-k chip, but Mostek's Konrad says his firm's unit "will be about 0.9 times the price of two 16-k ROMs, or about $15." □

Fiber optics

Bell link to give in-service experience

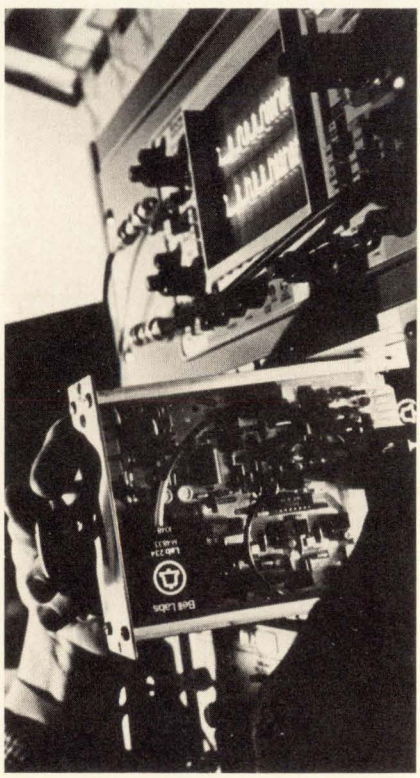
When AT&T's fiber-optic communications system starts operating under the streets of Chicago by midsummer, it will be proving more than just the efficacy of light communications. "What we want is to gain installation experience with fiber-optic systems," explains Ira Jacobs, director of the Wideband Transmission Laboratory at Bell Telephone Laboratories Inc. in Holmdel, N.J. "We want to put cable in the ground, pull it through real ducts and into manholes, and do it under real conditions—rough handling by craftspersons of Illinois Bell and exposure to water, dirt, and freezing temperatures."

Cooperation. The system, to carry voice, data, and video signals, is an undertaking among four Bell System entities: American Telephone & Telegraph Co., Bell Laboratories, Western Electric Co., and Illinois Bell Telephone Co., which will provide the facilities for the tests.

Bell will be relying on equipment it began trying out early last year in a field trial at Western Electric facilities in Atlanta [*Electronics*, July 22, p. 43]. But the tests in Atlanta were not held under actual operating conditions. Light sources will be gallium-aluminum-arsenide injection lasers and infrared light-emitting diodes. Like much of Bell's phone traffic, information in the test system will be digitized except for an analog voice order line. It will be transmitted at the 44.7-megabit/second rate needed to carry several Picturephone video signals.

"At a 44.7-Mb/s data rate, we can go no more than 3 kilometers with LEDs before inherent material-dispersion loss in the graded-index, germanium-doped silica fibers cuts us off," points out Joe Mullins, who heads Bell Labs' Fiberguide Trunk Development department in Holmdel. "The laser sources will go 6 or 7 kilometers." The solid-state lasers have an average output of 0.5 milliwatt at a 0.82-micrometer wavelength. The simpler and cheaper LEDs are desirable, however, for transmitting over shorter hops. Detectors are silicon avalanche diodes sensitive enough to provide an extra 15 decibels of margin.

Ribbons in cable. A ½-inch-diameter cable in Chicago will carry a pair of flat, 12-fiber ribbons—24 of the 100 micrometer-diameter fibers in all, instead of the 144 used in the Atlanta trials. One ribbon will be used for commercial traffic. "The rest will be used for other tests, including the order wire for maintenance [messages] and some fibers for measuring losses," says Mullins. A single pair of fibers will be able to carry 576 conversations.



Trial. Receiver module for Bell System's fiber-optic link fits in equipment rack.

Two central offices will be connected over an almost-1-mile link. A second ½-mile link will connect one of the offices and an office building. However, no single cable run will be longer than 1,000 feet, and Illinois Bell will gain the needed field experience of installing and splicing the cable through manholes in the field.

Two of the fibers will be used to implement voice trunks; a second pair will carry about 80 subscriber loops, even though its capacity is 1,120. All four will be backed by redundant fibers that will take over if the first sets fail—determined by measuring the system's bit-error rate. The remaining four fibers in the ribbon are dedicated to a pair of two-way Picturephone links. In addition, Bell's Digital Data Service will be tested on one of the links and, according to Jacobs, the black-and-white 4-MHz Picturephone signal will be transmitted at the 44.7 Mb/s rate using a differential pulse-code-modulation encoder recently developed by Bell Lab engineers. □

Careers

EMC adopts tighter demand-data policy

Round one of the dispute over the manpower-demand data compiled and published by the Engineering Manpower Commission, research arm of the 36-society Engineers' Joint Council, goes to the EMC's critics. Responding to growing complaints that the demand projections have encouraged colleges to pump too many engineers into an already overcrowded marketplace, the full commission unanimously adopted last month a policy statement on manpower demand studies.

Essentially the same as the final draft adopted by the EMC's executive committee late last year [*Electronics*, Jan. 6, p. 40], the statement calls for

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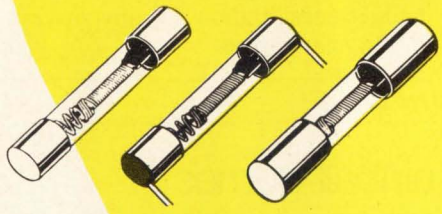

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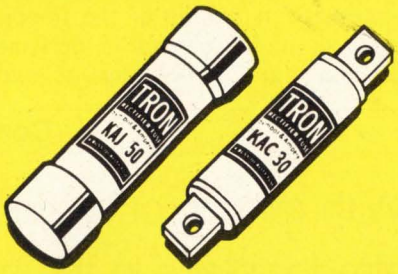

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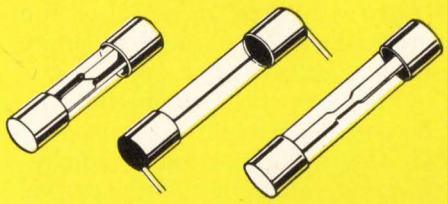

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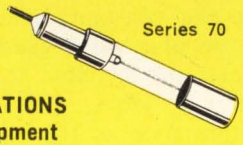

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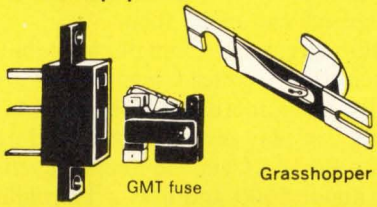

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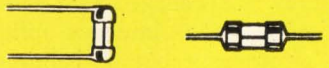

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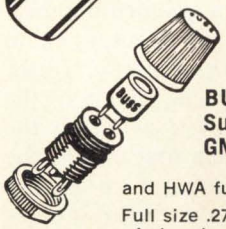

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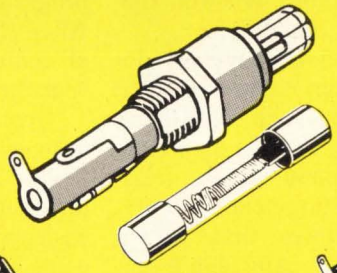

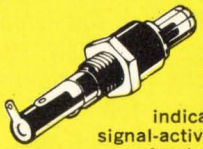

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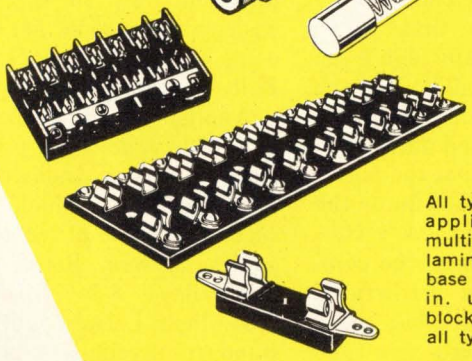

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the commission to downplay the "predictive" nature of its demand studies. The move goes part way —areas like data accuracy and gathering methods are also under fire— toward meeting the chorus of critics who have been demanding that the EMC either change the way it gathers and disseminates demand data [*Electronics*, Sept. 16, p. 75] or altogether abandon its demand projections [*Electionics*, Oct. 14, p. 36].

"I think the commission has become more realistic," says Hans C. Cherney, a personnel administrator at International Business Machines Corp. in Poughkeepsie, N.Y., and vice chairman of the U.S. Activities Board of the Institute of Electrical and Electronics Engineers. Cherney has charged that industry and educational interests influence EMC's forecasts, but he believes the policy statement "certainly is a step in the right direction."

Another view. Robert A. Rivers, president of Aircom Inc. in Union, N.H., and a member of the EMC, has been another strong critic of the demand studies. He thinks it's "a good thing" that the policy statement has been adopted. In his view, "most of EMC's verbiage is aimed at maintaining the educational input and output of engineers." But now, he says, "we've finally got something that will keep them from making all those wild predictions. We won the all-important first round."

Some EMC officials, however, do not think the policy statement will bring any changes. John D. Alden, executive secretary and the man who conducted the demand surveys, feels that the policy statement "simply spells out principles that we've always followed. I really don't see anything new that would alter the way in which we've been gathering or disseminating demand data."

Alden also believes that the policy statement will put no restraint on the predictive nature of the EMC's conclusions because he insists the commission has not made predictions. "You can project ahead, but that's not predicting," he asserts.

The same opinion is held by commission chairman Art Gilmore of Grumman Aerospace Corp. in Bethpage, N.Y., and its vice chairman, Paul Doigan of the General Electric Co. in Schenectady, N.Y. Gilmore, though, does not believe that the work of its *ad hoc* committee on supply and demand has been for nothing. "We now have a much better understanding of the importance of and problems in deriving demand data, processing it, and presenting it." He believes that more work is needed in the demand area but will require greater effort and money—"money that is not in our current budget."

Thus, while those seeking a revamping have gained some ground, those who wanted an end to the studies might win by default. The budget doesn't allow for any surveys in the near future. □

Consumer

With microprocessors, pinball games aim for place in the home

Lacking only a coin-slot, the first microprocessor-controlled pinball machines for home use have rolled into the consumer market, joining the popular video games. The machines are as close to the arcade types in looks, feel, sound, and performance as the microprocessor programs can make them.

For example, Fireball, a pinball machine introduced last month by Bally Manufacturing Corp. of Chicago, can play seven songs, including "The Party's Over" to losers. It sells for about $900 and uses a Fairchild F8 microprocessor set. Bally is already in production with a follow-up machine, called Evel Knievel, reprogrammed for a new playing field. All of the components in Fireball are of commercial machine quality except the switches.

"Arcade pinball machines are designed to make money as well as be fun to play. The home unit is different only in that scoring is easier since people are not putting coins in it," says Jack O'Donnell, Bally field service manager.

Another home pinball machine has just gone into production at Allied Leisure Industries Inc. of Hialeah, Fla., which markets a successful line of consumer video games as well. Based on an MOS Technology 8-bit microprocessor, the Allied Leisure units also have standard arcade-size playing fields (22 inches by 42 in.) and use commercial components. However, while the Bally Fireball has a standard table and scoring panel, the two Allied Leisure machines are coffee-table height, are played sitting down, and are covered when not in use. "The idea was to make the machine useful as furniture so that it can be put into a room and played only when desired," explains Ian Richter, chief engineer. This machine will sell for about $900, he adds.

Both the Bally and Allied Leisure games feature programmed diagnostics run by the microprocessors to check out the working parts for user maintentance. When put into the diagnostic mode by a switch in the back, Bally's system first checks the entire playing program to ensure that the control circuit board is operating properly. The six-digit light-emitting-diode score panel is a convenient way of displaying test results to the user. If the panel comes out all zeroes, for instance, the program test is positive. If not, the entire circuit board can easily be replaced.

The second sequence covers all the numbers, lights, and solenoids (the user listens for five thumps to indicate all's well with the solenoids). The third test is for all the switches. If one or more are sticking, an identifying code number appears on the scoring display.

The Allied Leisure system is similar. At the flip of a switch the program sequences first the scoring program, then the switches (where it

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Clear, color closeups of the giant planet Saturn, its rings, and its satellite Titan will be transmitted to earth beginning in 1979, when Pioneer 11 is closest to the planet. Regular observations will begin in July 1977. Two instruments aboard the spacecraft were built by Santa Barbara Research Center (SBRC), a Hughes subsidiary. One, an imaging photopolarimeter, will take the pictures; the second, an infrared radiometer, will measure the temperatures of the planet and its rings.

Once the spacecraft has arrived, the temperatures it takes will be telemetered home so that scientists can continue to study the delicate heat balance of the solar system.

As part of the US Navy's standard hardware program, the Hughes-built AN/UYK-30 microprocessor has been designed onto six Standard Electronic Modules (SEMs) in a 20-cubic-inch space. The SEM-2A modules are 1.9 x 5.6 inches. The 16-bit UYK-30 has already been integrated in 11 military-system programs that involve application with the Navy, Army, and Air Force.

Like the existing production version of the UYK on three 5.6 x 6.5 inch modules, this new SEM version will use multisource, off-the-shelf, bipolar Schottky TTL LSI microprocessor chips for a capability of 340-660 thousand operations/sec, using up to 65,000 words of memory. Value of the SEM concept, of course, is a family of off-the-shelf, reliable, electronic modules, each performing certain standard functions. This facilitates the design, production, and support of electronic systems.

Hughes Missile Systems Group has many immediate openings, in Canoga Park, California, for engineers and scientists in new, expanding, long-range R&D. Typical openings include circuits engineers (RF/IF, digital, or analog), systems analysts (missile-system preliminary design), electronic product engineers (product designs for state-of-the-art systems), RF systems engineers (microwave systems design & test), RF product engineers (product designs of state-of-the-art RF components), and many others. Graduation from an accredited university, varying amounts of experience, and US citizenship are all required. Please send resume to: Engineering Employment, Hughes Aircraft Company, Canoga Park, California 91304.

During the recent Big Thompson River disaster in Colorado, lives were saved through use of a heat-sensitive infrared viewer. A police sergeant aboard a US Army helicopter, during a 2-day period, scanned the entire length of the canyon through a Probeye(R) Infrared Viewer, which identifies heat, rather than light, patterns. The sergeant was able to locate people stranded or clinging to the canyon walls in woods and heavy brush. The scanning operation enabled the rescue teams to avoid searching the canyon by foot.

also identifies which are stuck), then the lamps, and finally the "bonus" procedure, which rewards high scorers with extra turns. Practically all of the breakdowns uncovered by the diagnostics can be repaired by the user, so that maintenance, the biggest headache with the old electromechanical machine, is kept to a minimum. □

Solid state

Laser diode emits at 7,276 angstroms

While progress in semiconductor laser technology tends to be incremental—more efficient material here, a better junction there—from time to time the increments add up to make new applications possible or old ones more attractive. For a case in point, look at the improvements in a new laser at RCA Laboratories, Princeton, N.J. It uses gallium arsenide alloy to operate continuously at room temperature at wave lengths as short as 7,276 angstroms.

That emission frequency is the highest reported to date for a continuous wave laser diode with any material at room temperature. Presently available long-life cw laser diodes generally emit in the spectral range of 0.8 – 0.85 micrometer.

Henry Kressel, head of the semiconductor device materials research lab, says the higher frequency could become important in scanning applications because the device's high-intensity beam can be more sharply focused in high-resolution systems. It also provides a better spectral match with the coding inks used in much equipment.

What's more, he notes, photographic materials have increased sensitivity at shorter wavelengths. Higher-frequency emissions can also handle more information in optical communications and provide a better, more accurate beam in laser-guiding systems.

A key feature of the work, supported by the Hampton, Va., Longley Research Center of the National Aeronautics and Space Administration, is that the achievement came not from using exotic material structures, but from optimizing the fabrication process. It involved overcoming or reducing the technological problems connected to the behavior of dopants, the structural quality of layers in the diode, and the stresses caused by lattice mismatch in high-frequency-laser emission.

The devices consist of fairly standard double heterojunction materials ($Al_xGa_{1-x}As/Al_yGa_{1-y}As$) enriched in

News briefs

Rockwell unveils new microcomputers

Rockwell International's Microelectronics Device division is bringing out two single-chip microcomputers for immediate delivery. They join its first such device, the MM77, introduced in March 1976. The new MM76 has 640 8-bit words of read-only memory and 48 4-bit words of random-access memory; the MM78 offers 2,048 8-bit words of ROM and 128 4- bit words of RAM. Three new versions of the MM76 are scheduled for production later in the year, with an optional counter, 12-bit converter, and expanded ROM. What's more, an economy device, the MM75, is also being readied. It will reduce input/output lines from 31 to 22. Volume prices are $5 for the MM76, $9 for the MM77, and less than $3.50 for the MM75.

First airborne data terminal delivered by Hughes

Hughes Aircraft Co. has delivered for performance testing to the Boeing Co. the initial time-division multiple-access terminal for the Air Force's E-3A airborne warning and control system aircraft. Designated AN/ARC-181, the terminal will provide continuous real-time information exchange over a single network on a time-ordered basis, resulting in a data pool that is constantly updated and available to all members.

Electronics review

aluminum content to reach emissions below 0.8 μM. Zinc is used instead of germanium for p-type doping. Telluride was used as the n-type doping in preference to the more conventional tin, which could not be incorporated in sufficient concentrations for the desired high-frequency emissions.

The RCA work improves several aspects of this aluminum-rich process. For one thing, an accelerated growth rate is employed with very careful control of timing during the process. Moreover, gross structural defects could be eliminated by maintaining low optical levels in the furnace and by carefully cleaning the substrate. □

Communications

SBS approval limits IBM's role

The threat of a Federal court appeal still lingers, but it looks like the Federal Communications Commission's approval of Satellite Business Systems' plan for the nation's first 12–14-gigahertz all-digital domestic satellite communications system will stand. The key elements to the lengthy FCC ruling, still being written, are the limitations placed on relations between SBS, its three corporate partners, and their parent companies, particularly International Business Machines Corp. Parents with IBM are Comsat General Corp. and Aetna Casualty & Surety Co.

The commission ruling stressed that SBS could not have a "bundled" or "packaged" offering of communications and data processing services. IBM will not be permitted to sell, promote, offer discounts or other preferences to its customers for SBS services. Conversely, SBS will not be able to sell or promote IBM equipment or services.

For interconnections, the commission will require SBS technical specifications be available to all equipment makers and users, limit its ability to dictate specs, and require any contracts between the joint venture and its parents be submitted to the commission for prior review.

Anticompetitive and antitrust issues were raised against the SBS proposal by its 12 opponents—a list that includes virtually all U.S. carriers, including AT&T and the Justice Department. But the FCC concluded that "public interest benefits outweigh potential anticompetitive concerns, and the proposal viewed as a whole serves the public interest—particularly in view of the conditions imposed."

Moreover, the FCC said it "will scrutinize this market and SBS on a continuous basis," and take further action as appropriate. Opponents of SBS have not yet indicated whether they will appeal the commission's decision in the courts.

Plan. Although SBS rates remain to be determined on the basis of experience, the two-phase operating plan calls for a six-month program to evaluate equipment performance using IBM earth stations at Poughkeepsie, N.Y., and Los Gatos, Calif., with a rented 4–6-GHz transponder from a domestic satellite.

In a second phase, the same two earth stations plus five others will provide private-line communications to IBM and others on a common-carrier basis. The five new stations will be chosen from IBM locations at Gaithersburg, Md., Manassas, Va., Boca Raton, Fla., Atlanta, Ga., Lexington, Ky., Greencastle, Ind., Rochester, Minn., Austin, Tex., and Boulder, Colo.

The operational system will use two satellites in stationary orbit, a ground spare, and several hundred small earth stations with 5–7-meter-diameter antennas. Tracking and telemetry command centers will be in New Jersey and California.

SBS will be funded at $165 million—$55 million from each partner—for the period between FCC approval and the beginning of operations. The firm puts the system's costs from the January 1971 beginning by its predecessor—CMB Satellite Corp.—to the start of commercial operations at $235.5 million and outlays through 1986 at $406.9 million. □

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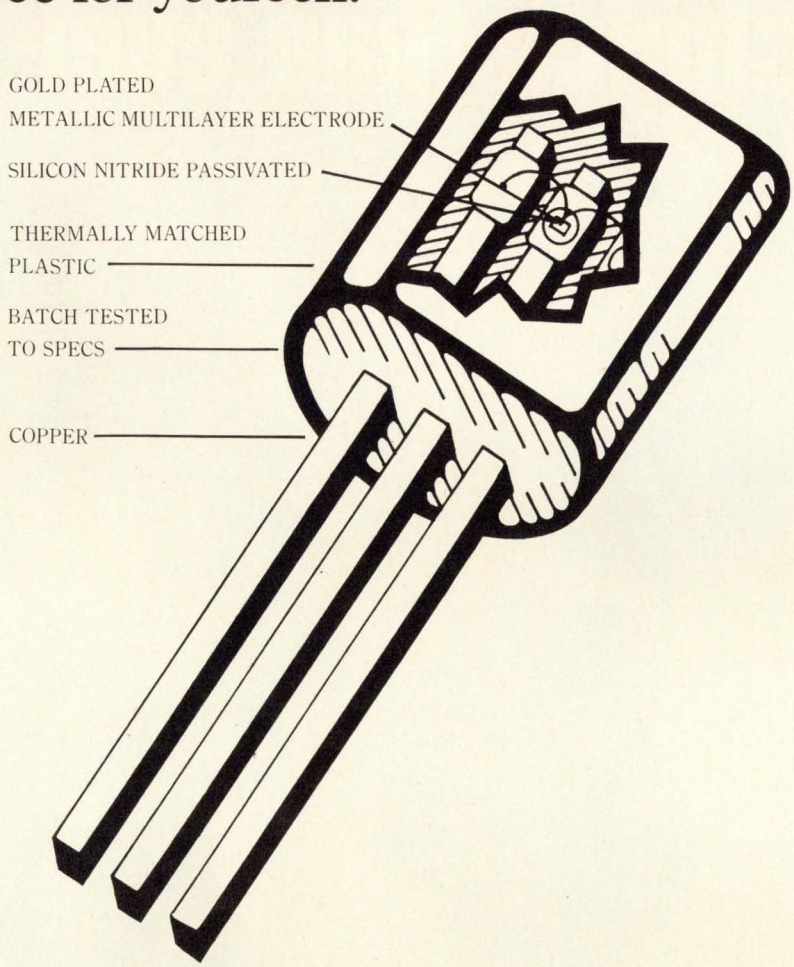
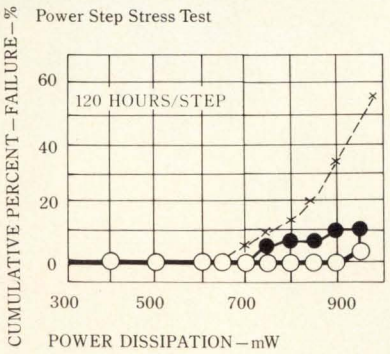
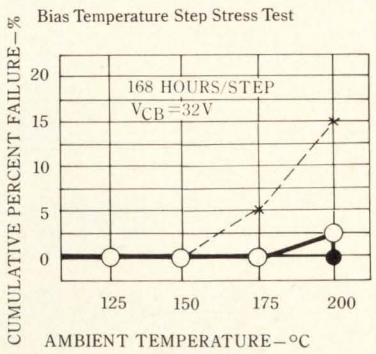


—○— High Reliability TO-92 Transistor (Pc MAX.=300 mW)
—●— TO-18 Metal Case Transistor (Pc MAX.=300 mW)
– –x– –Conventional Mold Transistor (Pc MAX.=250 mW)





"Standard practice" can now change for the better—and cheaper. Up to now, industrial transistors have been specified in cans, to get reliability under heat and humidity. Consumer products have been able to tolerate the less expensive but less stable plastics. Now NEC has incorporated 5 technical advances that make these TO-92 plastics the equal of any hermetic metal case for most applications—and you get the lower price to boot!

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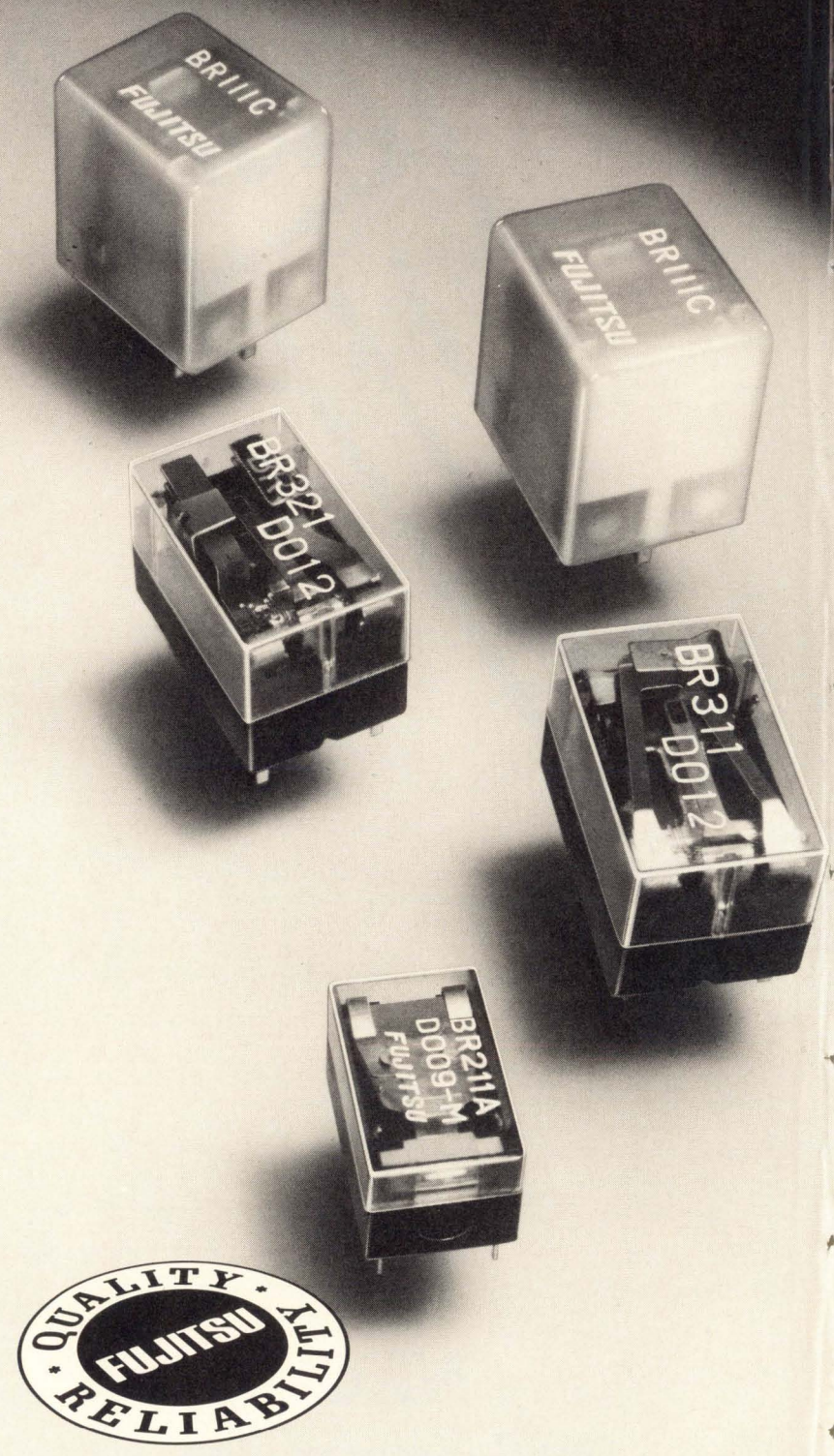

Model	Contact Arrangement	Contact Rating	Coil Voltage
BR111	1 Form C	3A 24V DC or 100V AC	5/6/9/12/ 24V DC
BR211	1 Form C	1A 24V DC or 0.5A 100V AC	1.5/3/5/6/9/ 12/24V DC
BR221	2 Form C		1.5/3/5/6/9/ 12/24V DC
BR311	1 Form C	3A 24V DC or 3A 100V AC	5/6/12/ 24V DC
BR321	2 Form C		5/6/12/ 24V DC

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Circle 56 on reader service card

Washington newsletter

Wage council hits plan to curb TV imports

Color-TV prices will go up and American consumers will be the losers if the International Trade Commission supports the position of domestic manufacturers and imposes a quota or increases tariffs on receiver imports, says the White House Council on Wage and Price Stability. **The council challenged the position taken by U.S. color-set producers** and 11 of their unions before the commission that they will be wiped out by imports unless limits are imposed [*Electronics,* Jan. 20, p. 49].

To illustrate its point, the council claimed an annual quota of 1.3 million imported receivers, based on the 1971 to 1975 level, would boost the price of "a typical color set" by $43 to $323, forcing consumers to pay $317 million more per year. While $211 million of this would go to the industry, "the remaining $106 million would be lost to the American economy" because of reduced import activity. Alternatively, either a 10% boost in tariffs on top of the present 5% or a tariff-quota combination of 10% on imports above the 1.3-million-set level would hike set prices by $28. Consumers would then pay $221 million more a year, of which industry would get $132 million and the Government $36 million.

Raising tariffs or invoking quotas to raise domestic jobs by 4,150 to 31,900 would cost an annual $70,000 per job, the council noted. Instead it urged the commission "to consider adjustment assistance to workers to find other employment as a less costly method."

NATO commonality behind Brown's cuts

There is more than a desire for short-term savings behind Defense Secretary Harold Brown's proposal to cut the Air Force's fiscal 1978 purchase of Boeing's E-3A airborne warning and control system (AWACS) from six planes to four, his supporters contend. "He is very strong on NATO systems standardization and cost-sharing," says one, "as well as upgrading our own AWACS fleet." Thus, Brown **will push harder for NATO purchases of a new version of the system,** upgraded with automatic initiation of tracking of low-flying aircraft, increased tracking capacity, and an electronic support capability. The U.S. R&D budget for this NATO version is $15.7 million.

Once developed, the Air Force and NATO versions would become standard. Of the nearly $529 million sought for six more of these planes, $411 million is for procurement, some 10% less than this year's price for six planes, while RDT&E costs of $117.6 million are 12.4% more.

White House OTP loses funds to Commerce, may fold

The White House Office of Telecommunications Policy is not going out of business—yet. Nevertheless, the outlook is not good. The fiscal 1978 budget submitted by Gerald Ford to Congress **cuts proposed OTP outlays by 64%** from this fiscal year to $2.94 million. Most of the lost money turns up in the Commerce Department's Office of Telecommunications, whose fiscal 1978 funding request of $6.93 million is 350% more than 1977's.

Officials at OTP contend that the shift represents nothing more than an accounting change that gives the Commerce office the responsibility for spectrum-management functions that OTP had been paying it to perform anyway. But a number of OTP staff members are looking for jobs.

One way to salvage OTP would be to merge it into the rejuvenated White House science adviser's shop now known as the Office of Science and Technology Policy. There, the budget is up nearly 40% to $3.2 million. But most friends of OTP fear the telecommunications policy functions would lose too much visibility to remain effective if that occurs.

Washington commentary

Harold Brown's planned program changes

President Jimmy Carter's Secretary of Defense, Harold Brown, clearly agrees with the final watchwords of Donald Rumsfeld, his predecessor, to the Congress. "In strength there is freedom," Rumsfeld said in concluding his final annual report on America's defense posture. Near the end of January, Brown modified those words only slightly in his first official appearance before Congress as Pentagon chief. "The hallmark of our enterprise must be strength *and* flexibility," he observed.

Brown still has some weeks before detailing to Congress how the Carter Administration proposes to achieve that flexibility through amendments to Gerald Ford's last defense budget (see p. 77). In fact, he has already indicated that Carter wants more time—a month or two—beyond the February deadline for a production decision on the Rockwell B-1 bomber.

However, the new Pentagon chief is expected to recommend killing the Navy's request for a new strike cruiser in view of Carter's desire to develop a navy made of larger numbers of smaller, faster ships. Terminating that program would cut more than $203 million from the Ford budget request. That cut is almost a certainty, even though it would remove one platform for RCA's Aegis missile for fleet air defense, leaving it for deployment on the DDG-47 class destroyers.

An M-X slowdown?

More distressing to military professionals, however, is the prospect of a major cutback in the $294.4 million sought for beginning full-scale development of the M-X strategic intercontinental ballistic missile as a follow-on to the Air Force Minuteman series. Gen. George S. Brown, chairman of the Joint Chiefs of Staff, appeared before Congress with the new Secretary of Defense and made a point of defending the M-X as "the most significant strategic initiative being proposed" in view of its "improved guidance and increased numbers of highly accurate MIRV warheads, together with a mobile, highly survivable basing mode." Nevertheless, secretary Brown is considering a call for reducing the fiscal 1978 level of effort unless the Air Force can rejustify its need for—and ability to spend—$294.4 million in a single year. The new DOD boss believes that nothing will be lost if the M-X effort is limited for another year to continued work on the guidance and warhead subsystems.

Large carryovers of unspent funds from one fiscal year to another throughout the military command chain troubles Harold Brown, just as it has troubled large numbers of congressmen and senators, who have long lamented that they lose track of DOD's unspent funds from prior years. Brown calls it an "inefficiency" that he intends to correct. Those carryovers, whether intended or not, limit DOD's flexibility, Brown believes. Best remembered as one of Defense Secretary Robert McNamara's "whiz kids" during the Kennedy and Johnson Administrations of the 1960s, Brown knows how the Pentagon works from his prior experience as Secretary of the Air Force and as Director of Defense Research and Engineering.

How will Brown achieve results? Clearly, he faces strong opposition from the military chiefs who favor long-term funding programs and shudder at the prospect of zero-base budgeting, which requires justification of existing as well as new spending programs each fiscal year. Whether Brown fully adopts this budgeting technique within the Pentagon, the concept is getting strong support throughout the Carter Administration, and lines of bureaucrats and industry reps are already forming for the Feb. 25 Washington seminar on the subject by its originator, Peter A. Phyrr, and other experts in the field.

The rush to zero-base budgeting

Now financial vice president of Alpha Wire Corp., Phyrr developed zero-base budgeting while at Texas Instruments Inc. and served as a special consultant to Georgia's then-Governor Jimmy Carter. "I can't afford to miss this," said one military electronics contractor's man. "It's got to be a bargain at $15," he said of the registration fee to be charged by the sponsoring Association of Government Accountants. The seminar is expected to pack George Washington University's Lisner Auditorium, one of the larger meeting halls in the Capital.

An investment of one day and $15 will hardly make anyone an expert in the technique, particularly someone lacking a background in accounting. Certainly it is going to provide little, if any, insight into how President Carter is going to direct his new Secretary of Defense to amend Gerald Ford's budget proposals. But, as one middle-management budget planner in the Pentagon expressed it, "we need all the help we can get."

In view of Harold Brown's proposals—coupled with the fact that he is the first Secretary of Defense with professionsl training in science and high technology—many military bureaucrats are going to need help keeping up with their new leaders. **Ray Connolly**

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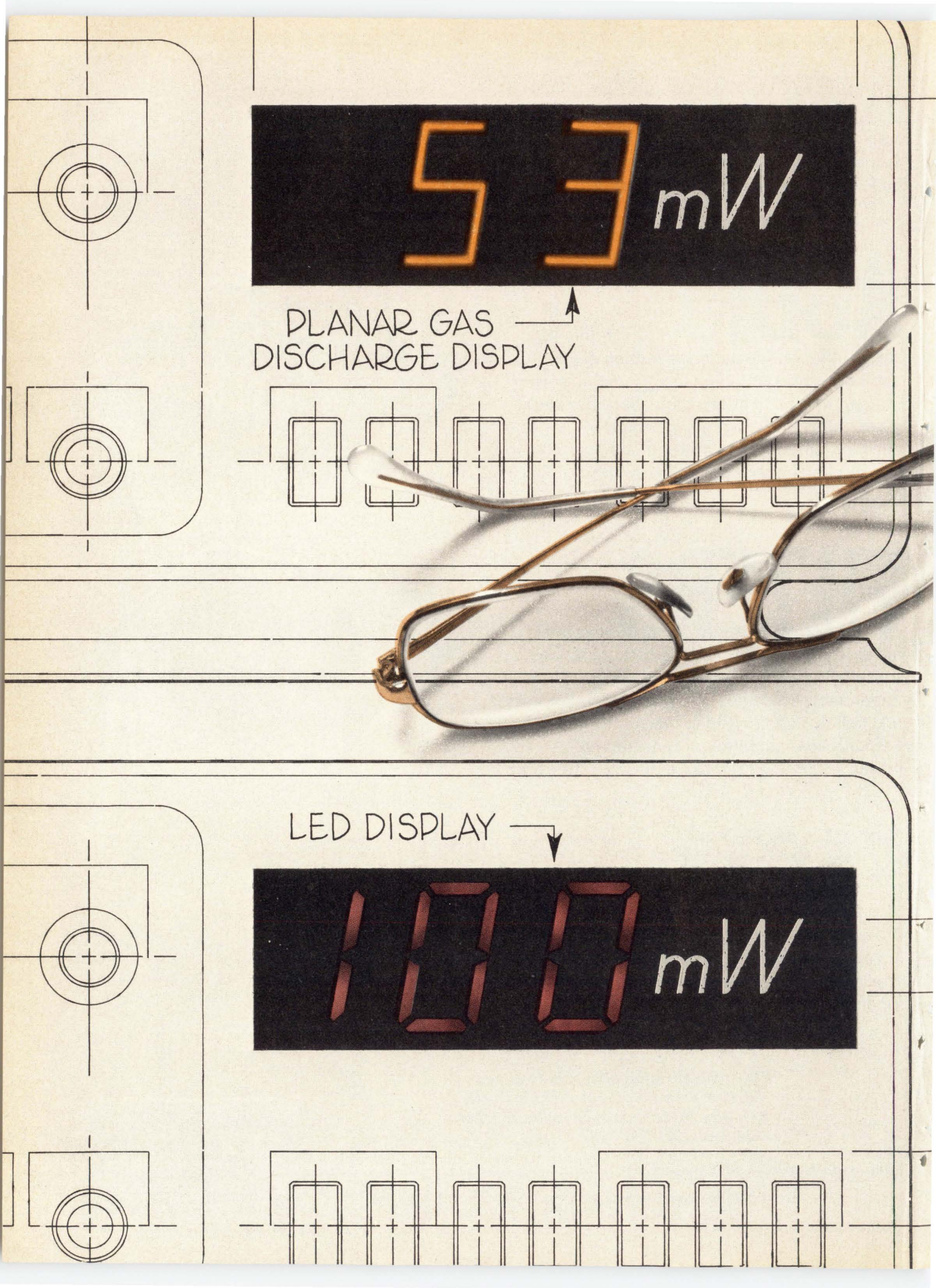
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PGD uses less power than LEDs

LEDs consume more power than PGD displays of similar character size. That's fact. Look at the power-consumption comparison chart that follows. Among others, it compares the Beckman SP-350 display with the efficient Litronix 747. Both are essentially half-inch displays. Both were measured at factory-recommended, typical current levels.

In this case, specified voltage drop across the LED is 3.4 volts. When it's driven from 5 volts, total power consumption for the LED and driver is 100 mW per segment. That's 700mW for a complete figure "8". Conversely, total per-segment power consumption for the SP-350 is 53 mW; or, 371 mW for a figure "8"...about one-half that of the LED.

And, that's only part of the story. Check the chart and compare the resulting, readable brightness figures for three different sizes of Beckman PGD displays with those of comparable LEDs.

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LED vs. PGD Power Comparison

	Litronix 747	IEE 1720	Monsanto MAN6610	HP 5082*	SP-101	SP-350	SP-330
Size	.6"	1.0"	.5"	.43"	1.0"	.55"	.33"
Segment Current	20mA	20mA	20mA	20mA	700μA	330μA TYP	180μA TYP
Forward Voltage Drop	3.4V	3.3V	2.0V	2.1V	135V	135V	135V
Power Per Digit (+DP) (Display Only)	510mW	495mW	320mW	336mW	690mW	330mW	190mW
Power Per Digit (+DP) (Display and Driver)	700mW	800mW	800mW	800mW	820mW	371mW	225mW
Brightness in F.L. Approx. Measured Value	35 F.L.	14.4 F.L.	65 F.L.	130 F.L.	225 F.L.	208 F.L.	208 F.L.

*NOTE: Operating Temperature Range at This Brightness is only +50°C

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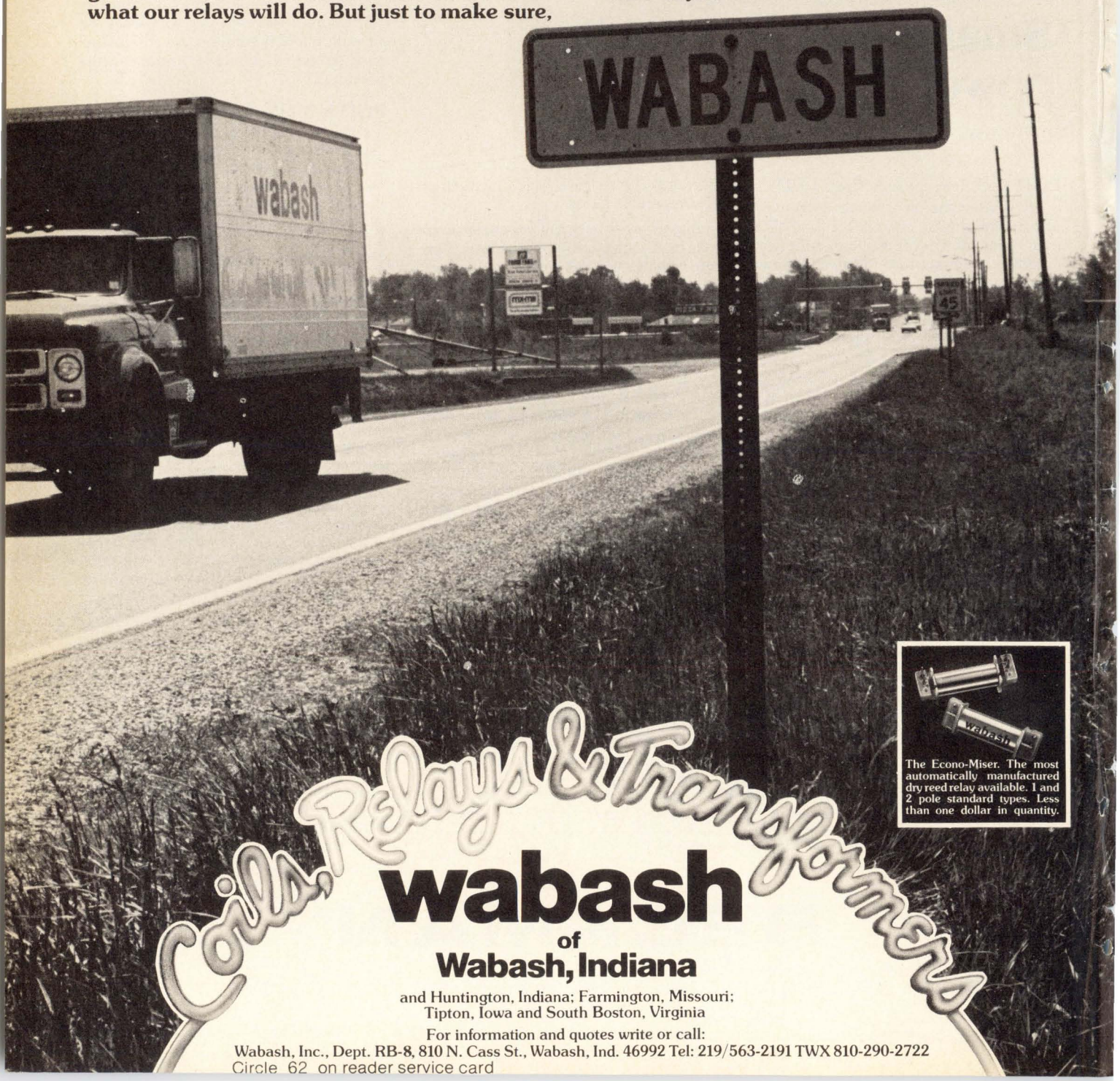

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Circle 62 on reader service card

International newsletter

Europeans ponder their future in semiconductors . . .

Prodded mainly by West Germany and the Common Market Commission, European semiconductor makers and the governments behind them figure to step up their efforts to put together strategies to hack down the overwhelming share of European integrated-circuit markets taken by U.S. producers and ward off the threat of Japanese inroads. The stimulus has come from a study of the European semiconductor industry by the British firm Mackintosh Consultants at the behest of the West German government, with support from France, the United Kingdom, the Netherlands, and the commission. The study's conclusions are still secret, but after late-January briefings in Bonn and Brussels, some information has come out.

The UK has just announced its own modest program for spurring components development, and France also has one painfully taking shape. But commission officials hope they can find enough common ground among governments and industry to start drafting proposals for an aid program that will bolster the community's technology arsenal in computers and building blocks for them. **The commission wants its nine member governments to set up a fund of roughly $120 million to subsidize cross-frontier R&D from 1978 through 1981.** Most of the money would go for peripherals and software development, but some $13 million would be earmarked for key components like big memory circuits and microprocessors. The fund would add up to about 10% of the amount spent on strictly national programs during the four-year period.

. . . and British to boost components industry with $34 million

The British government has set aside about $34 million to help components companies improve their efficiency and competitiveness. The three-pronged plan offers partial support for new-product development, restructuring a company or a group of companies, and buying associated capital equipment needed for either. **For projects costing more than $85,000, selected applicants, which need not be British-owned companies based in the United Kingdom, may receive support ranging from 15% to 50% of costs,** depending on the category. More money may be made available.

Motorola bucks trend in acquiring Italian subsidiary

Though other companies are backing off from investments in Italy, Motorola SpA in Milan has bought the outstanding 38% of the shares to take complete control of the consumer-electronics firm Autovox SpA. Motorola even plans to develop new product lines and won't necessarily restrict them to the consumer sector, says Levy Katzir, Motorola's vice president in charge of Autovox operations in Rome. The company's annual sales are estimated at $34 million, mainly in Western Europe.

Motorola was persuaded to increase its investment because of **help from government officials, especially in overcoming financial obstacles, a reversal in labor-union views toward competitiveness of products, and the dedication of talented Italian workers.** The company was also encouraged by the recent fall in the lira's exchange value, which effectively lowers Italian production costs in relation to those of international competitors. Moreover, many of the components are available in Italy for manufacturing Autovox product lines—car radios and cassette recorders, as well as color and monochrome television sets.

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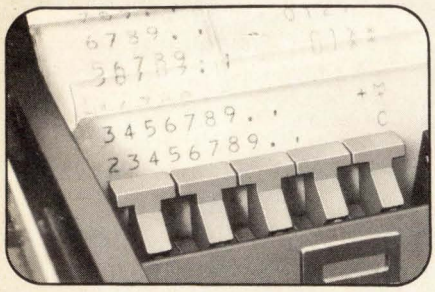

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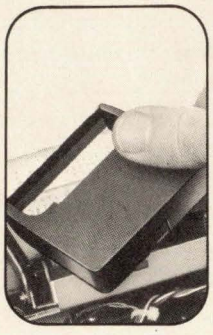

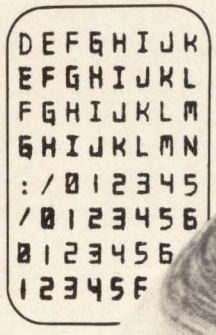

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Circle 64 on reader service card

Valvo microwave module detects moving objects for burglar alarm

Although still relatively small, the market for electronic burglar alarms and object-protection systems in Europe is developing fast. In fact, an exhibition dedicated specifically to protection equipment was launched in Europe several years ago, and by now, a growing number of components firms have developed electronic equipment for just that market.

One of the latest protection products is a microwave module that Valvo GmbH in Hamburg, West Germany, is offering producers of motion-detection systems. Using a Gunn-oscillator source, the MDX0520 module sets up an electromagnetic field and, by radar-doppler principles, detects any object that moves within the field. Capable of sensing a moving human within a range of about 15 meters, the module sends its output to an evaluation unit that gives the alarm when motion is detected.

Its geometry and small dimensions distinguish the Philips subsidiary's MDX0520 from competing products, points out Jürgen Siebeneck, who developed it. Only 70 millimeters in diameter and 25 mm deep, the module is smaller than a typical tuna-fish can. This tiny space contains a microwave transmitter and receiver, the antenna with associated filter networks, and a voltage-stabilization circuit.

Antenna. The module's unusual planar antenna, an integral part of the module, consists of microstrips on Polyguide plastic material. Arranged in a single plane are the antenna's transmitting and receiving segments, each consisting of two parallel-coupled half-wavelength resonators. The microstrips are produced by etching the copper-layered Polyguide material. The antenna's aperture is 50° in the horizontal direction and 30° in the vertical, referenced to the 3-dB points. Its gain is 9 dB and bandwidth is 200 MHz.

Because it is so compact, the module with the antenna on the front plate can easily be installed flush with the surface of a ceiling or wall in much the same way as those familiar household wiring or electrical distribution boxes. The unit can be covered with wallpaper.

The MDX0520, approved by the German Post Office, transmits in the X band at 9,350 megahertz. Since the doppler frequency lies within the low-frequency spectrum, designers can use conventional design techniques for the signal amplifiers in the motion-detection equipment.

Stability. The Gunn oscillator, which is supplied with a stabilized 12 volts, has a radio-frequency output of 10 to 15 milliwatts. Within the range from −10°C to +40°C a high-frequency stability of less than −0.5 MHz/°C is guaranteed, but adequate operation from −30°C to +70°C is possible, Siebeneck says. A band-rejection filter eliminates un-

Around the world

Electret-foil form data cells for display

At Thomson-CSF's Corbeville Research Laboratories near Paris, researchers are working on units based on bistable electret foils for large wall displays. Although considerably more development is necessary before electret displays will be ready for the market, their inherent characteristics are very promising. A low 50-microampere current can switch the basic cell from on to off in 200 milliseconds—plenty fast for the display—and no holding current is needed between switchings. To be sure, the switching pulses have to be fairly high—typically, close to 500 volts, so far—but they can be provided by high-voltage transistors or pulse transformers.

The basic cell design is a plexiglass block 30 millimeters long and 11 by 11 mm in cross section, with a deep notch cut at one end and a frosted face at the other. The polypropylene electret foil, blackened to make it opaque, is fixed in the closed end of the notch, but it is free at the open end. Depending on which side of the notch it is switched to, the electret blocks out backlighting or lets it pass to the front face (reflective versions are also possible). The contrast ratio between the two positions is higher than 1,000. Because of the permanent electric charge it carries, the electret adheres to the metallic electrodes on either side of the notch until switched.

FFT processor aimed at pleasure-boat radars

Britain's Mullard Research Laboratories has developed a digital fast-Fourier-transform processor using MOS shift registers. It could lead to a reliable low-power radar unit for use up to 25 miles, the range usually needed by small-boat owners. MRL employs a frequency-modulated continuous-wave (fmcw) radar that needs only 10 watts of mean radiated power, well within the capability of solid-state sources. Computer simulation showed that one 1,024-point FFT using 12-bit arithmetic would give adequate spectrum analysis to derive target range and size.

A potential low-cost commercial version awaits two developments that are out of MRL's control—cheap charge-coupled-device shift registers and monolithic FFT arithmetic units, both under development in other companies. MRL's developmental hardware consists of three basic parts: the data collector, including the fmcw radar head, amplifier, and analog-to-digital converter; the FFT processor, and the "reshuffling" part, which rearranges the processor's output into the right order for analog display on a scope.

wanted second-harmonic signals.

The module's tangential sensitivity is −85 dBm at a signal-to-noise ratio of 6 dB. The high sensitivity, Siebeneck explains, is achieved by using in the receiver's mixing stage a number of beam-lead diodes integrated in hybrid fashion into the antenna structure. To obtain optimum sensitivity, the diodes are supplied with direct current by the stabilized voltage-supply circuitry. □

Japan

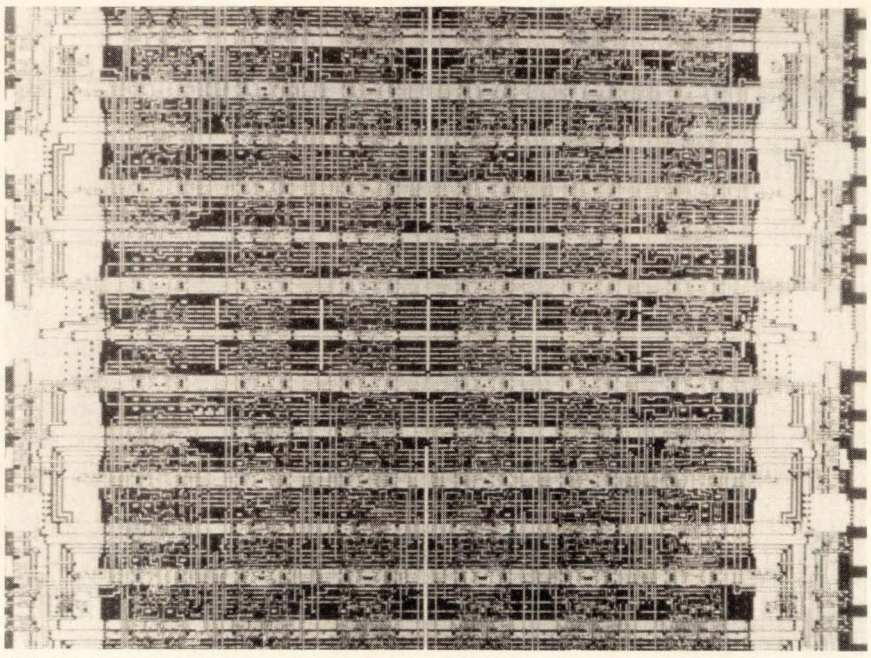
ECL chip developed for phone exchange

The master-slice approach has been adopted for the high-speed large-scale-integrated circuits to be used in Japan's upcoming generation of electronic telephone exchanges. Internal gates with low-level emitter-coupled logic powered by a −2-volt supply provide fast operation with minimal power dissipation.

External gates, which are compatible with Motorola MECL 10,000 devices, operate from a standard −5.2-V power supply. The small dissipation of the low-level gates makes possible about 200 gates with the relatively low propagation delay of 2 nanoseconds per gate.

The basic device, the first large-scale-integrated logic chip to be used by the Nippon Telegraph and Telephone Public Corp., was designed by its Musashino Electrical Communication Laboratory. It will be manufactured by NTT's four electronic-exchange suppliers—Nippon Electric Co., Hitachi Ltd., Oki Electric Co., and Fujitsu Ltd. These suppliers may get permission to sell the same device or variations of it to other customers and may also put other devices in the 72-pin ceramic package, which was developed by the laboratory in cooperation with Kyoto Ceramic Co.

Interchangeable. Devices made by these four companies will vary only slightly because of slightly different fabrication methods, but they will be interchangeable because of fine-tuned processing to obtain the target speed and current specifications. The chips are nominally 5 millimeters square, but each company makes a slightly different size and shape. Although the exchanges to be built with these ICs will have the same capacity as the present ones—about 40,000 lines—their higher speed will enable them to handle more traffic at one time.



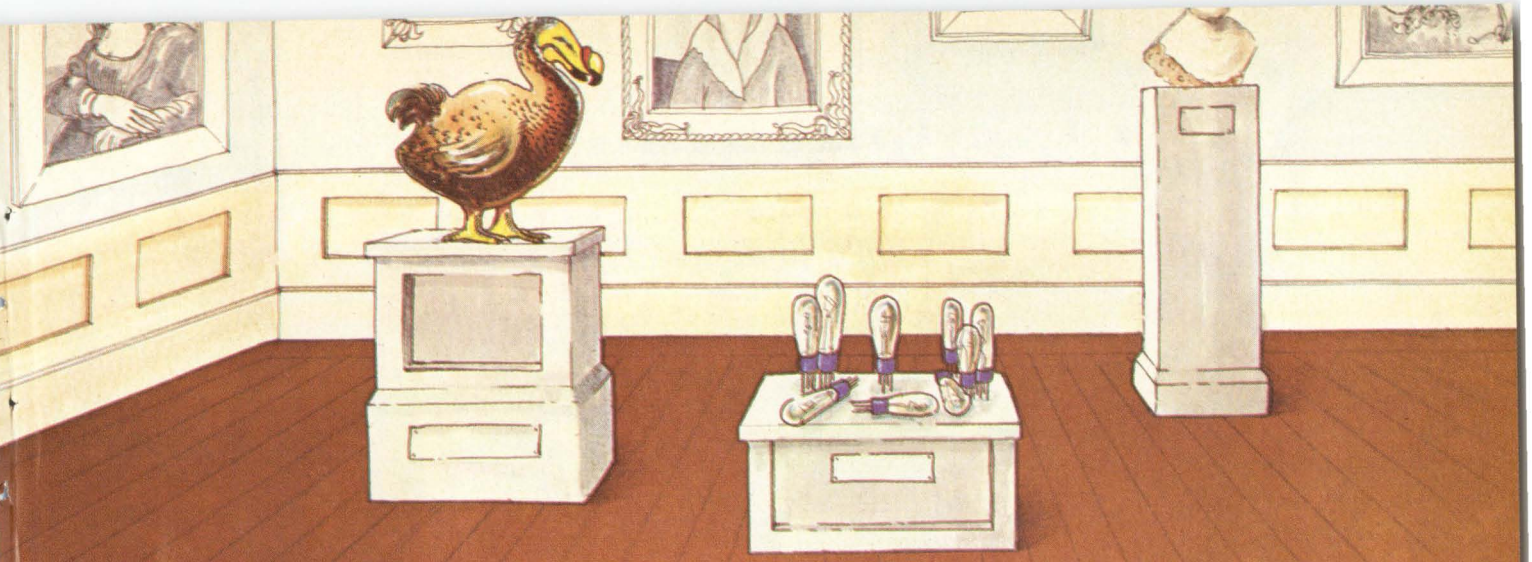
Cellular. Master-slice emitter-coupled-logic chip for Japanese electronic telephone exchange ALU and peripheral interface has 12 rows and 14 columns of cells.

Researchers have completed development of two devices that will be used in the electronic exchanges, and the four manufacturers have delivered samples to the laboratory. One is a 4-bit-slice arithmetic/logic unit that has the equivalent of more than 200 gates, including a shift register that is 2 bits wide by 4 bits long. Eight of these devices will be used in each central processing unit to get a data width of 32 bits. Each exchange requires 16 chips because the equipment is duplicated. The second device, a peripheral interface, consists of data latches in addition to a multiplexer.

Cellular. The basic chip has 168 gate cells, arranged in 12 rows and 14 columns. The chip also contains 12 reference-voltage power supplies—one for each row—and 22 cathode followers to match 50- or 75-ohm terminations. When operated from the −2-V supply, the gates, for internal logic, dissipate only 3 milliwatts.

When operated from a −5.2-V supply, the gates are used for output to drive adjacent chips with an MECL-10,000-compatible logic swing. They draw 15.6 mW. Either way, the delay is only 2 ns. When two or three gates are operated in a series arrangement, they are connected to a −5-V power supply, and spare transistors, either in the same or a nearby cell, can provide the level shift. The emitter followers, connected to the −2-V supply, draw 22 mA.

An extensive arrangement of connecting two or three internal gates in series can provide a chip with the equivalent of about 250 gates, but a level of about 150 to 200 is more common. For standard functions, gates are interconnected by two levels of metalization, separated by a layer of silicon dioxide or a proprietary dielectric. The ceramic package, 28 mm square, has thermal resistance of 17°C per watt. Maximum dissipation rating is 1.5 W. Pins, arranged in two nested squares, are spaced so that they fit in a 2.54-mm grid pattern. □



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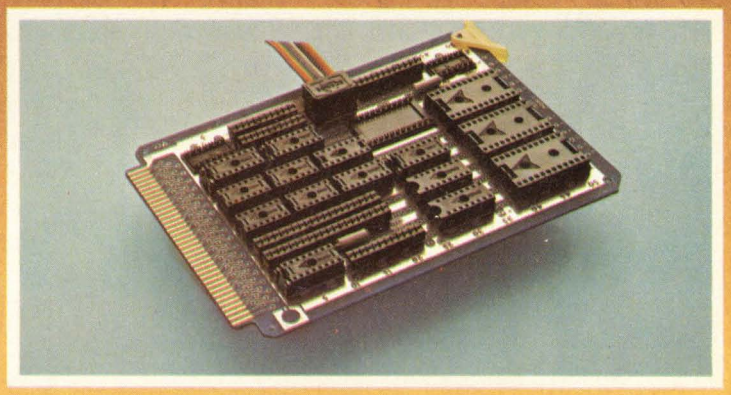

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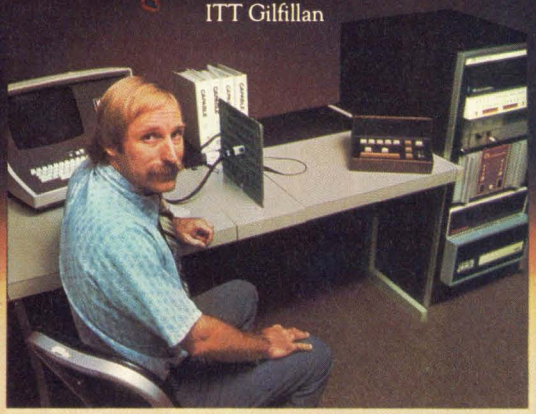

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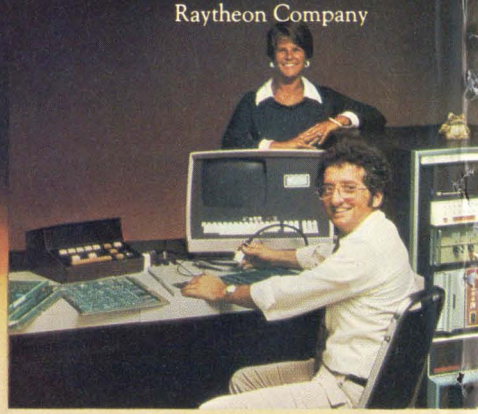

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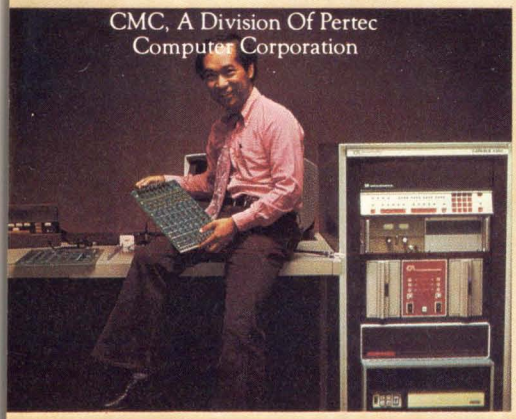

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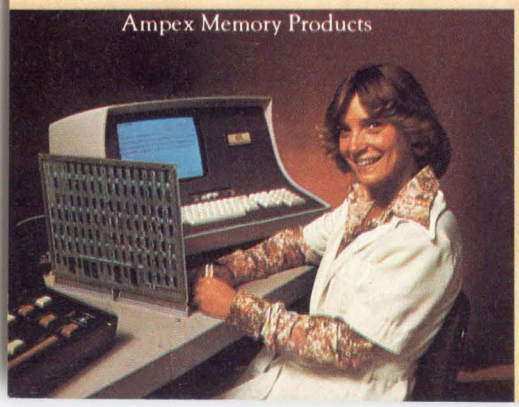

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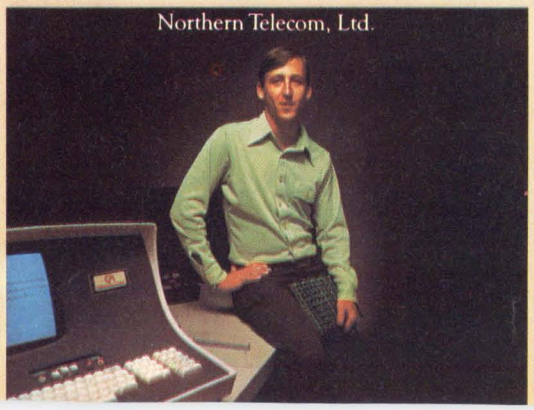

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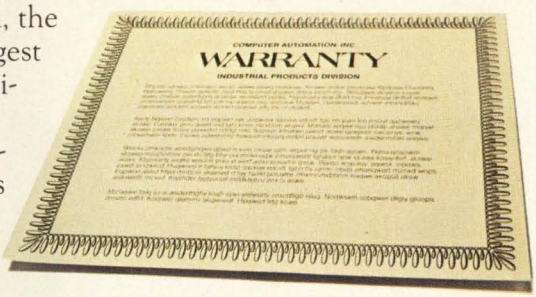
One reason is experience. We've been designing and manufacturing automatic test systems since 1967. Our first customer was our own company's Naked Mini Division, the industry's second largest shipper of OEM minicomputers. Solving their 35,000 board-a-year testing problems has given us the first-hand experience necessary to meet high-volume test requirements in hundreds of installations for other companies around the world.



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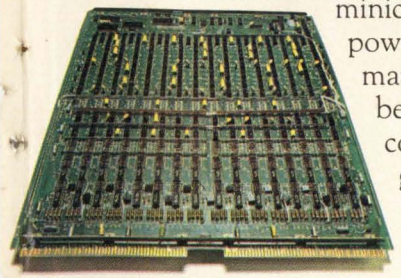

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Circle 69 on reader service card

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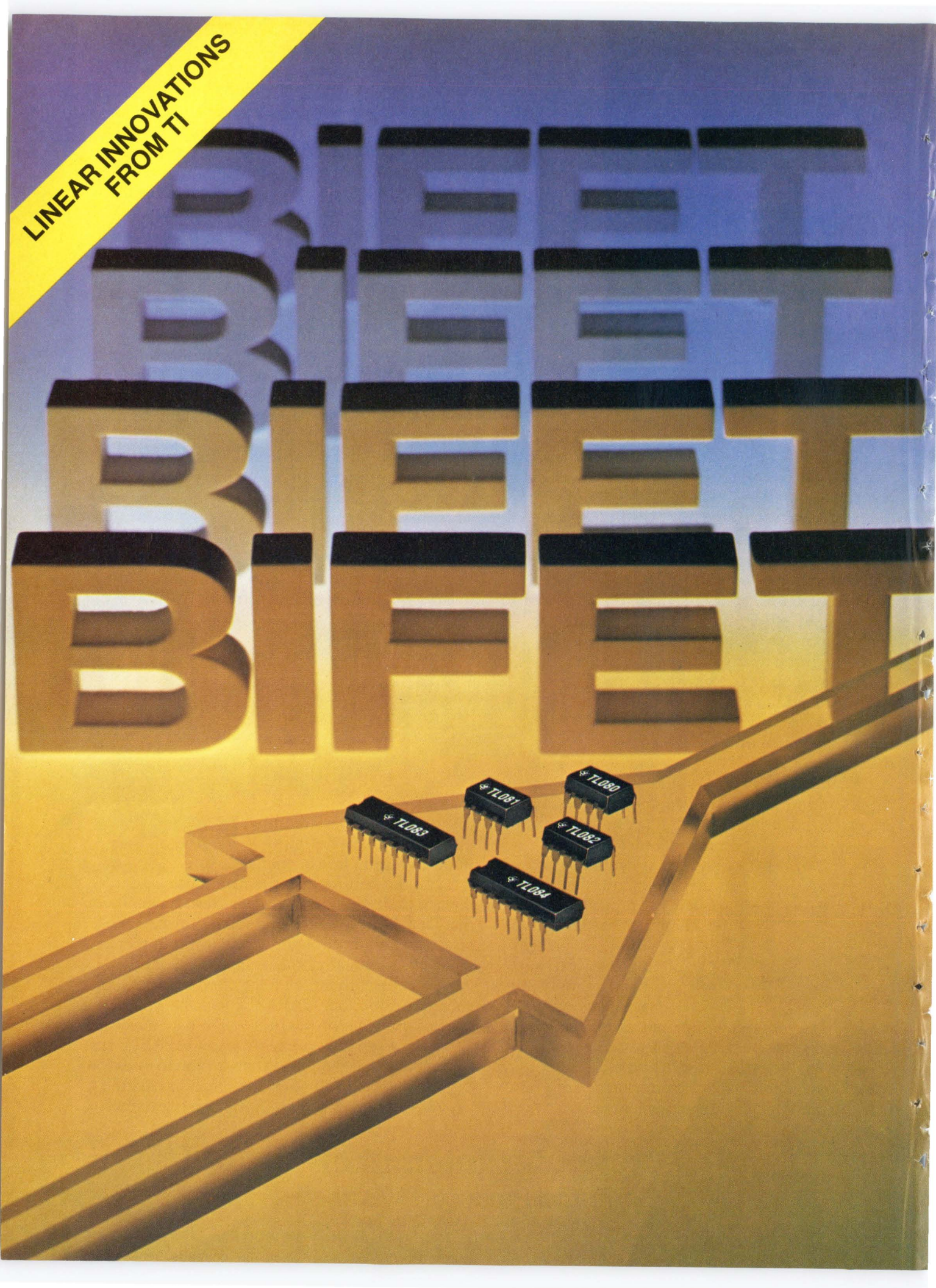

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TL082	2	Yes	No	LM358; MC1458; RC4558
TL083	2	Yes	Yes	μA747
TL084	4	Yes	No	LM324

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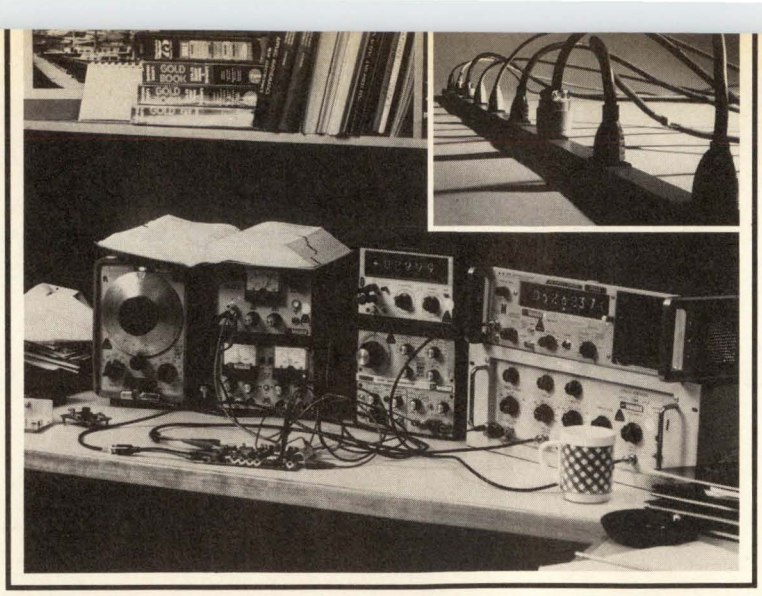

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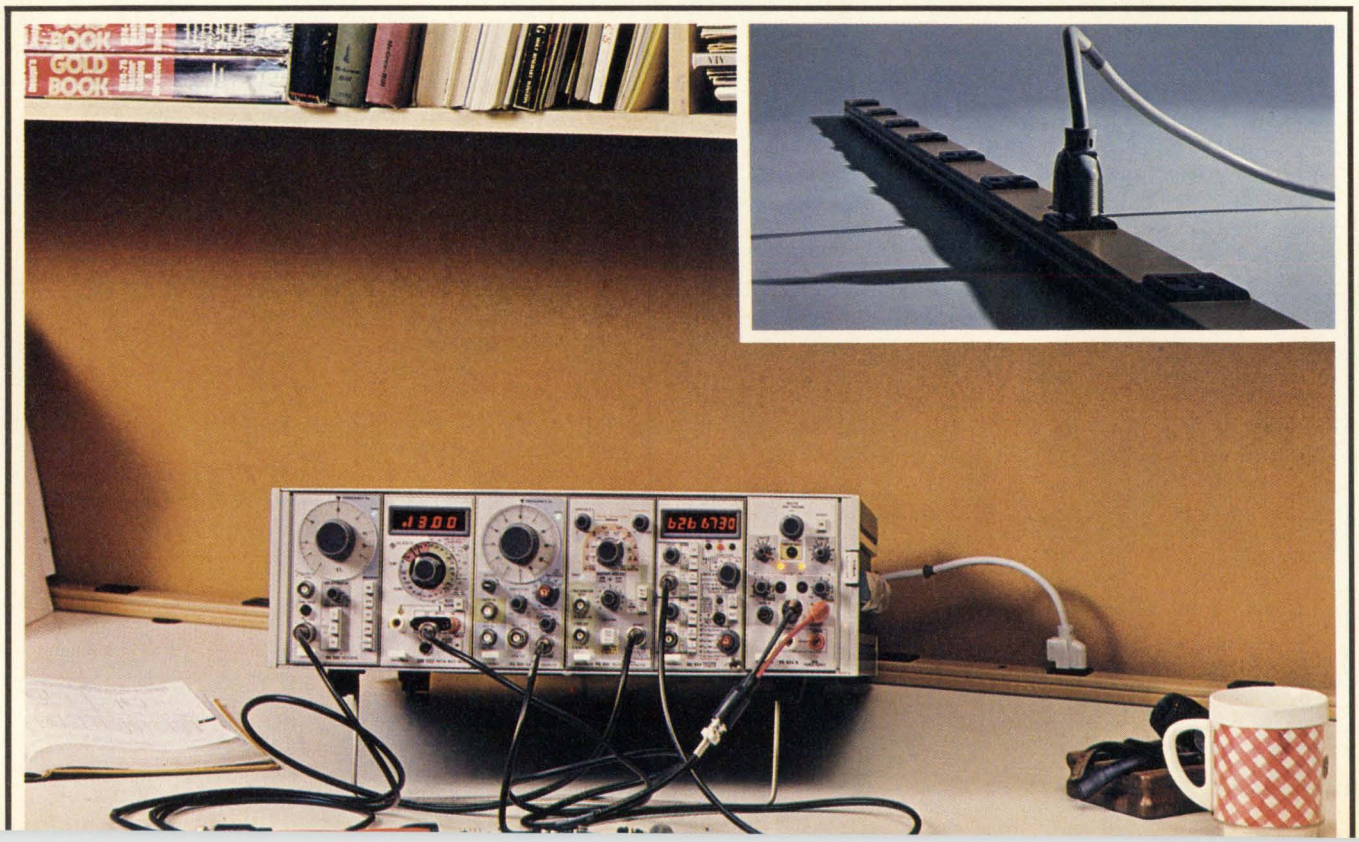

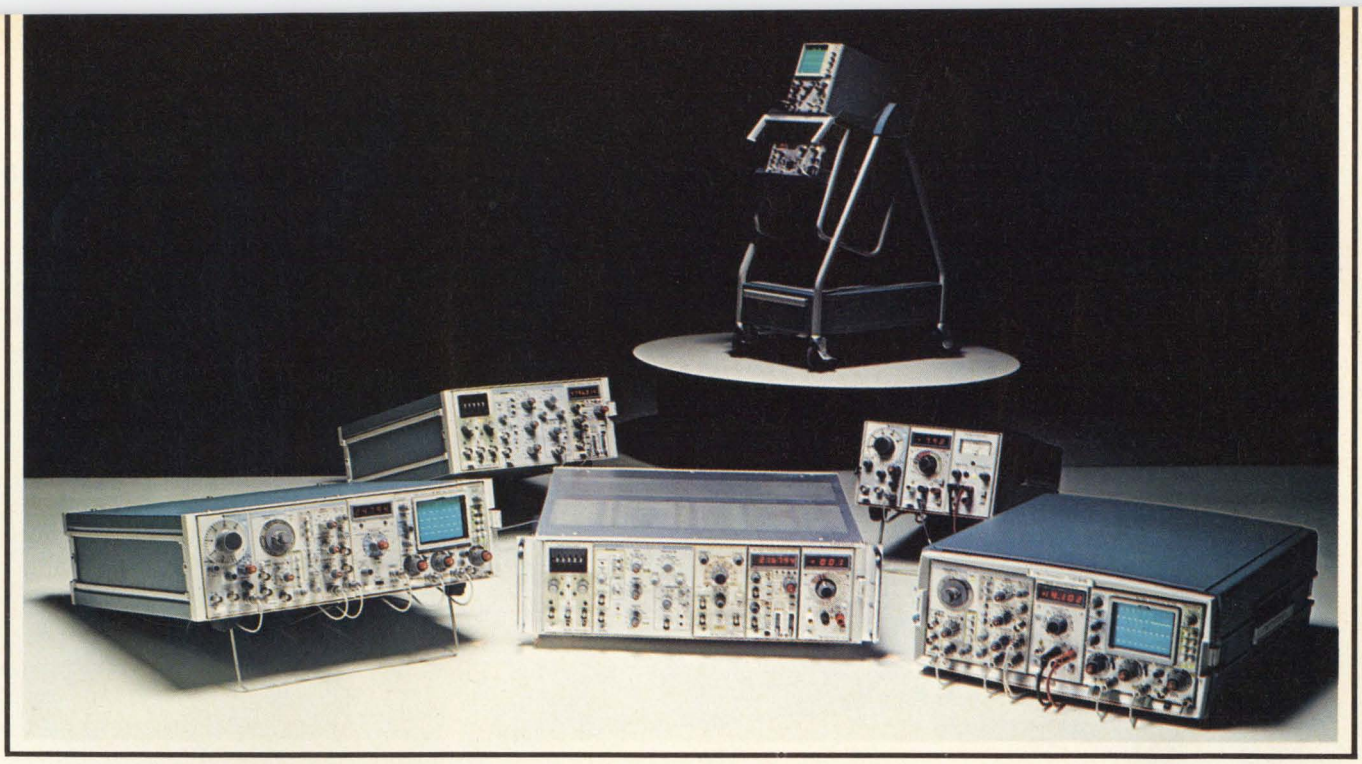

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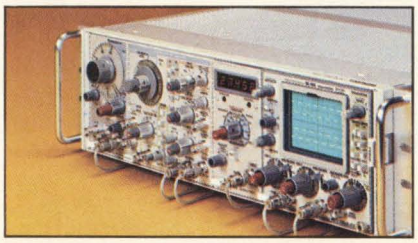

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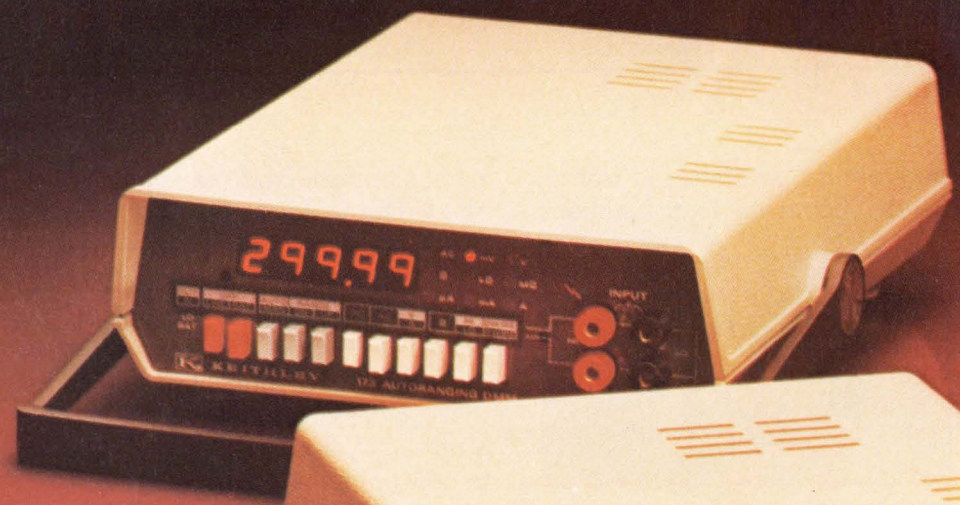
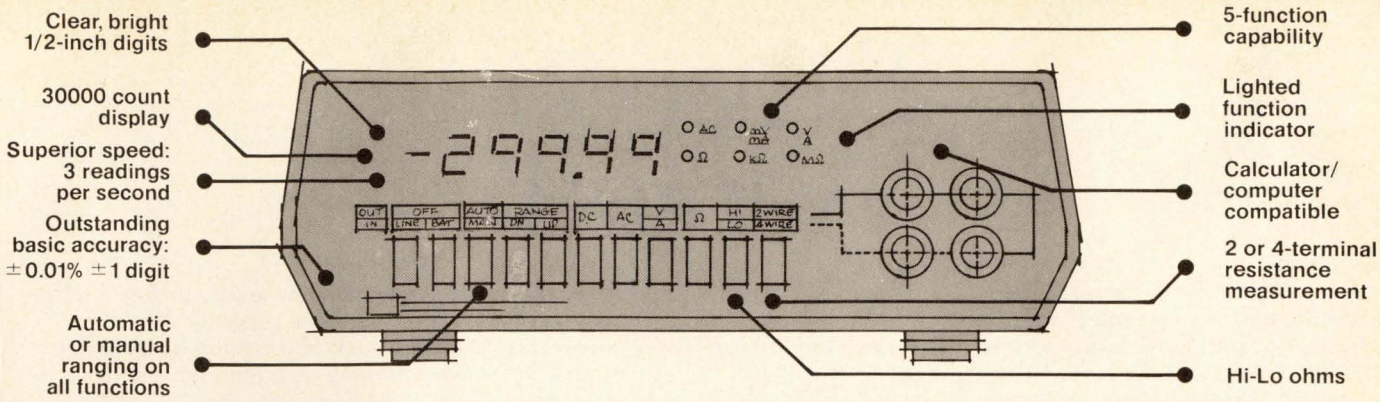


Model 173

Model 172



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Military and space stand tall

Departing Ford budget officials push military total to $123 billion and leave Carter Administration virtually forced to accept rise

by Ray Connolly, Washington bureau manager

It was one of his last acts as President, and Gerald Ford had nothing to lose. So with the delivery of his $440 billion fiscal 1978 spending program to the Congress, he threw Jimmy Carter a curve.

It is a rising curve of Federal outlays for the year beginning Oct. 1. It is marked by sharp increases in military spending and significant new starts in space that are out of sync with President Carter's expressed priorities. Yet the Carter White House indicates it may be forced to watch the ball go by this year, taking a strike and learning from the experience.

A Carter transition staff recommendation now circulating in Washington urges the new President to move cautiously at the start and avoid any major political confrontation with—and possible defeat at the hands of—the 95th Congress. Thus Carter's proposed budget amendments, scheduled for delivery to Congress before March 1, seem unlikely to significantly alter any major electronics spending programs.

Major proposals to consolidate the nation's energy agencies into a single department and to restructure the executive branch will occupy much of Carter's first 100 days, as will programs to reduce unemployment and Federal income taxes. "We won't truly have a chance to look at many individual military programs for a while," admits a Carter staffer, "so we're going to have to trust the judgement of Harold Brown," the new Secretary of Defense.

What Brown has to deal with is Ford's record proposal for $123 billion in military obligations, an increase of nearly 12% from fiscal 1977. Of the total, $110 billion is proposed as expenditures in the new fiscal year. This reflects significant spending increases and new starts in procurement as well as research and development (see tables).

But there is a catch: if Congress approves the Pentagon's 27% jump to $23.8 billion in its procurement "wish list" for fiscal 1978, then the Defense Department will be committed to hardware purchases that will require another 21% rise to $28.8 billion in fiscal 1979.

The 217,000 defense-industry jobs that Ford's budget would create would bring the total of such jobs to more than 2 million, a 12% increase from the present level (itself a jump of more than 9% from last year). "A lot of those will be in electronics and aerospace in view of new program priorities," observes one contractor's budget analyst. Defense Department comptroller Fred Wacker says much of the increase in jobs is attributable to larger outlays for research, development, test, and engineering. Military RDT&E spending in the Ford budget is set at $11.3 billion, up 13.6% from fiscal 1977's level, which rose 12% from the previous year.

While the National Aeronautics and Space Administration's numbers for fiscal 1978 are less extraordinary

than those proposed for defense, they are at least going up after several stagnant years. Ford's proposal to boost NASA spending by 5.3% next year to $3.9 billion is modest on its face. But the new and accelerated programs he calls for would push up NASA spending another 11% in fiscal 1979 to $4.3 billion.

The space agency proposes production starts on three additional Space Shuttle orbiters to complete a fleet of five—a plan that could stall in Congress. And James C. Fletcher, Ford's NASA chief, wants to begin four new programs: the long-delayed Large Space Telescope for 1983 orbit by the shuttle, a Jupiter Orbiter Probe for shuttle launch in 1981, a fourth Landsat for 1981 launch with an information capability 10 times greater than the predecessor Earth Resources Technology Satellites, plus a search and rescue satellite for development with Canada and other countries.

Like those for defense, the space program proposals could prove an embarrassment to Jimmy Carter's White House if it tangles with Congress over trying to alter too many of them too quickly. "Budgets are a little like landslides," smiled one departing Ford official in the Office of Management and Budget as he emptied his desk. "They start slowly but acquire an awful lot of energy and momentum as they build up over the course of a year. Once they begin moving, they are awfully hard to stop. And you can get killed trying to change their direction."

Defense cuts will come hard

Jimmy Carter's reaction to Gerald Ford's proposed 12% increase in fiscal 1978 military outlays to $110 billion is not yet clear. That's what Defense Secretary Harold Brown was saying when he told a listener during a break in his Senate confirmation hearings that "I wouldn't guess at this point" how Carter will seek to modify Ford's budget plan. The temper of the new 95th Congress, with its large Democratic majority, is not yet measurable either. First industry estimates in Washington are that there is little room for fiscal 1978 cuts in programs with high levels of electronics spending.

The Ford plans would push up outlays by more than 10% a year to $121.3 billion for fiscal 1979 and $133.8 billion for fiscal 1980. The annual growth rate would taper off to 8.8% for $145.6 billion in 1981 and 7.5% for $156.4 billion in 1982.

Carter and future Congresses are sure to modify those numbers, but Ford's programs will be hard to alter. "Beyond the very real Soviet threat," points out one Pentagon economist, "there are just too many jobs involved in too many industries for Carter's people to tinker much until they develop alternatives."

Hardware. Of the $35.1 billion in procurement money the Pentagon wants authority to spend—some in

MAJOR REQUESTS FOR WEAPONS PROCUREMENT
(in millions of dollars; quantities in parentheses)

	FY 1977	FY 1978	Contractor
ARMY AIRCRAFT			
C-12A cargo	$16.6 (20)	0	Beach Aircraft
AH-1S Cobra/Tow	128.6 (82)	$142.8 (83)	Bell/Avco/Hughes
UTTAS, helicopter	213.0 (15)	270.9 (56)	Sikorsky/GE
NAVY AIRCRAFT			
A-4M Skyhawk, USMC	92.7 (21)	7.7	McDonnell
A-6E Intruder	80.2 (6)	185.9 (12)	Grumman
EA-6B Prowler	135.5 (6)	143.6 (6)	Grumman
A-7E Corsair II	220.4 (30)	58.4 (6)	Vought
F-14A Tomcat	700.9 (36)	940.7 (44)	Grumman
F-18 strike fighter	346.9	655.9	McDonnell/Northrop
CH-53E Sea Stallion (1)	105.5 (6)	86.9 (6)	Sikorsky/GE
AH-1T Sea Cobra	64.3 (23)	31.2 (8)	Bell
P-3C Orion	239.3 (12)	321.6 (14)	Lockheed
S-3A Viking	0.4	58.1	Lockheed
E-2C Hawkeye	156.5 (6)	196.6 (6)	Grumman
AIR FORCE AIRCRAFT			
B-1 bomber	1,555.7 (3)	2,153.9 (8)	Rockwell
A-10 close support	613.3 (100)	840.9 (144)	Fairchild
F-15 Eagle	1,524.8 (108)	1,766.3 (108)	McDonnell
F-16 ACF	499.3	1,695.5 (105)	General Dynamics
* Advanced Tanker Cargo (ATCA)	28.8	276.6 (6)	McDonnell/Boeing
E-3A AWACS	564.6 (6)	528.9 (6)	Boeing
ARMY MISSILES			
Chaparral, surface-air	66.4 (2,000)	55.1	Ford Aerospace
Hawk, surface-air (1)	107.3 (526)	111.2 (559)	Raytheon
*U.S. Roland, surface-air	85.0	131.1	Hughes
*Stringer, surface-air (1)	25.8	105.6 (890)	General Dynamics
Dragon, antitank (1)	90.0 (16,080)	93.7 (20,671)	Multiple
TOW, antitank/assault (2)	108.8 (13,051)	102.6 (14,866)	Hughes/Emerson
Lance, surface-surface	75.7 (360)	82.9 (360)	Vought
*Pershing, surface-surface	0	18.7 (6)	Martin Marietta
AN/TSQ-73, Hawk/Nike controls	42.2 (12)	48.0 (12)	Litton
NAVY MISSILES			
Poseidon, FBM	20.9	21.8	Lockheed
Trident I, FBM	1,542.2 (48)	1,500.1 (96)	Lockheed
Sparrow, air-air (3)	169.2 (1,320)	180.0 (1,725)	Raytheon/GD
Sidewinder, IR air-air (3)	95.5 (1,420)	151.8 (2,900)	Raytheon/Ford
Phoenix, air-air	91.2 (240)	95.9 (210)	Hughes
Shrike, air-surface (3)	51.3 (1,275)	41.6 (900)	Various
Standard Arm, sir-surface	0.2	3.0	General Dynamics
Harpoon, ship/air-surface	150.4 (245)	155.8 (315)	McDonnell
Standard, MR, surface-air	87.3 (500)	126.7 (480)	General Dynamics
Standard ER, surface-air	55.7 (36)	71.7 (40)	General Dynamics
AIR FORCE MISSILES			
Minuteman II/III, ICBM	770.0 (60)	338.3	Multiple
AGM-69A/B SRAM, air-surface	40.8	70.6	Boeing
*AGM-86, air-surface cruise	79.2	164.5	
AGM-65A/B, E/O Maverick, air-ground	4.9	8.3	Hughes
*AGM-65C, Laser Maverick	40.0	47.9 (100)	Hughes
*AGM-65D, IIR Maverick	11.2	67.2	Hughes
Aerial targets/drones (4)	153.9	176.1	Multiple
NAVY VESSELS			
SSN 688, attack sub	1,290.8 (3)	531.0 (2)	Newport News/GD
DD 963, destroyer	203.6	70.8	Litton
CSGN, strike cruiser (Aegis)	33.3	203.1	Newport News
DDG-47, destroyer (Aegis)	11.0	935.0	Not selected
PHM, hydrofoil/missile	42.6	1.2	Boeing
FFG, missile frigate	1,283.0	1,616.0	Bath Iron/Todd
OTHER PROCUREMENT			
Navstar GPS, Global Satellites	62.0	112.4	GD/Rockwell
Space Shuttle, USAF booster	60.1	167.1	
*M557A1, tracked command post	0	54.2 (565)	FMC Corp.
*MICV, combat vehicle	29.8	89.5 (107)	FMC Corp.
M60A1/3 tank (1)	491.9 (927)	606.2 (960)	Chrysler
Artillery Missile Radar	1.2 (48)	2.8 (140)	Not selected
CLGP, laser shell	36.1	54.1	Martin Marietta
MK-48, torpedo	139.5 (214)	163.8 (300)	Gould
MK-60, ASW mine (Captor)	65.4 (240)	90.2 (550)	Goodyear
*MK-30, mobile ASW target	2.9	21.5 (12)	Northrop
*MK-15 CIWS Phalanx, ship gun	38.9	81.8 (21)	General Dynamics
FLTSATCOM, satellite	72.9	62.3	TRW
DSCS, satcom	219.9	138.2	TRW

(1) Includes Marine Corps procurement (2) Includes Navy/Marines procurement
(3) Includes USAF procurement (4) Includes Army/Navy requirements
† In competition * First major production

Source: DOD

WEAPONS R&D FUNDS
(in millions of dollars)

	FY 1977	FY 1978	Contractor
ARMY			
Advanced Attack Helicopter (AHH)	$130.8	$200.0	Bell
AFAADS, air defense	0.2	24.2	
Ballistic Missile Defense Technology	100.1	107.7	McDonnell
BMD Advanced Technology	102.7	107.3	Multiple
Hellfire, heliborne missile	17.8	50.5	
Patriot (SAM-D), surface-air	180.2	214.6	Raytheon
SSM, surface-surface missile	5.0	30.1	
Tri-Tac, joint tactical communications	37.3	58.9	GTE-Sylvania
NAVY			
V/STOL aircraft developments	44.0	101.1	Multiple
LAMPS ship helicopter	73.7	107.3	Multiple
AEGIS, surface-air	26.3	27.2	RCA
HARM, air-surface radiation	30.0	29.7	TI
Tomahawk, sub/air-launched missile	119.5	234.3	General Dynamics
SES, surface effect ship	48.0	43.9	Rohr Ind.
Advanced ASW Torpedo	18.0	26.5	
ELF communications	14.8	23.7	
Wide Aperture Array Sonar	9.2	23.1	IBM
AIR FORCE			
Advanced Medium STOL	29.3	25.0	McDonnell/Boeing
E-4 AABNCP, command post	98.7	65.8	Boeing
*NATO AEW&C aircraft (E-3A)	0	15.7	Not selected
Precision Location Strike System	12.0	30.2	Not selected
*RF-X, tactical air recon.	0	1.0	
*Advanced MR missile, air-air	5.0	42.5	Multiple
*GLCM, ground-launched missile	0	3.9	
*M-X, MIRVed ICBM	69.0	294.4	Boeing
*WVR missile, air-air (AIM-9L folo)	0	5.9	Not selected

*New R&D start — Source: DOD

later years—the Navy is in line for some $15.4 billion, of which nearly $6.5 billion is for ships. The Air Force is budgeted for $13 billion, two-thirds of which will go for aircraft, including beginning production of the B-1 bomber and major purchases of two fighters. The Army is left with $6.3 billion, with big shares budgeted for a new M-60 tank and missiles for air and tank defense.

Of the $12 billion in new R&D authority, Air Force and Navy programs also dominate, with respective shares of $4.4 billion and $4.2 billion. The Army receives $2.6 billion. Biggest full-scale development start is the M-X intercontinental missile with multiple warheads to follow the Boeing Minuteman series. The Air Force is ready to spend nearly $295 million, more than four times its fiscal 1977 program.

Of the other five major Air Force efforts, contractors are watching the accelerated competition for an advanced medium-range air-to-air missile to succeed Raytheon Co.'s troubled AIM-7 Sparrow in the mid-1980s [*Electronics,* Jan. 20, p. 25]. Proposed for the F-14, F-15, F-16, and F-18 fighters, the new radar-guided missile's budget jumps to $42.5 million from $5 million this year. Already competing on the project are Northrop Corp., a new entrant in the field, plus Ford Aerospace and Communications, Hughes Aircraft, General Dynamics, and Raytheon.

A second new air-to-air missile competion is the system known as Within-Visual-Range, or WVR. It begins with $5.9 million to develop a follow-on to the short-range, infrared Sidewinder AMI-9 that is now produced by Raytheon and Ford Aerospace.

Although the Army's major R&D programs remain essentially unchanged, several are up for significant funding boosts, such as Bell's Advanced Attack Helicopter and Raytheon's Patriot air defense system using the SAM-D missile.

To fill the gap until it gets its Advanced Scout Helicopter, the Army is programming $18.3 million to design and test a system using a laser target designator for precision-guided munitions fired by attack helicopters or ground forces.

Aircraft. Some of the biggest product allotments next fiscal year will go for aircraft and their associated avionics, with the largest purchases being made by the Air Force. Nearly $1.7 billion is programmed for 105 of General Dynamics Corp.'s F-16 Air Combat Fighter, for example. Production of the McDonnell Douglas F-15 Eagle holds steady at 108 planes, although funding will rise nearly 16% to $1.7 billion. Output of Fairchild's A-10 close-support plane is programmed to accelerate to 144 from this year's level of 100.

While the Navy is phasing out the Marine Corps' A-4 Skyhawk, it wants $940 million to boost production of Grumman's F-14A Tomcat to 44 planes—eight more than this year. Grumman would also get $186 million for a dozen of its A-6E attack aircraft—double the fiscal 1977 number—plus $143 million for six of the all-weather, tactical jamming versions, the EA-6B.

First production money for the McDonnell F-18 fighter is set at $29.3 million, while RDT&E funds for the plane almost double last year's level to $626.6 million. Lockheed Aircraft's only big chunk of Navy aircraft money will come from the $321 million purchase of 14 more P-3C antisubmarine patrol planes.

Missiles. While the Air Force proposes to accelerate development of its new intercontinental M-X, it has slashed production money sought for the Minuteman series by more than half to $338 million. That cutback is less likely to arouse congressional ire than the doubling of Air Force funds for Boeing's AGM-86 cruise missile to $164.5 million. Designed for use with the B-52 and B-1 bombers, the missile is sure to stir up a Capitol Hill controversy over claims that it duplicates the Navy's Tomahawk being developed by General Dynamics. McDonnell Douglas is developing the Tercom guidance system for both weapons.

Hughes Aircraft's AGM-65 Maverick air-to-ground missile proves to be a big winner in the Air Force budget with four models funded, including the first purchase of 100

Generating energy. Frank G. Zarb, left, who was President Ford's energy czar, talks over budget request with OMB official.

laser-homing versions. Altogether, Maverick is budgeted for $123 million.

Ships. The Navy's budget for fleet additions is again dominated by its request for nearly $2 billion for two more Trident missile-launching submarines from General Dynamics' Electric Boat division. The figure is only 54% more than this year's $1.28 billion for one boat, but long-lead-time funds already spent will make the boats considerably more costly.

In its only other billion-dollar ship program, the Navy wants a 26% boost to $1.6 billion for 11 more of its 440-foot guided-missile frigates. This year it is buying eight of the ships under contracts to Bath Iron Works and Todd Shipyards.

NASA looks for upturn

The number of jobs at contractors of the National Aeronautics and Space Administration will slip below the 100,000 mark next September for the first time in 15 years. But NASA Administrator James C. Fletcher—who is fighting hard to keep his own job—foresees an upturn next year, providing Congress approves his $3.9 billion spending program.

The prospect that Congress will give NASA the authority to spend $3.9 billion is good. Similarly, Fletcher is also believed to have a good chance to stay on in the Carter Administration, at least for a while.

The space agency's budget requests in Gerald Ford's lame-duck budget for fiscal 1978 are not expected to be altered much by President Carter, according to Administration officials. Ford's Office of Management and Budget pared Fletcher's initial requests by $170 million before leaving.

Scientific approach. H. Guyford Stever, science adviser to the President, conducts briefing on his office's budget request.

One consequence of that beating will be the drop in contractor employment to 98,600 by September. But if NASA gets its way with Congress, the industry job level should rise to 107,200 by September 1978. That figure is far below the 376,700 jobs the agency generated at its June 1965 peak, and not even up to last June's 108,000. "But at least we have bottomed out—I hope," a NASA budget specialist says.

New starts. In addition to the $1.2 billion sought for Space Shuttle design, development, test, and evaluation, the agency wants another $141 million to begin production of the final three orbiters for a fleet of five. The bulk of the money for electronics in the DDT&E request is contained in the $690.5 million for the orbiter itself and the $133.5 million for the launch and landing systems. While the orbiter request represents a 19% drop from fiscal 1977, the launch and landing systems money represents a 50% boost.

For the 2.4-meter space telescope, NASA wants $36 million. The promise of the system during its decade or more of operation, Fletcher asserts, is its "unparalleled capability" when operating above the obscuring layers of the earth's atmosphere.

The new Jupiter Orbiter Probe is budgeted for $20.7 million. However, declines in older programs such as Viking, Pioneer Venus, and the 1977 Mariner probe of Jupiter and Saturn produced a 23% overall drop in planetary program funds to $148.2 million for next year.

The $21.9 million NASA wants for a Landsat D earth-resources satellite accounts for nearly all of the 42% gain in the $92 million earth resources detection and monitoring program.

Transportation. While NASA officials seem relieved at the prospect of minor gains after years of hardship, the atmosphere within the Department of Transportation, its Federal Aviation Administration, and the Coast Guard is grim. Programs with significant electronics content are hard to find, even in the FAA. The $2.7 million budget of that agency represents a 1.7% increase. A total of $1.8 billion will be used for air-traffic-control and navigation systems, as well as for enforcement of civil air regulations and for airport administration.

Another $213 million will go largely for electronics, including automated air-traffic control, new radars, improved air navigation facilities, and landing aids. The FAA's research, engineering, and development budget comes out with a mere $85 million, a figure that both the bureaucracy and its contractors hope will be increased by the Congress with support from Carter. □

Energy R&D gets 28% increase

The Federal Government is continuing to pack a good deal of its civilian R&D muscle into energy. Of the $9.4 billion proposed for those outlays—up 6% over fiscal 1977—energy-related projects will consume $3.7 billion, 28% more than last year.

The Energy Research and Development Administration is the major funnel, planning to spend $229 million of its $4.4 billion in total R&D outlays for solar energy work. That's $68 million more than last year's expenditure and a whopping $136 million more than the solar energy outlay for fiscal 1976. A key reason for this year's increase is the $65 million to be spent for a solar electric central receiver pilot plant, a 10-megawatt facility.

At the National Science Foundation, the other agency with a major mission of overseeing and funding scientific R&D, there is a restoration of funds to Research Applied to National Needs. That broad category, which includes such items as earthquake engineering, finding nonconventional food sources, and weather modification, will account for $78 million, compared to the fiscal 1977 expenditure of $69 million—a figure about the same as in fiscal 1976.

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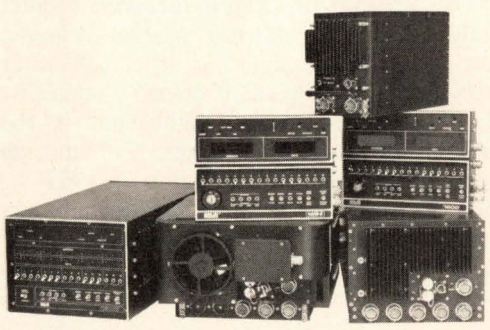

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ITALIAN ELECTRONICS MARKETS FORECAST
(IN MILLIONS OF DOLLARS)

	1975	1976	1977
Total assembled equipment	**1,214**	**1,429**	**1,664**
Consumer electronics	264	348	431
Communications equipment	312	356	406
Computers and related hardware	400	460	527
Industrial electronics	136	155	179
Medical electronics	47	50	60
Test and measurement equipment	33	36	38
Power supplies	22	25	29
Total components	**331**	**398**	**436**
Passives	149	173	191
Semiconductors	94	112	127
Tubes	84	110	114

(Exchange rate: $1 = 875 lire)

Note: Estimates in this chart are consensus estimates of consumption of electronic equipment obtained from a survey made by *Electronics* in September and October 1976. Domestic hardware is valued at factory sales prices and imports at landed costs.

Italy's electronics to outpace economy

by Andrew Heath, McGraw-Hill World News

While Italy's World Cup skiers battle Austria's, their competition has had to share headlines at home with the crisis-ridden Italian economy, which continues to perform its own version of the downhill and slalom. Yet, in another sense, the economy is actually going nowhere. It is dragging a burdensome international debt of $18 billion, a 1976 trade deficit of $5.8 billion, and an inflation that is heating up to the 20% neighborhood.

Government planners have announced that, although Italy's gross domestic product will increase 21% in 1977 to $190 billion, it will only keep pace with inflation, which is also pegged at 21% for the year. In short, unless the government and the unions come to terms on economic policy, a year of zero growth lies ahead for the Italian economy, say the planners. Still, electronics is expected to fare better this year than the economy as a whole.

For the electronics industries, the focus of attention is the government's proposed industrial-restructuring plan. Through it, makers of components, telecommunications, computers, and other equipment see the opportunity to inject some coordination and state planning into their operations after many lean years of disordered development.

Moreover, in a "white paper" recently published by FAST (the Federation of Technical and Scientific Associations), electronics manufacturers are making known to the government their need for an electronics-industry plan and for research and development funds. To date, virtually all the R&D in Italy has been commercially financed. Electronics-industry sources say the objective is around $230 million.

Says Enrico Villa, international sales and planning manager at SGS-Ates, who helped prepare the study, "The industry needs to know which sectors need developing. With state financing of research, funds that companies have put to R&D could be used in other ways, rather than having to turn to the banking system for financing."

Privately, most industry sources are betting that the unions will win their showdown with the Italian government because they will maintain their wage levels and spend their way past the deflation that the planners predict for the second half of the year. That kind of reasoning, plus Italy's strong lean to the export market with products like semiconductors, telecommunications, and some business machines, leads many companies to look on 1977 as a year in which electronics will outperform the Italian economy.

Color TV ahead. One of the mainsprings of optimism is that Italy is as close to getting color-television broadcasting as it has ever been. CIPE, the government's powerful economic planning committee, has given its nod of approval to color broadcasts by RAI, the national network.

Though no date has been set for the start of colorcasting, the entertainment and components industries are moving ahead as if 1977 will be the year for color TV in Italy. Production of sets, which was nearly 600,000 in 1976, is expected to rise to 750,000 to 800,000 this year and to 1 million in 1978. The industry exported approximately 75% of its production in 1975 and 50% last year. Exports are expected to reach the same level in 1977. Italy's TV manufacturers are aiming at a larger share of the small-screen (up to 20 inches) color market.

Semiconductors for export. *Electronics'* survey pinpoints the Italian components market for 1977 at $435.7 million, up 9.5% from 1976, with semiconductors at $126.8 million, up 13%. Manufacturers predict a fair, if lackluster, market at home, buoyed mainly on the consumer side—especially if color TV makes its entry. Another bright spot is the electric-organ market: $17 million worth of semiconductors in 1977.

For the Western European markets, Italians foresee an average 12% growth. But for most Italian companies, neither Italy nor Western

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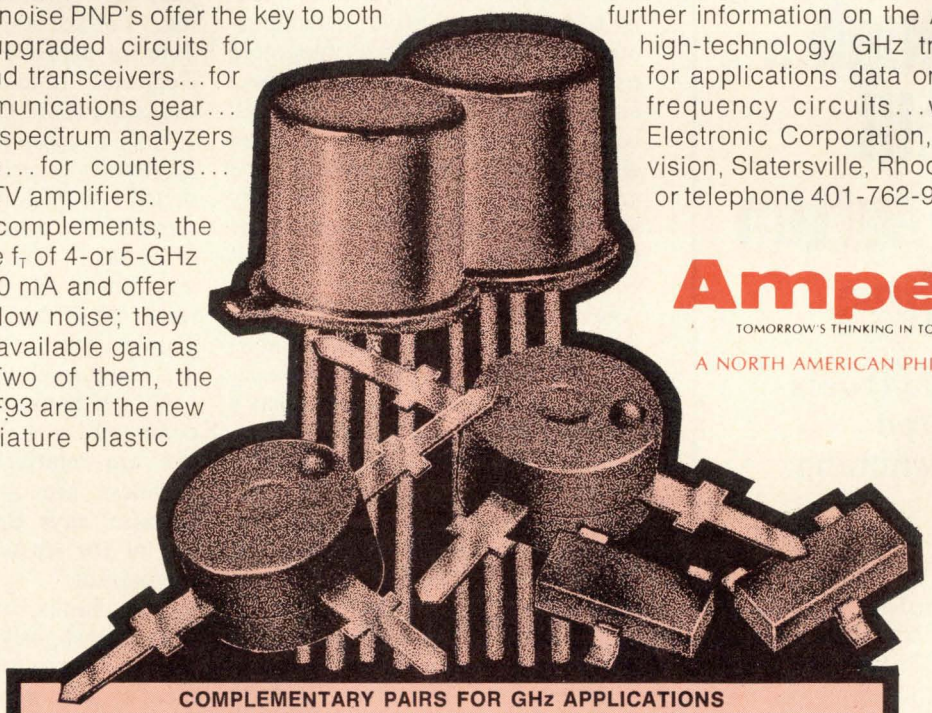

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A441 (TO-72)	f_T . . . . 5 GHz @ 30 mA NF . . . 2.4 dB @ 200 MHz G_{max} . . 14 dB @ 500 MHz	$2.65	**A401** (TO-72)	$1.75
ON586 (SOT-37)	f_T . . . . 5 GHz @ 14 mA NF . . . 2.5 dB @ 500 MHz G_{max} . . 19 dB @ 500 MHz	$2.85	**BFR90** (SOT-37)	$2.25
BFQ23 (SOT-37)	f_T . . . . 5 GHz @ 30 mA NF . . . 2.4 dB @ 500 MHz G_{max} . . 15 dB @ 500 MHz	$3.15	**BFR91** (SOT-37)	$2.45
BFT92 (SOT-23)	f_T . . . . 4 GHz @ 14 mA NF . . . 2.7 dB @ 500 MHz G_{max} . . 17.5 dB @ 500 MHz	$2.53	**BFR92** (SOT-23)	$2.30
BFT93 (SOT-23)	f_T . . . . 4 GHz @ 30 mA NF . . . 2.4 dB @ 500 MHz G_{max} . . 15.5 dB @ 500 MHz	$2.70	**BFR93** (SOT-23)	$2.45

*In 1000 piece quantities

Probing the news

Europe is where the best growth potential lies these days. Aldo Toscano, SGS-Ates' international marketing director, explains that his company will be pushing its semiconductors harder into the United States, Latin American, and Far Eastern markets in 1977. "Only 30% of our sales are in Italy, and in Europe, we have a penetration that would be costly to improve. We'll follow the growth of the European markets, but we expect to double our penetration of the U.S. and Far East markets."

SGS-Ates, Italy's major semiconductor maker, plans to broach the U.S. market mainly with the company's more innovative consumer-oriented products, such as integrated circuits for TV sets, car radios, power amplifiers for portable and citizens' band radios, and MOS electric-organ circuits, such as the rhythm and arpeggio generators. The company also plans to enter the U.S. computer market through the clients that it already has in Europe. In Latin America and the Far East, SGS-Ates will mainly tap the consumer market, although the telecommunications market in Latin America has a potential for products like the company's channel amplifier and channel modulator.

Looking abroad. For telecommunications manufacturers too, the export market appears to be the best bet in 1977. As in other countries, thanks to hearty spending by state telephone agencies, telecommunications has for years thrived in Italy while other areas languished. However, in recent years, installation of electronic switching has not moved ahead fast: the target set at the end of 1973 of 950,000 new subscriber lines per year has not been met. Says one manufacturer: "The number of new lines depends on the availability of funds, and, although SIP [the state-owned phone company] has raised telephone rates, the traffic has been dropped back. Add inflation, the high unit cost of labor in Italy, and the lack of capital, and the future looks somewhat obscure." *Electronics* estimates the Italian telecommunications market at $400.4 million, up 12.5% from 1976.

The rate of gloom, though, is proportional to each manufacturer's dependence on the domestic market. A big firm like SIT Siemens, with 50% of the Italian market, will push exports hard. On the other hand, Telettra, with a small domestic share, already is in 50 countries.

The 25% fall in the value of the lira in 1976 bore some fruit for Italy's telecommunications companies, as it did for those in other sectors, and the advantages will continue to be felt in 1977. "However," says Mastalli, "we import many components from the dollar and mark areas. We also suffer when the lira falls and have to pass this burden along in our pricing." For the Italian market in 1977, Telettra plans to install in Turin an electronic time-division-multiplexed exchange to be named Sintel.

Italy's computer market, which *Electronics* estimates will rise 14.6% in 1977 to $526.6 million, is behind those of the other industrial nations of Europe. "That," says Mario Speranza, head of Honeywell's market research in Italy, "is its strength. The less mature a market, the more it is immune to economic trends."

While bank accounts of Italy's communes and other local authorities are relatively lean, they nevertheless are fair sales prospects because, says Speranza, "they are one of the least mature sections of the market."

The banks, whose liquidity is limited to slightly over 40% of deposits, are investing well in the development of existing systems. Honeywell estimates the bank market grew at an annual 18% over the last two years and expects the trend to continue.

Interest a millstone. Overall, Italy's computer manufacturers and distributors estimate that 1977 will be a positive year. What could slow the market is the cost of money and its availability, since 80% of the computers in Italy are rented. Says Speranza: "With bank interest at over 20%, we have a financing problem. In 1975, interest payments were over $9 million on sales of $100 million. If we could halve that, we could put $4.5 million to sales development or to R&D." □

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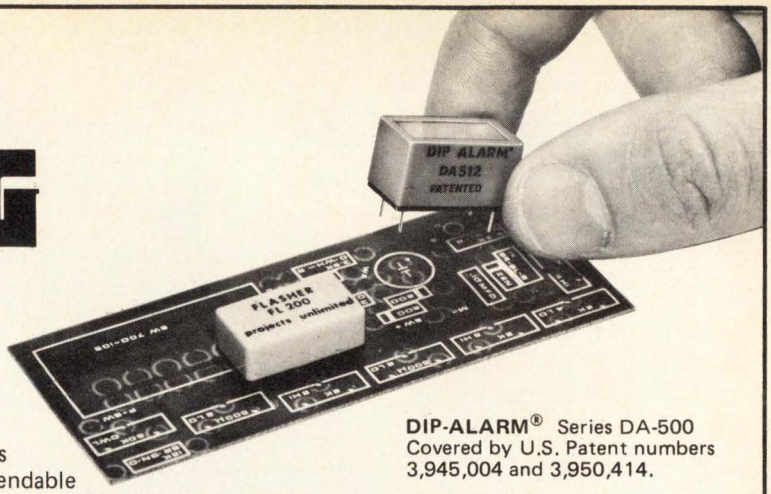

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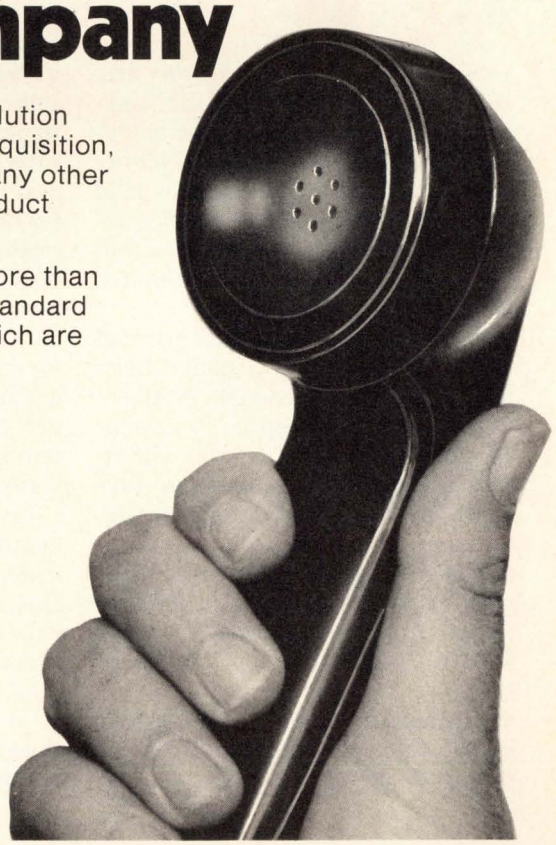

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Here comes the watch/calculator

by Bernard Cole, San Francisco bureau manager

Don't be surprised if, by the end of this year, the top-of-the-line digital watch and calculator become one and the same—an expensive watch/calculator combination.

The hybrid products will not, however, be as costly as the first model that appeared on the market about a year ago—the $1,000 five-function unit with light-emitting-diode display that a Japanese manufacturer built for Pulsar. Neither will they be as expensive as the $500 to $700 ones marketed last Christmas by Pulsar and Uranus. Nor will this newest generation be as limited in terms of functions.

A bellwether was demonstrated this month at the Consumer Electronics show in Chicago by National Semiconductor Corp.'s Consumer Products division, Santa Clara, Calif. The 20-to-25-function, full-capability watch/scientific calculator has only a six-digit liquid-crystal display, but can present a 12-digit readout in two parts. It will retail to the jewelry-store customer for $200 to $350, depending on the retail markup.

Competitors. But that's not all. At least four electronics companies are poised to plunge into the market, and several digital-watch merchandisers are already offering combinations for less than $500. Hughes Aircraft Co.'s Solid State Products division, Newport Beach, Calif., is producing an eight-function, complementary-MOS module to operate with LED displays. National, through its Semiconductor division, is also selling C-MOS-based watch/scientific-calculator chips and modules with six-digit liquid-crystal displays and is at work on eight-digit versions. Hewlett-Packard Co. is reported to be developing a combination based on a custom C-MOS chip designed by American Microsystems Inc. Moreover, AMI, Intel Corp., and Harris Semiconductor have announced processor-like watch chips, but to date, they have focused on multifunction chronographs for the high-end digital watch market.

Eric McCleod, National Semiconductor's watch/calculator design manager, comments: "The high-end digital watch is basically a piece of jewelry. The way you get value added to your product in that market is by adding features. The advantage of a ROM/RAM-based processor architecture is that you can add or change features with little additional processing cost. What is involved is basically a change in programming." The multifunction chronograph units built by Intel and AMI represent what can be done at one extreme, says McCleod, and National's watch/calculator chip holds down the opposite end.

Time and total. Module from Hughes features 8-digit display for nine-function calculator and four-function watch.

Variations. Between these extremes, numerous variations exist "and we'll see them all," says McCleod, "if not from one of the major digital-watch and calculator makers, then from one of dozens of entrepreneurs and assemblers." Other products being considered include true-timing computers in which the calculator, in addition to timekeeping, performs manipulations such as storing dates, calculating past dates, converting days, hours, minutes, seconds in increments down to nanoseconds, and calculating time-zone differences.

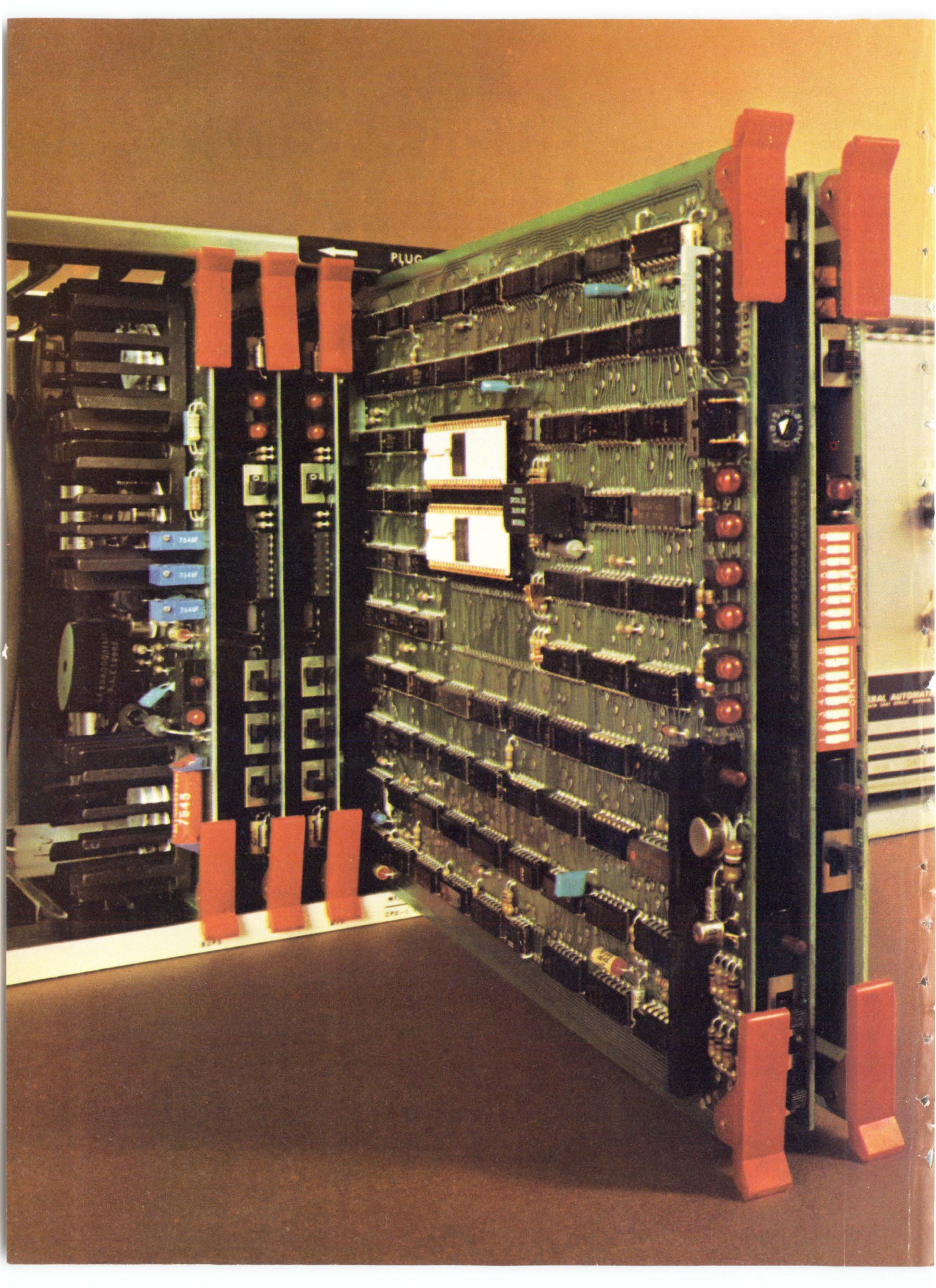
Other kinds of sophisticated 20-to-25-function watch/calculator combinations are also being considered. One provides financial notation, and another is devoted exclu-

sively to metric conversions. Another type is the wrist calculator, which has no timing capability, but has more memory and added computing capability. Eventually, say a number of company executives, limited-function watch/calculators of the Pulsar checkbook type should be available for about $100, "if not this year," says one executive, "then, at the very least, by the middle of '78—in time for Christmas."

The technology that makes this possible also runs the gamut. Pulsar uses an 8-to-10-chip C-MOS hybrid combination, although the chip count of more recent units has been reduced to four to six. Hughes modules are based on a three-chip design—two for calculator functions and one for timing. National uses a two-chip C-MOS design borrowed directly from its p-channel MOS calculator-oriented processor designs. Containing 16 kilobits of read-only memory and 384 bits of random-access memory as well as a 4-bit binary adder to handle arithmetic and logic functions, a 32,000-bit countdown chain provides a 1-hertz program-controlled interrupt function for timekeeping. The device, which operates from a 3-volt supply, has a voltage doubler on chip to provide 5-V switching for the direct-drive liquid-crystal display.

Adaptations. The HP calculator/watch is a one-chip custom C-MOS design somewhat similar to what AMI uses in its standard programmable watch chip, which itself uses an architecture developed for one of the company's calculator chips. However, neither company is revealing any details.

All these watch/calculator designs have produced a fallout of all-C-MOS calculators that carry the concept of nonvolatility one step further. "The closest the industry has come so far to nonvolatility," says McCleod, "is in higher-end calculators where C-MOS memory uses a trickle charge from the battery to retain information when the calculator is turned off." What happens, he asks, when the battery goes dead? One executive predicts that all-C-MOS designs will allow calculators—priced both over $100 and under $20—to operate from a set of batteries for a year or more. □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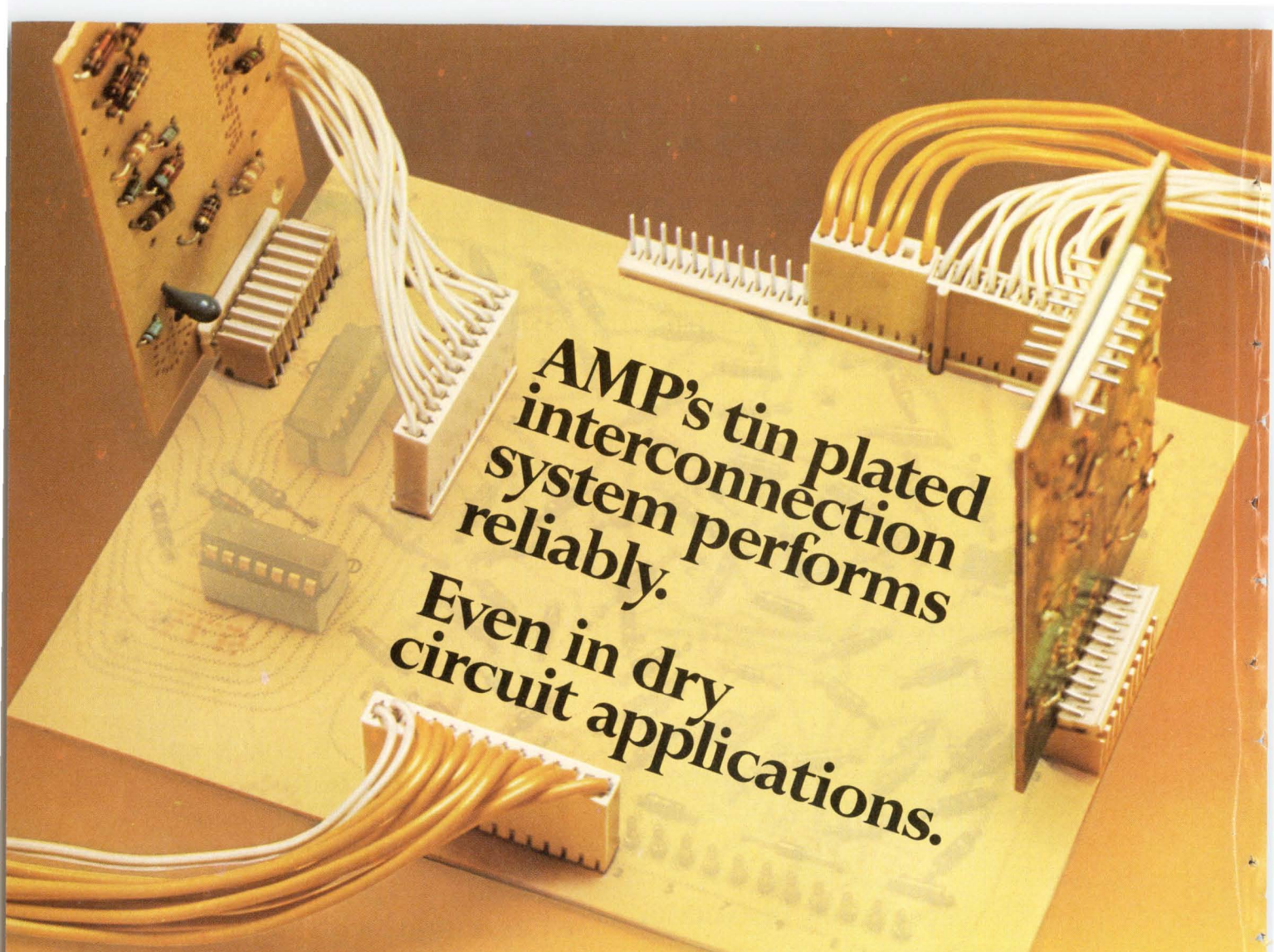

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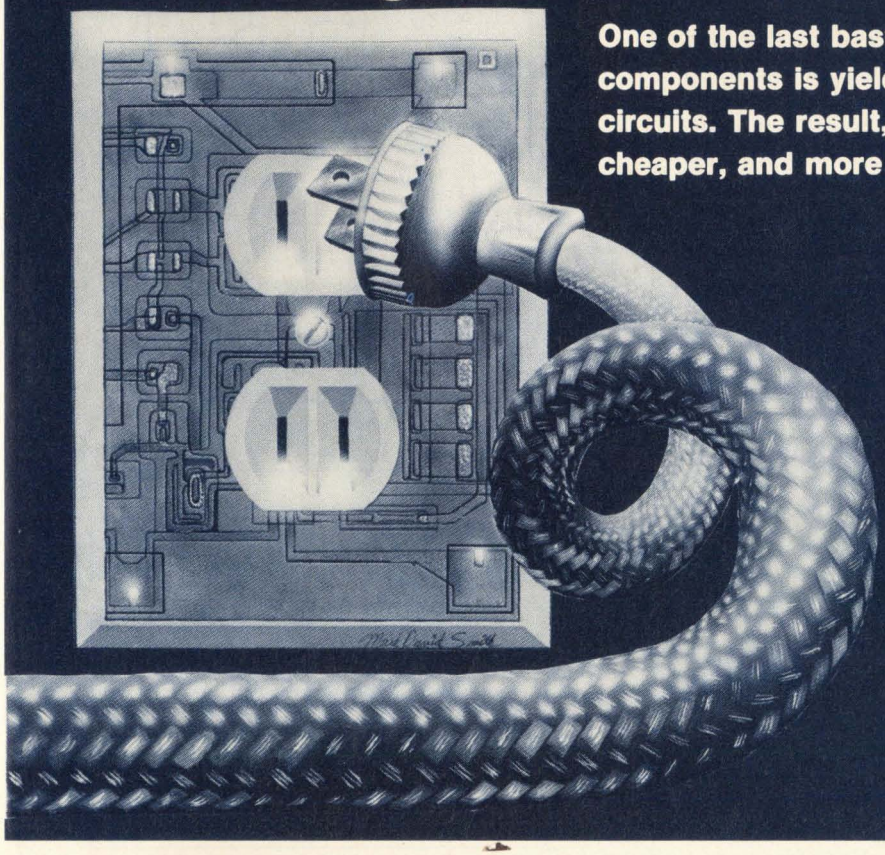
SPECIAL REPORT

Powering up with linear ICs

One of the last bastions of discrete components is yielding to integrated circuits. The result, for designers, is simpler, cheaper, and more reliable power supplies.



by Lucinda Mattera, *Components Editor*

Power supplies, the lifeline of electronics, are finally falling under the influence of integrated circuits, and already the field is showing signs of the kinds of changes that surged through analog and digital signal processing in the wake of circuit integration. Switching supplies are suddenly becoming a lot easier to design, and ultrastable voltage references need no longer mean anguished trial-and-error design sessions.

Both developments stem from the increasing use of linear ICs to to build power supplies. Besides resulting in units that are smaller, cheaper, and more reliable than those built with discrete components, ICs also simplify their design—a crucial factor in the growth of both switching supplies and ultrastable reference circuits. Performance, too, is frequently just as good as that delivered by supplies built with discrete parts.

Since most power-supply ICs serve as control devices or as sources of a regulated dc voltage, they still require one or more external power transistors for current boosting. But output currents are getting higher, and the near future will bring monolithic regulators that can deliver several amperes of current at a tightly regulated stable dc voltage.

Even within the last year, new classes of these devices have emerged, including conveniently adjustable versions of inexpensive three-terminal voltage regulators and large-scale ICs, which replace from 20 to 40 discrete parts for controlling switching-mode power supplies. And the next generation of devices is promising both better performance and more applications flexibility.

The switching trend

Not so long ago, switching-regulated power supplies were used only when power levels had to be 500 watts or higher. Below that level the series-regulated supplies prevailed. Unlike series-regulated units, switching supplies involve complex control circuitry and require special filters and shields for low-noise operation. However, they offer high power density as well as high efficiencies, usually on the order of 80% to 90%, whereas the simpler series-regulated units are bulky and relatively inefficient. (For a more detailed review of these two power-supply techniques, see "Brushing up on linears and switchers," p. 93.)

What has recently brought the switching supplies into their own has been the availability of switching power transistors capable of handling many peak watts of power at frequencies of 20 kilohertz or higher. Now that such devices are being sold for attractively low prices, the power-rating crossover point for choosing either a

switching or a series supply has dropped—to approximately 100 watts.

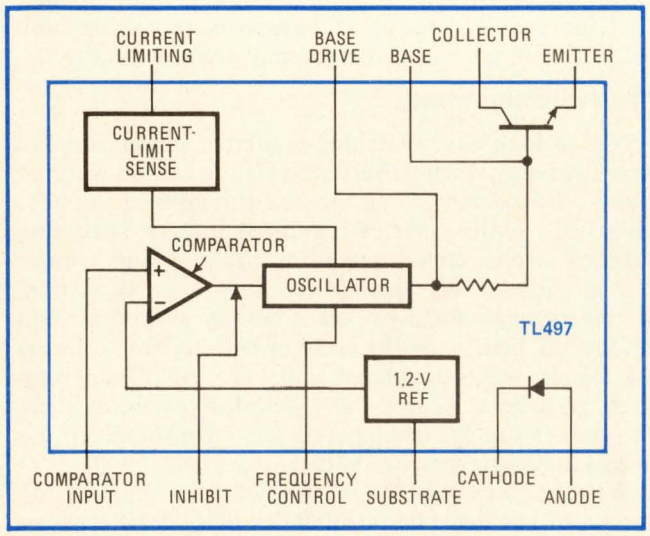
That 100-W boundary may drop even lower, with the advent of monolithic chips for directly controlling the switching power transistors. But even with the crossover at 100 W, switching supplies are being widely used in computers, communications and aircraft equipment, and a variety of other applications where their combination of efficiency and small size and weight is essential.

Still, in terms of sheer numbers, switching supplies are nowhere near ousting series-pass regulators from their No. 1 position. As a result, monolithic versions of series-pass regulators continue to be the best-selling of all power-supply ICs. They encompass both positive-output and negative output regulators, in either fixed-value or adjustable versions, as well as dual-output tracking units.

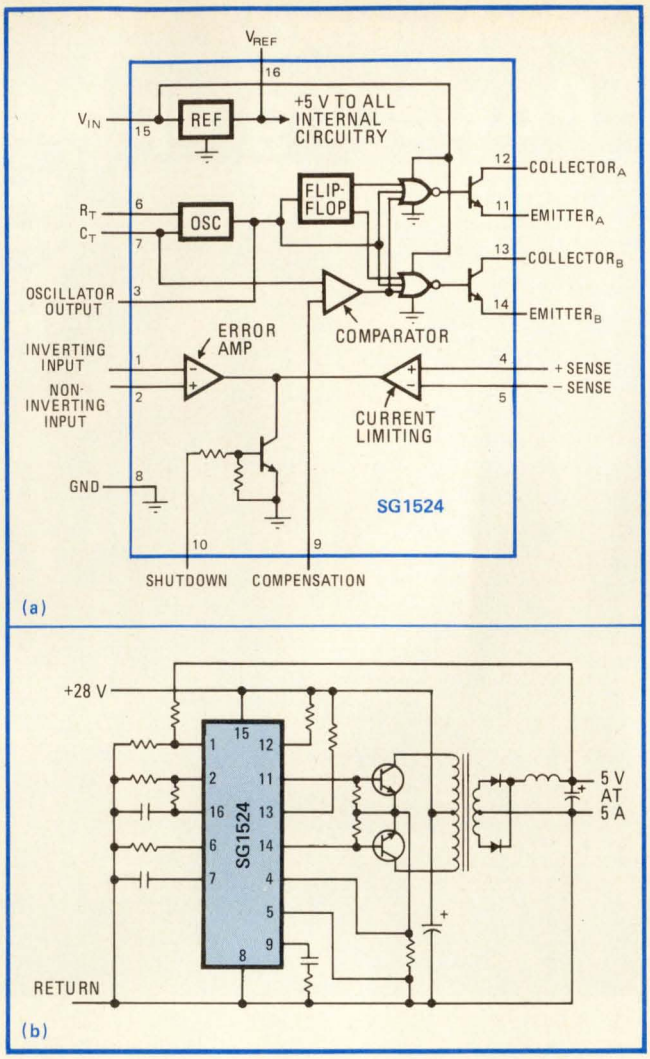
Most of today's power-supply ICs fall into this or the switching category. A third category, the voltage references, are strictly speaking not power devices at all, but rather are stable sources of a fixed dc voltage. They provide output voltages accurate to within tens of millivolts and excellent stability with both time and temperature—characteristics in great demand for instruments, as well as analog-to-digital and d-a data converters.

Controls for switching supplies gain in popularity

The half-dozen versions of IC controls for switching supplies at present in production are none of them more than 15 months old, so new is the field. Yet already two semiconductor manufacturers—Texas Instruments in the U.S. and Sescosem in France—are promising new models that will give their users more freedom in designing with them.



1. Single-ended control. Monolithic switching regulator from Texas Instruments includes its own oscillator, voltage reference, and protection circuitry. With its output of 35 V at 500 mA, the device is primarily aimed at voltage-conversion systems applications.



2. Double-ended control. Because of its dual alternating output switches, this regulating pulse-width modulator (a) from Silicon General can be used for push-pull control of switching supplies. Additionally, it can operate as a dc-dc converter (b).

Existing products (four in the U.S., two in Europe) replace anywhere from 20 to 40 discrete components and put varied assortments of functions on chip. But all contain pulse-width-modulated driver transistors and some kind of voltage reference, and most include an oscillator, error amplifier and on-chip protection.

In the U.S., Texas Instruments Inc. of Dallas was the first to build a monolithic switching-regulator control, announcing its TL497 chip last April. The TI device (Fig. 1) is a fixed-on-time variable-frequency regulator with on-chip shutdown circuitry, current limiting, and an internal reference. Intended for single-ended operation, it requires only a minimum of external parts—two resistors, one capacitor, and an inductor—to produce a supply from an unregulated input. It delivers an output of 35 V at 500 milliamperes.

Voltage-conversion applications are where the TL497 should do best. They are common in transistor-transistor-logic systems where a voltage other than 5 V may be needed for metal-oxide-semiconductor memories, emitter-coupled logic, microprocessors, operational

Brushing up on linears and switchers

At ratings of up to 500 watts, most power supplies are either series-pass-regulated or switching-regulated designs, both of which can take advantage of the convenience of power-supply integrated circuits. These two power-supply design techniques differ significantly in configuration and performance.

With the linear or series-pass supply (a), the ac line voltage passes through a 60-hertz transformer before being rectified, filtered, and regulated by a pass element. This element is usually a series-connected transistor that operates in its active region, varying its voltage drop to keep the output voltage at a constant level.

However, with the switching supply (b), the ac line voltage is generally rectified immediately, chopped up into a regulated dc voltage with a duty-cycle-modulated switching element, and only then stepped down (or up) by a high-frequency transformer. Then it is rectified again and filtered. As a rule, the regulating element is a transistor, which switches between its saturation and cutoff regions of operation.

Because the linear supply is basically a 60-Hz system, it requires fairly bulky transformers and filter components. The switching supply, on the other hand, operates at frequencies of 1 to 100 kilohertz, so its transformers and filter components need not be nearly as large or heavy.

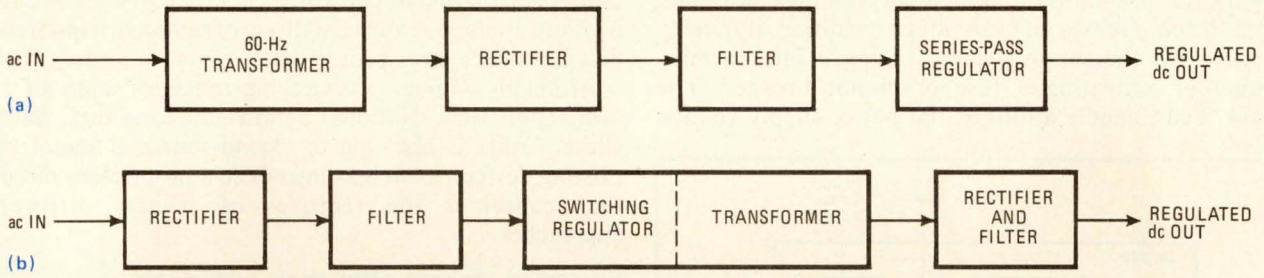
Also, power losses are much higher for the linear supply, because of the continuous operation of the series-pass regulating transistor in its active region. So it is hardly a surprise that its power efficiency is a relatively poor 10% to around 50%. In the switching supply, though, the regulating transistor is either saturated or cutoff. Power losses are held to a minimum, and power efficiency is very good, ranging anywhere from approximately 60% to better than 90%.

However, the switching supply does not win hands down. Its fairly complex circuitry pushes its cost up to a prohibitive level for power ratings below 100 W, just the region where the comparatively simple series supply provides the best economics.

Furthermore, there are performance parameters as important as efficiency, and in these respects the series supply shines. It provides the lower ripple and noise and can deliver somewhat tighter regulation. In fact, because of its fairly high switching frequency, the switching supply may be troubled not only by noise on its output but also by noise induced or conducted into the ac input lines.

The series supply also has a faster transient response—faster by a factor of 10 or greater. Briefly, the transient response is the time required for the output voltage to return within its regulation limits when there is an abrupt change in either the line voltage or load current.

All things considered, then, the designer must analyze his system needs carefully before choosing either a series or a switching supply.



amplifiers, or comparators. But the device can be used in the reverse direction, as it were, in battery-powered systems, like automobiles, or in communications and remote equipment that use TTL circuitry.

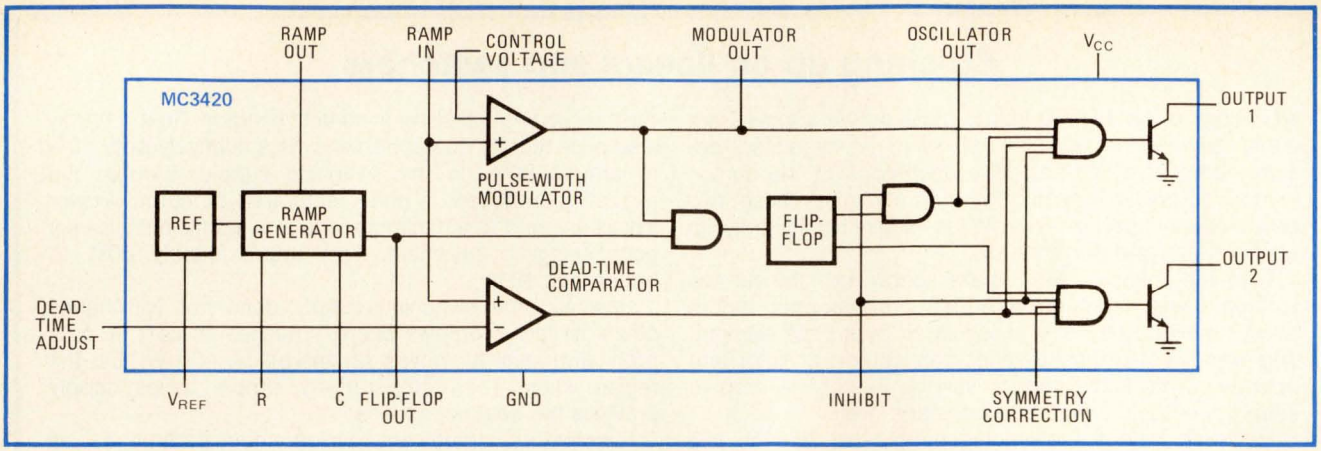
Not to be outdone, Silicon General Inc., Westminster, Calif., quickly followed TI with a device of its own—the SG1524, which can be used in push-pull as well as single-ended configurations. Besides its obvious usefulness for switching regulators of either polarity, the SG1524 can serve in transformer-coupled dc-to-dc converters, transformerless voltage doublers, and polarity converters.

On the 75-by-80-mil chip (Fig. 2a) are the inevitable voltage reference, plus an error amplifier, oscillator, pulse-width modulator, pulse-steering flip-flop, and dual alternating switches. Current-limiting and shutdown circuitry are also on chip. The device can operate at frequencies above 100 kilohertz, and it provides line and load regulation to within 0.2%. From an input voltage of up to 40 V at 10 mA maximum, it develops alternating 5-V outputs of up to 100 mA. In the circuit of Fig. 2b, the chip is being used in its push-pull operating mode for a transformer-coupled dc-dc regulating converter that produces 5 V at 5 A from a 28-V line input.

TI is now gearing up to second-source Silicon General's SG1524. But, according to TI, the 1524's major limitation is the very restricted common-mode input voltage range of the current-limiting sense amplifier. So TI expects to have a third-generation part out this year that will have a current-limiting sense amplifier operable from both the positive rail and from above the positive rail and that, in general, will embody "the best of what's available in switching regulators now."

From Motorola Semiconductor Products Inc., Phoenix, Ariz., comes yet a third version of a monolithic switching control, the MC3420, which the firm is labeling an inverter control circuit. It can be used for pulse-width-modulated push-pull, bridge, and series-type switched-mode power supplies. The device (Fig. 3) includes an on-chip voltage reference and dead-time comparator plus a 100-kHz symmetrical oscillator, a modulator, and a phase splitter.

Output frequency can be varied from 2 to 100 kHz, and both operating frequency and dead time are inde-



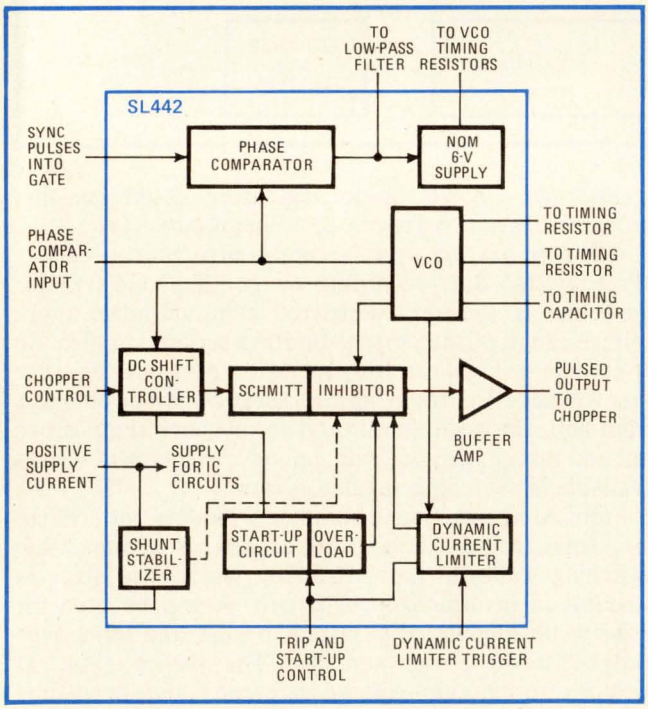
3. With soft-start. Motorola's inverter control circuit has an internal dead-time comparator to avoid transistor overlap at its output. There is also a controlled start-up feature, as well as protection against double pulsing during a load transient condition.

pendently adjustable. The unit's open-collector output delivers up to 50 mA from an input voltage of 10 to 30 V at 16 mA maximum. Moreover, the device has a controlled start-up feature, as well as on-chip protection against double pulsing of the same output during a load transient condition.

(Incidentally, Motorola is also making a monolithic overvoltage sensing circuit, MC3423. Introduced just this past fall, the device requires an external "crowbar" silicon controlled rectifier, plus an appropriate resistor network to program its protection voltage threshold. When the chip senses an overvoltage condition, it quickly short-circuits the supply, either forcing it into current-limiting or activating a fuse or circuit breaker. The MC3423 can handle a differential power-supply voltage of 45 V, and it has an output of 3 V at 300 mA.)

Lastly, Plessey Semiconductors, Irvine, Calif., has a proprietary control circuit for either series or parallel switching supplies and inverters. The SL442 power-supply control (Fig. 4) has a soft-start capability that allows its output voltage to increase at a predetermined rate to the required level. There is also an on-chip oscillator, the frequency of which is set externally, and the option of phase-locked control for external synchronization. Current limiting is dynamic, with the current limiter reset automatically on alternate half cycles of the oscillator pulses. An externally programmed trip circuit provides overvoltage protection.

Although without a switching-regulator chip of its own at this time, National Semiconductor Corp., Santa Clara, Calif., is planning to second-source a few of the existing devices, as well as introduce a proprietary circuit that combines the features of several different approaches.



4. Dynamic current limiting. Besides soft-start capability, Plessey's switching-regulator control circuit offers dynamic current limiting—that is, the on-chip current limiter is reset automatically on alternate half cycles of the oscillator pulses.

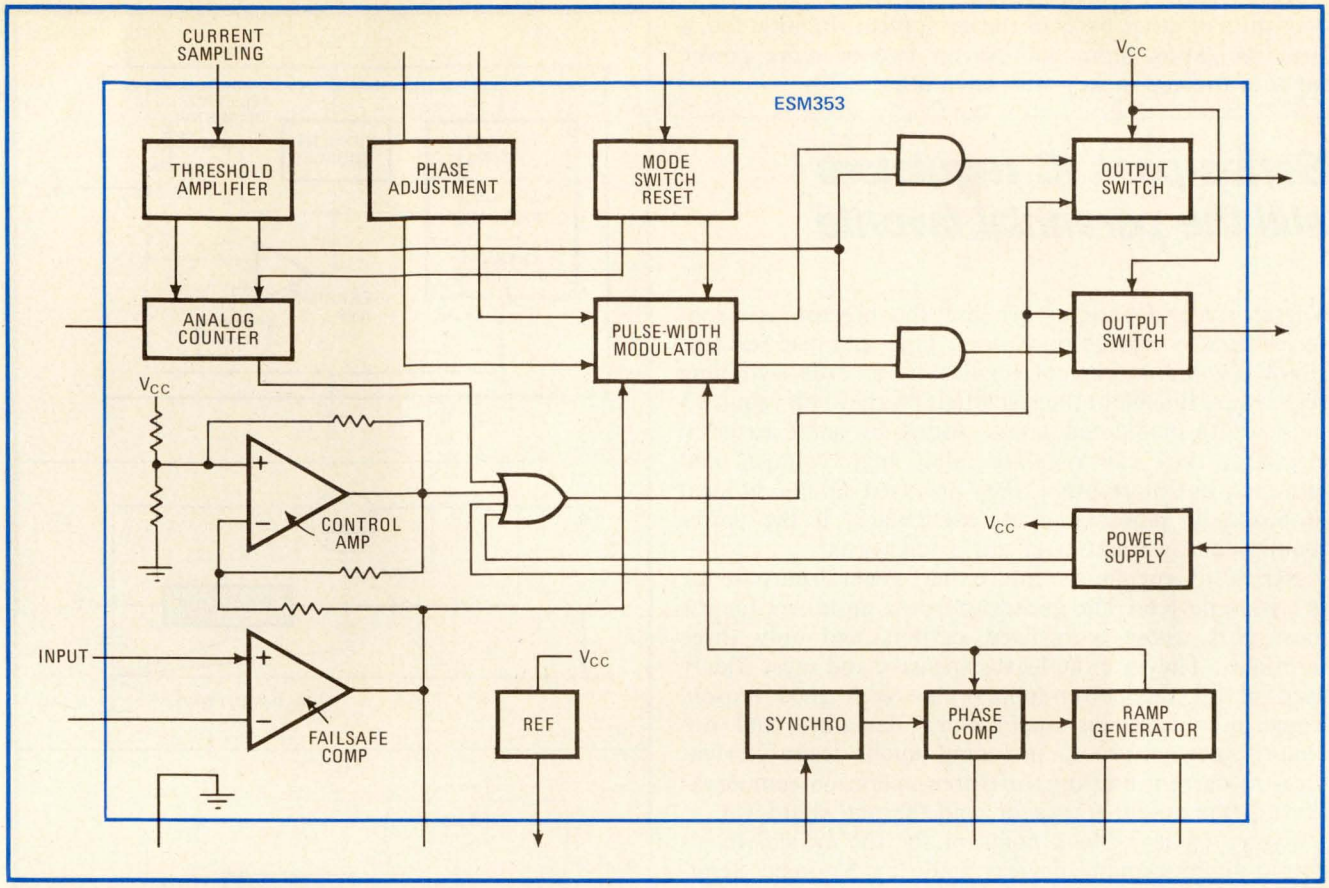
European makers offer their own designs

In Europe, switching supplies are also hot. Indeed, England's Ferranti may be said to have beaten TI to the draw, having introduced its device, the ZN1066E, as early as December of 1975.

The chip is made with the firm's collector-diffusion-isolation technology, a bipolar epitaxial process that gives a packing density almost as good as that of MOS and uses only a third the chip area of comparable TTL circuits, says Ferranti.

Onto the 85-mil-square chip, Ferranti packs a shunt regulator, a series regulator, an oscillator, a ramp generator, a comparator, steering-function circuitry, two pairs of push-pull transistor outputs, and two amplifiers. The ZN1066E typically needs fewer than 20 external components to control up to 100 watts. The device can be switched on and off at a frequency of between 20 and 30 kHz. When operated in a push-pull configuration, it develops an output current of 60 mA typical. Also, the chip provides automatic protection against transistor overlap.

In the Netherlands, the Elcoma division of Philips is already making its monolithic control for switching supplies, the TDA1060. Besides a temperature-



5. Adaptable. From Sescosem in France will shortly come a switching-supply control chip that permits choosing the output pulse train for driving either transistors or thyristors. The device also has an internal analog counter that keeps track of the number of reset attempts.

compensated voltage reference, the chip incorporates: a sawtooth generator, a pulse-width modulator, remote on/off switching, demagnetization, adjustable duty cycle, an external synchronization input, and an internal stabilized power supply. Also on chip are current limiting and protection against low-supply voltage, overvoltage, and loop fault.

The TDA1060 can be driven with a maximum of either 18 V or 30 mA, delivering up to 40 mA at the output. The voltage reference, which is typically 3.73 V, is maintained to within ±100 ppm°C. Maximum frequency for the sawtooth generator is 100 kHz.

Operating on the Miller-integrator principle, the oscillator generates a sawtooth that is applied to the input of the pulse-duty-cycle modulator. The output from the power supply is then compared with the voltage from the reference, generating an error signal that controls the duty cycle of the pulses before they are applied to the amplifier. The oscillator can be either free running, under control of an external RC network or triggered by applied positive-going pulses.

Most exciting of all are the plans of the Sescosem division of France's Thomson-CSF. With an eye towards the tremendous growth potential of switching supplies, Sescosem is both expanding its line of switching-oriented power transistors and planning to bring out its own switching-regulator circuit in the second half of 1977. To be dubbed the ESM353 (Fig. 5), the bipolar chip will provide protection against short circuits, a sudden loss of load, or serious overvoltage on the line. In addition, it will have failsafe shutdown and a driver transistor that can go as high as 500 mA.

The priority protection will be against overcurrent in the external switching-transistor circuit. This current is to be sampled outside of the chip, and the resulting potential applied to a threshold amplifier having a very precise voltage reference. If there is an output from the amplifier, indicating that the switching-transistor current is too high, a direct cutoff signal will be applied to the gates that control the output stages. Inhibit signals will also develop when the supply voltage to the ESM353 becomes too high or too low, or if there is an out-of-limits output from the on-chip failsafe comparator.

Another plus will be ease of use: the chip design will make it easy to tailor the switching supply to the application. For example, by using an outboarded potentiometer with the ESM353, it will be possible to set the output of the supply at anywhere between zero and the maximum rectified voltage of the output transformer. The designer will also be able to select, via external capacitors or potentiometers, parameters like minimum and maximum control-pulse width, the reference voltage, and the number of reset attempts that an on-chip analog counter will permit.

Then there will even be an input pin that permits choosing output pulse trains for driving either thyristors or transistors. Designers will be able to set the frequency of the on-chip oscillator so that it does not disturb

operation of other parts of the equipment. Finally, too, a synchronization input will permit two or more power supplies to keep in step with each other.

Series-pass IC regulators still the perennial favorite

Versatility and ease of use are the biggest assets of series-pass IC voltage regulators. They can also serve as shunt regulators, current regulators, or even switching regulators, though in the last situation they still require a pulse-width-modulated input. Aided by some external circuitry, they can regulate fairly high voltages and currents, but more often, they are used simply as local on-board dc power sources, particularly if the power requirement is a matter of just a few watts.

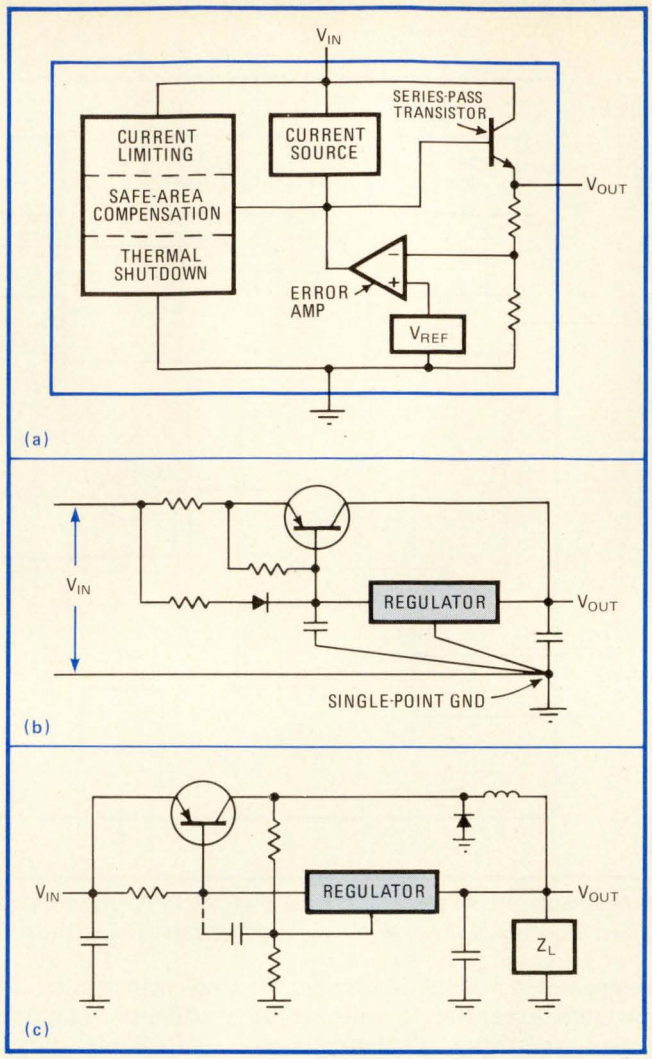
Series IC regulators are either general-purpose or precision devices. The general-purpose units are, for the most part, those with fixed outputs and only three terminals. They are the least expensive and most widely used of all the power-supply ICs—with good reason. They offer excellent applications flexibility and are almost blowout-proof, including such desirable features as current limiting, safe-area-operation compensation for the output transistor, and thermal shutdown.

Figure 6a is a block diagram for the typical fixed-output three-terminal devices made by National Semiconductor, a leading vendor of these power-supply ICs. Essentially, the error amplifier compares the reference voltage to the fraction of the output voltage determined by the resistor divider network. The signal developed by the error amplifier controls the base drive of the series-pass transistor, in this way regulating the supply voltage. If any of the protection networks is activated, the base drive to the series-pass transistor is either limited or turned off completely, so that the regulator is not damaged.

Fixed-output regulators of this kind come in both positive and negative models, and they can be adapted to a variety of applications besides voltage regulation. When supplemented with varying amounts of external circuitry, they can be used as current sources, current regulators, or even in combination for dual-output supplies. For example, with just a little external circuitry, a positive three-terminal device can operate as either a high-current regulator (Fig. 6b) or a switching regulator (Fig. 6c).

But there are a few limitations

Although they are easy to use in many applications, fixed-output three-terminal regulators do have some drawbacks. The table includes the performance ranges of available regulators, arranged by nominal output voltages—principally those for powering digital circuitry, like bipolar and MOS logic and memories, as well as analog circuitry, like operational amplifiers and comparators. Output cannot be precisely adjusted from the nominal fixed value, and output current capability is more limited than in other IC-regulator types.



6. Multipurpose. Fixed-output three-terminal series-pass regulators (a) are rugged, including protection against excessive currents, overvoltages, and overheating. A major producer, National, suggests their use as current regulators (b) or even as switching regulators (c).

Still, their performance is improving. Output current, which is now up to 3 A for 5-V models, will be going up to a few amperes for other voltage values.

Breakdown voltage for the series-pass output transistor is also climbing. Philips and its U.S. subsidiary, Signetics Corp. in Sunnyvale, Calif., offer guaranteed minimum breakdowns of 60 V for their 78HV00 family of positive regulators. They achieve this high-voltage performance with a special linear bipolar process that employs a thick sloped oxide on each transistor structure, instead of the conventional stair-step profile. Varying the angle of the oxide slope changes the breakdown voltage from a guaranteed minimum of 60 V up to about 110 or 125 V, depending on the particular constraints of a regulator family.

At Signetics, work is also under way to boost the minimum breakdowns to about 150 V by ion-implantation techniques, without any other substantial changes in processing.

Three-terminal fixed-output regulators are readily available from a number of semiconductor houses,

FIXED-OUTPUT THREE-TERMINAL VOLTAGE REGULATORS						
Nominal output voltage (V)	Maximum output current (mA)	Input voltage range (V)	Regulation		Typical ripple rejection (dB)	Output voltage accuracy (mV)
			Maximum line (mV)	Maximum load (mV)		
2.6	100	4.75 — 20	100 — 125	50	51	± 130 — ± 260
5	100 — 3,000	6.7 — 50	3 — 200 typ	10 — 100 typ	70 — 85	± 250 — ± 500
6	500 — 1,500	8 — 35	60 — 120	60 — 120	65 — 85	± 250 — ± 300
6.2	100	8.5 — 20	175 — 200	80	46	± 250
8	100 — 1,500	9.7 — 35	60 — 160	80 — 160	62 — 80	± 400 — ± 800
8.5	1,500	10.5 — 35	85 — 170	85 — 170	70	± 350
12	100 — 1,500	13.7 — 35	100 — 250	100 — 240	42 — 71	±500 — ± 1,200
15	100 — 1,500	16.7 — 35	100 — 300	150 — 300	60	± 750 — ± 1,500
18	100 — 1,500	19.7 — 35	100 — 360	175 — 360	59	± 900 — ± 1,800
20	500 — 750	22 — 40	100 — 400	400	58 — 70	± 1,000
24	100 — 1,500	25.7 — 40	100 — 480	200 — 480	43 — 70	± 1,200 — ± 2,400
−3	100	−4.7 — −30	60 — 80	72	51	± 150 — ± 300
−5	100 — 1,500	−6.7 — −35	25 — 200	50 — 100	49 — 70	± 100 — ± 500
−5.2	1,000 — 1,500	−6.2 — −35	25 — 105	50 — 105	67 — 68	± 100 — ± 260
−6	500 — 1,500	−8 — −35	60 — 120	120	60 — 65	± 250 — ± 300
−8	500 — 1,500	−10 — −35	80 — 160	80 — 160	59 — 62	± 300 — ± 400
−8.5	1,500	−10.5 — −25	80 — 160	80 — 160	60	± 300
−12	100 — 1,500	−13 — −35	10 — 250	25 — 240	60 — 80	± 500 — ± 1,200
−15	100 — 1,500	−16.7 — −35	10 — 300	25 — 300	59 — 60	± 300 — ± 1,500
−18	100 — 1,500	−18.7 — −35	180 — 360	170 — 360	46 — 60	± 700 — ± 1,800
−20	500	−23 — −35	80	300	58	± 800
−24	100 — 1,500	−25.7 — −40	80 — 480	200 — 480	43 — 58	± 1,000 — ± 2,400

SOURCE: ELECTRONICS

including: National, Texas Instruments, Motorola, Silicon General, Fairchild Semiconductor of Mountain View, Calif., Signetics, Raytheon Co. of Lexington, Mass., Germany's Siemens AG, Philips' Elcoma division in the Netherlands, and France's Sescosem.

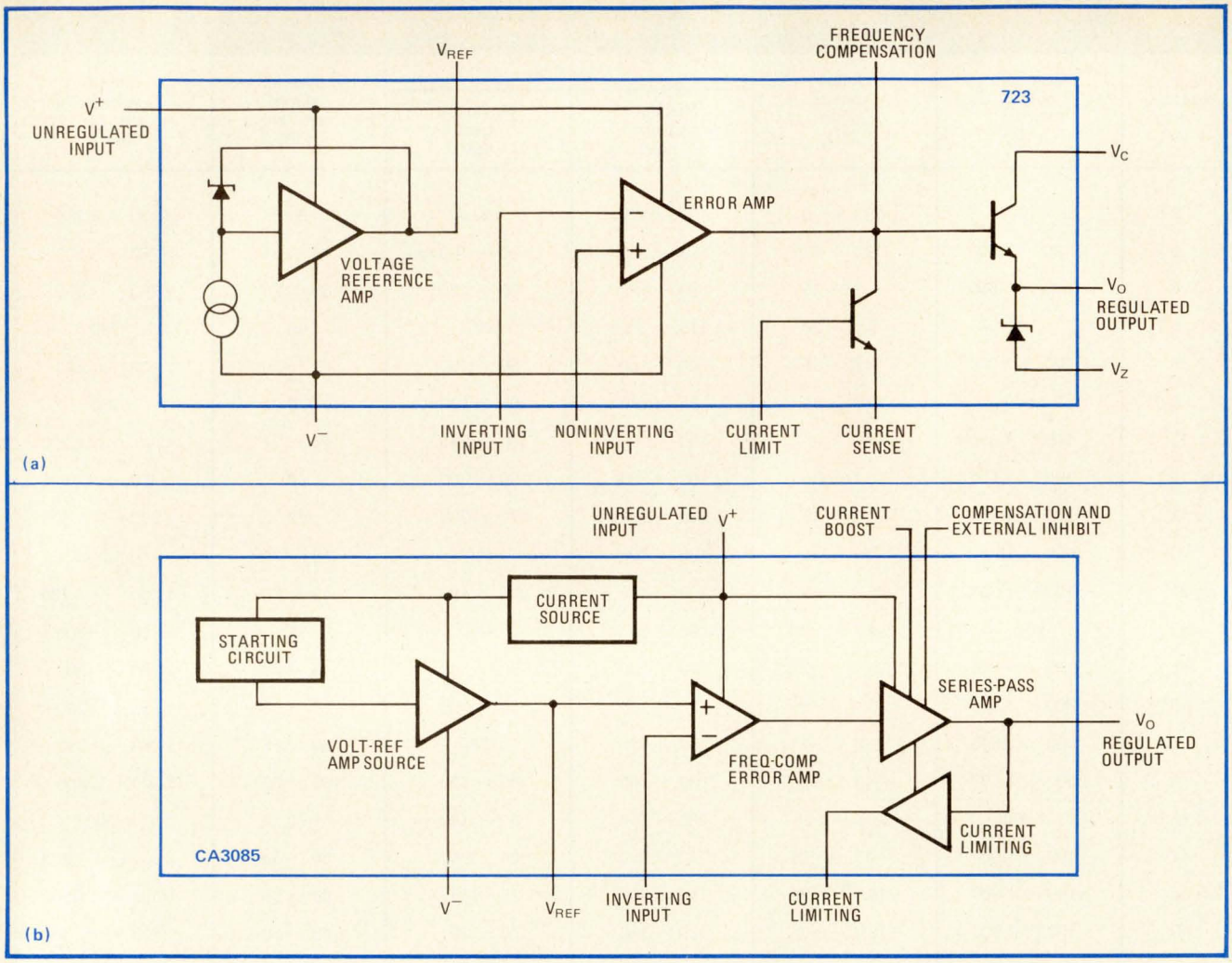
Some three-terminal models are adjustable

In the last year, to the relief of all those ever stymied by the fixed output, adjustable versions of positive three-terminal regulators were introduced by National. These LM117 devices supply up to 1.5 A over a 1.2-to-37-V variable output range. Like their fixed-output counterparts, they include short-circuit protection, thermal shutdown, and safe-area compensation for the output transistor. Lacking an internal ground, they are essentially floating regulators, so they can control power supplies of several hundred volts as long as the input-to-output differential of 40 V is not exceeded. Line regulation is about 0.01%/V, and load regulation around 0.1%/V typically.

TI, Motorola, and Silicon General are presently second-sourcing the LM117 series. However, some time this year, Motorola plans to introduce 100-mA and 3-A versions of adjustable positive three-terminal regulators. Never one to be left behind, National will shortly be coming out with its own 3-A model, the LM150. Also in the works, but four to six months away, are negative versions of both the LM117 and LM150.

Recently, TI also announced a rather unusual three-terminal device—an adjustable shunt regulator, the TL430. A pair of external resistors sets its voltage anywhere between 3 and 30 V. As a result, it can serve as a programmable zener diode that exhibits "a knee as sharp as a tack"—a major advantage over conventional low-voltage zeners, says TI. The TL430 is also as good as many discrete reference diodes available today when it comes to typical temperature coefficient: it achieves 100 to 110 ppm/°C. Other uses for the device are as a current regulator or as a current-limit sense amplifier. It can sink up to 100 mA.

For greater applications flexibility and better supply performance, the designer can turn to the precision



7. Precision. Since its introduction by Fairchild several years ago, the 723 precision regulator (a) has become an industry standard. Some later devices, though, offer better performance—like RCA's CA3085 precision regulator (b), which provides typical regulation of 0.025%.

series-pass IC regulators. Every one of them can operate over a fairly broad range of input and output voltages with no degradation of regulator performance. They have more than three terminals and come in both positive and negative models.

More pins for precision regulators

To some extent, precision variable regulators rely for protection on external devices. The user determines their current-limiting value with an external circuit and can also achieve electronic shutdown with a fairly simple outboarded network, but for thermal shutdown must go to a rather complex external circuit. In compensation, precision regulators do permit him to obtain high output voltage and currents easily, without the addition of many extra components and without sacrificing ultimate supply performance. In general, they are used as series, shunt, switching, or current regulators.

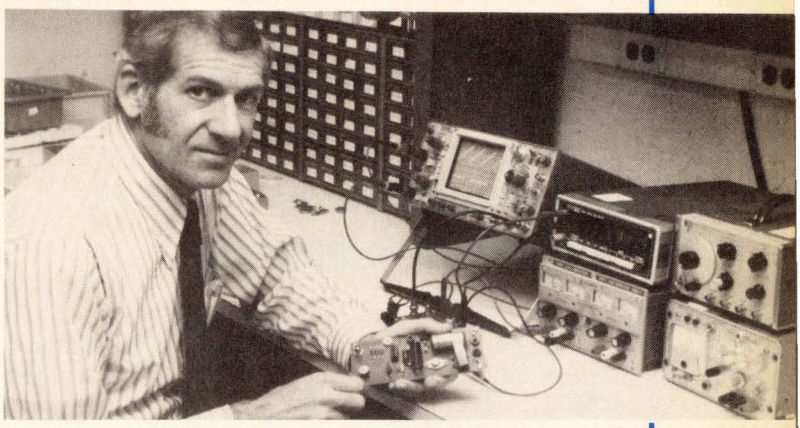
One of the most popular precision regulators is the 723 (Fig. 7a). Originally introduced by Fairchild several years ago, it has since become an industry standard. It includes a temperature-compensated reference amplifier, an error amplifier, a series-pass transistor, and a current-limiting circuit. Inputs for adjustable current limiting and remote shutdown are independently accessible. From inputs of 9.5 to 40 V, the 723 delivers an adjustable output of 2 to 37 V at up to 150 mA. Typical load and line regulation is 0.03%.

Naturally, later precision regulators improve on the 723's performance. RCA Corp.'s CA3085 positive regulator (Fig. 7b) provides slightly better line and load regulation (0.025% typical) and operates over a wider input range of 7.5 to 50 V, delivering an output that is adjustable from 1.7 to 46 V at a current of up to 100 mA. RCA is now in the midst of forming a regulator program to use its gold-chip technology for higher output currents. Instead of the usual unprotected aluminum metalization, RCA deposits silicon nitride on a tri-metal system of titanium-platinum-gold, making the chip inherently hermetic. Gold interconnections can carry about 10 times as much current as equivalent aluminum interconnects, says the firm.

Other key U.S. companies making precision IC regulators include Motorola, National, TI, Silicon General, Signetics, and Raytheon—not surprisingly, the same firms who lead in general-purpose units.

An entry from Europe should not be ignored. From the Italian semiconductor producer, SGS/Ates, comes a

Bob Mammano: his forte is IC regulators



As an emigré from the aerospace industry, Bob Mammano draws on his systems design experience to create linear integrated circuits that replace entire boards of discrete components. The manager of advanced development at Silicon General Inc., Westminster, Calif., for the last eight years, he has been applying his know-how principally to ICs for power supplies. He has designed all of his firm's voltage-regulator products, including what he says is the industry's first dual-tracking series regulator.

His most recent achievement is the SG1524, a monolithic control for switching supplies that can be operated in single-ended or push-pull fashion (see p. 93). Although the product is only about six months old, it already looks like it will become an industry standard. The largest semiconductor manufacturer, Texas Instruments Inc., is announcing plans to second-source it.

Mammano worked for six years for Arinc Research Inc. in Santa Ana, Calif., a consulting firm that does reliability and design analyses for military systems. Before that, he packed a broad sweep of design experience under his belt, developing guidance and control systems for missiles, as well as power supplies and instruments, for a number of California-based aerospace companies.

He recalls the frustration of designing military equipment in the 1960s, when "the semiconductor industry was concentrating on digital circuits, and the linear area was getting short shrift." So in May 1969 he helped to form Silicon General as a linear specialty house, with the emphasis on custom circuits.

That goal has not changed appreciably. As a small linear-IC specialist, Silicon General "is satisfying needs not otherwise being met by the major semiconductor houses," he says. For the next generation of ICs for power supplies, Mammano declines to make specific predictions. "The added features will include more power-handling capability," he notes.

A native of California, Mammano only left to earn a 1957 degree in physics at the University of Colorado. His outside interests center on backpacking and skiing.

Larry Waller **Los Angeles bureau manager**

precision variable regulator, the L200, which should be ready for the market in the second half of 1977. Although tagged as a voltage regulator, the L200 is precise enough to serve as a voltage reference, because of its low thermal drift of just 100 ppm/°C. The device's output voltage can be set anywhere between 3 and 30 V by outboarded potentiometers or resistors. What's more, its output voltage can be selected by a digital input by pairing open-collector logic to the outboarded resistors. Nor is additional control circuitry necessary if two of the devices are operated in parallel.

The L200 handles fairly heavy currents—up to 3 A for an input-output differential of 17 V—so it has been thoroughly protected against thermal overloads and short circuits. The maximum input voltage is 40 V, but the circuit has second-breakdown and overvoltage protection that can handle spikes up to 60 V. Typical load regulation is 0.1%, and ripple rejection is better than 70 decibels, even at high voltages.

Tracking outputs from dual regulators

Dual tracking regulators are actually two regulators, one positive and the other negative, in a single package. Their two output voltages literally track each other—that is, the midpoint between the positive and negative output voltages stays at ground potential. They are primarily intended for powering operational amplifiers, MOS logic circuits, or a combination of TTL and MOS circuits, and National, Motorola, and Silicon General are among the few companies to make them.

National's three series of tracking regulators accept input voltages of up to ±30 V and have outputs of ±15, ±12, or +5, −12 V at output currents of up to 100 mA. They are protected internally against thermal overload, and their current limiters are externally adjustable. Typical line and load regulation is 0.06%.

Motorola's dual ±15-V 100-mA regulator, the MC1468, has outputs balanced to within 1%. Although output voltage is internally set, it can be varied externally from 8 to 20 V for both output polarities. Standby current drain is 3 mA, and the outputs vary by no more than 1% because of temperature changes. Current limiting is externally adjustable.

From Silicon General comes what may well be the industry's oldest dual tracking regulator, the SG1501A. Its nominal output voltages are ±15 V at currents of up to 200 mA, but they can be simultaneously varied from 8 to 23 V with a single external adjustment. Input voltages can be as high as ±35 V. The same company also has an adjustable dual-voltage regulator, which develops positive and negative outputs that can be independently adjusted from 10 to 28 V. Output current goes up to 100 mA for this SG1502 regulator, while line and load regulation is 0.1%.

Just this past August, the Munich-based Siemens AG announced its dual regulator, the FZY101/105, which it designed mainly as a power-supply for high-noise-immunity IC-logic families, as well as for powering MOS and complementary-MOS devices.

Each device can accept inputs of up to 30 V maximum. But one regulator delivers selectable outputs of 12, 13, 14, 15, or 17 V at 120 mA, while the other provides an

output voltage of 12 or 17 V for a load of up to 25 mA.

The outputs of both voltage sources are connected internally to an on-chip pnp transistor. The purpose of this is to keep the output impedance low when there is no supply voltage—the idea is to prevent the outputs of logic devices from being inadvertently activated under no-supply conditions.

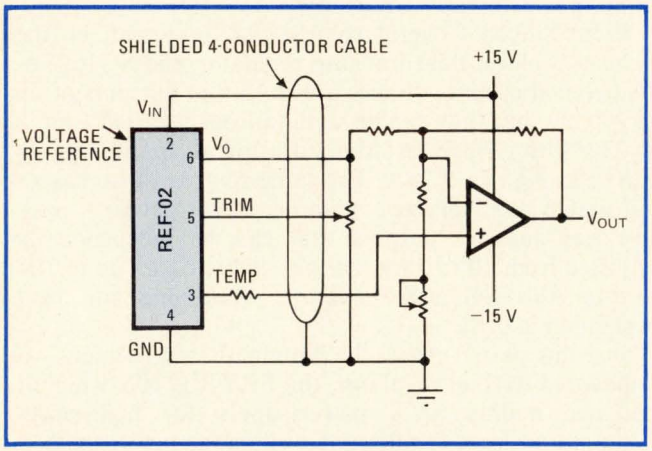
Voltage references—the ultimate in stability

Monolithic voltage references are perhaps the simplest answer to the need of instruments or data converters for a dependable standard voltage. Certainly the chips perform as well as and often better than zener circuits put together from discrete parts—and without all the troublesome backup that discrete reference diodes frequently need, like precision current sources and thermostatic controls.

Motorola, National, and Ferranti all offer models, and two prominent manufacturers of data converters, not otherwise interested in the IC regulator business, have also had the foresight to get involved here.

Analog Devices Inc. of Norwood, Mass., makes a monolithic three-terminal band-gap reference to complement its line of data converters in systems applications. The AD580 develops a fixed output of 2.5 V from inputs of 4.5 to 30 V. It operates at a low quiescent current of only 1 mA, maintaining its output to within ±1%. Over the temperature range of 0°C to 70°C, output drift is held to 10 ppm/°C, and long-term stability is a tight 25 microvolts/month.

Within a few weeks, the company will be offering another monolithic reference—one made with on-chip silicon-chromium thin-film resistors that are laser-trimmed at the wafer stage for both absolute reference value and temperature coefficient. The new device will maintain its 10-V output to within ±2 mV and offer a temperature coefficient of below 10 ppm/°C.



8. Monolithic thermometer. Adjustable voltage reference from Precision Monolithics has an unusual application—as a temperature transducer. One of the unit's output pins develops a voltage that is directly proportional to the temperature of the device.

Precision Monolithics Inc., Santa Clara, Calif., the other data-converter maker, has two band-gap voltage references, the REF-01 and the REF-02, for converter applications. Both contain on-chip compatible thin-film resistors that are trimmed at the wafer stage for output voltage and temperature coefficient. A zener-zap trimming technique avoids the surface damage typically caused by laser trimming, says the firm.

The REF-01 develops a 10-V output from inputs of 12 to 40 V, requiring only 1 mA of current. Its output, which is accurate to within ±30 mV, can be adjusted over a ±3% range. The REF-02 is a 5-V reference, accurate to within ±15 mV and adjustable over a ±6% range. It accepts inputs of 7 to 40 V, operating at a low current drain of 1 mA. Interestingly, it can also function as a monolithic thermometer. One of its output pins develops a voltage that is directly proportional to device temperature, permitting the unit to be used as a remote transducer in temperature-sensing applications (Fig. 8).

Just released by Motorola is its MC1403, a precision laser-trimmed low-voltage reference. For use with data converters, the device delivers a nominal output voltage of 2.5 V, ±25 mV. It operates over an input range of 4.5 to 35 V at a typical quiescent current of 1.2 mA. Output current can go up to 10 mA, and typical temperature coefficient is 10 ppm/°C.

Two-terminal references vie with discrete zeners

Some monolithic references are two-terminal devices, so they even compete for the same pins as discrete reference diodes. National has a selection of such two-terminal bipolar ICs—a pair of band-gap references, as well as a pair of buried-zener references.

The LM113 is a band-gap device providing a low breakdown voltage of 1.220 V and a dynamic impedance of 0.3 ohm from 500 μA to 20 mA. Its temperature stability is typically 1% over a range of −55°C to +125°C. The other band-gap reference is the LM136, which has a 2.4-V breakdown.

The buried-zener references are the LM199 and the LM129, which each have a breakdown voltage of about 6.9 V. Dynamic impedance is under 1 ohm for both, and operating current range is wide—0.5 to 10 mA for the LM199, 0.5 to 15 mA for the LM129. An on-chip temperature-stabilization network is the main difference between the two—the LM199 has one, the LM129 does not. This integral heater maintains chip temperature at a constant value for the LM199, giving it a temperature coefficient of 1 ppm/°C or better without the need for special external circuitry or environmental controls.

From Ferranti in England came two low-voltage two-terminal band-gap references—the ZN423T, a 1.26-V device, and the ZN458T, a 2.45-V device. Priced attractively low, these sources also offer very low slope resistance over their full operating current range and freedom from the need of a precisely controlled operating current. The ZN423T can operate from a 1.5-V input, while the ZN458T requires 2.6 V. For a 5-V input and a 2-mA reference current, line and load regulation is 0.03%/V for the ZN423T, 0.1%/V for the ZN458T. □

High-reliability semiconductors: paying more doesn't always pay off

The premium paid for high reliability is usually worth it for discretes, but not necessarily for integrated circuits

by Eugene R. Hnatek, *DCA Reliability Laboratory, Mountain View, Calif.* *

☐ Is it worth paying extra for high-reliability semiconductors? No, probably not for integrated circuits, whether digital or linear. But the large premiums paid for hi-rel diodes and transistors do guarantee lower failure rates—well, most of the time.

Those are the eye-opening conclusions of a recent extensive test study of nearly 190,000 devices, procured over an 18-month period from a variety of reputable semiconductor vendors.

But the study has implications beyond reliability and cost. Hi-rel semiconductor devices have such long delivery times—sometimes a year or more—that they can introduce serious delays into a project. Needless to say, these delays are pointless if, in the end, they yield devices that make little or no difference in system reliability.

The 190,000 device total breaks down into over 42,000 diodes, more than 51,000 transistors, about 32,500 linear ICs, around 41,500 bipolar digital ICs, and approximately 20,500 complementary-metal-oxide-semiconductor ICs. Each group consists of a reasonably adequate mix of device types that have four ascending levels of reliability. In all cases, the lowest reliability level is the military-temperature-range grade, which undergoes none of that extra screening that inflates costs.

For discrete semiconductors, the other three reliability grades are JAN (for Joint Army Navy), JANTX (where TX stands for extra testing), and JANTXV (where V represents visual). JAN diodes and transistors also do not undergo any additional screening but are made on production lines certified by the Defense Electronics Supply Center to the provisions of MIL-S-19500. In contrast, JANTX devices, which are made on certified production lines, too, are subjected to screening to the requirements of MIL-S-19500 and MIL-STD-750. Similarly, JANTXV products fulfill all JANTX prerequisites, but they also undergo a "precap visual"—a visual inspection before capping.

The differentiation among the reliability grades for ICs is not quite as clear-cut. Beyond the mil-temp category, some devices satisfy MIL-STD-883, to either a class A or class B quality level, and others meet the requirements of MIL-M-38510, to the class B quality level. The fourth product grade mostly consists of mil-

*Now with Monolitic Memories Inc., Sunnyvale, Calif.

GRAPH 1: RELIABILITY COST COMPARISON

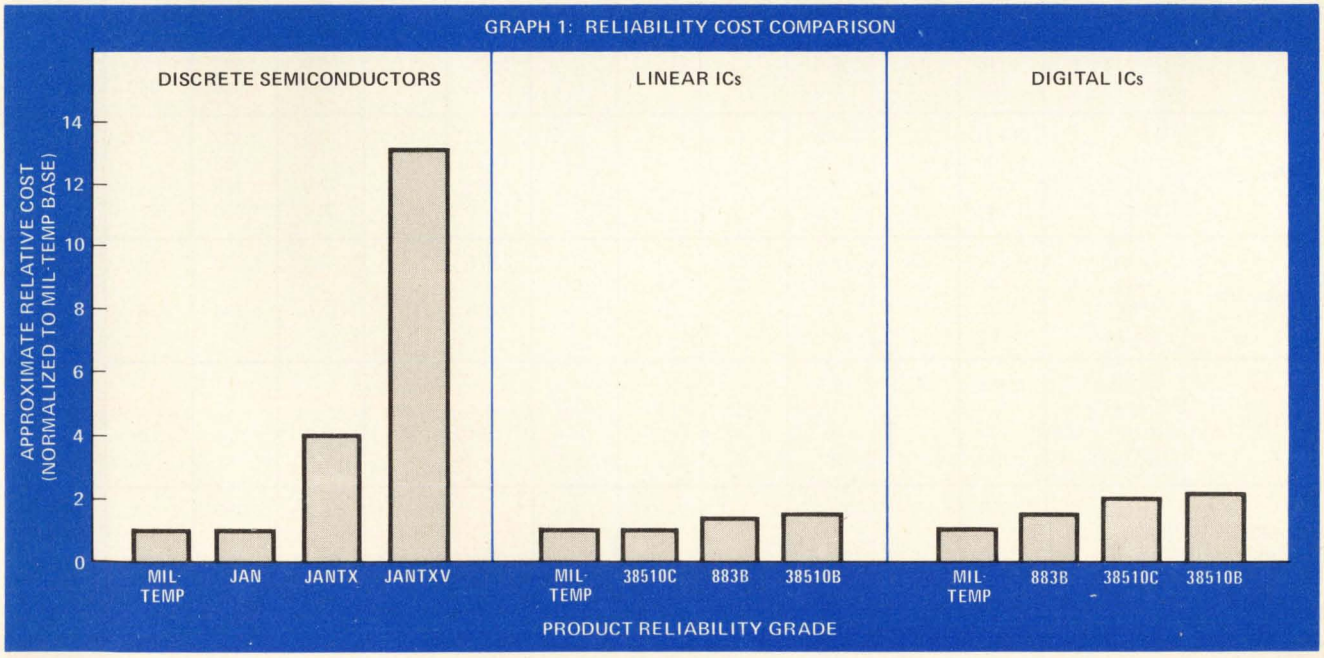


TABLE 1: SCREENING SEQUENCE VS. PROGRAM

PROGRAM \ SCREEN	External visual	Bake	Temperature cycle	Centrifuge	Fine hermeticity	Gross hermeticity	Electrical at 25°C	X-ray	Burn-in, 168 hours	Burn-in, 240 hours	Electrical at 25°C	Electrical at −55°C	Electrical at 125°C	Electrical ac at 25°C	External visual
HEAO	•	•	•	•	•	•	•	•		•	•	•	•	•	•
Space Shuttle	•	•	•	•	•	•	•	•		•	•	•	•	•	•
GPS*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pioneer Venus*	•	•	•	•	•	•	•	•	•	•	•				•
Block V **	•	•	•	•	•	•	•	•	•		•	•	•	•	•
Fleet Sat Comm	•	•	•	•	•	•	•	•		•	•	•	•	•	•
Program M	•	•	•	•	•	•		•	•		•	•	•	•	•
Program N	•	•	•	•	•	•		•	•		•	•	•	•	•
Program W	•	•	•	•	•	•		•	•		•	•	•	•	•

*For diodes and transistors: 168-h reverse-bias burn-in, plus 168-h forward-bias burn-in
For all ICs: 240-h operating burn-in
**For all devices: electrical test at 25°C after 168-h burn-in, followed by another 168-h burn-in

temp devices receiving a level-A precap visual inspection at the water stage with a scanning electron microscope (SEM), but which are not subjected to any environmental screening.

Graph 1 indicates the approximate relative costs of the four grades of reliability for discrete semiconductors, linear ICs, and digital ICs. It is based on price schedules for lot sizes of 100 to 999 devices. For linear and digital ICs, the highest reliability grade is about 1.5 to 2.5 times as expensive as the unscreened mil-temp category. However, hi-rel discrete semiconductors may cost over 10 times as much as their unscreened equivalents.

The parts tested for this study were purchased under nine Government programs, which put them through a variety of screening sequences (Table 1).

Outlining the programs

Most of the nine programs are for putting special-task satellites into orbit. To list all nine, however, they are:

- The High-Energy Astronomical Observatory (HEAO) satellite, a National Aeronautics and Space Administration program to measure quasars, pulsars, and black holes in outer space.
- The Space Shuttle, another NASA program, which is intended to transport workers and/or objects between earth and space and to place satellites in low earth orbit.
- The Global Positioning System (GPS), a satellite program run by the Air Force's Space and Missiles Systems Organization (Samso) for aiding air, land, and sea navigation.
- Pioneer Venus, the satellite probe to Venus from the NASA/Ames Research Center.
- Block V, a group of satellites for Samso that form the radar/weather sensor portion of a defense/meteorological system.
- Fleet Satellite Communications (Fleet Sat Comm), a Navy program for communciations between ships, as well as from ship to shore.
- Three classified Government programs, designated here by the letters M, N, and W.

TABLE 2: PROGRAM DATA SUMMARY

Component	Product grade	HEAO			Space Shuttle			GPS			Pioneer Venus		
		Number tested	Number types	% failure	Number tested	Number types	% failure	Number tested	Number types	% failure	Number tested	Number types	% failure
diodes	1N	3,150	26	18.8	–	–	–	1,840	4	13.5	486	6	17.5
	JAN	2,270	15	12.3	–	–	–	1,866	6	6.4	15	1	0*
	JANTX	3,116	12	9.8	–	–	–	5,006	11	5.9	531	7	3.2
	JANTXV	100	1	9.0*	–	–	–	9,286	25	8.5	1,930	35	6.7
transistors	2N	3,463	34	19.8	–	–	–	1,183	10	18.6	1,332	23	15.8
	JAN	2,409	14	23.6	–	–	–	1,438	3	11.9	103	3	17.5*
	JANTX	715	3	7.7	–	–	–	1,848	9	22.9	488	8	20.9
	JANTXV	240	6	7.5	–	–	–	7,010	16	8.4	1,660	21	6.6
linear ICs	mil-temp	4,279	23	18.0	4,734	1	9.4	3,070	1	7.5	38	2	39.5*
	precap/SEM	–	–	–	4,058	4	30.0	–	–	–	–	–	–
	883B	–	–	–	–	–	–	3,616	10	17.6	1,206	24	17.0
	38510B	57	1	51.0*	–	–	–	–	–	–	–	–	–
TTL ICs	mil-temp	15,918	30	9.5	–	–	–	–	–	–	–	–	–
	precap/SEM	–	–	–	629	3	12.0	–	–	–	–	–	–
	883B	–	–	–	–	–	–	781	7	20.9	528	13	13.4
	38510B	100	1	0*	–	–	–	–	–	–	–	–	–
C-MOS ICs	mil-temp	1,328	4	33.4	–	–	–	–	–	–	386	3	18.4
	883A/SEM	–	–	–	–	–	–	–	–	–	7,066	47	10.7
	883B	85	1	25.9	–	–	–	–	–	–	34	1	11.8*
	38510B	100	1	10.0*	–	–	–	–	–	–	–	–	–

*Extremely small population, so valid conclusion cannot be drawn

No matter what the program or procured reliability level, every part went through an initial visual inspection, followed by a stabilization bake, temperature cycling, acceleration testing via a centrifuge, and hermeticity checks. It also underwent some form of burn-in, preceded by an electrical test and followed by another for dc parameters at room temperature. Some of the programs, however, added X-ray examination, a second burn-in, post-burn-in electrical tests at minimum and maximum operating-temperature extremes, and a final visual inspection. (All the extra screening was done at an independent test facility by program mandate.)

Furthermore, each program had a common requirement—certain screening tests, selected at random, had to be witnessed by Government-source-inspection personnel, who then validated the test results. Additionally, GSI personnel were on hand when the fully screened parts were shipped.

Establishing electrical-test criteria

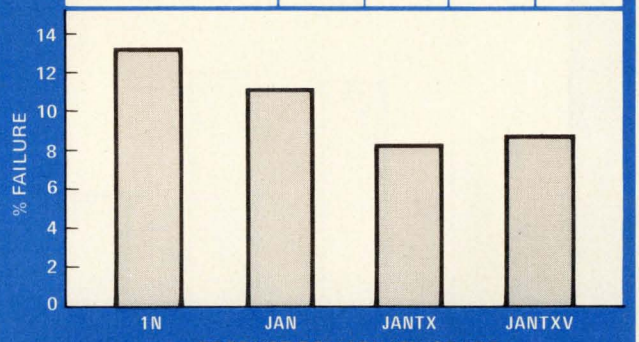
All transistors and diodes, including unscreened mil-temp devices, were tested electrically against the appropriate "slash sheet" of MIL-S-19500 for both specification limits and excessive parameter drift. In contrast, only MIL-M-38510 ICs were tested electrically in accordance with this military document's conditions and parameter limits. All other ICs were tested against their published data-sheet electrical conditions and limits, as well as against program-established post-burn-in parameter-drift criteria.

Table 2 summarizes the test results for all the programs, showing the number of different part types involved and the percentage of devices that failed at each level of reliability. In some instances, the same part type number was procured with two different grades of reliability—for example, the JANTX 2N2222A and the JANTXV 2N2222A transistor types—because of a program's delivery constraints and the availability of certain reliability grades. For the most part, all the devices, as well as the mix of different part types, came from a broad spectrum of vendors, with one restriction—

GRAPH 2: DIODES

SCREENING SUMMARY

Screen	% Failure			
	1N	JAN	JANTX	JANTXV
hermeticity	1.0	0.4	0.1	0
pre-burn-in electrical	2.7	1.1	2.5	1.2
post-burn-in electrical	8.6	7.2	3.3	3.5
X-ray	0.7	1.6	0.9	3.4
other	0.3	0.7	1.4	0.3
total number tested	14,496	6,469	9,913	11,427
overall % failure	13.3	11.0	8.2	8.4

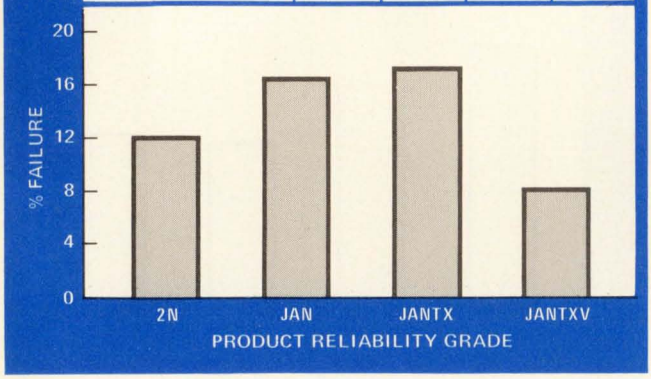


Block V			Fleet Sat Comm			Program M			Program N			Program W		
Number tested	Number types	% failure	Number tested	Number types	% failure	Number tested	Number types	% failure	Number tested	Number types	% failure	Number tested	Number types	% failure
199	6	13.6	1,288	20	13.8	–	–	–	6,899	8	10.5	634	9	12.9
138	1	2.9	312	6	3.9	–	–	–	1,335	6	15.7	533	7	16.1
109	1	5.6*	–	–	–	–	–	–	203	2	66.0	948	16	4.2
111	6	9.9*	–	–	–	–	–	–	–	–	–	–	–	–
144	1	20.1	1,210	12	13.3	–	–	–	24,552	14	9.7	1,408	18	21.2
–	–	–	47	1	2.1*	–	–	–	856	5	5.0	13	2	0*
25	1	8.0*	–	–	–	–	–	–	–	–	–	962	11	10.8
142	2	9.8	–	–	–	–	–	–	–	–	–	–	–	–
27	2	22.2*	1,009	11	7.6	–	–	–	9,403	11	14.3	750	11	15.2
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
156	4	21.2	21	2	0*	–	–	–	–	–	–	130	1	26.9
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
652	15	16.0	2,807	23	3.5	–	–	–	18,149	30	3.2	823	30	8.0
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
219	7	23.7	–	–	–	–	–	–	–	–	–	201	10	20.9
–	–	–	–	–	–	713	5	7.0	–	–	–	–	–	–
–	–	–	–	–	–	11,465	31	12.0	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

GRAPH 3: TRANSISTORS

SCREENING SUMMARY

Screen	% Failure			
	2N	JAN	JANTX	JANTXV
hermeticity	1.4	1.8	0.8	0.7
pre-burn-in electrical	2.4	2.1	6.1	1.4
post-burn-in electrical	7.1	8.5	7.3	3.6
X-ray	1.0	3.6	2.4	2.1
other	0.1	0.4	0.4	0.2
total number tested	33,292	4,866	4,038	9,025
overall % failure	11.9	16.5	17.0	8.0

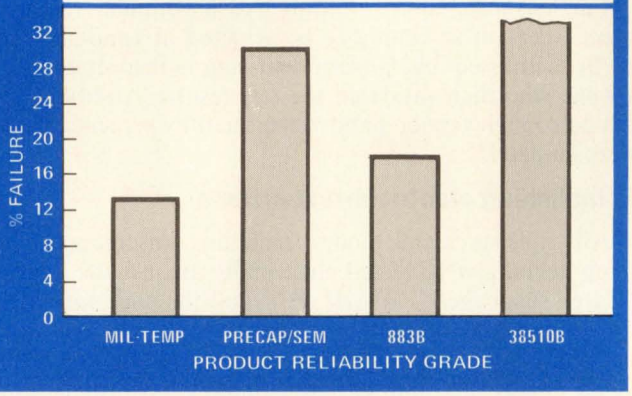


GRAPH 4: LINEAR ICs

SCREENING SUMMARY

Screen	% Failure			
	mil-temp	precap/SEM	883B	38510B
hermeticity	1.3	4.7	1.8	0
pre-burn-in electrical	5.4	2.1	4.1	21.0
post-burn-in electrical	4.4	14.8	6.6	28.1
X-ray	0.9	8.1	4.9	1.7
other	0.7	0	0.3	0
total number tested	23,310	4,058	5,129	57
overall % failure	12.8	29.8	17.7	50.9*

*Extremely small population, so valid conclusion cannot be drawn



all of them appear on the qualified-parts lists written by various Government agencies.

For all devices, electrical failures before burn-in were primarily due to out-of-specification defects. But electrical failures after burn-in were due to both out-of-spec defects and critical parameter-drift faults—indeed, parameter drift accounted for approximately 30% to 40% of the post-burn-in rejects. Causes of most other failures were hermeticity faults and X-ray rejects, and there were also some visual failures from the centrifuge test and the like.

Out of all five component groups, diodes most nearly delivered what they promised. Graph 2 shows the test results for the diode population, which is made up of switching, zener, and reference types.

As should be the case, the overall failure rate is lower for prescreened JANTX and JANTXV devices than it is for unscreened JAN and 1N devices. However, it is hard to understand why prescreened burned-in JANTX diodes exhibit twice as many pre-burn-in electrical failures as JAN products, which are not burned in.

The rate of post-burn-in electrical failures for prescreened JANTX and JANTXV diodes is approximately half that of unscreened JAN and 1N parts, which is as it should be. But again, it is hard to understand the similarity of the JANTX and JANTXV diode failure percentage, particularly since the JANTXV devices did much worse on the X-ray examination than any other reliability category.

The picture for transistors is cloudier than that for diodes but still clear enough (Graph 3). This population reflects general-purpose and high-speed switching types, as well as a range of power devices. Although the JANTXV devices have the lowest reject rate, inexplicably the JANTX parts have the highest. In fact, even though JANTX transistors have already been through a burn-in, their pre-burn-in electrical failure percentage is nearly three times higher than JAN and 2N devices, which have not been burned in. Also, both JANTXV and JANTX products have abnormally high reject rates for post-burn-in electrical. Moreover, unscreened 2N products have the fewest X-ray failures.

To sum up for discrete semiconductors, then, the most cost-effective procurements appear to be JANTX or JANTXV reliability levels for diodes and 2N or JANTXV for transistors. But for high-reliability applications, additional screening of these products to a "TX" test sequence is probably advisable.

Unscreened mil-temp ICs are the best buy

To be fair to the three IC groups, their test results are somewhat skewed by the presence of one or more single-vendor populations.

The linear ICs (Graph 4) are no exception. They represent quite an assorted population, including operational amplifiers, comparators, voltage regulators, analog switches, diode arrays, and digital-to-analog converters. For this group, unscreened mil-temp devices unquestionably have the lowest failure percentage. But the population in the highest reliability category (38510B) is very small, and all the parts are the same type number and came from the same vendor—too slim a basis for valid statistical conclusions.

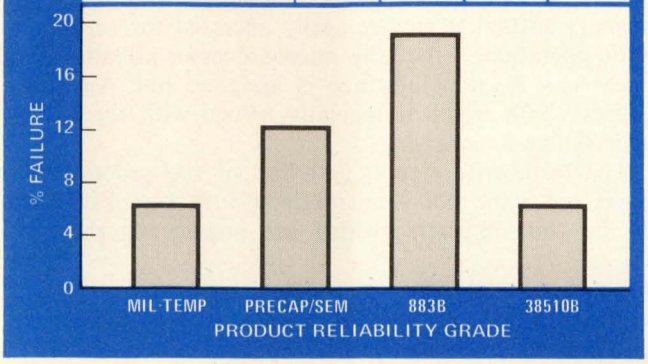
Ironically, prescreened burned-in 883B linear ICs have more pre-burn-in electrical failures than the precap/SEM devices, which are neither burned in nor prescreened. What's more, unscreened mil-temp parts have the lowest reject rate after burn-in, and precap/SEM products exhibit an extraordinarily high number of X-ray failures. (But the precap/SEM devices all came from one vendor.)

Graph 5 summarizes the test data for bipolar digital

GRAPH 5: TTL ICs

SCREENING SUMMARY

Screen	% Failure			
	mil-temp	precap/SEM	883B	38510B
hermeticity	1.1	0.8	9.4	0
pre-burn-in electrical	1.0	0.3	1.3	0.1
post-burn-in electrical	2.1	1.1	2.9	6.0
X-ray	1.4	9.5	4.1	0
other	0.4	0.3	1.0	0.1
total number tested	38,349	629	1,729	813
overall % failure	6.2	12.1	18.8	6.3

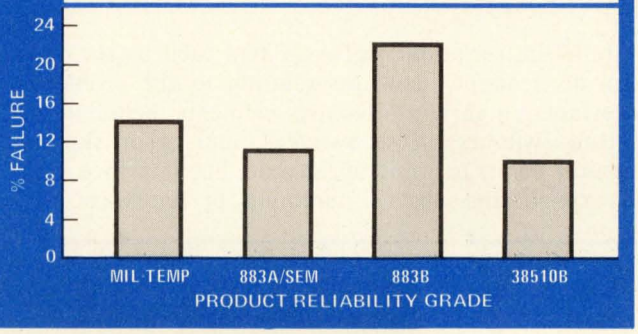


GRAPH 6: C-MOS ICs

SCREENING SUMMARY

Screen	% Failure			
	mil-temp	883A/SEM	883B	38510B
hermeticity	2.3	0.2	0	0
pre-burn-in electrical	6.4	1.5	2.5	1.0
post-burn-in electrical	4.0	2.0	19.3	9.0
X-ray	1.7	4.1	0	0
other	0.1	2.9	0	0
total number tested	13,179	7,066	119	100
overall % failure	14.6	10.7	21.8*	10.0*

*Extremely small population, so valid conclusion cannot be drawn



ICs. These are mainly transistor-transistor-logic circuits, divided about equally between small-scale and medium-scale devices. Once again, as with linear ICs, unscreened mil-temp parts exhibit the lowest reject rates, although the prescreened 38510B products also make a similar showing. (But the sample size for this group was extremely small, involving only six part types from two suppliers.)

Hermeticity rejects are very high for the 883B devices, though supposedly they had already been subjected to this test at the vendors' facilities. Also, while pre-burn-in electrical failures are consistently low for all reliability categories, post-burn-in electrical defects are higher for burned-in 883B and 38510B parts than for the non-burned-in precap/SEM and mil-temp products. Curiously, just like linear ICs and diodes, the bipolar ICs in the reliability grade with the most stringent precap visual requirements (precap/SEM, in this case) have the highest X-ray reject rate.

The population of C-MOS ICs (Graph 6) is almost as varied as that of linear ICs and ranges from simple gates all the way up to complex memories. However, this data is skewed to some extent because most of the parts came from a single vendor. Further, although the highest reliability grade (38510B) exhibits the lowest reject rate, the population of this category (and that of 883B) is really too small for making conclusive inferences.

Still, the indications are consistent with the results for other IC groups. Post-burn-in electrical failures are higher for C-MOS ICs that were supposedly already burned in than for unburned-in parts, and X-ray and visual reject rates are highest for the visually prescreened 883A/SEM products.

For ICs then, the results of this study indicate that the most reliable product category is the unscreened mil-temp grade for linear and TTL ICs, and the 883A/SEM parts for C-MOS ICs. In all cases, however, the failure percentages caused by subsequent screening are quite high, so additional testing is obviously mandatory.

One area of particular concern is the surprisingly high reject rate of 883B TTL ICs when, as products of a reasonably mature manufacturing process, they should be very reliable.

Summing up

There are no decisive answers to the many questions raised by the data presented here. The high incidence of post-burn-in electrical failures may be due to different or more stringent burn-in conditions for the programs surveyed here, or perhaps the large number of devices that failed because of parameter drift.

The higher number of X-ray rejects for precap visually inspected products over noninspected or lower-level parts does not invalidate the effectiveness of precap visual inspection. Essentially, there is no real correlation between X-ray examination and precap visual. X-ray examination locates package-seal defects and die-attach residue, as well as undesirable wire dress, only the last of which may be found with a precap visual inspection. In effect, defects discovered by X-ray examination are a measure of how good the vendor's assembly process is and how clean his manufacturing operation is.

The major difference in the results—that is, for discrete semiconductors, the highest-level devices are the most reliable, whereas this is not generally true for ICs—may have two simple reasons. Discretes are both less complex than ICs and more mature. In all likelihood, as IC production processes become more refined, the highest-level ICs will become the most reliable.

At present, however, the most expensive semiconductor devices are not necessarily those that will provide the best reliability. Substantial cost savings may be realized by making an intelligent selection from the other product grades. □

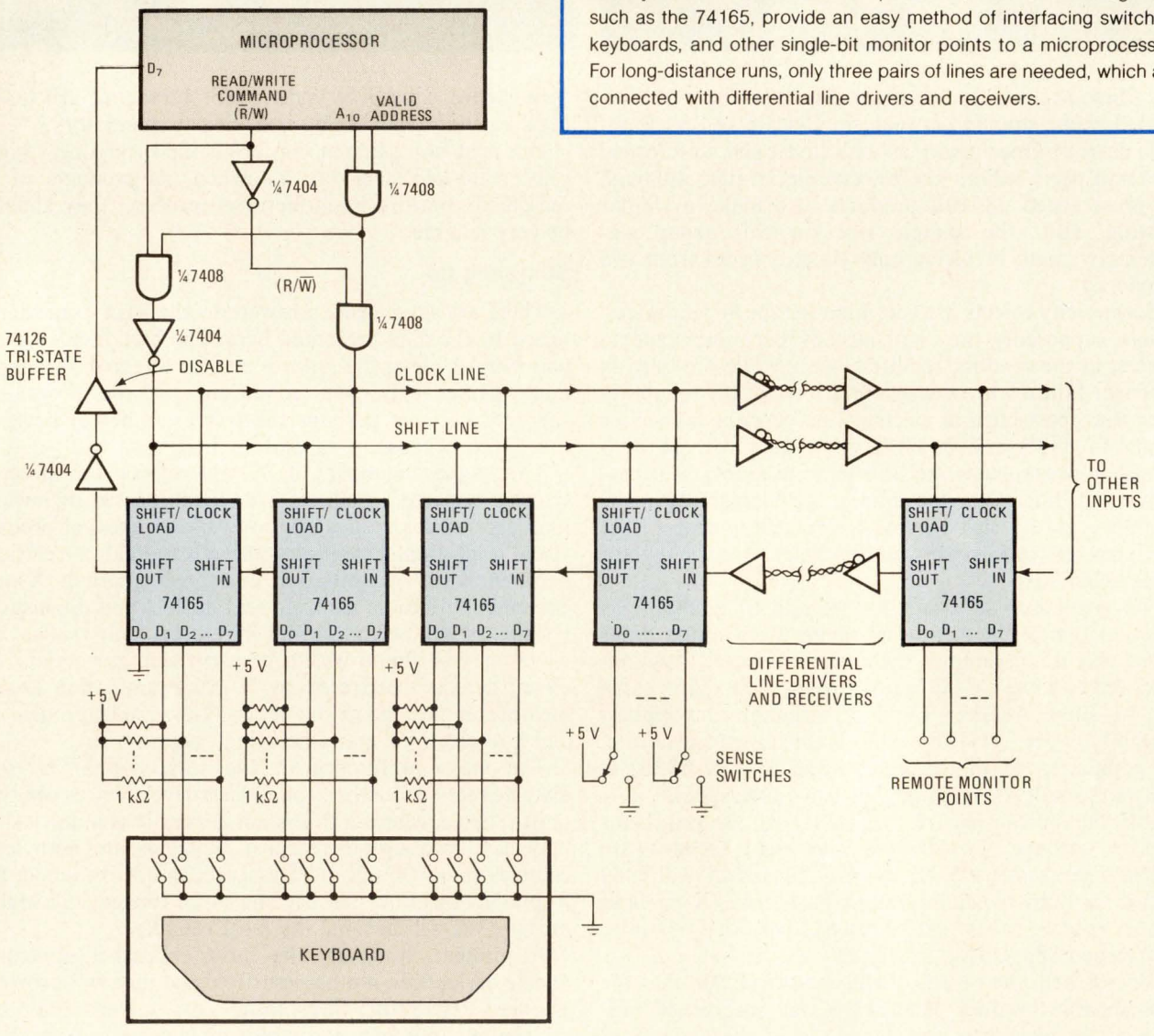
Shift registers act as control interface for microprocessor

by Felix J. Sawicki
University of Texas, Austin, Texas

Parallel-in, serial-out shift registers such as the 74165 provide a simple, low-cost solution to the problem of interfacing a variety of control elements including push button switches, sense switches, and other single-bit monitor points to a microprocessor. The interface is easy to expand and uses a minimum of hardware, since microprocessor software performs most of the decision-making functions. This technique also minimizes the bit manipulations necessary to determine the state of the monitor points.

The figure shows a shift-register interface connecting a microprocessor to a keyboard, sense switches, and remote sensors. The interface is assigned an address in memory so that it can be easily accessed for read and write operations. Since the microprocessor already uses lines A_0 - A_9, the interface is assigned line A_{10} (hex address 200), which is logically ANDed with the valid-address line for enabling.

The read/write line ($\overline{R}/W$) line of the processor is connected to the mode-control line (SHIFT/LOAD) of each of the shift registers, which are strung together by



Microprocessor interface. 8-bit parallel-in, serial-out shift registers, such as the 74165, provide an easy method of interfacing switches, keyboards, and other single-bit monitor points to a microprocessor. For long-distance runs, only three pairs of lines are needed, which are connected with differential line drivers and receivers.

connecting their shift-in and shift-out lines, as shown. This technique transforms the many parallel monitor points into a more manageable serial sequence of bits.

When a write operation is performed by the microprocessor at its interface address (A_{10}), the information is transferred from the switches and keys to the shift registers in parallel format. A series of read operations are then started at the interface address.

In a read operation, the $\overline{R}/W$ line from the microprocessor goes low, causing the shift registers to work in the serial mode. The read operation shifts the contents of all the 74165s one location, allowing the microprocessor to examine a new bit. The first parallel input of the first shift register is not wired to a switch since the first shift operation occurs before the microprocessor samples the input bit. The input bit is connected to the most-significant-bit input of the microprocessor, D_7.

Since the bit being examined is the MSB of the word being loaded, the read operation sets the condition code of the microprocessor to indicate whether the input word is negative (MSB = 1) or nonnegative (MSB = 0). A branch on the condition code will then allow immediate action to be taken by the processor, based on the state of the switch just tested. Thus the input routine of the microprocessor can determine most efficiently whether the bit that is being read is a 1 or a 0.

It is very simple to expand this circuit to examine more switches by adding additional shift registers. If a group of switches is located at a distant point, only three pairs of differential line drivers and receivers (which provide noise immunity) are required. Two pairs are used for the read/write and clock lines controlling the sampling and shifting, and the other carries the incoming data.

The software needed for this interface will vary according to the type of devices being monitored and the application for which they are used. For the application in the figure, the main functions are: keeping track of which point is being examined; switch debouncing (for momentary contacts); and differentiating between newly and previously closed switches (for keyboards).

The problem of key bouncing can be circumvented by waiting a long enough time for the keys to settle before rescanning. This is usually about 20 to 50 milliseconds. If the initial scan of the keys is done while a key is bouncing, it doesn't matter if the key is being read or not, as it will have settled by the next scan.

A microprocessor register or memory location should be used as a counter to keep track of which switch or monitor point is being examined. □

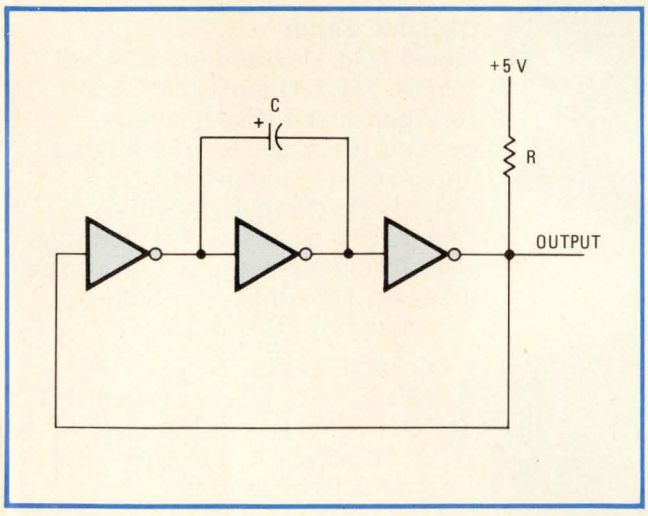
Adjustable TTL clock maintains 50% duty cycle

by Wilton Helm
Seventh-day Adventist Radio-TV-Film Center, Thousand Oaks, Calif.

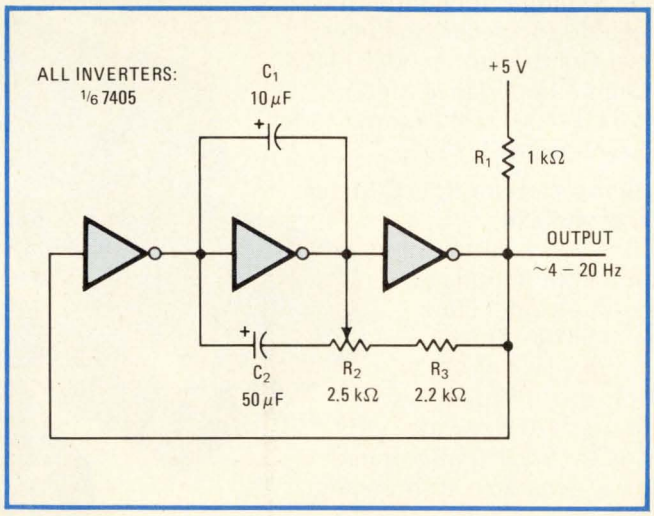
The utility of the basic free-running transistor-transistor-logic clock can be greatly increased by adding a few components to provide a variable-frequency output over a 5:1 range or better, while still maintaining a 50% duty cycle of the square-wave output.

A common design of the free-running oscillator is shown in Fig. 1. Three inverters are connected as a three-stage inverting amplifier, with intermediate stages biased by the output of the previous stage, and the last stage pulled up to +5 volts by a bias resistor to provide a TTL-compatible output. Capacitor C, connected across the second amplifier stage, provides the necessary time delay to ensure positive feedback, and thus determines the frequency of oscillation.

Adding a resistor, capacitor, and potentiomenter (R_2,



1. Free-running oscillator. Simple design of a TTL clock uses inverters. Frequency is determined by time constant of capacitor C with internal chip resistors. Low component count and good symmetry make it a natural for noncritical applications.



2. Adjustable counterpart. With the addition of three parts, the frequency of oscillation can be adjusted over a 5:1 range, while the attributes of the original design are maintained: the component count and cost is low, and the duty cycle is constant at 50%.

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Model 1248. Devices tested: 14 and 16 pins. TTL, DTL and CMOS @ 5V. Tests performed: Fixed pattern, dynamic functional test. Performs 2^{20} inspections per test in from 1 to 5 seconds. No comparison with a "good" IC is necessary. 4-digit display gives absolute test results. Can also be used to check continuity of resistor network. Price: $725.

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C_2, and R_3), as in Fig. 2, enhances the versatility of the circuit. Capacitor C_1 performs the same time-delay function as C in the design of Fig. 1, but now serves to determine the upper limit of oscillation frequency, since it is paralleled by C_2.

The combination of C_2 and R_2 adds a time delay to the transitions of the second amplifier stage, additional to the delay of the upper-limit capacitor C_1. But the resistance in series with C_2 could tend to upset the symmetry of the square wave, as is usually the case when attempts are made to vary the frequency of the free-running-oscillator design of Fig. 1.

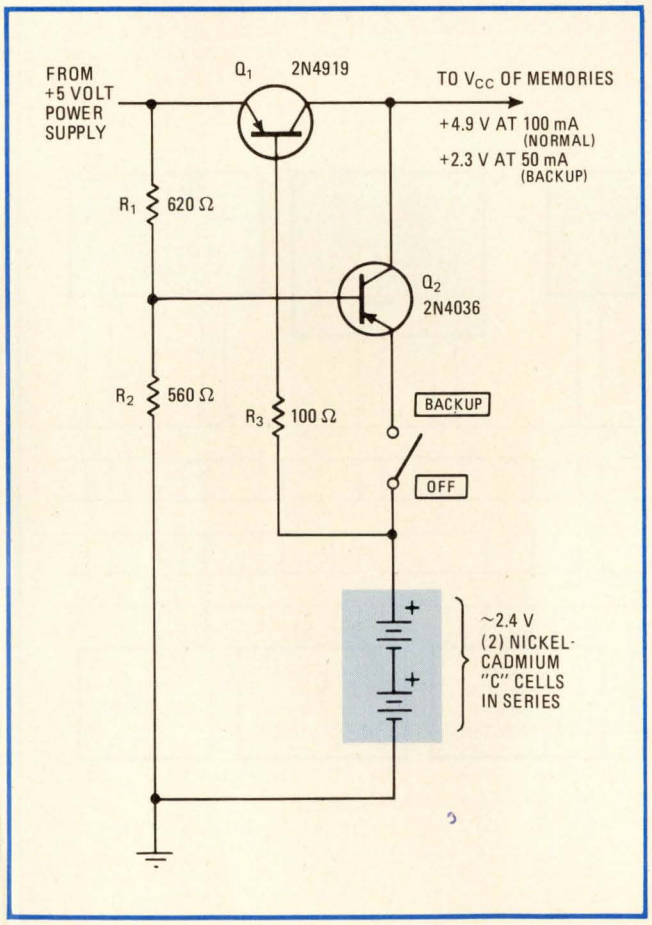
Symmetry of the square-wave output is maintained by connecting the right side of R_2 through resistor R_3 to the output of the third amplifier stage. This changes the charging current to the capacitors in proportion to the setting of frequency-adjusting potentiometer R_2. Thus, a duty cycle of 50% is constant over the entire range of oscillation.

The lower frequency limit is set by capacitor C_2. With the components shown, the frequency of oscillation can be varied by R_2 from about 4 to 20 hertz. Other frequency ranges can be obtained by changing the values of C_1 and R_3, which control the upper limit of oscillation, or C_2, which limits the low-frequency end.

Note that the inverters used in the adjustable oscillator are open-collector types, such as the 7405. The inherent low impedance of other types of inverters would swamp the effect of charging-current resistor R_3 and should not be used in this application. □

2.4-V battery backup protects microprocessor memory

by Raymond N. Bennett
Advanced Technology Laboratories Inc., Bellevue, Wash.



Memory saver. A series pair of nickel-cadmium "C" cells, each nominally rated at 1.25 volts, puts out about 2.4 volts and can deliver 2.3 volts to microprocessor memories to prevent loss of data in the event of supply failure. Transistors saturate to less than 100 mv.

Using diodes to isolate a backup battery from the power supply of microprocessor memories works fine—if the 0.7- to 1.0-volt drop across each diode can be tolerated. A more efficient circuit (see figure) substitutes saturable switching transistors that have a drop of less than 100 millivolts, which minimizes current drain and therefore extends battery life.

Moreover, the voltage of the nickel-cadmium battery supply need only be 2.4 volts, since during a power failure a saturated transistor then delivers all of 2.3 v to the memories. That is more than enough for such metal-oxide-semiconductor devices as the 2102 static random-access memory, which begins to lose data if its supply drops below about 2 v.

The circuit shown in the figure is connected between the +5-v power-supply line and the supply input of the memories. When the 5-v supply is functioning normally, transistor Q_1 is biased heavily into conduction by the difference between the supply voltage and that of the Ni-Cad batteries: 5 v − 2.4 v = 2.6 v. The voltage delivered to the memories is then about 4.9 v, since the drop across Q_1 is at most 100 millivolts. During this time, the R_1-R_2 voltage divider holds transistor Q_2 off, and the batteries receive a charge of about 20 milliamperes through R_3 and the base-emitter junction of Q_1.

When power failure occurs and the 5-v supply drops below about 3.1 v (which is 2.4 v + V_{BE}), Q_1 begins to cut off, isolating the dying 5-v supply from the load. At the same time, Q_2, biased by the R_1-R_2 voltage divider, begins to conduct, connecting the backup batteries to the load. The reverse bias on transistor Q_1 prevents the Ni-Cads from discharging through the supply circuit.

Both Q_1 and Q_2 were chosen for their very low saturation characteristics. Although their current ratings seem far in excess of what is needed, the result is that they exhibit a $V_{CE(SAT)}$ of less than 100 millivolts. But any pnp power transistors of the same general qualifications as those specified, such as the GE Powertab series, should suffice.

The standby switch has been included to permit defeating of the battery backup feature. □

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.

Avoiding missteps in programming and memory

by Norman E. Peterson
Digitech Data Industries Inc., Ridgefield, Conn.

Designing programming flexibility and enough memory into microprocessor-based equipment is something like walking a tightrope: a misstep can turn into a disaster. If the designer does not anticipate users' needs well enough, he—and his design—will fall on their faces.

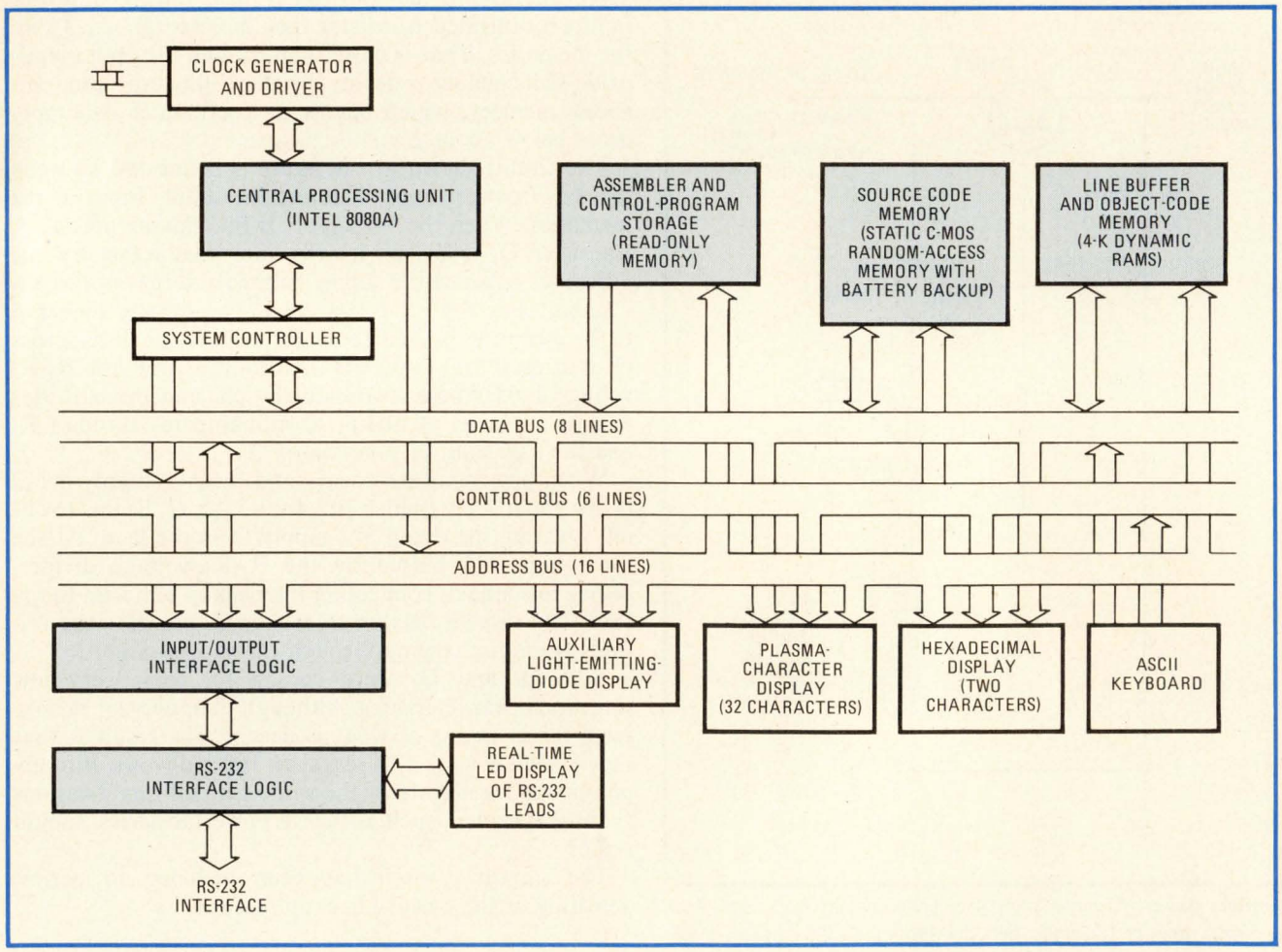
Anticipation of how the equipment will be used is especially important when it must handle a wide variety of user-written programs. The designer must have a good idea of how much instruction code is required and the amount of memory the user will need for applications programming.

Not all requirements can be pinned down beforehand, but some design foresight can make operational program changes just a matter of adding a stand-alone piece of instruction code without rewriting existing programs. Such foresight is important. Rewriting a major program to accommodate the new code is costly, especially since it will again require extensive debugging.

Case in point

The importance of these considerations was borne out by the design process of a data-line monitor and interactive simulator based on the Intel 8080A. The unit, the Pacer (Fig. 1) lets the user configure and execute a custom test program and view the test results on an alphanumeric display.

It was designed to provide comprehensive diagnosis of data networks, to isolate hardware problems, and to debug network software. It selectively monitors and displays all protocol, control, and test characters, and it detects and controls the status of the EIA RS-232



1. The inside view. The hardware design of the Pacer follows conventional microprocessor architecture. The major design effort was the input/output and the RS-232 interface logic, which allow the instrument to monitor and simulate any line discipline under CPU control.

interface lead. Moreover, it actively transmits polling/response sequences and variable test messages to simulate operating performance of data-terminal or communications equipment.

Getting flexibility

The RS-232 interface is a natural entry point for testing telecommunication networks and equipment. But providing both passive monitoring and active simulation has always posed a design problem of flexibility. Although the number of elemental operations that can be performed at this 25-pin interface is small, the permutations, combinations, and sequences that make up a particular line discipline is infinite. It is virtually impossible to design sufficient universality into a test instrument with only hard-wired logic.

The answer is the low-cost microprocessor. Its programmability proved the only way to provide custom performance from a standard developmental program of macroinstructions (a group of instructions for a particular function) for each of the elemental operations at the RS-232 interface. With the macros, the user can compile specific applications programs to test each line protocol with the resident line assembler.

Selecting a device

Since 8-bit data from the interface must be handled, the choice of an 8-bit microprocessor was obvious. After comparing the performance of available 8-bit processors, it also was obvious that all would perform at least adequately.

The Intel 8080A was chosen only because it had the highest production volume and the best second-sourcing. Selecting a technically superior chip and finding out after initial production that it is no longer available would require a total rewrite and debugging of the program.

The hard part

Choosing a microprocessor was the easiest part of the tightrope walk. Writing a developmental program suited to user needs and deciding how much memory was enough yet not too much proved to be more of a balancing act.

During field tests of the Pacer, it turned out that users wanted to write longer test programs than anticipated. Rather than use several small test programs to test individual functions one at a time, they wanted to punch a button and have the instrument do the rest. What they asked for was equipment that would permit them to write instruction codes testing each of the functions and then to combine the codes into a single program.

The initial design did not include enough memory space to accommodate the application-program lengths users wanted. In structuring the program code, then, a key requirement was enough memory to allow program expansion without a rewrite. But blindly adding more memory just increases the cost of the instrument and lowers its competitive edge. So the designer must know how it will be used.

SAMPLE PROGRAM

Program step	Code	Instructions	Argument
00	63	Program identifier	monitor NAK responses
01	37	Turn off display	—
02	11	Turn off receiver 2 or 3	3
03	51	Set counter A	ϕ
04	30	Clear display	—
05	55	Display contents of counter	A
06	31	Display characters	NAK sequences
07	13	Receive and log through sequence	NAK
08	53	Add one count to counter	A
09	04	Branch back	−5

2. Sample program. This 10-step instruction code programs the instrument to detect and count the number of messages on lead 2 of the RS-232 interface that were received in error and had to be retransmitted. The negative-acknowledgement (NAK) sequences displayed after step 06 are not destroyed when the program branches back to step 05 and redisplays the contents of counter A.

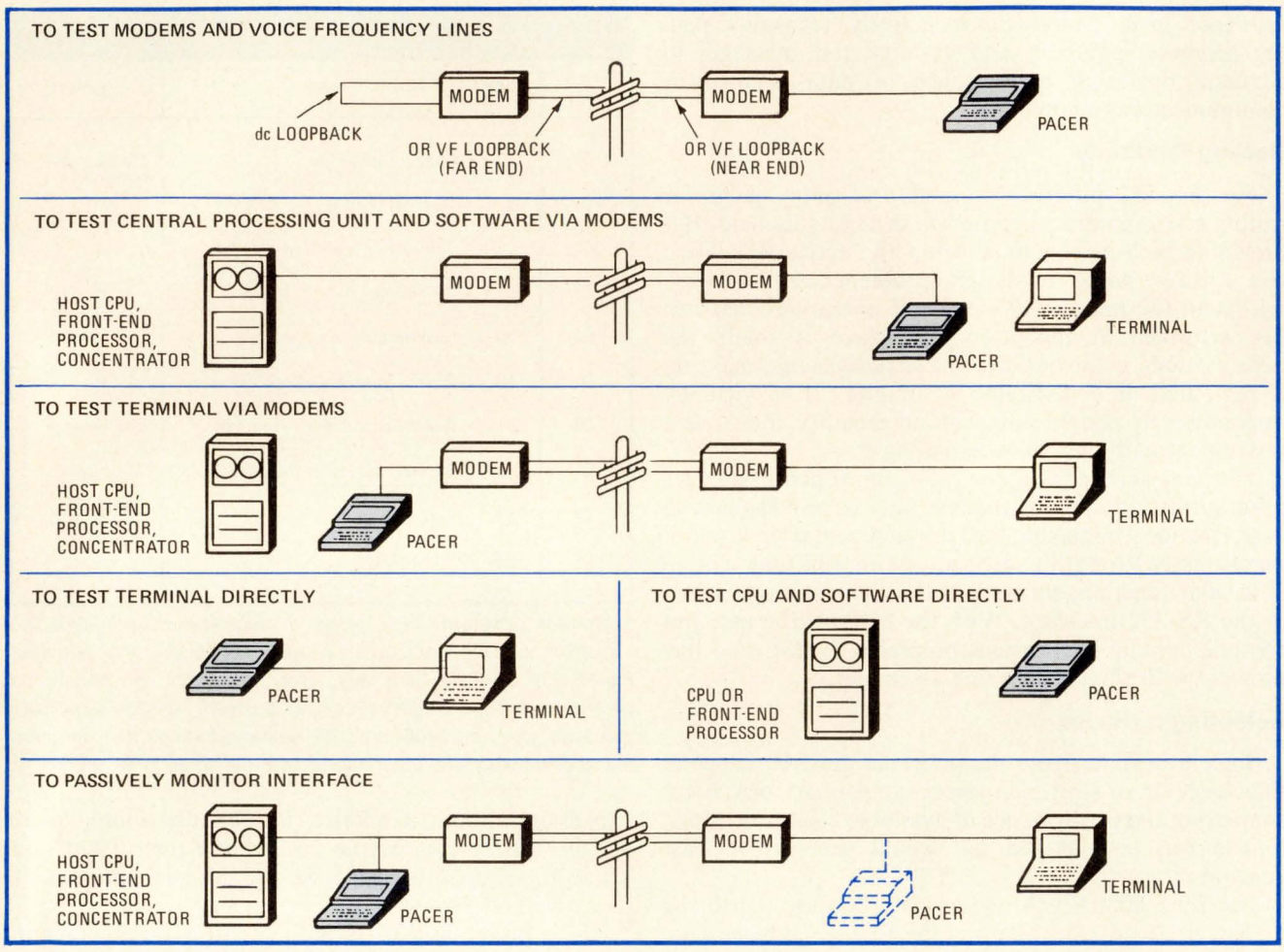
The solution was to initially write a developmental code that could handle a buffer random-access memory that can be expanded as needed. Delimiting in the instruction code tells the user the limits of the available memory.

As well as providing access to enough memory, the developmental code must be long enough to handle the number of instructions anticipated. A two-digit code is sufficient for more than 10 and less than 100 instructions, and so one was devised. A brief sample program that uses a 10-step instruction code to detect messages received in error is shown in Fig.2.

However, if it appears that about 90 instructions will be needed, it is best to go to a three-digit code. Such a code does not cost much more initially, but it avoids a major software rework if additional instructions are needed later on.

Freedom of choice

The initial consideration for the read-only memory containing the developmental program was programmable ROMs tailored to each user's needs. But they would effectively put the designer into the user's loop before settling finally on the design—a practice that is



3. Many uses. Through simple keyboard commands, the user can quickly configure and execute custom test programs for checking interfaces, terminals, CPUs, and software, as well as modems and voice-frequency lines, and view the results on the alphanumeric display.

all too frequently fraught with errors.

Instead, a relatively simple two-pass ROM assembler was included that lets the user build his own program on the spot. In the first pass, he selects the required macros, which consist of machine codes for one of the elemental interface functions, and transfers them from ROM to buffer RAM, where the program is assembled. During the second pass, he adds the jump addresses for the instruction code and arguments (specific instructions).

Lasting memory

Re-entering the longer, more complex applications programs every time the instrument is turned on would be a chore. A nonvolatile memory was needed to store the users' programs in source-code statements, which are called out and compiled as required. The Pacer uses a small battery-supported complementary-metal-oxide-semiconductor RAM. Under typical operating conditions, it was found that two 5.6-volt mercury batteries will last about a year.

Even with these changes in software and memories, the instrument was brought into full production status with a minimum of hardware changes. Almost all the bugs were removed by software rewrite. A number of the more typical applications of the Pacer are shown in brief outline in Fig. 3.

Long life

Furthermore,a simple software update extends the life of the Pacer beyond the normal cycle. The instrument can be made to track the improving capabilities of telecommunication circuits and equipment. Thus it avoids obsolescence as new line protocols are developed and are put into use.

A bonus with these microprocessor-based instruments shows up when testing personnel are unfamiliar with programming. Users can simply load source codes into the instruments from a central location by using modems and telephone lines. All the field technicians have to do is to perform the tests. □

Low-cost dual delayed-sweep method eases measuring time

Extending the oscilloscope's circuitry with mostly standard components produces sophisticated time-interval tests

by Bill Law and Abraham Taghioff, *Tektronix Inc., Beaverton, Ore.*

☐ Adding dual delayed-sweep capability to oscilloscopes takes no more than a technique relying on simple logic. Incorporated into a topside option, the technique eases and speeds the scopes' measurements of time intervals and their inverse, and, as a bonus, voltage, resistance, and temperature measurements.

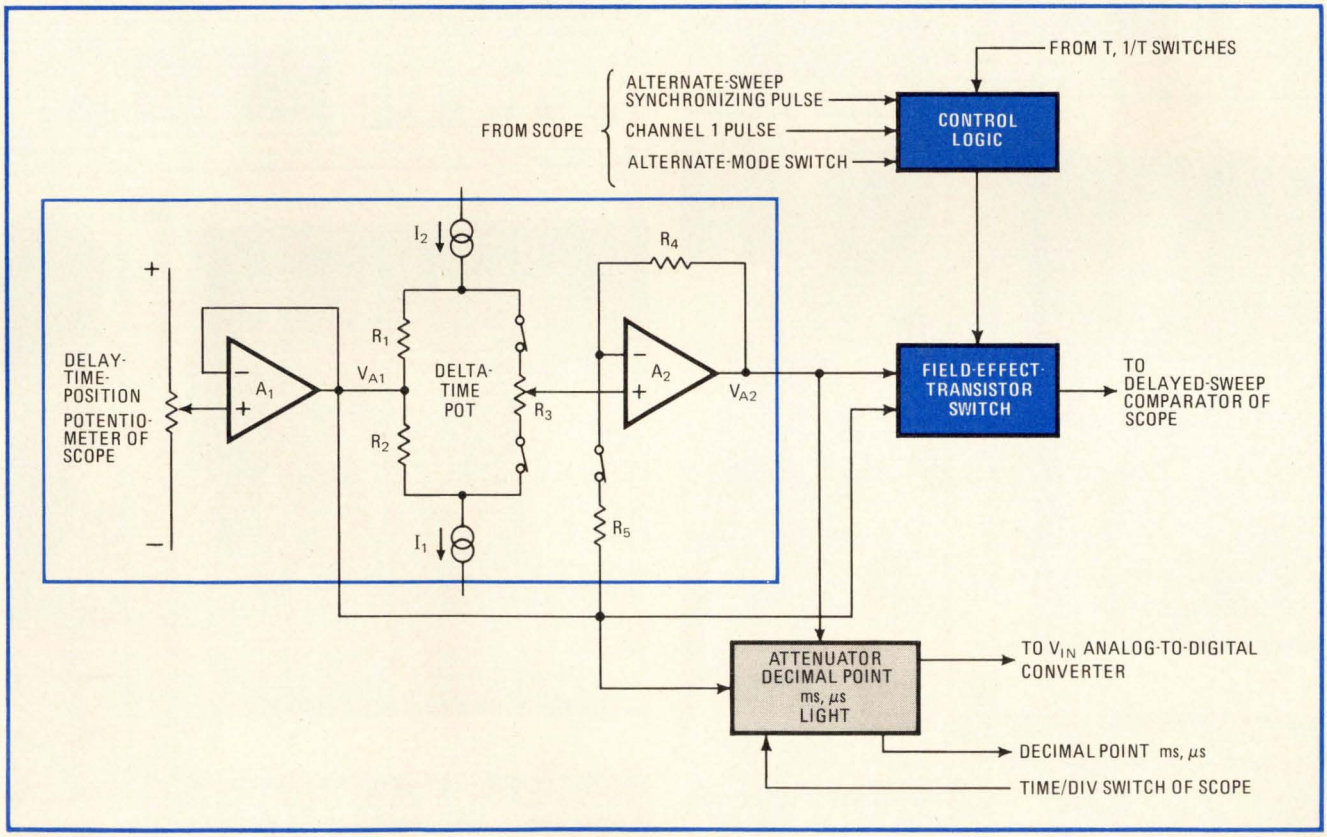
The DM44 option incorporates the latest in oscilloscope time-measurement techniques (see "Simplifying time measurement," p. 116). Like other dual delayed-sweep techniques, it is faster and simpler to use than earlier techniques, but it is cheaper.

The option achieves lower cost by using vastly simpler circuitry than do other dual delayed-sweep scopes, which rely on a microprocessor-like chip, digital-to-analog conversion, and two comparators. Without using a processor chip, it extends the scope's circuitry to provide dual delayed sweeps. A single-supply quad operational amplifier provides buffer and comparator functions. Maximum use of standard components permits automatic insertion on the production line, and the main printed-circuit board has interfacing circuitry that mates with most of the 400 series of portable scopes.

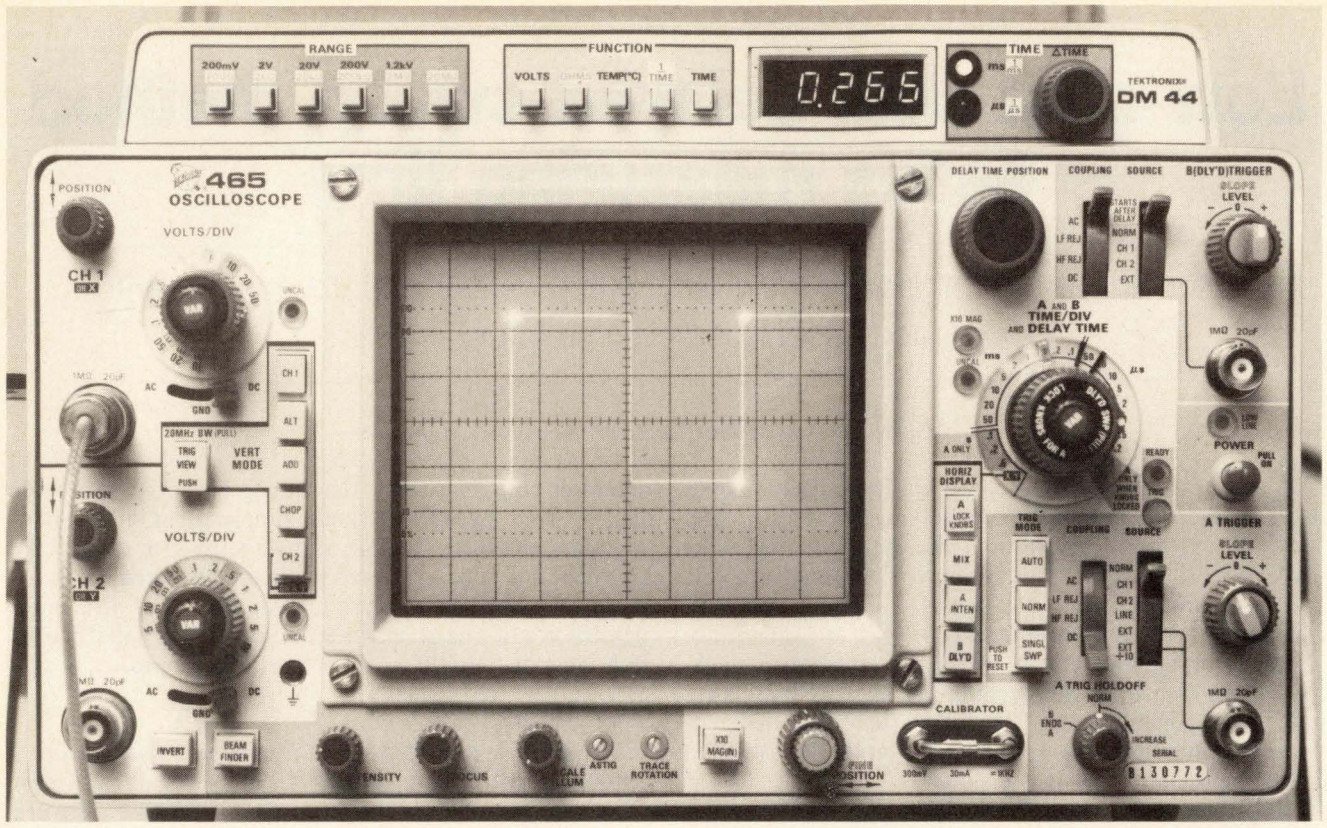
Simplifying circuits

The DM44 circuit (Fig. 1) uses the oscilloscope's delay-time-position potentiometer to provide the first delay voltage. This voltage feeds a resistive network through a buffer amplifier, A_1. The A_1 output, V_{A1}, sets the first delay time after the trigger.

To produce the second delay voltage, two approxi-



1. Teamwork. An input from the oscilloscope's delay-time-position potentiometer results in V_{A1} which sets the first delay time after the trigger. The amplified output voltage, V_{A2}, of the DM44's delta-time pot sets the second delay time after trigger.


RANGE
200mV
2V
20V
200V
1.2kV
FUNCTION
VOLTS
TEMP(°C)
TIME
0.265
TIME
ΔTIME
TEKTRONIX
DM 44
465
OSCILLOSCOPE
POSITION
VOLTS/DIV
CH 1
CH 2
ONLY
UNCAL
AC
GND
DC
1MΩ 20pF
20MHz BW (PULL)
TRIG VIEW
PUSH
VERT MODE
CH 1
ALT
ADD
CHOP
CH 2
INVERT
BEAM FINDER
INTENSITY
FOCUS
SCALE ILLUM
ASTIG
TRACE ROTATION
X10 MAG(IN)
PRIME POSITION
CALIBRATOR
300mV
30mA
≈1KHZ
DELAY TIME POSITION
COUPLING
SOURCE
B(DLY'D)TRIGGER
SLOPE
LEVEL
STARTS AFTER DELAY
NORM
CH 1
CH 2
EXT
LF REJ
HF REJ
A AND B
TIME/DIV
AND DELAY TIME
X10 MAG
A ONLY
READY
HORIZ DISPLAY
A LOCK KNOBS
MIX
A INTEN
B DLYD
TRIG MODE
AUTO
NORM
SINGL SWP
PUSH TO RESET
LINE
EXT ÷10
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A TRIG HOLDOFF
B ENDS A
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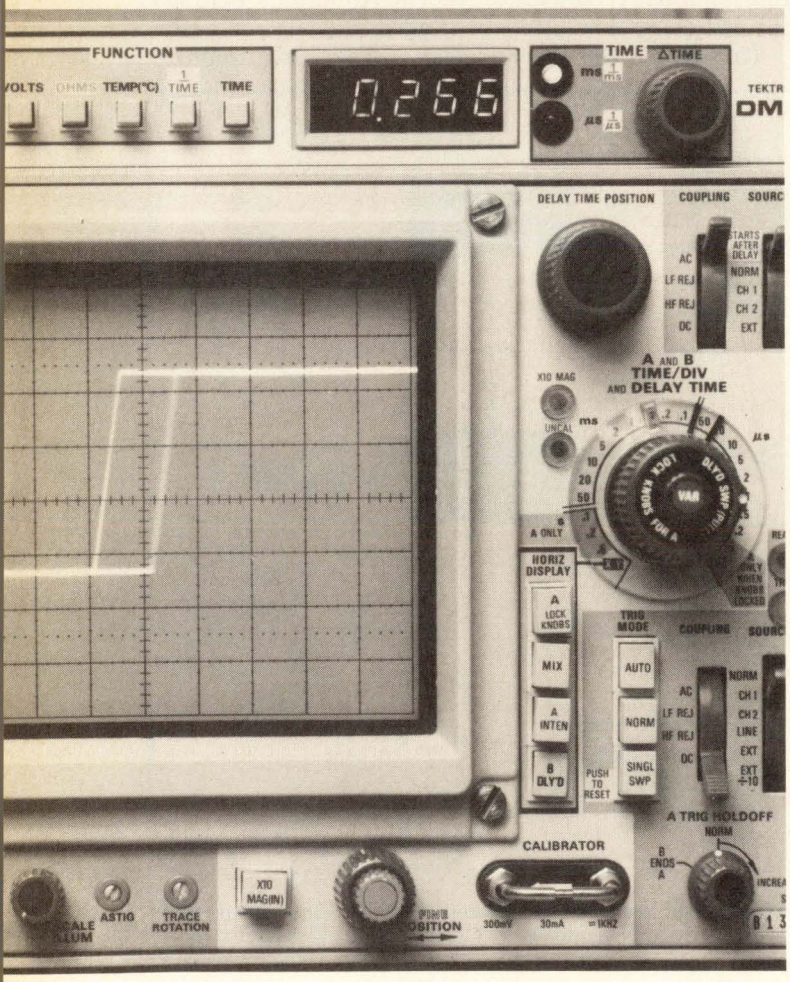
PULL OFF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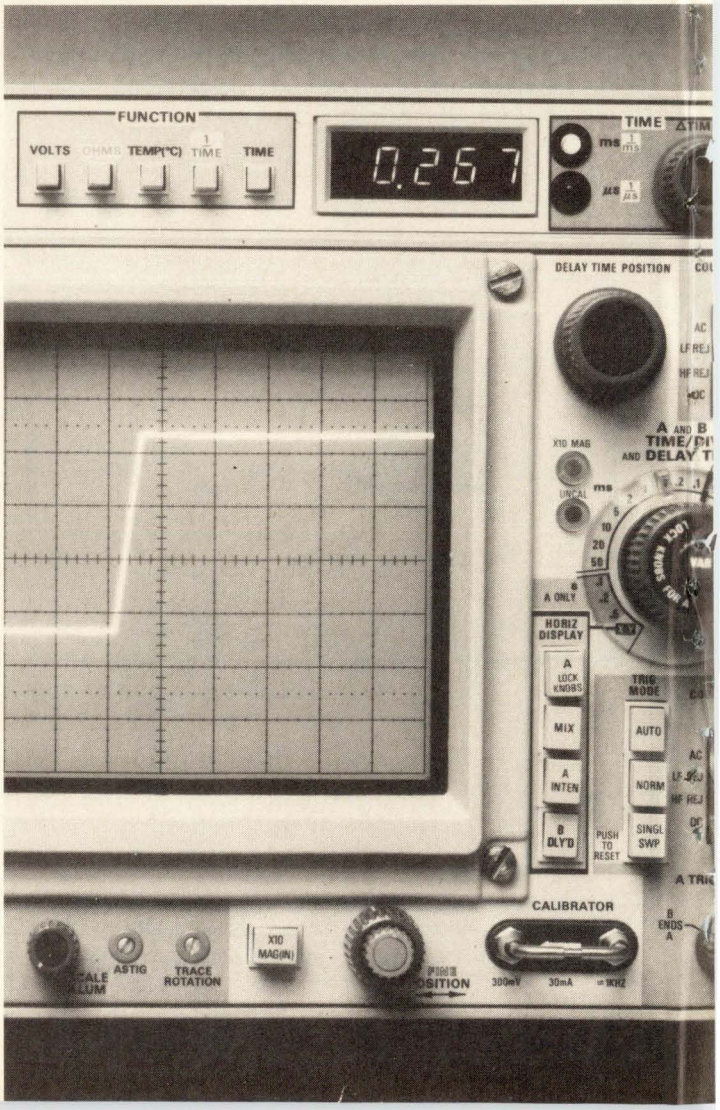
A TRIG HOLDOFF
B ENDS A
CALIBRATOR
ASTIG
TRACE ROTATION
X10 MAG(IN)
300mV
30mA
≈1KHZ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AND DELAY TIME
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A LOCK KNOBS
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AUTO
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SINGL SWP
PUSH TO RESET
CALIBRATOR
ASTIG
TRACE ROTATION
X10 MAG(IN)
300mV
30mA
≈1KHZ

Easy does it

Measuring time intervals with the DM44 option and the oscilloscope is a simple two-step procedure. The operator sets the scope in its intensified mode and uses the dial of its delay-time-position potentiometer to position two intensified spots at the beginning and end of the time interval (left).

He switches the scope to its delayed-sweep mode and uses the delta-time dial to superimpose the end of the interval on the beginning (below, far left). The light-emitting-diode readout will give the value of the time interval with 1% accuracy (below, near left). Switching to the DM44's 1/time mode will give a direct readout of the reciprocal of time, which is often the frequency of the interval (below).

By eliminating the need for the operator to read dials, align traces precisely and make calculations, the equipment decreases the probability of errors. It also reduces measurement time, thereby facilitating the measurement process.

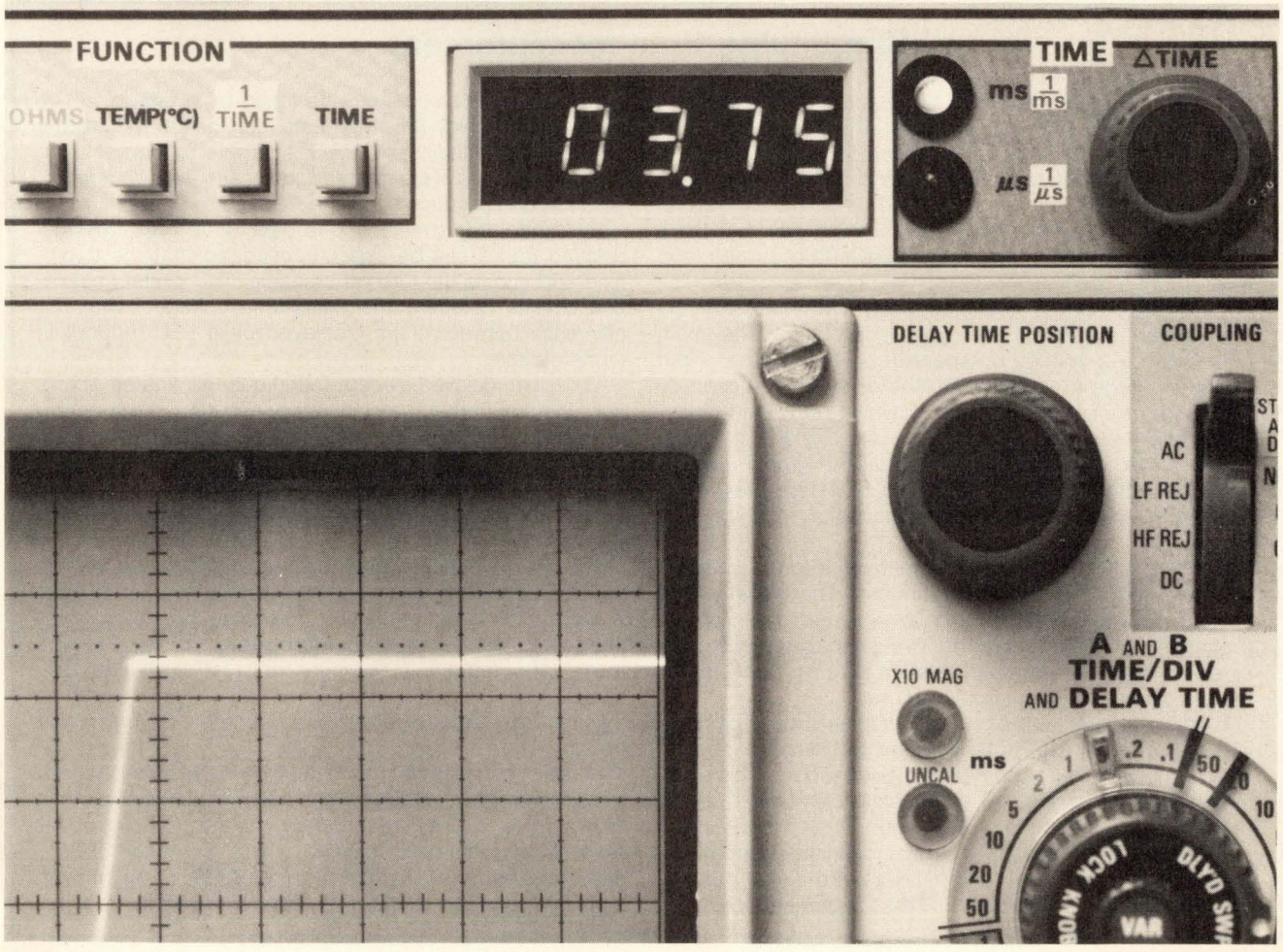
The dual delayed-sweep technique is particularly useful for checking and adjusting the timing on computers and their peripherals and other digital electronic equipment. It is especially handy when measuring the number of different time intervals that may be necessary when testing microprocessors during design, while troubleshooting, and in servicing.

mately equal floating-current sources, I_1 and I_2, develop a voltage across the DM44's delta-time pot, R_3. This voltage is twice that produced by the scope's delay-time pot. The output voltage of the delta-time pot equals V_{A1} plus or minus some ΔV determined by the pot setting. When amplified by A_2, this output voltage, V_{A2}, sets the second delay time after trigger. Thus the operator may generate two intensified spots or two delayed sweeps independently.

The two voltages, V_{A1} and V_{A2}, feed an inexpensive field-effect-transistor switch controlled by simple integrated-circuit logic. For voltage, resistance, and temperature measurements, the FET switch locks on V_{A1} since time is not being measured. For time measurements, the switch alternately gates the voltages to the scope's delayed-sweep comparator.

In the channel 1, channel 2, add, and chop modes of the scope, the alternate-sweep synchronizing pulse instructs the control logic to alternately feed V_{A1} and V_{A2} to the comparator at the end of each main sweep. In the scope's alternate mode, the channel 1 signal provides the instruction to ensure that V_{A1} is present to the comparator during the channel 1 display and V_{A2} during the channel 2 display.

The coincidence of the main-sweep voltage and V_{A1} or V_{A2} generates a delayed-sweep trigger. During display of the main sweep, the delayed sweep produces a bright segment on the trace. The position and length of this



segment reflect the delay time and the rate of the delayed sweeps. During the scope's delayed-sweep mode, the sweeps are displayed and can be positioned independently on the X axis of the cathode-ray tube by the operator.

Simple circuitry simultaneously provides the time-interval readout. A voltage differential, $\Delta V = V_{A1} - V_{A2}$, dependent only on the setting of the DM44's delta-time pot, is applied to the scope's time/division switching circuit for automatic selection of the proper attenuator. The attenuated voltage then feeds an analog-to-digital converter in the DM44, and the equivalent time is displayed on a 3½-digit light-emitting-diode readout on the option's face. The same circuits operate the millisecond and microsecond indicator lights that are next to the readout.

Inverting measurements

In many cases, the oscilloscope operator wants the reciprocal of the time interval, which is often the frequency of the pulse. Direct readout on the LED display of 1/t is easily obtained from the a-d converter consisting of the Siliconix LD110/111 digital voltmeter chip set. In this chip set, the net count to be displayed is equal to $k_1 (V_{in}/V_{ref})$.

For most measurements, V_{ref} is about 6.2 volts, V_{in} is less than 2 v, and the net count varies directly with V_{in}. To obtain 1/t, V_{ref} is varied and V_{in} is kept constant so that the net count equals k_2/V_{ref}, where $k_2 = V_{in}k_1$. Furthermore, varying V_{ref} directly with ΔT, where $\Delta T = V_{A1} - V_{A2}$, means the net count varies with $k_2/\Delta T$. This procedure allows a direct readout of 1/t.

Speeding the process

A step-by-step comparison against the conventional method for time-interval measurement gives an idea of the speed of the dual delayed-sweep technique. It also points up the ease with which 1% accuracy is achieved.

The conventional method requires a highly linear delay-time-position potentiometer with a vernier dial to keep track of the positions set in by the operator. Although reasonably accurate, this method requires seven steps to measure a time interval:

1. Set the oscilloscope in its intensified mode and use the delay-time dial to set the intensified spot at the beginning of the interval.
2. Switch to the delayed-sweep mode and precisely position the beginning of the time interval to a selected vertical graticule line.
3. Record the reading on the dial.
4. Return the scope to its intensified mode and position the intensified spot at the end of the time interval.
5. Switch back to the delayed-sweep mode, and, using the dial, precisely position the end of the time interval on the same graticule line as in step 2.
6. Record the new reading on the dial.

Simplifying time measurement

The calibrated time base made possible the measurement of time intervals with oscilloscopes. The interval between any two points on the scope's screen could be measured, within the limits of such factors as time-base accuracy, linearity, parallax errors, trace width, and the operator's visual acuity. The most crippling limitation was that there was no way to isolate and magnify events occurring long after a sweep begins.

The delayed-sweep technique, with two independently adjustable time bases, solved this problem. The main sweep feeds a voltage comparator, with the other input being a voltage proportional to the delay time chosen by the operator. The coincidence of sweep-ramp and delay-time voltages generates a trigger, starting the delayed-sweep ramp. The operator can adjust the second sweep, from the other time base, to a much faster speed. This magnifies the isolated event and increases measurement resolution.

Although the delayed-sweep technique is a significant advance, it still has several limitations. There always are the possibilities of human error in aligning a trace with a graticule line, of thermal drift between measurements, and of errors in the complex procedure that includes taking dial readings and making calculations.

One simplifying approach is to replace the calibrated dial of the delay-time potentiometer with analog calculation circuitry and a light-emitting-diode readout. This eliminates the calculations and the inaccuracies characteristic of dial readings. But there still is room for improvement.

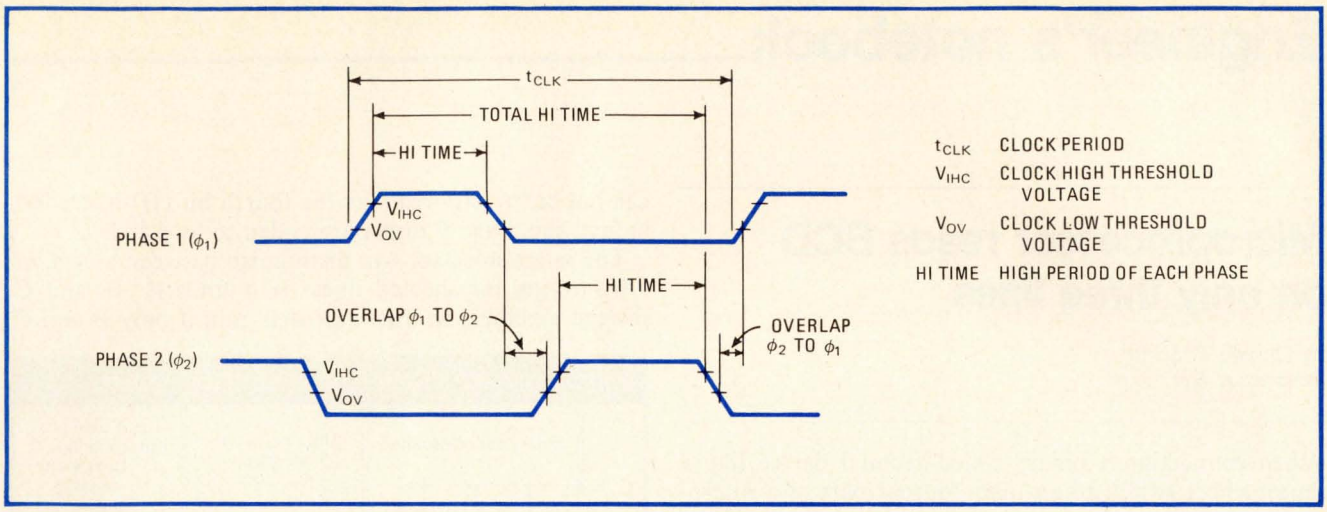
A further refinement is the dual delayed-sweep technique, incorporating two comparators and digital calculation circuits. This eliminates the alignment problem because measurements can be taken by overlapping two traces. Two delay-time voltages are generated in the conventional fashion and applied on alternate sweeps to the comparators. Two delay triggers are thus generated, which in turn produce separate delayed sweeps.

By careful adjustment of the delay-time pots, the two delayed traces can be superimposed, so that the beginning and end of the interval coincide. The digital calculation circuits compare the delay-time voltages, with the difference between them displayed on a LED readout in terms of time.

The dual delayed-sweep technique eliminates errors from thermal drift in the delaying sweep since both delays are affected equally. Measurement accuracies within 1% can be achieved. However, the technique adds about $1,000 to the scope's cost when it employs a microprocessor and a digital-to-analog converter as well as two comparators.

The microprocessor monitors the main sweep setting and generates the result: $\Delta T = k \Delta V$. The d-a converter is necessary because signals from the microprocessor must be converted to analog form before being supplied to the comparators. A summing network adds the delta delay signal (the operator-selected variation in interval) to the first delay signal in order to produce the second delay signal.

However, simpler circuitry can provide the dual delayed-sweep technique at lower cost. Such an approach is incorporated in the DM44 option to the Tektronix 400 series of portable oscilloscopes. The price of the option, described in the main article, adds $325, or $410 with temperature probe to the basic oscilloscope price.



2. Checking out a chip. Microprocessor testing often involves the measurement of various time intervals: clock period, or cycle time; pulse width, or the high period for each clock phase; total high time for both clock phases, and the delay between phases, or clock overlap.

7. Subtract the step 3 reading from the step 6 reading. Multiply the result by the main sweep's time/division setting, ensuring that the decimal point is properly positioned.

The result is an accurate measurement of the time interval, assuming no errors in dial readings, trace alignments, or calculations. These error sources are eliminated in the two-step measurement by the DM44 shown in the photographs on pp. 114-15:

1. Set the scope in its intensified mode and use its delay-time dial and the DM44's delta-time dial to position two intensified spots at the beginning and end of the time interval.

2. Switch the scope to its delayed-sweep mode and use the delta-time dial to superimpose the end of the interval on the beginning. The LED readout gives the value of the time interval with 1% accuracy. Switching to the DM44's 1/time mode will give a direct readout of the reciprocal of time.

As well as decreasing the probability of error, elimination of dial readings and computations reduces measurement time. Time-interval measurement becomes so easy that it is almost second nature to make measurements.

Applying the technique

The dual delayed-sweep technique allows easy checking and adjustment of timing on computers and their peripherals and other digital electronic equipment. A particularly useful application is in testing microprocessors—during design, while troubleshooting, and in servicing. For a typical microprocessor system, the scope operator may want to measure a number of different time intervals (Fig. 2): clock period, or cycle time; pulse width, or the period in which each clock phase is high (HI time); the delay between phases; or clock overlap, and total HI time. The DM44 simplifies making these measurements.

To measure clock period, the operator sets the scope's vertical mode to channel-1-only and its horizontal mode to main-sweep-intensified and the DM44 to its time mode. He sets the main sweep to display several clock periods and the delay sweep for the desired resolution. This displays only the phase 1 clock pulse. Using the two-step procedure described gives the scope operator a readout of the clock period.

To then measure pulse width, the operator leaves the scope's vertical mode in channel-1-only and returns the horizontal mode to main-sweep-intensified. Using the scope's delay-time dial and the DM44's delta-time dial, he moves the two intensified spots to the beginning and end of the HI-voltage threshold level (V_{IHC}) of a single clock pulse. Then he switches the scope's horizontal mode to delayed sweep so that the rising and falling edges of the pulse intersect at the V_{IHC} points. The LED readout will show the HI time for phase 1. For the phase 2 pulse width, the operator switches the scope's vertical mode to channel 2 and repeats the procedure.

Another variation

To measure clock overlap, the operator sets the vertical mode to alternate and the horizontal mode to main-sweep-intensified. Both channels now can be seen on the cathode-ray tube. After setting the two intensified spots at the LO-voltage threshold levels (V_{OV}) of phases 1 and 2, he switches the horizontal mode to delayed-sweep. Using the delay-time-position and the delta-time dials, he sets the V_{OV} levels to the same vertical graticule line. The readout will show the clock-overlap time from phase 1 to phase 2. To measure overlap from phase 2 to phase 1, a similar procedure may be used.

Total HI time can be measured by once more setting the vertical mode to alternate and the horizontal to main-sweep-intensified. The operator sets the first spot at the start of the V_{IHC} level in phase 2. He switches the horizontal mode to delayed-sweep and adjusts the DM44's delta-time dial to set both V_{IHC} levels to the same vertical graticule line. The LED display then shows the total HI time of the two clock pulses.

These procedures are much simpler and less time-consuming than those of conventional time-interval measurements. The savings in time, as well as the elimination of possible measurement errors, means greater efficiency and economy of operation in critical applications. □

Microprocessor reads BCD on only three lines

by Darwin T. Scott
Albuquerque, N.M.

When connecting a binary-coded-decimal device like a thumbwheel switch to an input/output port of a microcomputer, you could free some valuable I/O pins if the switch could be coded on three lines instead of the usual four. But everyone knows that 4 bits are required to encode 10 digits—or are they?

A BCD switch can be coded on three lines if the I/O ports can switch from input to output. Figure 1 shows the necessary wiring configuration. A Motorola 6820 peripheral interface adapter is shown as the I/O device, but the bidirectional ports on other PIAs or the Fairchild F8 chip set would work equally well.

The thumbwheel switch is coded in BCD complement, the simplest and most widely used configuration; that is, a logic 0 is placed on an output line by shorting that line to the common terminal. Hence, all lines with a 0 output are shorted together. For example, setting the switch to 4 ties lines A (2^0), B (2^1), and D (2^3) together. Notice how the most significant bit (D) of the switch is rerouted to ground, and the common lead is left unconnected.

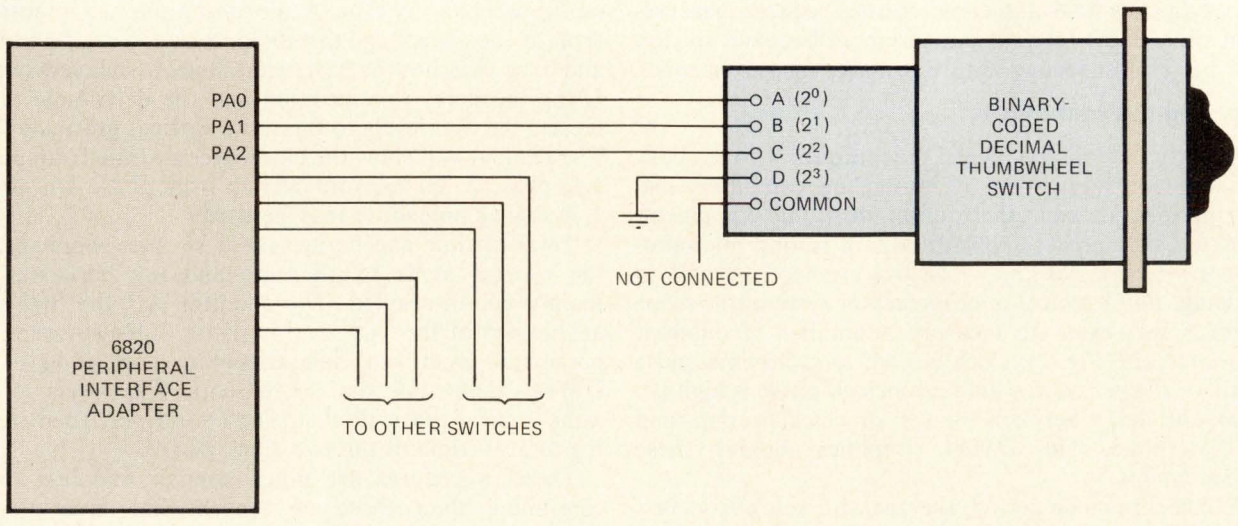
The table showing the BCD coding indicates that for digits 0 to 7 the decimal number is correctly coded on lines A, B, and C. For digits 8 and 9, however, the code can not be directly read, as the fourth bit (D) is needed; in fact, the 8 and 9 digits are coded to look like 7s.

The microprocessor can distinguish between a 7, 8, or 9 by testing for shorted lines. If it finds A, B, and C shorted together, an 8 is indicated, and if only B and C

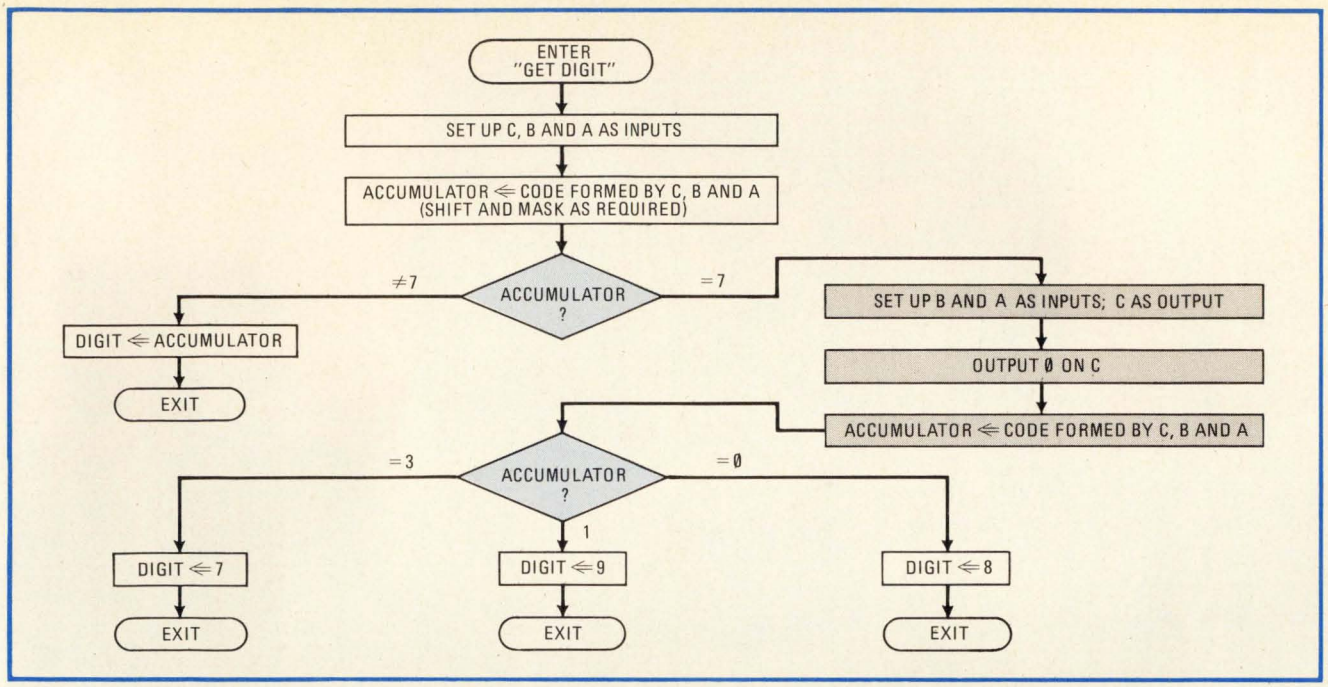
CODING INFORMATION FOR BCD ON THREE LINES

Digit	Binary-coded decimal				Input with all lines set up as inputs			Input with zero output on line C and lines A and B set up as inputs		
	D (2^3)	C (2^2)	B (2^1)	A (2^0)	C	B	A	C	B	A
0	0	0	0	0	0	0	0	X	X	X
1	0	0	0	1	0	0	1	X	X	X
2	0	0	1	0	0	1	0	X	X	X
3	0	0	1	1	0	1	1	X	X	X
4	0	1	0	0	1	0	0	X	X	X
5	0	1	0	1	1	0	1	X	X	X
6	0	1	1	0	1	1	0	X	X	X
7	0	1	1	1	1	1	1	X	1	1
8	1	0	0	0	1	1	1	X	0	0
9	1	0	0	1	1	1	1	X	0	1

X = not applicable



1. Three-line BCD? Binary-coded-decimal thumbwheel switches can be coded on three lines instead of four if the I/O port is switched to output to test for shorted lines. The 6820 peripheral interface adapter is shown, but any chip set with bidirectional I/O ports will work.



2. Procedure flow. This input routine, which requires about 50 more bytes than a conventional BCD-input scheme, discerns between digits 7, 8, and 9 by changing line C to an output and testing for a short between A, B, and C of the thumbwheel switch.

are shorted together, a 9 is indicated. Thus, using the I/O ports for output and testing for shorted lines, the CPU can acquire decimal information on only three lines.

Figure 2 shows the flow diagram of the procedure used to determine the position code of the switch. Coding on three lines increases the input routine of the central processing unit from 10 to about 60 bytes, depending on the microprocessor used.

Calculator notes

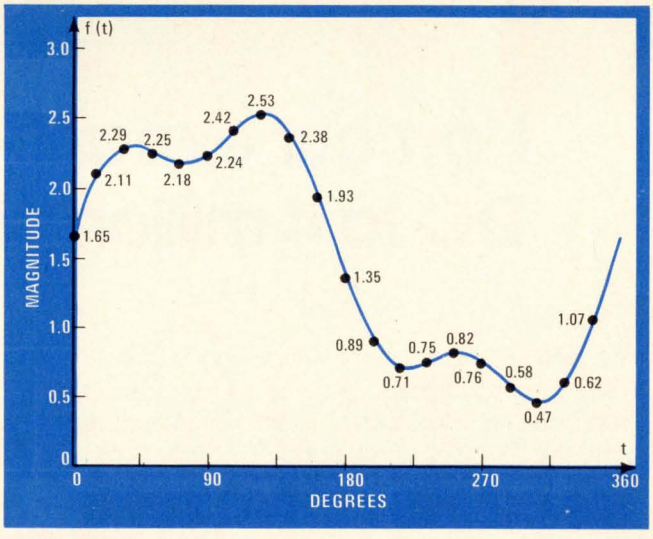
Program analyzes spectrum of oscilloscope waveforms

by Alan D. Wilcox
Walter Kidde & Co., Charlottesville, Va.

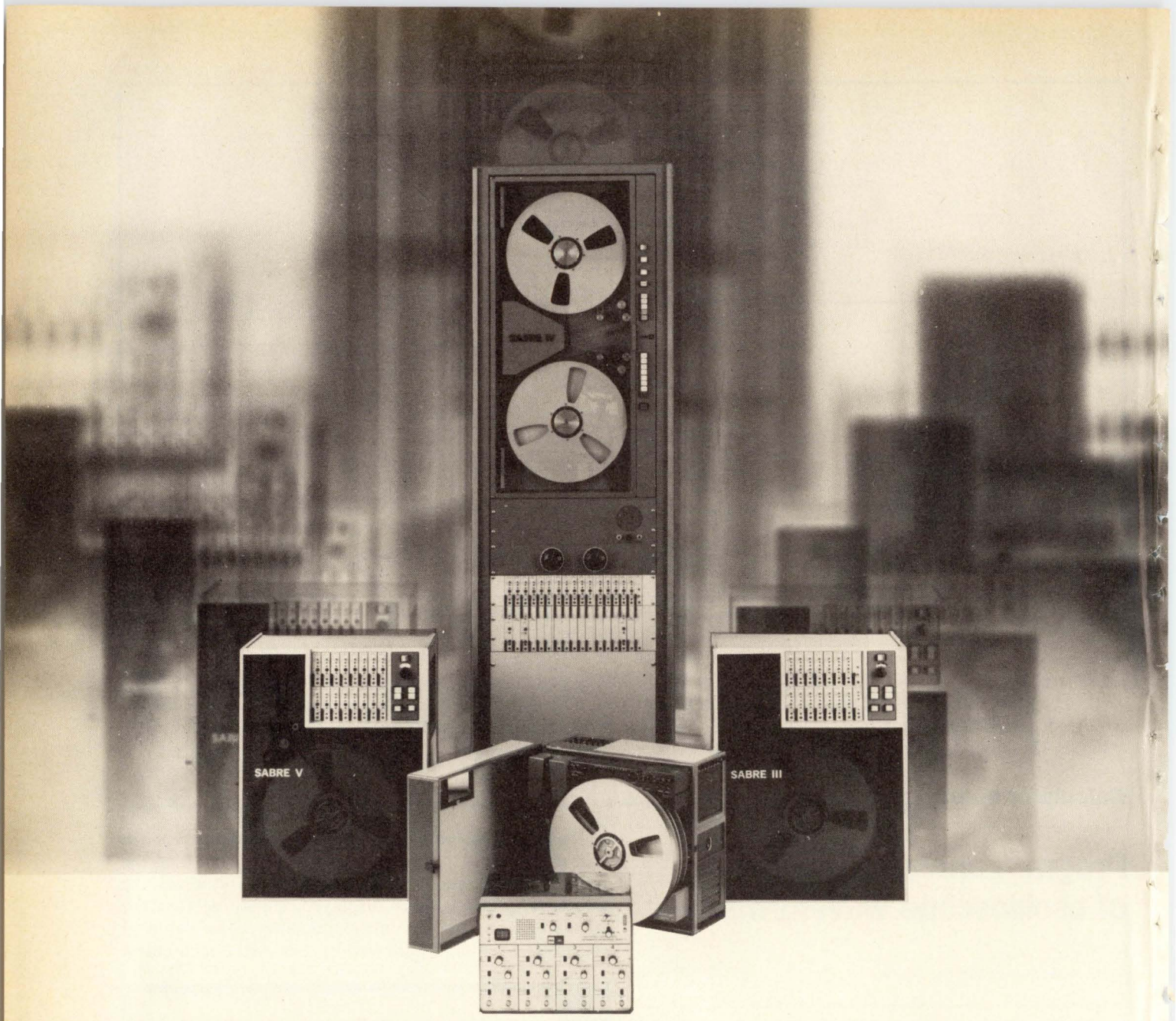
Thanks to Fourier, 19th century scientists knew that any periodic wave shape can be described by a series of harmonically related sinusoidal components of varied amplitude and phase. Thanks to Fourier and this HP-25 program, you can perform spectral analysis accurately on any waveform displayed on an ordinary oscilloscope.

The analysis is straightforward. A number of equally spaced data points are taken from the waveform displayed on the scope's screen—the more points, the better the accuracy. A good guide, from sampling theory, states that accurate representation of a waveform requires sampling at a frequency at least twice as high as that of the waveform itself. If accuracy in the 10th harmonic is required, at least 20 points must be taken. But avoid sampling at exactly twice the highest harmonic to be calculated, as for example, 10 points to calculate the fifth harmonic. In such cases, the high-frequency sine wave would be repeatedly sampled at the same point on its curve.

Spectral analysis begins with an HP-25 programmed as shown in the table. Next, key in the number of the desired harmonic, [J], followed by ENTER↑, and then the number of data points [N]. Keying R/S initializes the procedure, and 0.0000 is displayed, signalling that the calculator is ready for data-point entry. The value at each point is entered, followed by R/S. After each entry,



Oscilloscope display. A typical scope waveform is shown with data-point values that could be measured off the graticule. These data points, once entered into a suitably programmed HP-25, can yield accurate spectral information.



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HP-25 FOURIER ANALYSIS PROGRAM

LINE	CODE			KEY	COMMENTS
01	14	33		f REG	initialization
02	14	11	04	f FIX 4	
03	15	32		g DEG	
04	23	01		STO 1	
05	03			3	
06	06			6	
07	00			0	
08	71			÷	
09	15	22		g 1/x	
10	23	06		STO 6	
11	22			R↓	
12	23	00		STO 0	
13	00			0	
14	74			R/S	Repeat calculation for each f_i
15	23	02		STO 2	
16	24	05		RCL 5	$i-1$
17	24	00		RCL 0	J
18	61			X	
19	24	06		RCL 6	T
20	61			X	
21	23	07		STO 7	$T \times J\ (i-1)$
22	14	05		f COS	
23	24	02		RCL 2	
24	61			X	
25	23	51	03	STO + 3	accumulate A
26	24	07		RCL 7	
27	14	04		f SIN	
28	24	02		RCL 2	
29	61			X	
30	23	51	04	STO + 4	accumulate B
31	01			1	
32	23	51	05	STO + 5	
33	24	01		RCL 1	
34	24	05		RCL 5	
35	14	61		f $x \neq y$	
36	13	14		GTO 14	display i
37	14	74		f PAUSE	display last $i = N$
38	24	03		RCL 3	
39	24	04		RCL 4	
40	15	09		g → P	
41	02			2	
42	61			X	
43	24	01		RCL 1	
44	71			÷	
45	74			R/S	display $\lvert C_N \rvert$
46	13	01		GTO 01	

INSTRUCTIONS:

- Key in program.
- Enter harmonic number: *[J], ENTER↑*
- Key in number of data points: *[N], R/S*
- Input value of function: *[f_i], R/S*
- After last input, f_N, magnitude is displayed.
- Exchange x and y registers to display phase: $x \rightleftarrows y$
- For next harmonic, press *[J], ENTER↑*, etc.

REGISTERS	
R_0	J
R_1	N
R_2	f_i
R_3	A
R_4	B
R_5	i
R_6	$T = 360/N$
R_7	$T \times J\ (i-1)$

NOTE: $J < N/2$ REQUIRED

the index (i) of that value is displayed. Once the last data point ($i = N$) is entered, the program automatically solves for and displays the magnitude of the Jth harmonic. The phase angle, located in the y register, is displayed by exchanging the contents of the x and y registers.

Fourier analysis tells us that we can represent a function $f(t)$ in a way best suited to spectral calculations by the infinite series:

$$f(t) = a_o + \sum_{n=1}^{\infty} c_n \cos[(2\pi nt/T) + \theta_n]$$

where $c_n = (a_n^2 + b_n^2)^{1/2}$, $\theta_n = \tan^{-1}(-b_n/a_n)$, and T is the period of the fundamental wave, which for our purposes will be normalized to unity. Coefficient a_o is simply the dc component of the signal, found by taking the average of the function over a single period. Coefficients a_n and b_n are found by integrating:

$$a_n = 2\int_0^1 f(t)\cos(2\pi nt)\,dt$$

$$b_n = 2\int_0^1 f(t)\sin(2\pi nt)\,dt$$

Program efficiency is realized by approximating the integrals using the trapezoidal rule:

$$\int_0^T f(dt) \approx \sum_{i=1}^{N} 1/(2N)[f(t_i) + f(t_{i+1})]$$

The coefficients may then be found by the summations:

$$a_n \approx 2/N \sum_{i=1}^{N} f(t_i)\cos[2\pi n(i-1)/N]$$

$$b_n \approx 2/N \sum_{i=1}^{N} f(t_i)\sin[2\pi n(i-1)/N]$$

where, since $t_1 = 0$, the t_i become $(i-1)/N$.

A typical problem might be to determine the level of the third harmonic in the waveform shown in the figure. To do so, it is necessary to measure at least seven equally spaced data points, but preferably 10 or 20 points for greater accuracy. The 20 points are entered into the program and yield a third-harmonic component that has an amplitude of 0.3 and phase shift of 30°. Using the data points, you can calculate the amplitude and phase of the second and other harmonics as well.

In addition, the HP-25 enables easy calculation of the rms values of the harmonics. The total rms value, V_{rms}, is the sum of the dc component a_o and the ac component, $V_{rms(ac)}$. These values are related by the equation:

$$V_{rms} = (a_0^2 + V_{rms(ac)}^2)^{1/2}$$

and can be found using the statistical firmware:

- Enter each data point and hit the $\Sigma+$ key.
- Obtain a_0 by pressing $\bar{x}$.
- Since register R_6 holds the sum of the squared values, and R_3 holds the index, obtain V_{rms} by taking the square root of the quotient R_6/R_3.

The actual function of time used to generate the waveform in the example is:

$$f(t) = 1.5 + \sin(t) + 0.3\,\sin(3t + 30°)$$

Note that, since the waveform is symmetrical about its dc level, it necessarily contains no even harmonics. □

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.

Engineer's newsletter

String of diodes sets new hysteresis

A few diodes and a resistor will easily adjust the hysteresis of any Schmitt trigger, says M. S. Suresh of Bangalore, Ind. The voltage drops across diodes added to the input circuit do the job, independent of the upper trip point. A diode (or string of diodes) that has its cathode connected to the Schmitt input sets the upper point. **Then the lower one can be set to any lower number of diode voltage drops by placing another diode (or string) in inverse parallel across its upper-trip-point counterpart.**

However, there's a trick to getting different current paths for upper and lower points: connect a feedback resistor on the order of a megohm or so from the Schmitt trigger's output back to between the Schmitt input and the parallel diode network. Then the trigger's on/off condition will either forward- or reverse-bias the upper-trip or lower-trip diode strings. Zeners may be used in place of longer diode strings, of course.

The only point to keep in mind, adds Suresh, is that the output impedance of the signal source should be very much less than the feedback resistor. In most applications, this is no problem.

Counter/monostable combo gets back to 0 easily

Getting a decade counter to initialize to 0 when the power goes on is easy, says Barton A. Gravatt of Newfield, N.Y. Simply connect the counter's reset input to the Q output of a retriggerable monostable, such as the 74123. Then connect the +5-volt supply to the monostable's positive-transition triggering input. Use a 1-second RC time constant at the monostable's external R and C terminals. **When power is applied to both devices, the Q output will not go high for a second, avoiding contact bounce and resetting the counter.**

Getting more from your spectrum analyzer

If you've discovered there's more to spectrum analyzers than simple display of frequency spectra, you'll be interested in three application notes from Hewlett-Packard. They tell how to use the spectrum analyzer **to measure distortion, field strength, and noise figure.**

The distortion-measurement note (AN 150-11) describes harmonic and intermodulation distortion and explains the concept of intercept point in measuring intermodulation distortion. The field-strength note (AN 150-10) discusses antenna calibration factors and gives an example of measuring the field strength emitted by a garage-door opener. The noise-figure note (AN 150-9) describes a technique that, although perhaps not as precise as conventional noise-figure meters, allows frequency-selective noise-figure measurements without a calibrated noise source. Write to the Inquiries Manager, Hewlett-Packard, 1501 Page Mill Rd., Palto Alto, Calif. 94304

Get a jump on Uncle Sugar

It will soon be time again to calculate your income tax. One aid you might find worthwhile is the 1977 Tax Guide for Engineers, which has over 200 pages showing engineers how to save money on their taxes. The book reviews recent changes in tax law and explains several legal means of making the best of the tax bite. **The publisher guarantees that if you don't save at least $100 on your taxes, you may return the book within 30 days for a refund.** It's available from Academic Information Service Inc., P.O. Box 31391, Washington, D.C. 20031, for a (tax-deductible) $14.95, plus 85¢ for postage and handling.

Stephen E. Scrupski

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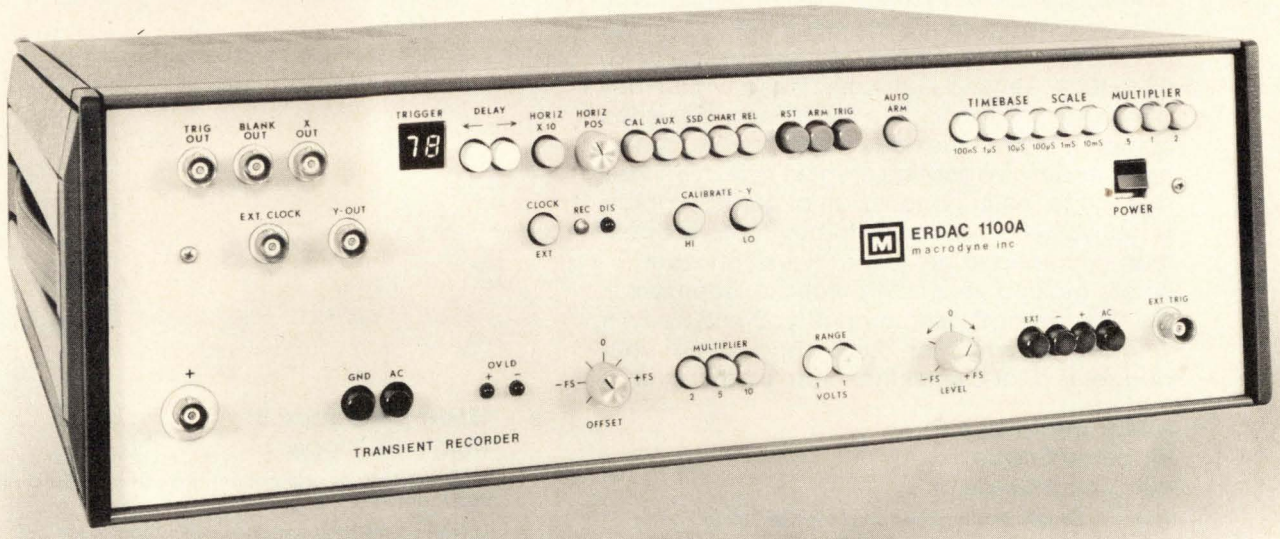

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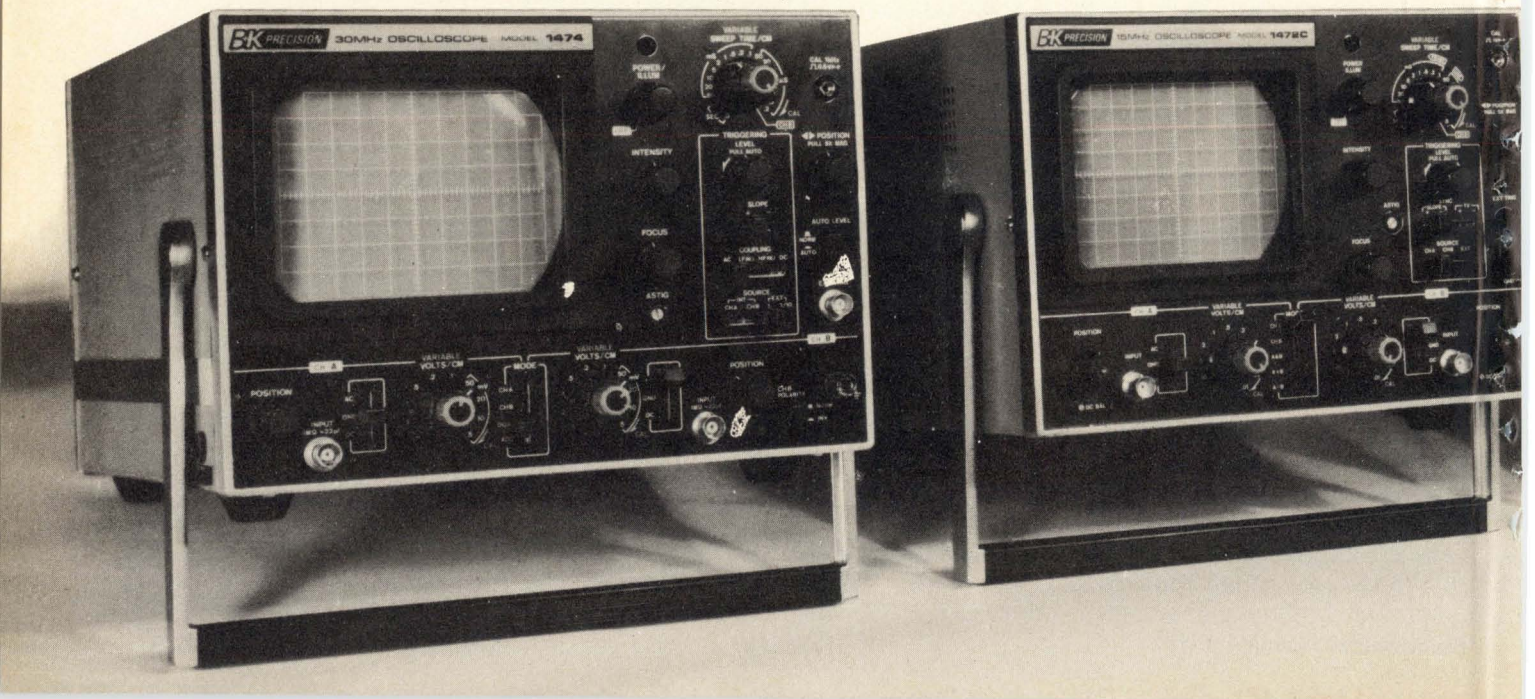

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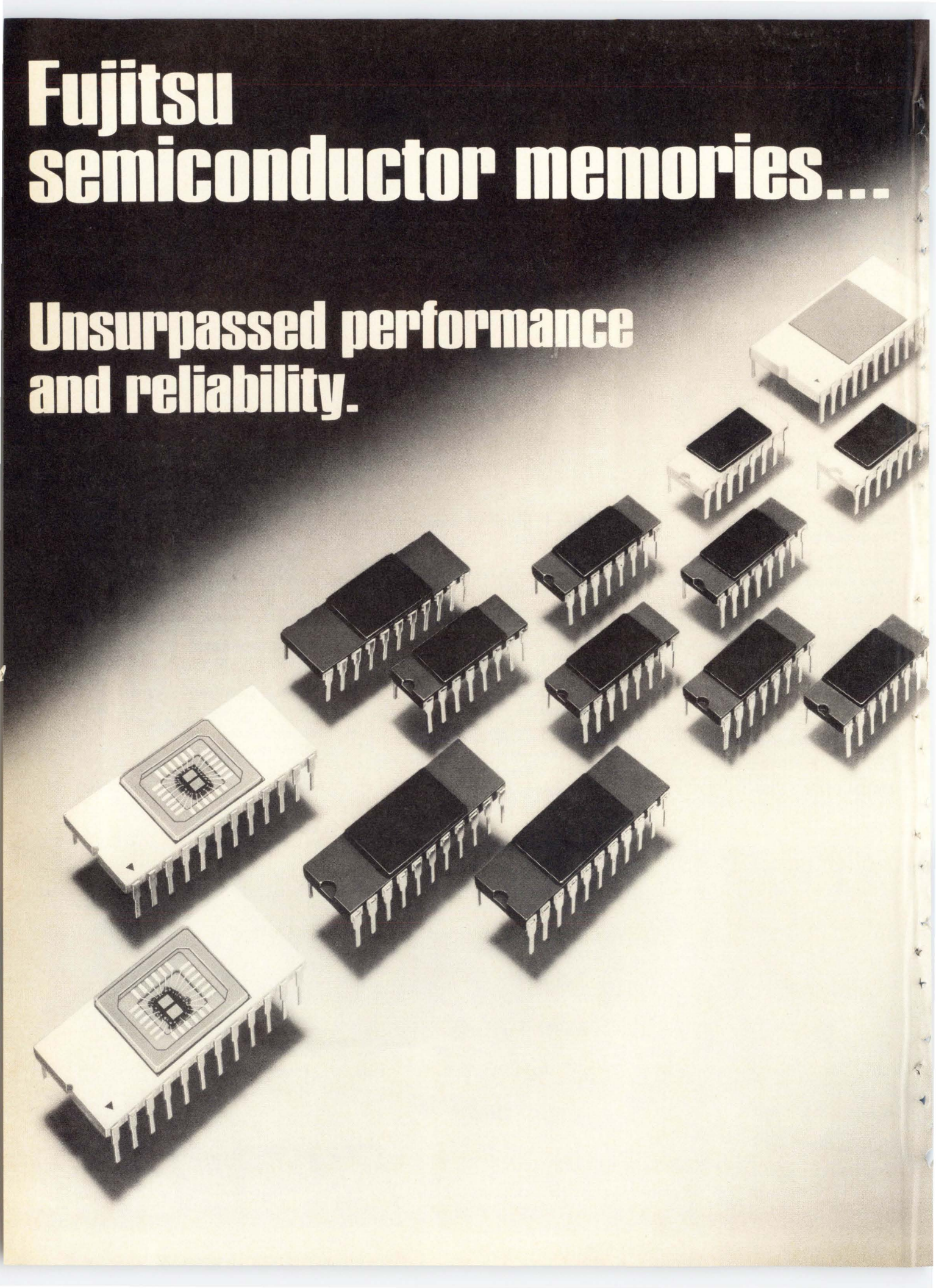

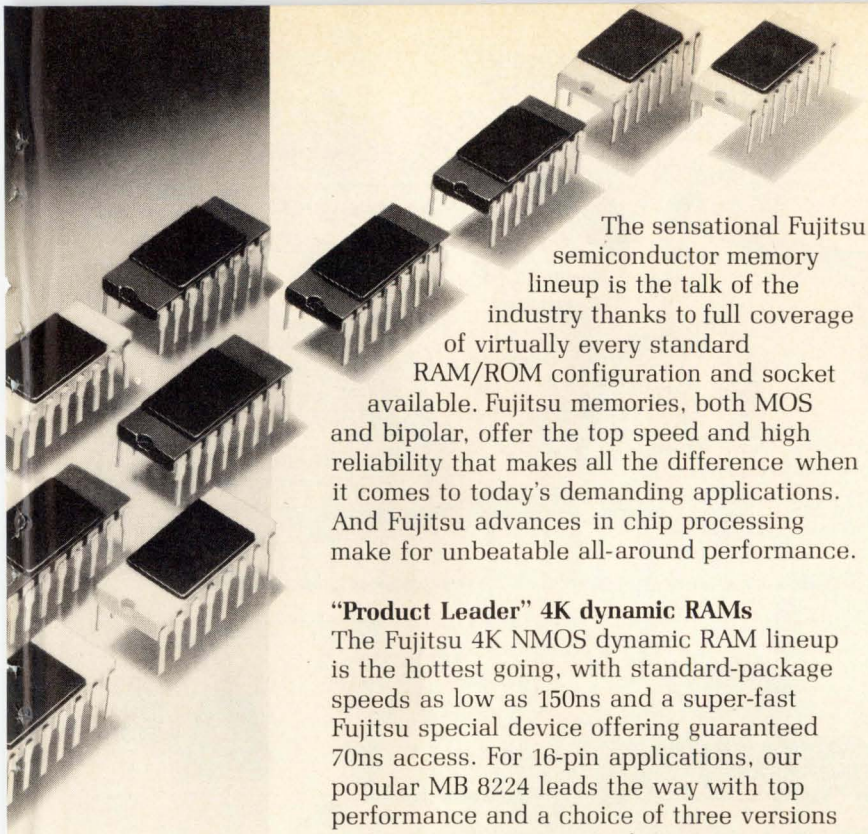

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The Fujitsu 4K NMOS dynamic RAM lineup is the hottest going, with standard-package speeds as low as 150ns and a super-fast Fujitsu special device offering guaranteed 70ns access. For 16-pin applications, our popular MB 8224 leads the way with top performance and a choice of three versions with access to 200ns. And more is coming, with our MB 8227 device (featuring gated $\overline{CAS}$ and page mode as standard) to be available in the near future. The MB 8107 is our 22-pin package "leader", offering four versions to 150ns. And when it comes to super-fast 4K applications, the Fujitsu MB 8215 wins running away; you get access times of 100ns and 70ns to choose from, and a great speed-power product for economical operation. Yes, Fujitsu 4K dynamic RAMs win the speed race "hands down".

Full-coverage 1K static RAMs
The Fujitsu 1K static RAM lineup is now bigger than ever. For high-speed sockets, the MBM 2115/25 devices give you superior 16-pin product selection with both open-drain and 3-state outputs available—and with access times as low as our soon-to-be-available 45ns version. The MB 8101/11/12 chips second-source the industry-standard 22/18/16-pin devices, respectively, and with two versions each to choose from. Fujitsu 1K statics—coverage and performance to meet your exact memory needs.

Ultra-fast bipolar lineup
Fujitsu bipolar RAMs are available in standard bit sizes from 128-bit to 1K, and offer the speed advantages of DOPOS and fine-pattern processing. The Fujitsu MB 7047 (128-bit) ECL memory, with 14ns guaranteed access time, is typical of our high-performance bipolar devices. You also have a choice of any of six other devices including our 15ns 256-bit ECL RAM (the MB 7042), our 35ns 1K ECL device (the MBM 10415A), and our 45ns 1K TTL memory (the MBM 93415A).

Two-speed 8K EROM choice
The Fujitsu MB 8518 8K EROM, with two speed versions for greater selection convenience, is the chip everyone's looking for. Fully UV erasable, and pin-for-pin compatible with your present device, the high-performance MB 8518 makes for superior experimentation and fast turn-around. And as part of our "total support" program, we also have the MB 8308 mask programmable 8K ROM (also with two speeds) for systems initially developed using the MB 8518.

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Superior Fujitsu technology gives you the top PROM lineup available today. You get wide coverage (four bit sizes to 4K), both pull-up and 3-state output versions, fast access times, and much more. And Fujitsu PROMs are the first to offer guaranteed 98% (typically 99%) programmability thanks to our unique testing after packaging.

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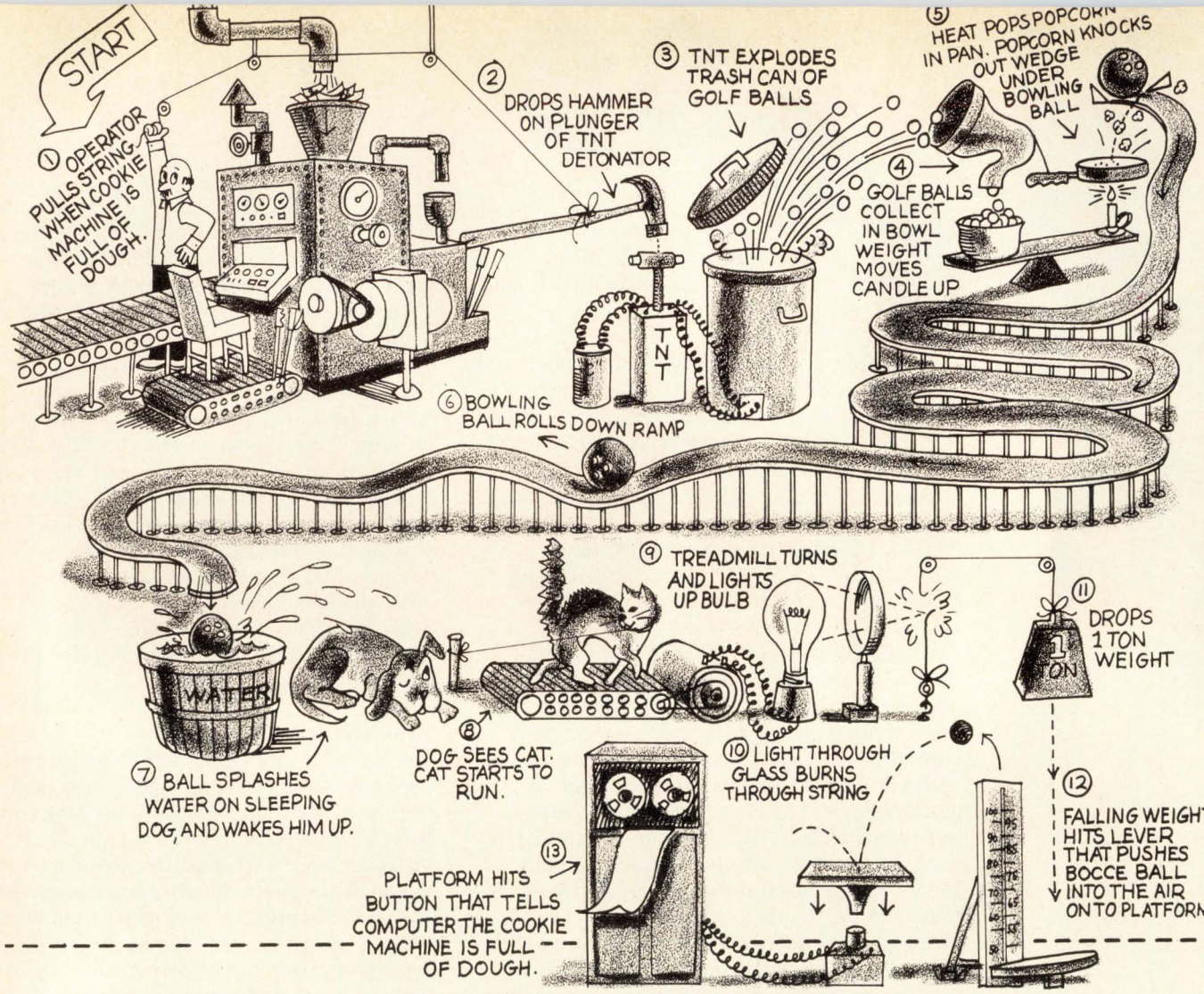
Communications and Electronics

Circle 127 on reader service card



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ICs streamline plasma-display units

Microprocessor-controlled terminals, designed as 'second-generation' peripherals, are reduced in size, price, and electrical complexity

by Larry Waller, Los Angeles bureau manager

Although compact, light-weight plasma-display terminals have been available since 1971, their high cost has limited them primarily to dedicated military applications. Besides the price of up to $30,000 each, another barrier to expanded use has been a complex and bulky electronics package, implemented with discrete components.

However, Interstate Electronics Corp. of Anaheim, Calif., has spent a year in developing a family of four plasma terminals that the firm calls the "second generation," since they are generally smaller, cheaper, and perform better than earlier models.

After delivering about 35 first-generation plasma terminals to military customers in its three years in the business, Interstate's redesign goal was to come up with a general-purpose computer-peripheral display. "It is meant to be a mass-market product, rather than a one-shot dedicated version," says Les Turner, applications manager of the project. "That's why we took the family approach, rather than concentrating on a single product." (A rack-mounted and a desktop model are shown in the photo.)

Turner calls the changes in the second-generation terminals "both obvious and subtle." Most apparent is the circuitry redesign and replacement of more than 4,000 discrete parts with fewer than 1,000 integrated circuits, mounted on only four boards. This permits a weight reduction, not including the keyboard, from 125 pounds to about 40 lb. or less for each terminal.

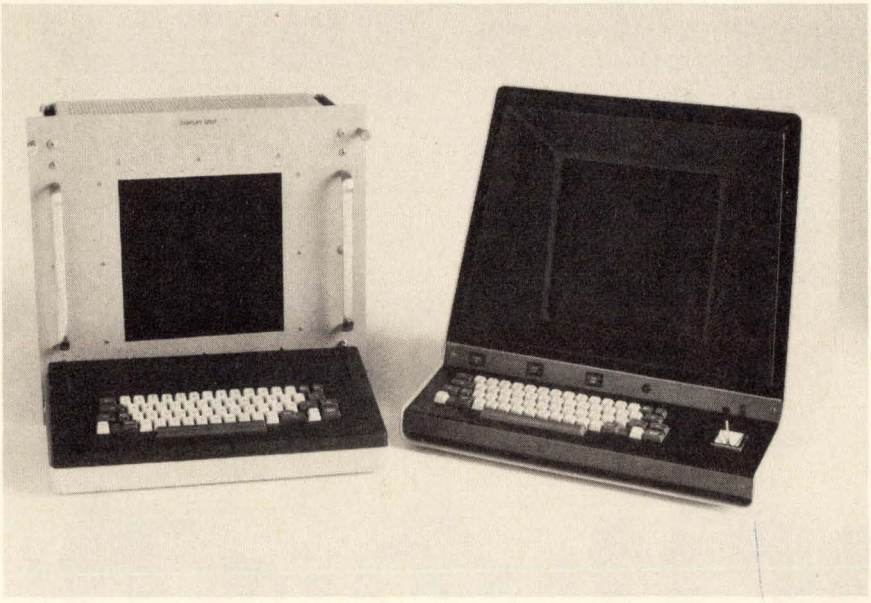
The dimensions have been cut significantly. The 10-inch depth of one model is only half that of previous displays. The width was shaved from 24 in. to either 18 or 13 in., depending on the model, and the height was reduced from 20 in. to either 19 or 14 in. In addition to cutting size and weight, the simplified design and fewer parts allow more efficient assembly techniques, such as flow-soldering, and therefore lower cost, Turner points out.

The subtle improvements were made in the three redesigned electronics elements. The principal one is employing a single sustainable waveform voltage, rather than the dual voltages used in the past models. This cuts by about 70% the number of components required in the logic control of the waveform-generation function, Turner says. In developing the new family, engineers recognized that a single variable voltage to only one coordinate of the display matrix could generate and sustain alphanumerics and graphics on the panel face. The company calls this advance important because it eliminates the synchronization problem involved in handling two complex high-frequency waveforms.

In the function of driving the 512 matrix points that are illuminated on the display face, Interstate has substituted IC chips that each drives four points for the 512 diode-transistors previously required. Texas Instruments, which supplies these chips, is now working on 32-point drivers as a further improvement.

Redesigning the power supplies for the terminal was a significant task because nine different voltages were needed, up to 195 v for igniting the neon gas inside the panel sandwich. The existing design used linear supplies that were only 40 to 50% efficient, a characteristic that was improved to 80%, with all supplies contained on one board.

For microprocessor control, Inter-



New products

state settled on the AMD 2901 4-bit slice whose 330-nanosecond execution time allowed a configuration producing what Turner calls the "fastest-writing terminal on the market." The need for speed is in generating graphics. For the 5-by-7-in. unit, the rate is 8,333 characters a second; for the 7-by-9-in. model, 6,250 characters a second. Each terminal uses 12 microprocessor chips.

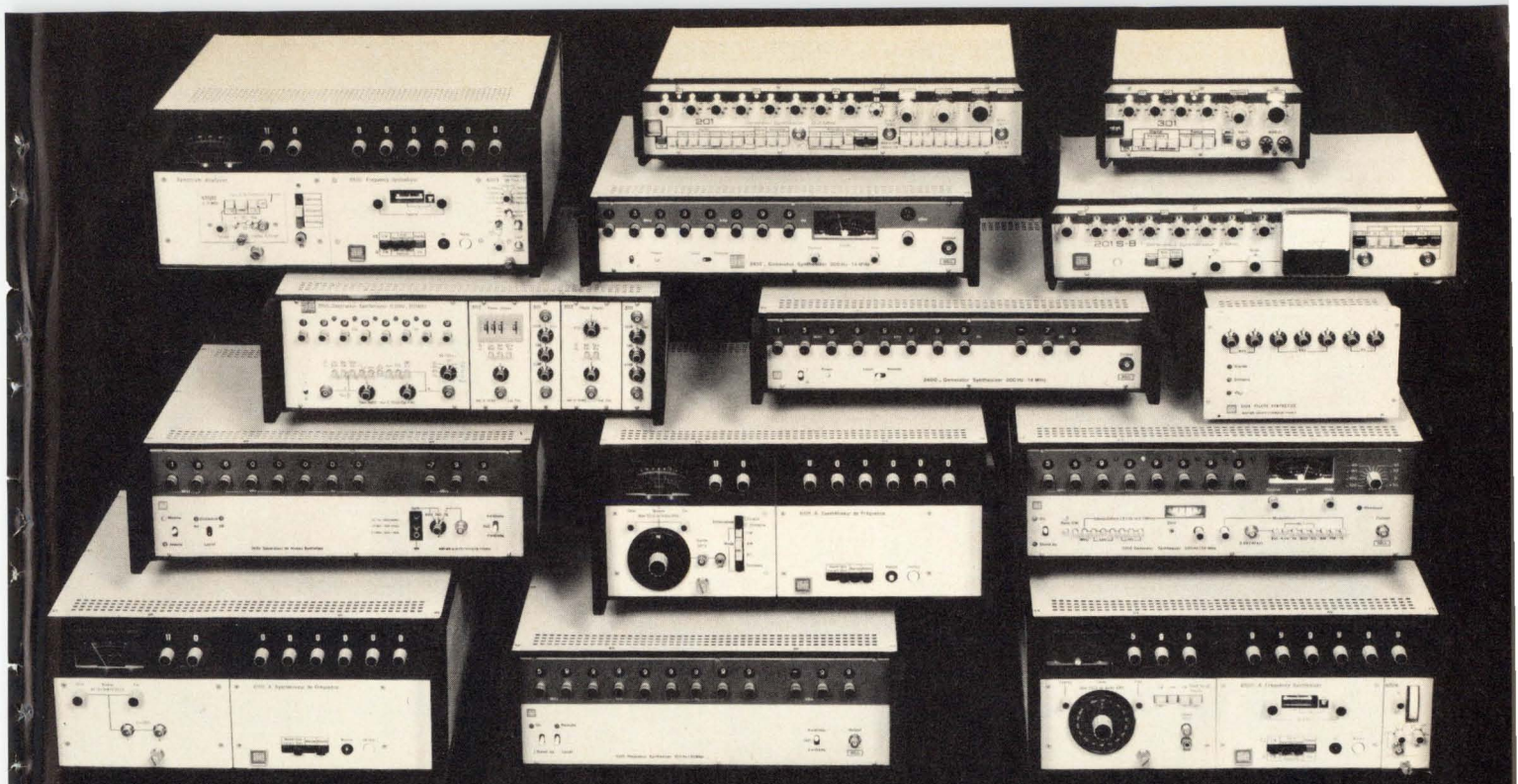
Faster operation includes doubling the data-transfer rate over the first-generation rate to 19,200 bauds, an advantage in time-sharing since the "computer can dump data fast and get off," Turner points out.

Varied usage. The new Interstate family is divided into units for commercial and for military use. At $8,900, the low-end PD1000 terminal is a commercial product intended for such applications as computer laboratories. The next step up, the PD2000, uses a combination of commercial and military-screened parts for more stringent environments. The two top terminals, the PD3000 and PD4000, are higher-priced, with the top-of-the-line PD4000 fully qualified for military environmental requirements and selling for $16,000. These two units also are smaller, 13 in. wide by 11 in. deep by 14 in. high. The lower-cost models measure 18 by 10 by 19 in.

Interstate expects production models of the new family to be available in March, with orders requiring about 90 days to fill. Turner says that marketing of the new family of plasma displays as general-purpose computer peripherals required development of extensive software and graphics packages. These represented about 10% to 15% of the total budget.

The four-model family is designed to be compatible with the PDP-11 minicomputer. Its modular design permits interchangeability, and design simplicity ensures that no adjustments need be made by the user.

Interstate Electronics Corp., Subsidiary of ATO, 707 Vermont Ave., P.O. Box 3117, Anaheim, Calif. 92803. Phone (714) 772-2811 [338]



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Series 2400.	A frequency and level generator. Three versions cover a range from 300 Hz to 18.6 MHz. There's a choice of output impedance and offset frequency for selective measurements.
Series 200.	Two versions, for systems and general use, cover the frequency range from 0.1 Hz to 2 MHz.
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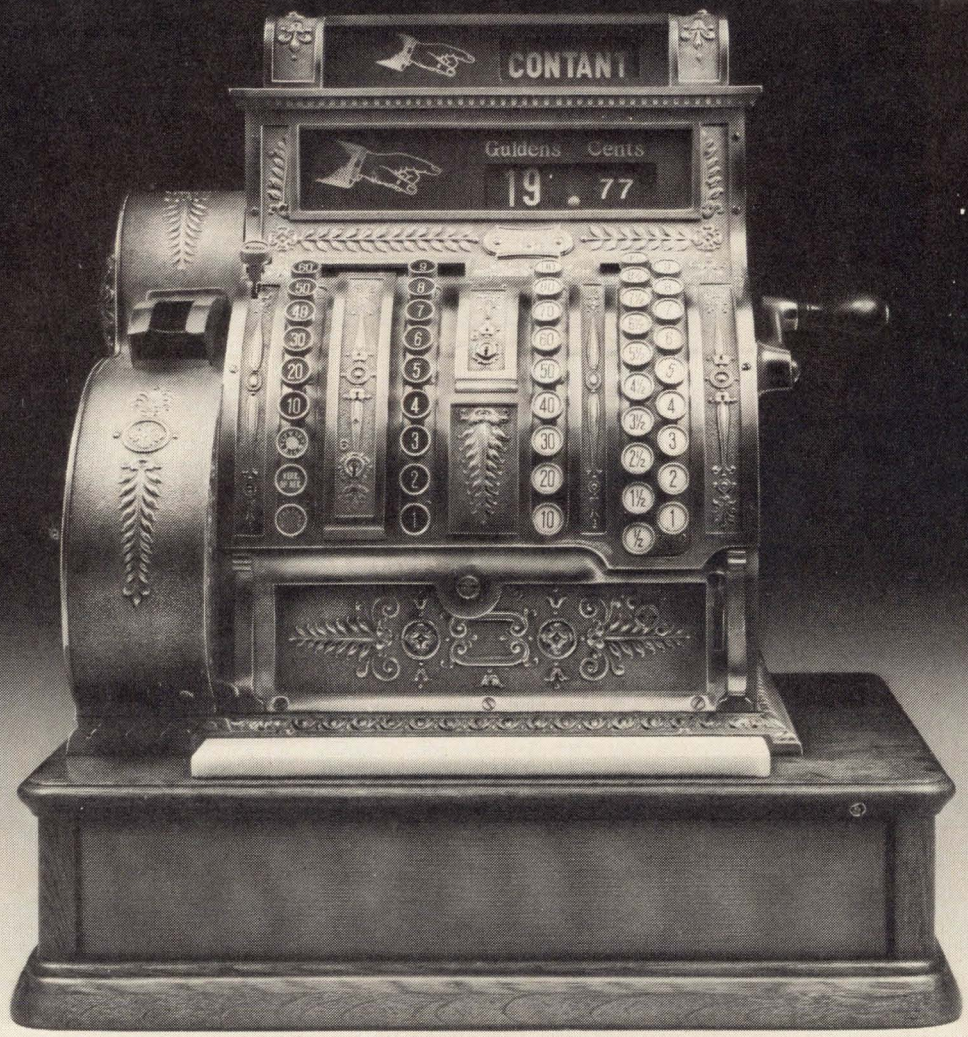

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Today's market demands a labour-saving integrated system for recording sales data. A complete system in which data are automatically registered on cassette at the point of sale. The Philips Data Logger is a vital part of such a system.

The Philips Data Logger is based on the Philips digital cassette recording system which is already proved in many different data-recording applications, and meets ECMA-34 specifications.

The Data Logger can be interfaced with electronic cash register systems currently in use or under development. Sales data recorded on cassette can conveniently and economically be processed by computer to meet all accounting requirements.

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Digital Recording Department HBS-2
Eindhoven The Netherlands
Tel 040-756935 or 757461

Instruments

ECL speeds up signal capture

Emitter-coupled logic in waveform recorder boosts processing rate

Looking to maintain a strong position in a market in which it pioneered, Biomation Inc. has introduced what it calls the industry's fastest waveform-transient recorder, the 500 megahertz model 6500. This kind of instrument records analog single-shot transients or signals as a function of time, converting the information to digital data and storing it in a memory.

Unlike a standard oscilloscope, the model 6500 can record the signal preceding the trigger point, an important feature in applications ranging from shock tests to capture of radar return pulses. This pretrigger capability ensures recording of the leading baseline and rise of a signal without the need for an external delay line. The real-time conversion and storage enables the capture of a large range of signals including one-time events.

Previous waveform recorders, including Biomation's model 8100, used standard transistor-transistor logic, metal-oxide-semiconductor shift registers, and linear bipolar technology. Therefore, they were limited to conversion rates up to 100 MHz and bandwidths of about 25 MHz. High-speed emitter-coupled logic in the model 6500 enables Biomation to increase the conversion rate fivefold to 500 MHz and to about quadruple the bandwidth to 100 MHz. The model 6500 has a 6-bit analog-to-digital converter made up in part of 64 ECL-based comparator circuits, and the converter is combined with a 6-bit-by-1,024-word memory made of high-speed 256-bit ECL random-access memories.

Arm and trigger controls and selectable record mode and sample interval allow the user considerable latitude in controlling the recording process. Lever-wheel switch adjustments for arm and trigger delays produce convenient trigger holdoff and delayed sweep. A dual time-base mode allows selection of two internal sample intervals for recording.

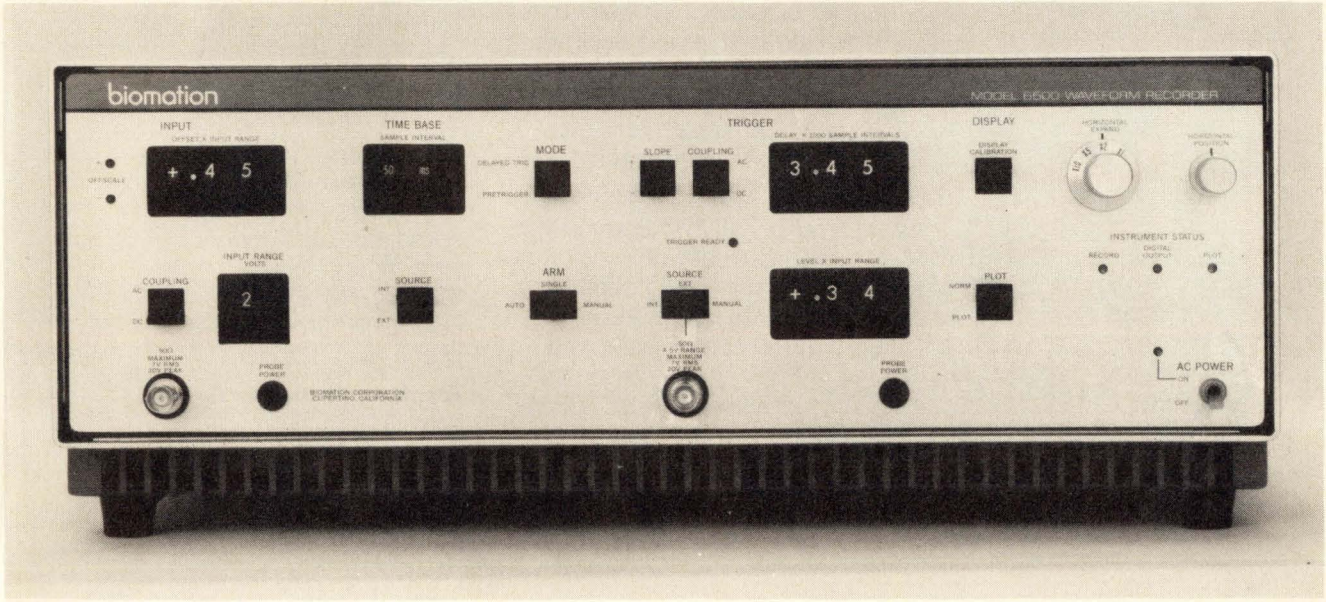
The stored information can be presented in one of three ways. A repetitive analog reconstruction of the stored signal is available, along with an appropriate sweep ramp and a retrace blanking signal. This produces a steady analog presentation on a CRT display or a bench oscilloscope. Alternatively, the analog reconstruction may be produced at a very slow rate for generation of hard copy on a strip chart or other recorder. Finally, the digital information can be extracted via an asynchronous data output when interfaced to a computer or mass-storage device.

Input impedance is 50 ohms, single-ended, and sample intervals may be selected externally or internally from 2 nanoseconds to 1 second. Five selectable input ranges—0.25, 0.5, 1.2 and 5 volts—full scale, are provided. A trigger delay is proportional to sample interval and selectable via three decade switches to 9990 sample intervals in increments of 10. Measuring 6.25 by 17 by 19 inches, the model 6500 is tentatively priced at $12,000.

Biomation, 10412 Bubb Rd., Cupertino, Calif. 95014 [351]

400-MHz storage scope writes 2,500 cm/μs

The high speed of the model 7834 400-megahertz storage oscilloscope, which writes at a maximum rate of 2,500 centimeters per microsecond, allows it to capture single-shot rise times as fast as 1.4 nanoseconds. When signals are repetitive, the scope can measure rise times that



People are beginning to see the light...

Corning is helping them do it!

Today, compact electronic panels are being used to display alphanumeric information on auto dashboards, airplane cockpits, POS terminals, and in many other areas where CRT's were used.

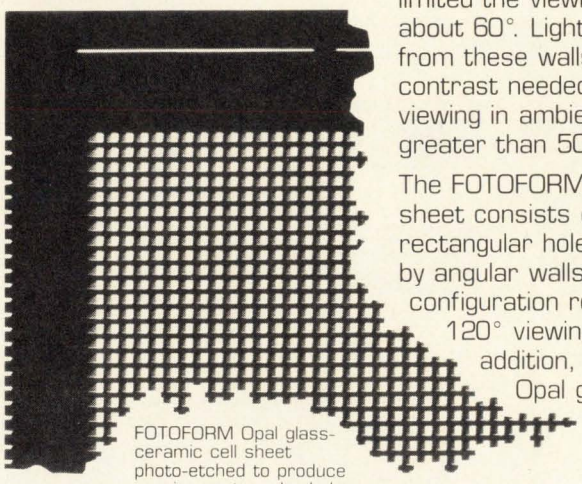
Problem: The numbers and characters must be clearly visible from a wide viewing angle under a variety of lighting conditions.

Corning FOTOFORM® Opal, a glass-ceramic, helped solve the problem.

FOTOFORM materials can be chemically machined to produce holes and channels of almost any size and shape, with precise tolerances of ±0.001 inch. And they have excellent electrical properties. Engineers at the Electronic Components Division of Burroughs Corporation took advantage of these characteristics to produce the new Self-Scan® panel displays.

Previously, a white material with limited machinability was used. The round gas cells had straight, high walls that limited the viewing angle to about 60°. Light reflections from these walls limited the contrast needed for good viewing in ambient light greater than 50 footcandles.

The FOTOFORM Opal cell sheet consists of rectangular holes separated by angular walls. This configuration results in a 120° viewing angle. In addition, FOTOFORM Opal glass-ceramic is dark in color which improves the contrast of the display.



FOTOFORM Opal glass-ceramic cell sheet photo-etched to produce precise rectangular holes.

Result: The information displayed on the Self-Scan panel is clear and sharp through a wide range of lighting conditions.

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For details about this application, and more information about FOTOFORM and FOTOCERAM materials phone or write:

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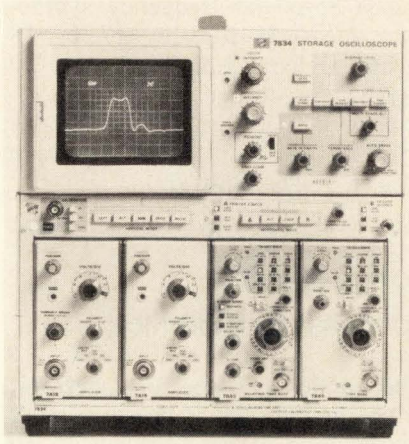
Corning Glass Works
Corning, New York 14830
(607) 974-8583

CORNING

are as short as 900 picoseconds.

The scope mainframe, which has four plug-in compartments, provides both variable-persistence and bistable storage modes. The 2,500-cm/μs writing rate is provided in the



variable-persistence mode only, and to achieve it, the scope must be operated with a reduced scan. In its bistable mode, the scope can write up to 350 cm/μs.

Among the capabilities that enhance the 7834's usefulness are a SAVE control, which prevents accidental erasure of the display while increasing viewing time up to 30 times, and an AUTOERASE control, which allows the display to be updated automatically at the end of an adjustable time interval. The 7834 mainframe sells for $6,900 and has a delivery time of 16 weeks.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97077 [353]

50-MHz logic analyzer ignores tiny glitches

An eight-channel logic analyzer with a maximum sampling rate of 50 megahertz can operate in a so-called true sampling mode that excludes all glitches that last less than one sample period. In this mode, the user can avoid being confused by unimportant spikes that occur in synchronous data streams. Like its 20-MHz predecessor, the model 20D, the model 50D can use almost any oscilloscope or X-Y display to present multiple-trace timing diagrams.

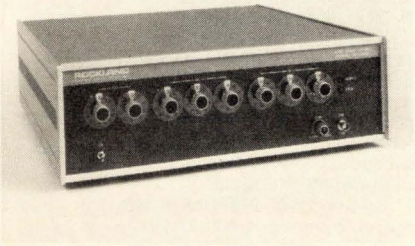
The model 50D contains two 4,096-bit memories, each of which is organized as 512 8-bit words. The two memories can be operated in a delayed mode so that the contents of one is a continuation of the contents of the other. For full 16-channel triggering and recording, two model 50Ds can be bused together, but the manufacturer is working on a factory-option retrofit that can upgrade a single 50D to 16-channel capacity.

Weighing only 18 pounds, the logic analyzer measures 4.5 by 8.5 by 14 inches and sells for $3,375. Delivery time is six weeks.

BP Instruments Inc., 10601 S. De Anza Blvd., Cupertino, Calif. 95014. Phone (408) 446-4322 [354]

Direct synthesizer spans 160 MHz; sells for $5,000

Priced at only $4,975, the model 5600 direct frequency synthesizer covers 0.1 to 160 megahertz with a typical switching time of 20 microseconds. Intended for use in satellite-communications systems, high-frequency receivers, spectrum analyzers, and similar applications, the 5600 keeps its spurious harmonic outputs more than 35 dB below the



fundamental, and its close-in phase noise is typically more than 70 dB down.

Programmable either from the front panel or by remote digital control, the 5600 has a constant resolution of 1 hertz. A buffered

New products

reference-frequency output can synchronize other equipment, and the output amplitude can be controlled by one external analog signal. A gated buffer register on the programming inputs stores the last frequency setting.

The 35-pound frequency synthesizer measures 5.25 by 17 by 18 inches. Delivery time is stock to 30 days.

Rockland Systems Corp., 230 West Nyack Rd., West Nyack, N.Y. 10994. Phone David Kohn at (914) 623-6666 [355]

Low-cost pulser operates up to 50 MHz

The model 850 pulse generator, priced at only $465, provides pulse widths from 10 nanoseconds to 50 milliseconds, delays that cover the same range, and repetition rates as high as 50 megahertz. Normal and complementary outputs have adjustable amplitudes that can maintain from 250 millivolts to 5 volts across 50 ohms. The output can be offset up to ±2 v dc, or the offset can be completely disabled at the flick of a switch.

Dytech Corp., 2725 Lafayette St., Santa Clara, Calif. 95050. Phone (408) 241-4333 [356]

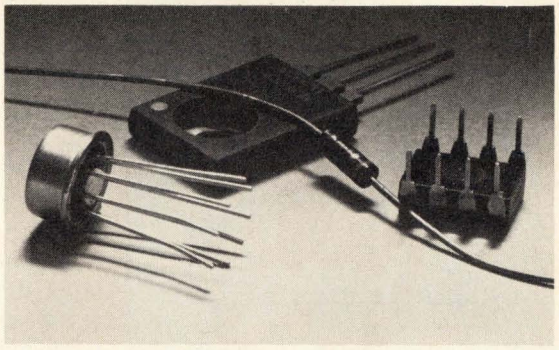
Two-channel active filter covers 0.02 Hz to 2 MHz

A versatile two-channel active filter that covers from 0.02 hertz to 2 megahertz can be operated in four modes: high-pass, low-pass, band-reject, and band-pass. In addition, each of the instrument's two sections can be switch-selected to act as either a Butterworth (maximally flat) or linear-phase filter.

Available options are: floating or differential inputs, battery operation, and greater than unity gain. Prices vary from $1,400 to $1,680; delivery time is two weeks.

A.P. Circuit Corp., 865 West End Ave., New York, N.Y. 10025. Phone (212) 222-0876 [357]

How a 2% IC failure can kill off 25% of your assemblies.



For example—if you produce 100 sub-assemblies that each takes 12 to 13 or more ICs, then with a 2% IC failure rate, you'll end up reworking 25 of those assemblies trying to find the 2 bad ICs.

The 2% is a typical rate to slip by a manufacturer's tests or your own in-coming screening. How come? A simple GO/NO GO test weeds out only the *dead-on-arrivals,* not those flawed ICs destined for *infant mortality.*

The way to find them quickly, economically, is through *preconditioning*—then testing.

With preconditioning procedures specifically tailored to your devices, we can condense a year's worth of stress on an IC down to less than a week.

Then we test.

And you stop reworking 25% of your assemblies.

Usually, a procedure we'll recommend will cut your failure rate down to about .3%. To reduce the rate further usually costs more than it's worth.

What can preconditioning and testing cost you? And what can it save you?

No two cases are exactly the same. But it's not hard for you to find out—because it's not that hard for our test analyst engineers to develop a recommendation for you.

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Free. Basic Handbook of Preconditioning and Testing Semiconductors

Here's your quick guide to some of the important ins and outs. It won't replace your need for experts—but it will certainly help you get the most out of them. Included: "Testing—how much, how little?" "The cost of testing vs. not testing." "How to test the test labs." And more.

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Semiconductor Testing

Packaging & production

Tester checks modules, cards

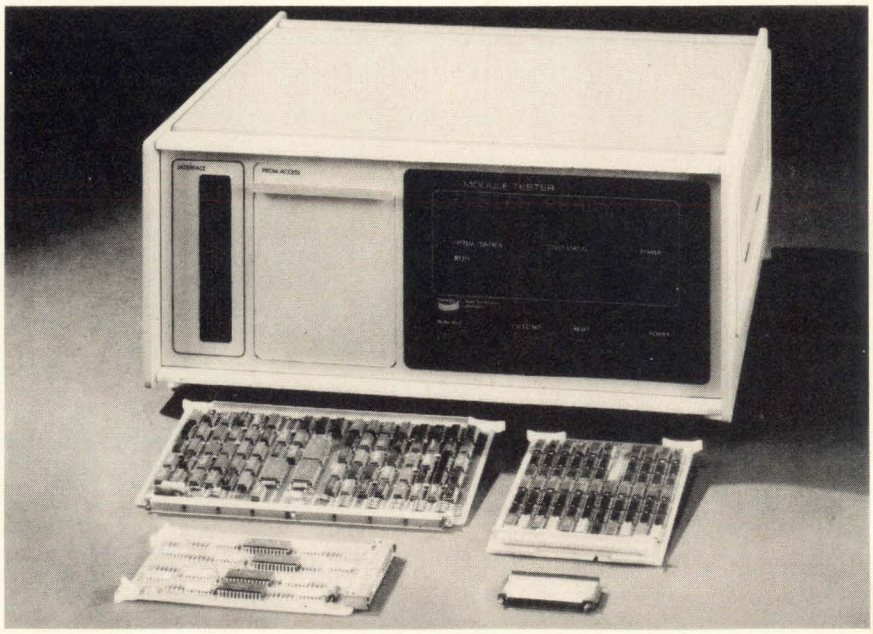
Microprocessor controls test sequence in portable, flexible troubleshooter

With the proliferation into the commercial/industrial marketplace of digital equipment such as point-of-sale and electronic banking terminals and electronic games has come a greater need for a low-cost instrument to do on-site troubleshooting and service testing of digital modules, hybrid circuit cards, ICs and large-scale-integrated chips. Bendix Corp.'s Test Systems division believes it can fill the bill with a portable, automatic, microprocessor-controlled module tester that will make its formal debut next month at Nepcon '77 West in Anaheim, Calif.

The module tester is the first "catalog" item for the division, heretofore a maker of $100,000 to $300,000 custom-engineered, computer-controlled test systems for military and commercial avionics. The tester uses both microprocessor and erasable, programmable read-only-memory (EPROM) technology to provide a small (18.6 by 18.8 by 7.5 inches), lightweight (30 pounds), flexible system that goes where the trouble is to accomplish on-the-spot testing. Familiarly called "Herbie," the instrument uses an Intel Corp. 8080 microprocessor to run the operating system, control the sequence of events, and maintain system performance by automatically testing itself every time power is turned on.

Test programs for the system are either provided by Bendix or generated by the user with the aid of Bendix's library of automatic test generation (ATG) programs. The library includes programs for changing pins, states, and levels, among other things, so that they are compatible with Flash, D-Lasar, and other standard ATG software packages.

The programs are stored on solid-state PROM cards to provide non-deteriorating, reusable data entry. However, an erasable PROM, Intel's 8,192-bit type 2708, is used so that programs can be changed by clearing with an ultraviolet light and reprogramming electrically in the usual way. The PROM card with the 2708 on it has a 5,120-word capacity, which can be doubled by use of a piggy-back card with a second 2708. This capacity will be doubled again



when 2708s with twice the memory become available later this year, says division marketing engineer Ted Schiffner. For very large test programs requiring greater memory, he notes, there is provision for a magnetic-tape cassette to plug in at the back.

The basic module tester, priced at $10,000, has an input/output capacity of 64 pins (channels), expandable to 256 pins in 32-pin increments at $1,000 per card. Each channel is compatible with C-MOS, diode-transistor logic, TTL and other 5-volt logic. Available in small quantities now and large quantities by late summer, the basic tester will perform go/no-go testing of digital cards, modules and devices, with a limited debugging capability. It has a 16-segment ASCII character-set alphanumeric readout. A second 2708 erasable PROM card plugs in to provide fault-isolation capability.

For extensive debugging, yet another 2708 would be used to enable the operator to get into an interactive mode and thereby create test programs on line.

The initial module testers offer digital test capability only but will have provision for expansion into hybrid testers via plug-in cards for voltage check, frequency counting, and other analog measurements—when these options become available later this year.

"We're targeting the module tester toward the military as well as the commercial/industrial market," Schiffner says. "We expect it to be used for testing cards and modules on Navy ships and at military depots where there's an increasing amount of digital equipment."

Bendix Corp., Test Systems Division, Teterboro, N.J. 07608. Phone (210) 288-2000 [391]

Plating modules speed up prototyping of pc boards

Many electronic manufacturers have the capability to make relatively simple single-sided printed-circuit boards in prototype quantities. How-

New products

ever, double-sided prototypes requiring plated-through holes often must be ordered on the outside, causing considerable delay.

But small, low-cost benchtop plating systems are now available from Proto-Plate Inc., and companies can use them to make their own plated-through pc boards. The new system consists of two plating modules, plus a complete package of chemicals for each. Boards up to 10 by 10 inches may be plated in the modules, which have complete instructions.

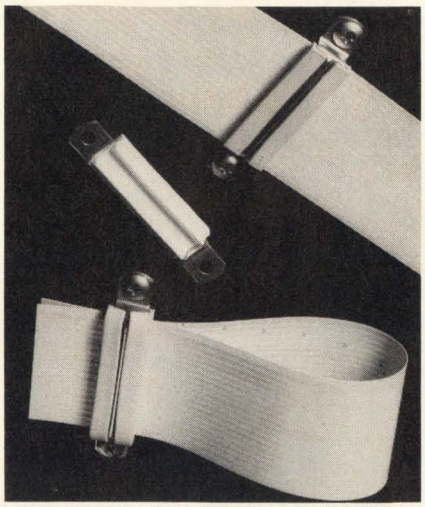
A user may choose between a completely electroless process (model 100) or a combination electroless/electrolytic process (model 100/101). Both models are completely portable. Each occupies less than 2 square feet of bench space and only requires a water source and 100 volts ac. Prices on the system range from $449 for the model 100 to $899 for the model 100/101 combination. Delivery is stock to two weeks.

Proto-Plate Inc., Box 3274, Allentown, Pa. 18106 [401]

Flat-cable clamp is self-extinguishing

As the use of flat cables becomes more widespread, a need is developing for a cable clamp that can meet key flammability specifications laid down by Underwriters' Laboratories and the Federal Aviation Administration. To meet this demand, TA Manufacturing Corp. has designed a unit with a metal frame covered with a self-extinguishing material instead of the usual plastic compound, which is reported to spread fire by dripping. Actually, two covering materials are offered: nitrile-butadiene and silicone rubber. The latter is a requirement in some military applications.

In addition to its fire-retardant properties, the new clamp is said to provide superior positive restraint. "We use a unique design that looks like a double windshield-wiper blade to provide positive restraint for even the most slippery cables," says Bob



Byerly, product manager. "It works whether the cable is made with round or flat conductors."

The clamps come in two versions—a two-piece type for holding cables away from a surface (model 08311) and a one-piece unit for clamping a cable onto a surface (model 08111). Both are available in 1- and 3-inch widths, and both operate from −65 to 400°F. A representative price, for lots of 1,000, is 35 cents each for the 3-in. one-piece clamp. Delivery is from stock to two weeks.

TA Mfg. Corp., A Viking Industries Co., 375 W. Arden Ave., Glendale, Calif. 91203. Phone (213) 240-4600 [392]

Modular signal source takes aim at automatic systems

A modular, programmable signal source designed for use in automatic test systems can act as a dc voltage source, a pulse generator, a high-performance function generator, and a frequency synthesizer. The basic SPG-800, which sells for $3,195, is both a programmable dc voltage source and a programmable function generator. The frequency synthesizer option adds $350 to its price, while the pulse generator adds either $295 (fixed rise and fall times) or $590 (variable rise and fall times).

Key features of the SPG-800 include field-installability to its plug-in options, frequency coverage

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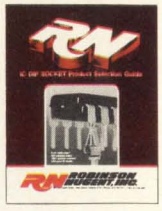
with these new ICL low-profile DIP sockets from Robinson-Nugent. Designed for high speed automatic assembly and maximum shock and vibration resistance. Has famous R-N "side-wipe" single leaf contacts, body meets UL94V-0 flammability rating. 8 thru 40 leads available.



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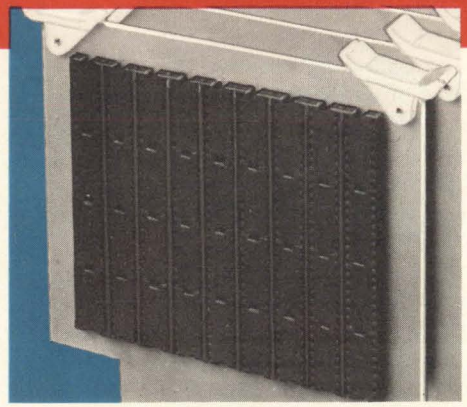
Send product information circle 175



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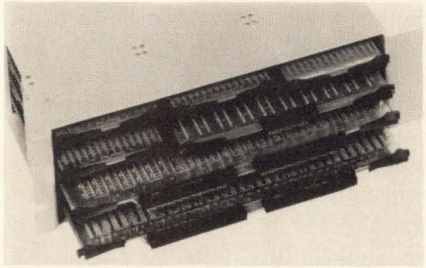
Interstate Electronics Corp., Dept. 7000, E. Vermont Ave., Anaheim, Calif. 92803. Phone Philip Brance at (714) 772-2811 [393]

Packaging system allows mixing of board sizes

A packaging system that permits the mixing of a variety of wrapped-wire panel sizes and IC densities in the same rack assembly can accommodate panels that contain from 32 to 192 ICs. Panels that range in size from 4.5 by 6.0 inches to 14.9 by 8.0 inches may easily be intermixed.

Each panel size or family is available with many IC socket-layout options, as well as multiple voltage supply planes. Some contain as many as four planes (including ground). The panels plug into three



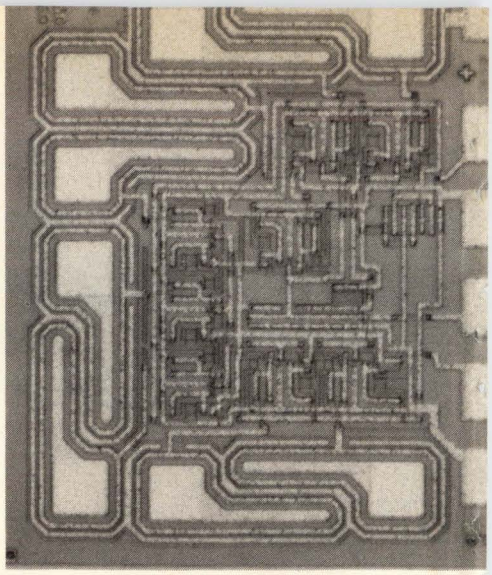
independent back planes, each of which may contain up to three voltage distribution planes, permitting unusual flexibility.

Mupac Corp., 646 Summer St., Brockton, Mass. 02402. Phone Arthur M. Largey Jr. at (617) 588-6110 [394]

Semiconductors

D-MOS invades analog markets

Signetics introduces devices in delay-line, FET, and switching areas



The double-diffused metal-oxide-semiconductor process has been hailed as one way of achieving increased complexity in digital LSI devices. Yet the first standard D-MOS products to be introduced by Signetics—the first U.S. company to develop the technique—are in three analog market areas. They are transverse filters and analog delay lines, discrete power field-effect transistors, and high-performance analog switches.

Perhaps the most interesting of Signetics' new products belongs in the first market. It is the SD5350 (shown above), a monolithic dynamic shift register with analog switches and serial outputs. Traditionally, Reticon's charge-transfer-storage MOS device and Fairchild's analog charge-coupled devices have fought for this market.

"With the D-MOS technique, each bit drives a low on-resistance D-MOS analog switch," says Tom Cauge, a marketing manager at Signetics. "Switching takes place on the positive-going edge of the clock pulse. If the clock is held high, all switches will be off, and if it is held low, all switches will be on." The process employs a single clock and a single 12-volt supply and has inputs compatible with transistor-transistor logic. Turn-off and turn-on propagation delay time is 30 nanoseconds, and dynamic operation is guaranteed from 1 megahertz to 10 MHz.

Applications for the SD5350 include those in which a clock controls switches for up to eight analog voltages with a 7-V limit. Cauge says that one of the prime uses is a video delay line to provide time-base correction in videotape recorders, a key application for the competing CCD delay-line devices. Other applications include a 16-bit synchronous sampled data filter, with two SD5350s in cascade, a multiplexer/demultiplexer, a pattern generator, and a dynamic signal summer. Pricing on the 14-pin, 30-ohm on-resistance device is $3.70 each for 100 to 999 and as low as $1.75 each in larger volumes.

Although the first discrete D-MOS parts produced by Signetics were for small-signal applications, the firm is also developing higher-power versions. Siliconix Inc. has already made a big splash in this market with its VMP series of MOS power transistors. The first in Signetics' family of D-MOS-based power FETs is the DMP4025, intended for 500-milliampere current-drain applications. The TO-39 three-lead device exhibits 5-Ω on-resistance, a 25-V drain-to-source breakdown, and typically 120-Ω transconductance at 15 V, 100 mA and 1 kHz.

Also being introduced is a companion power device, the DMS4025, which contains a fourth lead so that it can be used as a power analog gate, as well as for power-switching applications in which milliampere inputs switch outputs in the ampere range. These devices, similar to Siliconix' VMP series, are available at $3.25 each for 100 to 999 and as low as $1.50 in volume.

Aiming at high-performance analog-switch applications, Signetics is ready with samples of the SD5600, a monolithic D-MOS driver gate patterned functionally after the DG191 series of hybrid analog switches made by Siliconix. Containing four

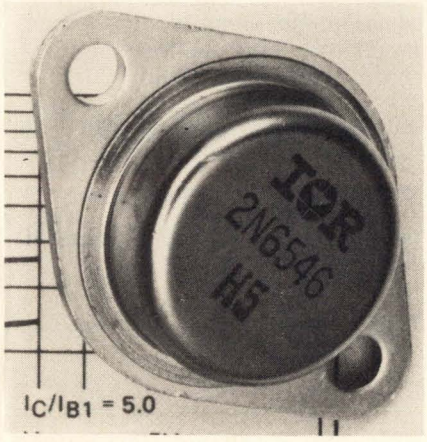
enhancement-mode D-MOS transistors in a dual single-pole, double-throw configuration, the SD5600 provides make-before-break action with a typical propagation delay of 75 ns. With +15-v power supplies and an analog signal of 7.5 v, the resistance of the device is typically 30 Ω, Cauge says. In the off state, each switch will block voltages up to 20 v peak to peak with a leakage of less than 1 nanoampere. The high-speed driver provides on/off times of better than 100 ns and isolation of better than 50 decibels. It is compatible with TTL, complementary-MOS, and MOS and is housed in a 16-pin ceramic dual in-line package for high reliability and military use.

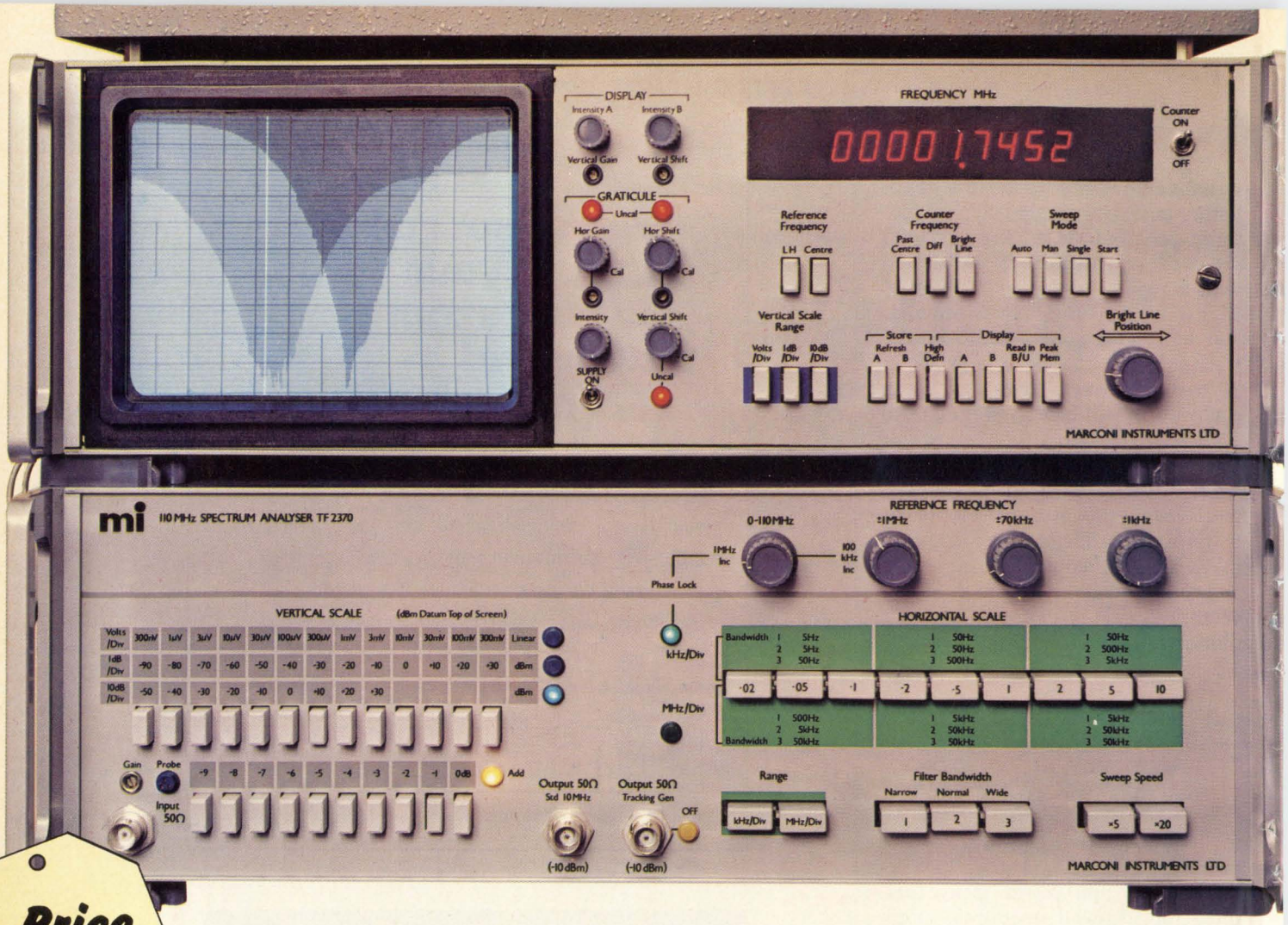
Signetics Corp., Subsidiary of U.S. Philips Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [411]

Fast power transistors switch inductive loads

A series of npn power transistors, rated for 175-watt operation, offers fast switching of inductive loads even at elevated temperatures. The maximum fall time is just 710 nanoseconds at a peak collector current of 10 amperes and a junction temperature of 100°C. Under the same conditions, the inductive switching time is 5 microseconds.

The series consists of two devices: the 2N6546, which has a collector-base rating of 650 volts, and the 2N6547, which is rated for 850-v operation. The 2N6546 has a dc





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current gain of 12 to 60 at a collector-emitter voltage of 2 V and a collector current of 5 A. The 2N6547 has a gain of 6 to 30 at 2 V and 10 A. Both units have peak current ratings of 30 A.

In quantities of 100 to 999 pieces, the 2N6546 sells for about $7.45, while the 2N6547 is priced at about $10.70.

Sales Manager, Semiconductor Division, International Rectifier, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 322-3331 [414]

Op amp has maximum offset current of 200 pA

With a maximum offset current of 200 picoamperes, a maximum bias current of 2.0 nanoamperes, a maximum offset voltage of 0.5 millivolts, and a power consumption of only 18 milliwatts with ±15-volt power supplies, the PM108A/308A is intended to compete directly with National's popular LM108A/308A operational amplifiers. By combining ion-implantation super-beta processing with zener offset-voltage trimming, Precision Monolithics believes it has solved the low-yield problem associated with these low-current op amps.

The PM308A, which operates from 0 to 70°C, sells for $4.50 each in hundreds. The 108A comes in four varieties. All operate from −55 to 125°C, and some are processed to MIL-STD-883A Class B. Their prices, in hundreds, range from $6.50 to $21.50 each.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050. Phone Donn Soderquist at (408) 246-9222 [413]

High-current rectifier withstands up to 1,500 V

The A390 series of silicon rectifiers has an average forward current rating of 400 amperes, a peak one-cycle surge current of 7,000 A, and a repetitive peak-reverse voltage rating of up to 1,500 volts. Available in a

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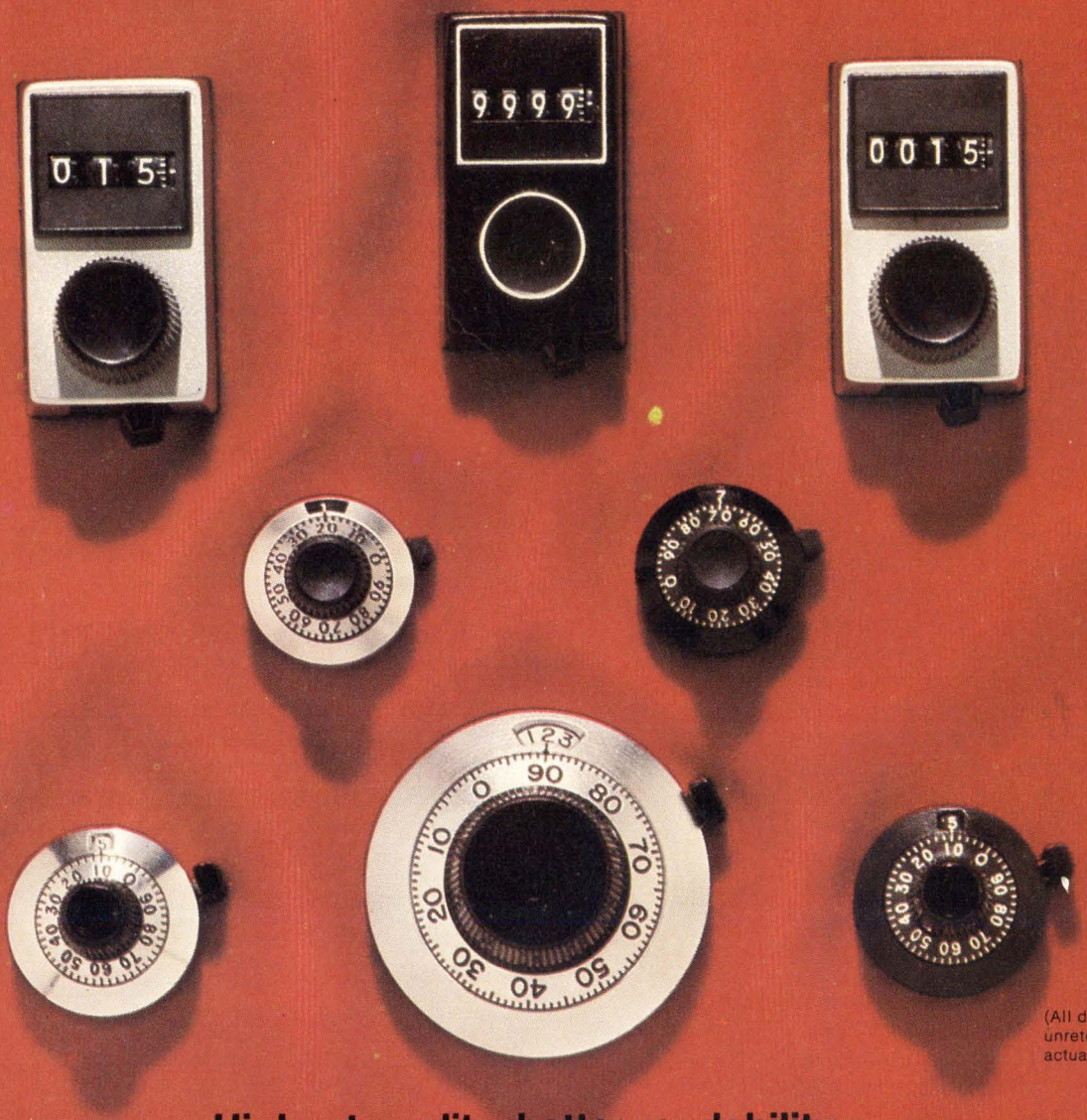

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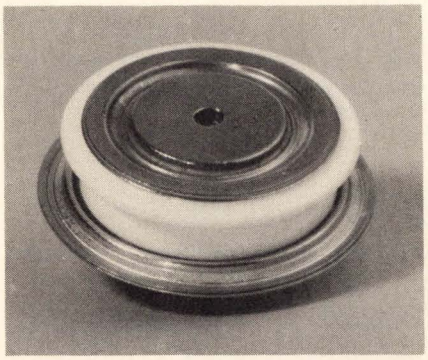
New products



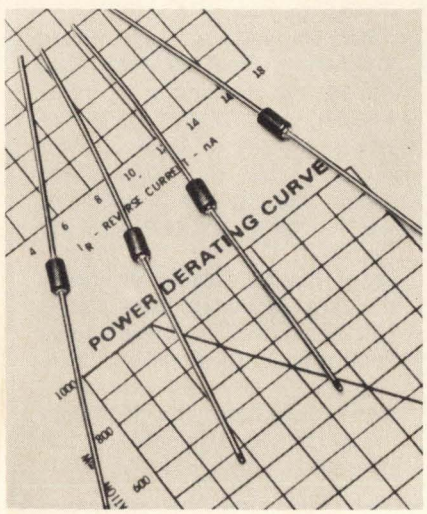
factory-assembled heat exchanger or ready to mount, the rectifier is offered in 15 voltage ratings from 100 v to 1,500 v. A typical price is $16.75 for the 1,000-v unit in hundreds. Delivery is from stock.

National Electronics, Geneva, Ill. 60134. Phone (312) 232-4300 [415]

1-ampere rectifiers recover in 100 ns

A series of fast-recovery rectifiers can handle an average forward current of 1 ampere and exhibit a reverse recovery time of 100 nanoseconds. The units have a peak repetitive forward-current rating of 6 A and a peak surge current of 25 A. The SPD series consists of six devices with peak inverse voltage ratings of 50, 100, 200, 400, and 600 volts. Reverse leakage current is 1 microampere.

In thousands, the rectifiers sell for 25 cents to 60 cents each. Delivery of



New products

the SPD series units is from stock. Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone (213) 921-9660 [416]

Quad op amp slews at 1.3 V/μs, minimum

Designed to combine the qualities that make the 741 a popular general-purpose operational amplifier with improved ac response, the RC/RM4156 has a minimum unity-gain bandwidth of 2.8 megahertz, a minimum slew rate of 1.3 volts per microsecond, and all of the dc parameters and offset specifications of the 741.

The unit's high slew rate guarantees it full-power response from 20 hertz to 20 kilohertz. Also its input noise voltage of 2 microvolts rms over that same bandwidth suits it for audio applications.

The 4156 is offered in three temperature ranges, two packages, and as probed wafers or chips. Raytheon Semiconductor, 350 Ellis St., Mountain View, Calif. 94040. (415) 968-9211 [417]

TOPICS

Semiconductors

Signetics, Sunnyvale, Calif., has introduced its model 2680 4,096-bit dynamic random-access memory as an alternate source to the Intel 2107B and the Texas Instruments 4060. . . . **TRW Capacitors, Solid State Operation, Ogallala, Neb.,** has raised the maximum current-handling capability of its line of power transistors from 30 amperes to 80 A—a design improvement that has also increased gains and reliability. . . . **Fairchild Camera and Instrument Corp., Analog Products division., Mountain View, Calif.,** has announced a single-supply dual operational amplifier that is said to virtually eliminate crossover distortion. The high-gain model μA798 is internally compensated.

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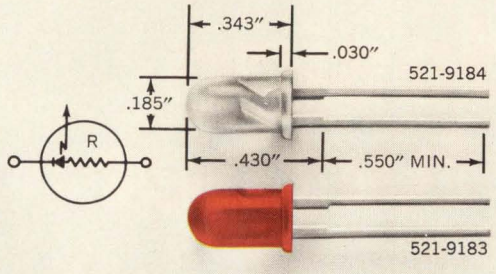

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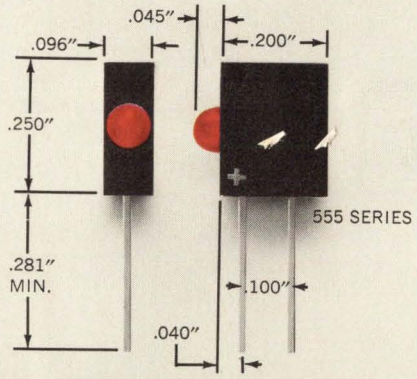
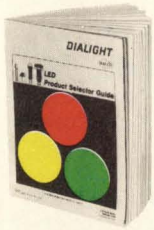


LED logic state fault indicators available in 14 models with voltage ratings from 1.7 to 14. Suitable for dense packaging on printed circuit boards—up to 10 units to the inch—IC compatible. With built-in series resistor. Polarity identified. Low power consumption.



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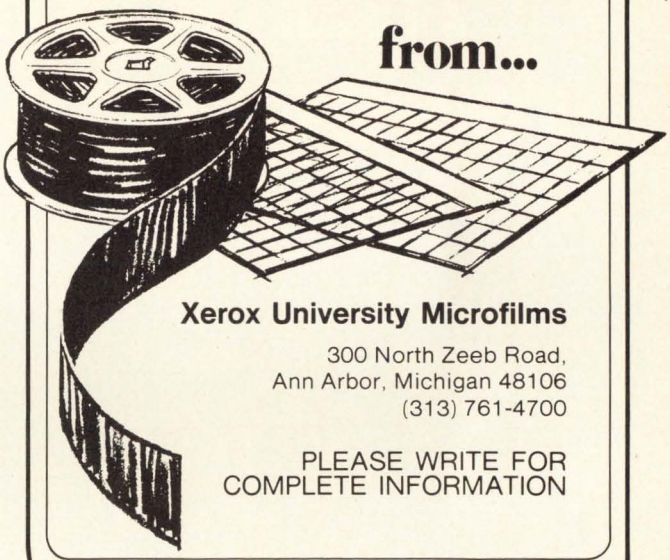

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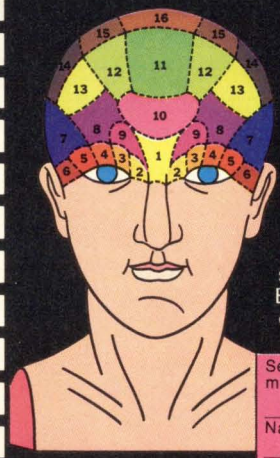

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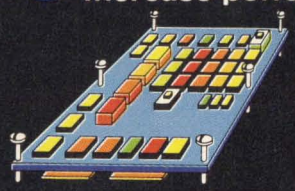

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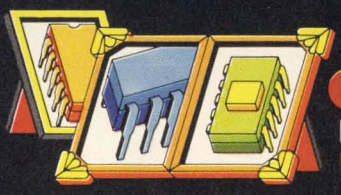

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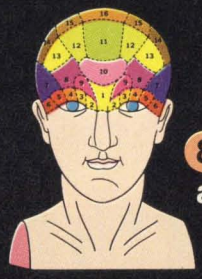
7 Microprocessor book describes design support systems available.



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Product	Description	Organization	Access Times (Max) (ns)
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2102AL	NMOS Static RAM	1K x 1	250-450
2111AL	NMOS Static RAM	256 x 4	250-450
5101	CMOS Static RAM	256 x 4	450
2205	Bipolar TTL Static RAM	1K x 1	45
403	Bipolar PROM (A.I.M.*)	256 x 4	60
405/25	Bipolar PROM (A.I.M.)	512 x 8	70
406/26	Bipolar PROM (A.I.M.)	1K x 4	80
2308	NMOS ROM	1K x 8	450
2316A	NMOS ROM	2K x 8	450

*Avalanche Induced Migration

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Data handling

Core ROM aimed at plant uses

Memory tolerates high electrical noise, offers nondestructive readout

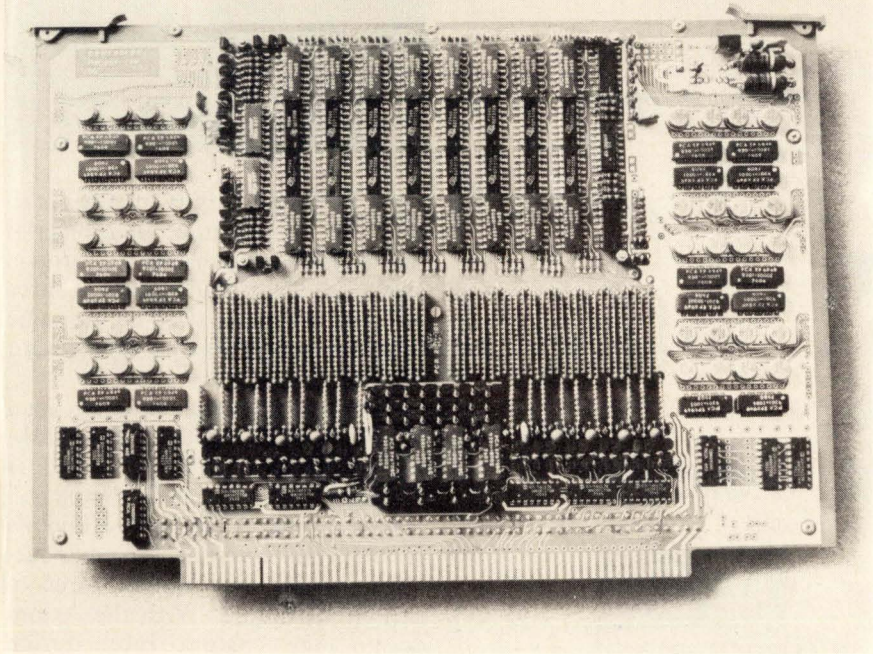
The growing use of microprocessors in industrial controls creates a need for memories that are not affected by power outages and operate reliably in environments with high electrical noise. For these applications, Controlex Corp., Van Nuys, Calif., has introduced a 4-kilobyte ferrite-core electrically alterable read-only memory that is compatible with 8-bit microprocessor-bus systems.

The Controlex CM203 alterable ROM uses conventional cores but includes a proprietary technique to achieve nondestructive readout (NDRO) [*Electronics*, April 1, 1976, p. 31]. "By operating in a true NDRO mode, in contrast to the classical core memory, where data has to be restored as it is read, our EAROM may be selectively read or written at any random address without affecting data stored at other locations," says Bruce Kaufman, Controlex president. The CM203 thus adds its nondestructive-readout capability to recognized core-memory strengths of nonvolatility and insensitivity to electrical impulse noise. Together, these characteristics allow the CM203 to function as a true nonvolatile RAM, Kaufman notes, with a simple switch control converting it into what is in effect a "RAM/EAROM mix."

The device also has an advantage over semiconductor memories for industrial uses because, he says, dynamic RAMs have to be refreshed, and both these and refreshed static RAMs lose data from a power outage. The Controlex alterable ROM's 350-nanosecond access time makes it competitive with semiconductor memory speed, Kaufman claims.

Other specifications are: 1-microsecond cycle time for read or write; TTL interface; operation with +5-volt and ±120-v dc supplies, and an operating-temperature range of 0 to 70°C. The memory is entirely mounted on 0.75-in. centers on a single 8.5-by-12-inch printed-circuit board.

Price of the CM203 is $500 when

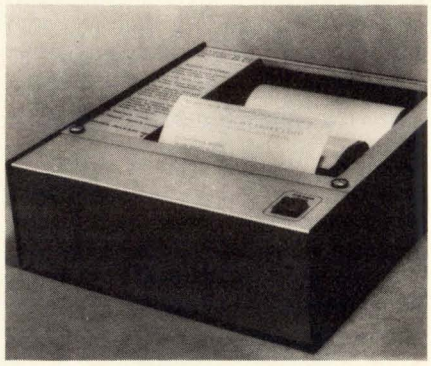


it is ordered in large quantities.
Controlex Corp., 16005 Sherman Way, Van Nuys, Calif. 91406 Phone (213) 780-8877 [361]

LSI chip boosts capability, cuts cost of line printer

The small Glendale, Calif., company that last year developed a microprocessor-controlled electrostatic line printer priced slightly below $1,000 [*Electronics*, Jan. 22, 1976, p. 40] has already designed that product into obsolescence. Axiom Corp. has replaced the read-only memory and 10 interface-circuitry chips with a single custom large-scale-integrated chip and put the entire printer control on a card 4 inches square. The Intel 4004 microprocessor is used in both versions.

"This design not only makes possible a $655 price," says vice president Simon Harrison, "but it is greatly simplified and allows the printer to do some things it couldn't before."



(The $655 price tag is for the parallel-input printer; price of the serial unit is $740.) Noteworthy, Harrison points out, is its ability to print three different character sizes on the same line to emphasize words and phrases.

The key LSI chip, built by Intel Corp., is based on the 4308 mask-programmable ROM. It is "affordable for a small company," Harrison says. Along with 8 kilobits of ROM, this chip has 16 input/output lines that may be configured to user specifications. With the Axiom design, the custom Intel device

replaces two microprocessor interface chips and eight TTL chips previously used in demultiplexing circuitry. Components on the first Axiom printer were mounted on two cards, one 8 by 6 inches and the other somewhat smaller. The power supply is separate.

Along with the LSI chip, the module card holds 1,024 bits of random-access memory, a power supply, the Intel 4004 microprocessor, a low-paper detector, and a hybrid chip being manufactured offshore. This hybrid converts microprocessor-controlled signals from the RAM to 45-volt pulses that drive the printing head. The only electronic components not on the replaceable card are the transformer and solid-state relay for turning current on and off.

"Our philosophy of building an inexpensive, simple but high-performance printer is letting the microprocessor do as much as possible," explains Harrison. "The 8 kilobits of ROM triple the character-generation capability we had on the first model and thus control sophisticated programs and routines up to three times as complex." The simplified design that reduces the component count cuts their cost by 60%, compared with the first Axiom printer, he says.

Although the first Axiom printer was intended for use in original-equipment systems, the new EX-800 is suitable for stand-alone operation.

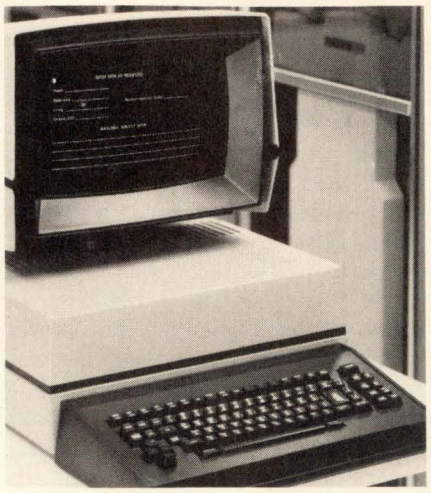
Axiom Corp., 5932 San Fernando Rd., Glendale, Calif. 91202. Phone (213) 245-9244 [362]

Display terminals work with standard protocols

The system 400 series of interactive cathode-ray-tube display terminals is designed to work with Honeywell 7700 VIP, Univac-Uniscope, and IBM 2265 and 3275 protocols. The terminals operate synchronously over dial-up or dedicated lines at speeds to 9,600 bits per second.

The fully buffered terminals allow

New products



printouts while the operator is entering data on the screen. It also includes such features as dual-intensity display, upper- and lower-case characters, user-defined program-function keys, and self-diagnostics.

Packaged in three modular units—keyboard, display, and control unit—the system 400 does not require cooling fans. Its removable keyboard has audible alarm and light-emitting-diode status indicators. Its keys provide both audible and tactile feedback.

International Communications Corp., 8600 N.W. 41st St., Miami, Fla. 33166. Phone (305) 592-7652 [363]

Vidicon camera system interfaces with computers

Twenty input/output lines enable the C-1000 camera system to exchange queries, information, and commands with analog and digital computers. The high-resolution (1,000-line) system is of modular construction, allowing the user to

purchase only those subsections needed for his particular task. All handshake and control lines are built into the system. Prices of the C-1000 start at $3,500; delivery time is 30 days.

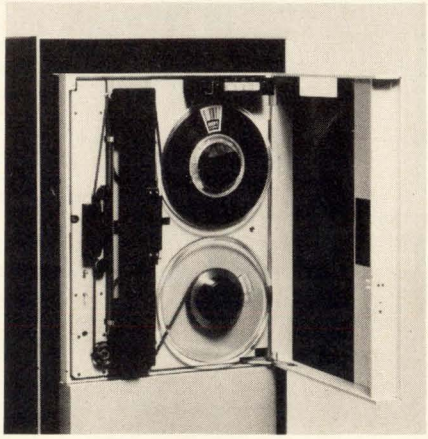
Hamamatsu Corp., 120 Wood Ave., Middlesex, N.J. 08846. Phone Ralph Eno at (201) 469-6640 [364]

Tape drive operates from 12.5 to 75 inches/second

The TME tape drive, which uses vacuum-column buffering for high performance, efficiency, and operational convenience, can operate at any speed from 12.5 to 75 inches per second. Standard speeds are 12.5, 25, 37.5, 45, and 75 in./s.

The drive accommodates 8.5-in. and 10.5-in. reels. It has a rewind speed of 200 in./s. A fast-forward speed of 150 in./s for search operations is available as an option.

The TME incorporates electronic de-skew, channel by channel, for both read and write. It precisely duplicates the IBM tape path in both guide spacing and guide diameter.



The drive has a transfer rate of 20,000 to 120,000 bytes per second and has a start time, at 75 in./s., of 5.5 ±1.0 milliseconds. Maximum rewind time is three minutes.

The TME sells for $4,200 in OEM quantities.

Ampex Corp., 401 Broadway, Redwood City, Calif. 94063. Phone (415) 367-4151 [365]

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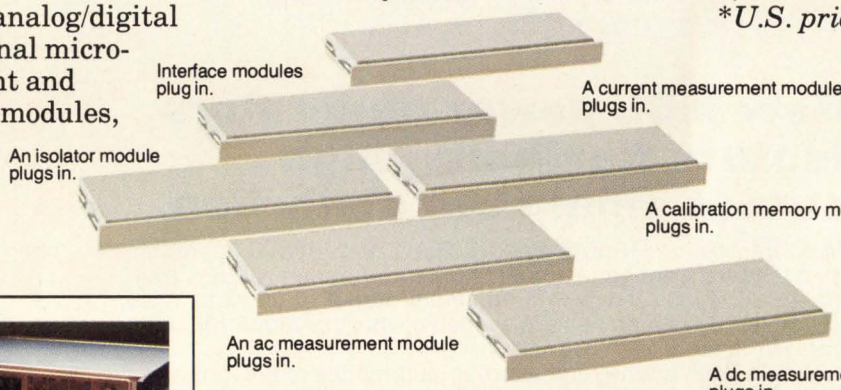


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New literature

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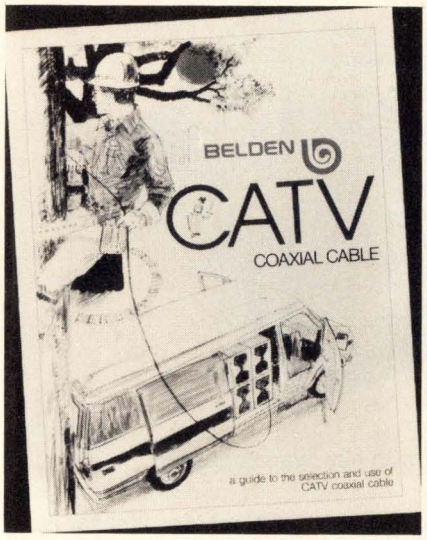
available from the Sales Dept., Union Carbide Corp., Components Dept., Box 5928, Greenville, S.C. 29606. Circle reader service number 421.

Hospital safety. The Directory of Audiovisual Aids for Hospital Safety Programs is a concentrated listing of motion pictures and other aids useful in the training of hospital and health-care personnel. It includes material on electrical safety. The 36-page directory can be purchased for $4 from Quest Publishing Co., P.O. Box 4141, Diamond Bar, Calif. 91765.

Cosmac manual. Written for electronics engineers with limited knowledge of computers and computer programming, the User Manual for the RCA CDP1802 Cosmac Microprocessor guides the reader through the microprocessor architecture and introduces a set of comprehensive, easy-to-use programming instructions. The 115-page manual, MPM-201A, may be obtained for $5 from RCA Solid State Division, Box 3200, Somerville, N.J. 08876.

Coaxial cable. Belden's coaxial cable guide describes 35 new or modified

constructions and gives data on more than 60 cables. The 20-page catalog features three cables with foam-polypropylene insulations, which offer better characteristics than solid



or foam polyethylene in some applications. For a copy, write to the manager, Marketing Communications, Belden Corp., 2000 S. Batavia Ave., Geneva, Ill. 60134 [424]

Transformers. An 84-page catalog from TRW/UTC covers the company's line of audio transformers and inductors, power transformers and inductors, pulse transformers, high-Q inductors, and electric wave filters. Supplementing the data for each product category is a brief explanation of product terms and theory, along with a one-page selection guide. Catalog 771 is available from TRW/UTC Transformers, 317 N. McLewsen St., Kinston, N.C. 28501 [425]

Encapsulated power supplies. A line of ac-dc and dc-dc encapsulated, miniaturized power supplies is described in a 12-page catalog put out by Arnold Magnetics Corp., 11520 W. Jefferson Blvd., Culver City, Calif. 90230. The publication includes complete specifications, prices, and ordering information. A design-as-you-order section provides the instructions and technical data for specifying custom power supplies. [426]

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MOS and Special-Purpose Bipolar Integrated Circuits and R-F Power Transistor Circuit Design, Bryan Norris, ed., McGraw-Hill, 228 pp., $16.50.

Management Handbook for Plant Engineers, Bernard T. Lewis, ed., McGraw-Hill, 719 pp., $29.95.

Exploring Laser Light, T. Kallard, Optosonic Press (New York), 298 pp., $11.50 (paper).

The 555 Timer Applications Sourcebook with Experiments, Howard M. Berlin, E & L Instruments (Derby, Conn.), 155 pp., $6.95.

Superionic Conductors, G. D. Mahan and W. L. Roth, eds., Plenum Press, 438 pp., $39.50.

EMP Radiation and Protective Techniques, L. W. Ricketts, J. E. Bridges, and J. Miletta, Wiley, 380 pp., $27.50.

Digital Computer Fundamentals, Jefferson C. Boyce, Prentice-Hall, 420 pp., $15.95.

Superconducting Electron-Optic Devices, I. Dietrich, Plenum Press, 140 pp., $19.50.

The General Theory of Alternating Current Machines, B. Adkins and R. G. Harley, Halsted Press, 279 pp., $22.50.

Preparation and Properties of Solid-State Materials, Vol. 2: Chemical Vapor Transport, Secondary Nucleation, and Mass Transfer In Crystal Growth, William R. Wilcox, ed., Marcel Dekker Inc. (New York), 192 pp., $22.50.

Communication Satellite Developments: Systems and Technology, Gilbert E. LaVean and William G. Schmidt, eds., MIT Press, 334 pp., (Vol. 1) and 419 pp. (Vol. 2), $55.

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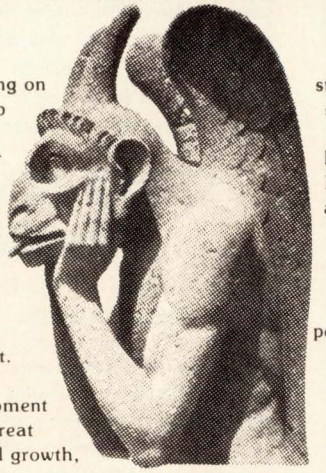

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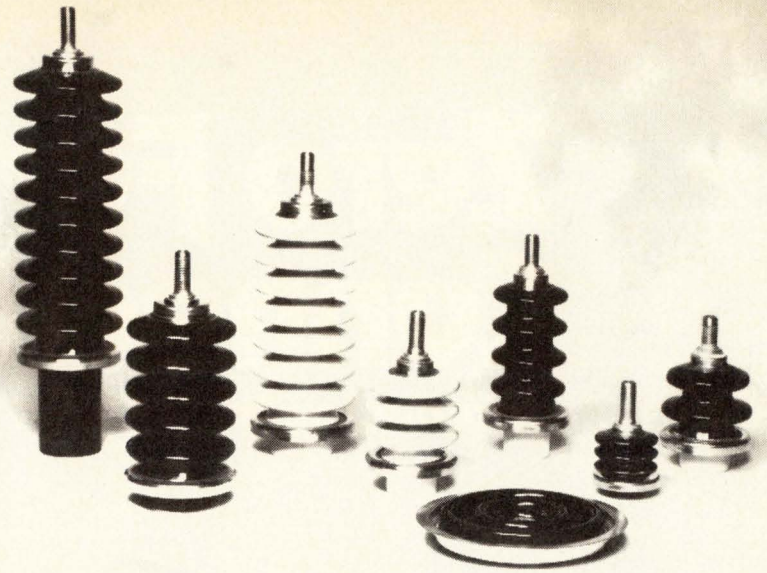

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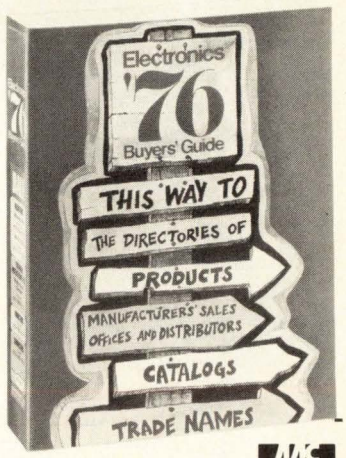

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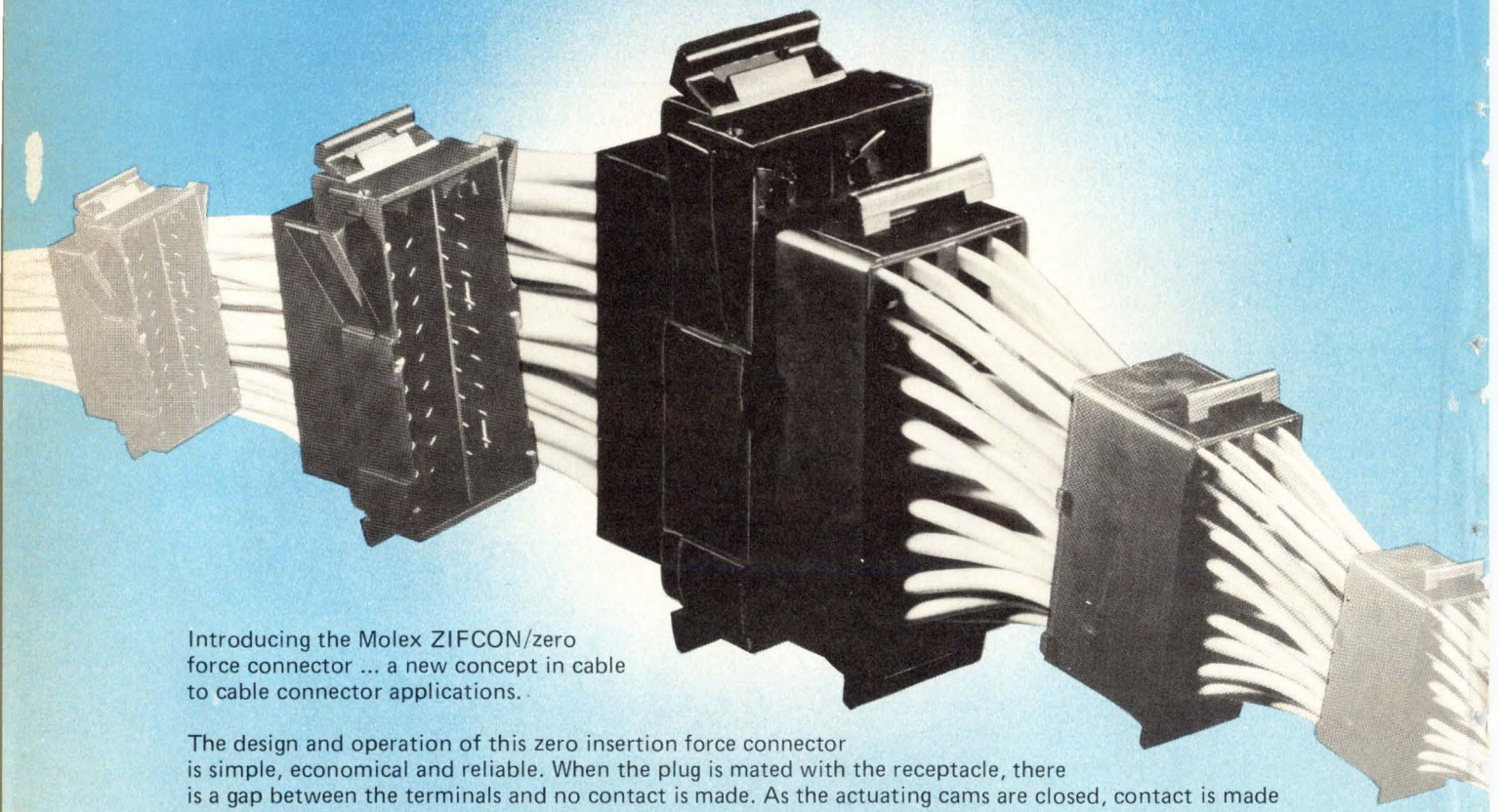

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