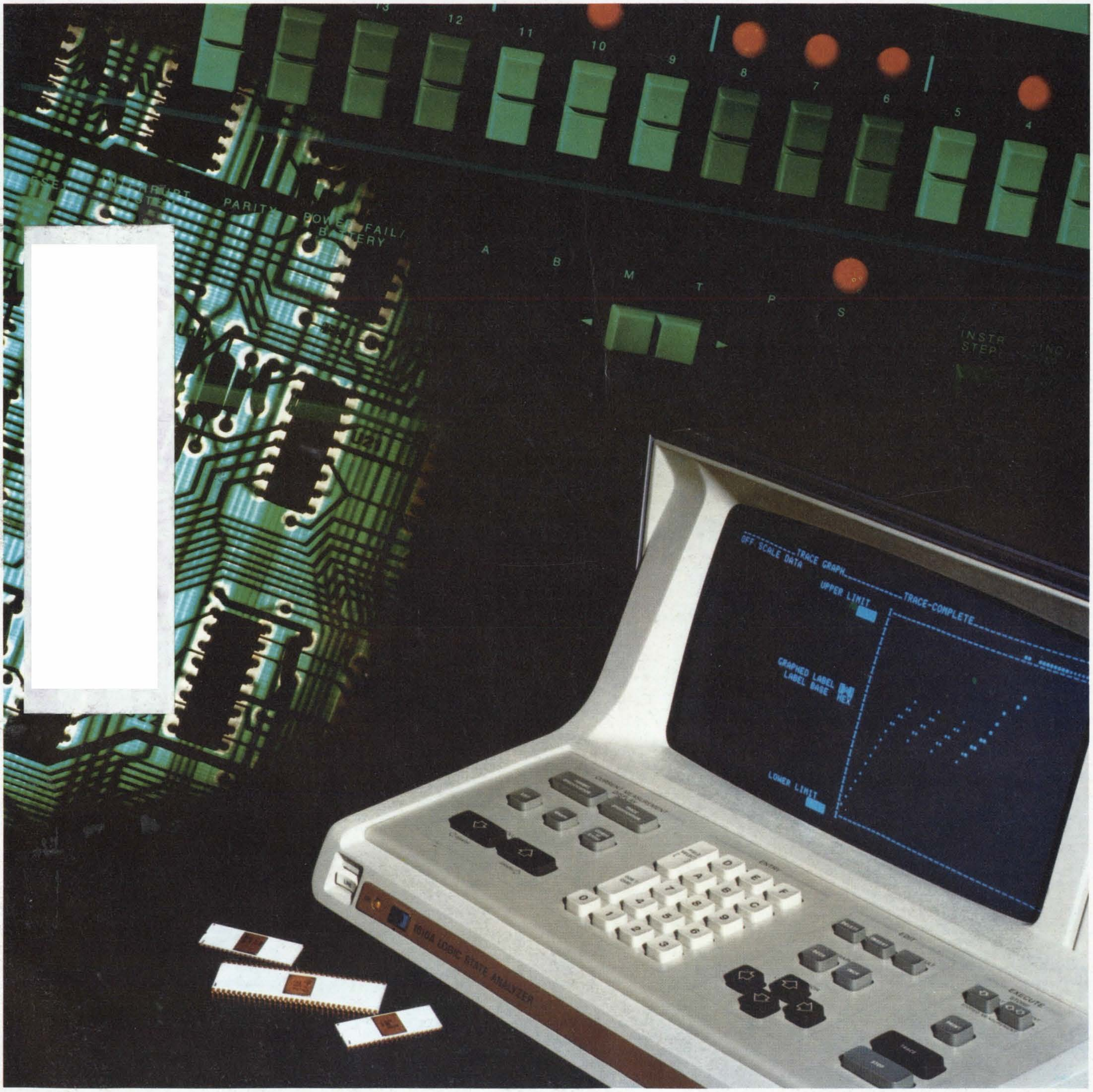
Electronic Design®

VOL. 25 NO. 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10,1977

The most extensive triggering yet in a microprocessor analyzer lets you dig into as many as seven nested subroutines. Use one bit, or as many as 32, to define the trigger. Trace into a loop from up to seven locations. Read an on-screen 'menu' to choose formats or capture criteria. Select display modes, too. On page 99.



Look inside our new Precision Pot...

For reliability, performance and savings.

Since our new potentiometer looks like others on the outside, here's the inside story . . . that's where Bourns makes the difference:

The total construction of this new 1% linearity, conductive plastic, single-turn pot is ingeniously simple. Our one-piece precious metal contact delivers tens-of-thousands more trouble-free revolutions than the typical failure-prone two-piece type. Then, our exclusive silver deposition between the molded-in terminals and the element guarantees a connection that won't migrate or weaken during installation and operation. And, proven techniques like low temperature firing and thermal swaging replace unreliable solder, conductive epoxy and silver cement throughout the potentiometer. No one matches our performance, and our price is just as eye opening — less than $6.00 in production quantities.

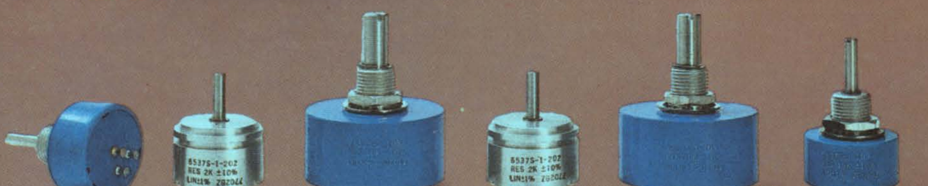
With fewer parts, unique packaging and solid connections, the result is obvious — the most reliable precision potentiometer you can specify for the price.

The $\frac{7}{8}$″ diameter model is available in either bushing (Model 6637) or servo mount (Model 6537) styles. The larger $1\frac{5}{16}$″ diameter bushing mount (Model 6657) also offers a full line of non-linear functions . . . all with the same outstanding design and price advantages.

Take a look inside any other precision pot and you'll see why Bourns makes the difference.

Send for our new catalog today for complete details.

TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, California 92507, Telephone (714) 781-5200 —TWX 910 332-1252.



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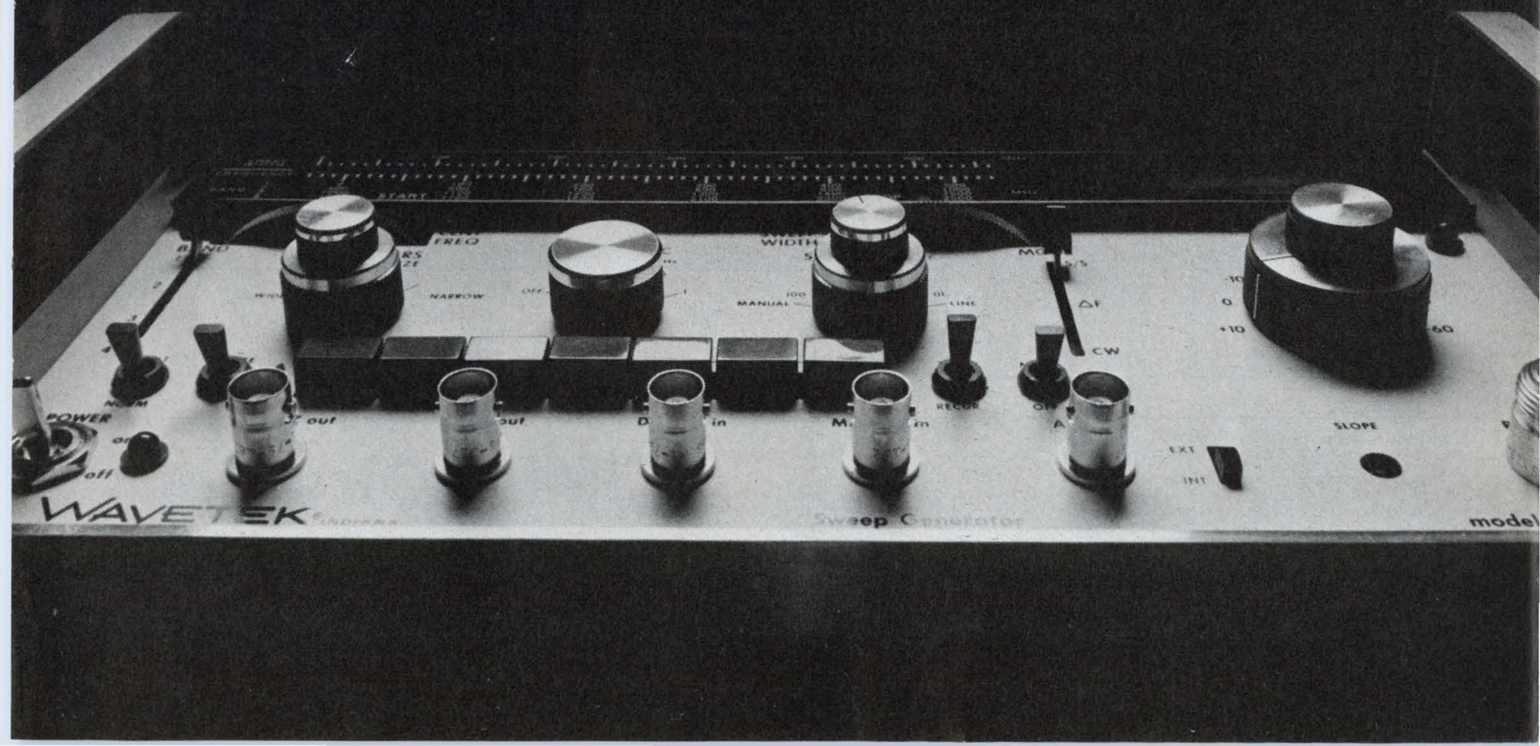
CIRCLE NUMBER 252

The sweep signal generator world has a new leader to look up to. Model 2002 sweeps from 1 to 2500 MHz in four bands. Or it can sweep the entire range using the band stacking option. It has more flexibility than any broadband sweeper we've made, along with +13 dBm output, ±0.5 dB flatness, 0.005% marker accuracy, and ±1% display linearity. Look at the Model 2002 from any angle and you'll become a follower. Send us $2700 and you'll become an owner. Circle our reader service number for details. WAVETEK Indiana Incorporated, P.O. Box 190, Beech Grove, Indiana 46107. Telephone (317) 783-3221. TWX 810-341-3226.

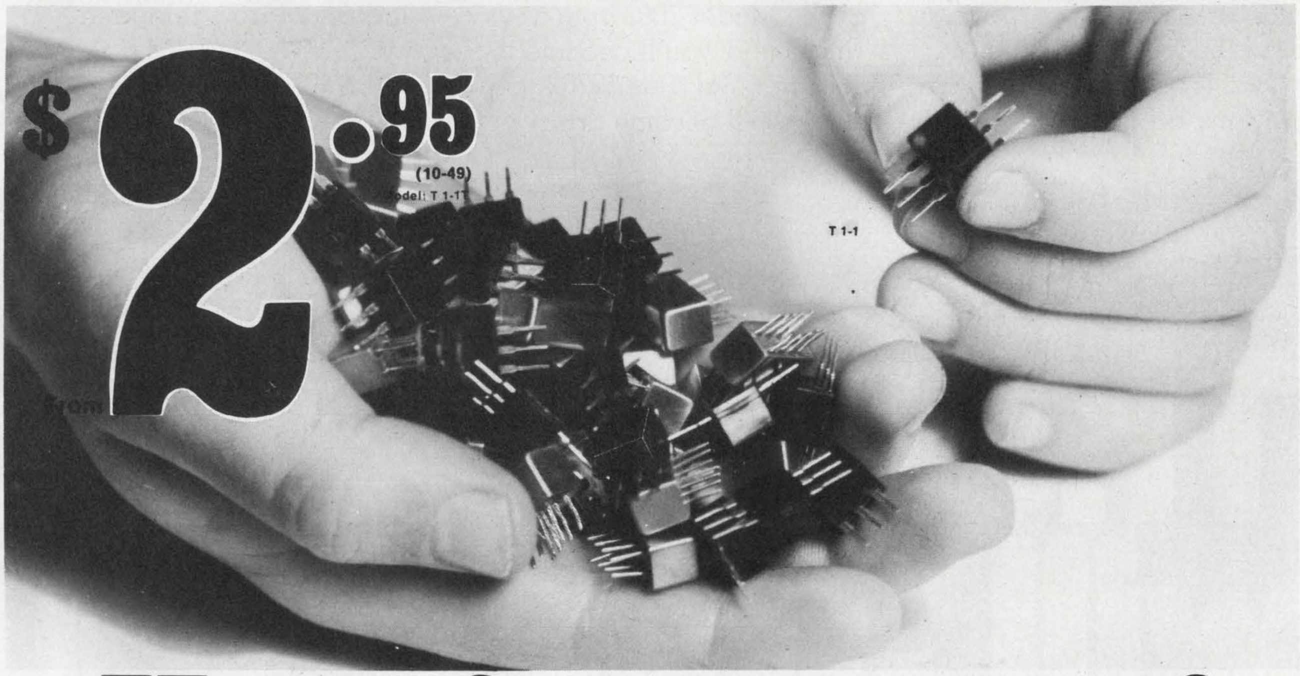
WAVETEK®

CIRCLE NUMBER 2

The new 2002 will sweep you off your feet.



RF TRANSFORMERS



Have it your way!

36 models to choose from, 10KHz-800MHz

It costs less to buy Mini-Circuits wideband RF transformers. The T-series (plastic case) and TMO series (hermetically sealed metal case) RF transformers operate with impedance levels from 12.5 ohms to 800 ohms and have low insertion loss, 0.5 dB typ. High reliability is associated with every transformer. Every production run is 100% tested, and every unit must pass our rigid inspection and high quality standards. Of course, our one-year guarantee applies to these units.

DC ISOLATED PRIMARY & SECONDARY (N×50 Ω / 50 Ω)

Model						
Metal Case	TMO 1-1	TMO 1.5-1	TMO 2.5-6	TMO 4-6	TMO 9-1	TMO 16-1
Plastic Case	T 1-1	T 1.5 -1	T 2.5-6	T 4-6	T 9-1	T 16-1
Freq. Range, MHz	.15-400	.1 -300	.01-100	.02-200	.15-200	.3-120
Impedance Ratio	1	1.5	2.5	4	9	16
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.15-400	.1 - 300	.01-100	.02-200	.15-200	.3-120
2 dB	.35-200	.2-150	.02-50	.05-150	.3-150	.7-80
1 dB	2-50	.5-80	.05-20	.1-100	2-40	5-20
Price, Model TMO	$4.95	$6.25	$5.95	$5.95	$5.45	$5.95
(10-49) Model T	$2.95	$3.95	$3.95	$3.95	$3.45	$3.95

UNBALANCED PRIMARY & SECONDARY (50 Ω / N×50 Ω)

Model					
Metal Case	TMO 2-1	TMO 3-1	TMO 4-2	TMO 8-1	TMO 14-1
Plastic Case	T 2-1	T 3-1	T 4-2	T 8-1	T 14-1
Freq. Range, MHz	.015-600	.5-800	.5-600	.15-250	.2-150
Impedance Ratio	2	3	4	8	14
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz
3 dB	.015-600	.5-800	.2-600	.15-250	.2-150
2 dB	.02-400	2-400	.5-500	.25-200	.5-100
1 dB	.05-200		2-250	2-100	2-50
Price, Model TMO	$5.45	$6.25	$5.45	$5.45	$6.25
(10-49) Model T	$3.45	$4.25	$3.45	$3.45	$4.25

DC ISOLATED PRIMARY & SECONDARY CENTER-TAP SECONDARY (N×50 Ω / 50 Ω)

Model							
Metal Case	TMO 1-1T	TMO 2-1T	TMO 2.5-6T	TMO 3-1T	TMO 4-1	TMO5-1T	TMO 13-1T
Plastic Case	T 1-1T	T 2-1T	T 2.5-6T	T 3-1T	T 4-1	T 5-1T	T 13-1T
Freq. Range, MHz	.05-200	.07-200	.01-100	.05-250	.2-350	.3-300	.3-120
Impedance Ratio	1	2	2.5	3	4	5	13
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.05-200	.07-200	.01-100	.05-250	.2-350	.3-300	.3-120
2 dB	.08-150	.1-100	.02-50	.1-200	.35-300	.6-200	.7-80
1 dB	.2-80	.5-50	.05-20	.5-70	2-100	5-100	5-20
Maximum Amplitude Unbalance MHz							
.1 dB	.5-80	1-50	.1-20	1-70	5-100	10-100	5-20
.5 dB	.05-200	.07-200	.01-100	.05-250	.2-350	.3-300	.3-120
Maximum Phase Unbalance Degrees MHz							
1°	.5-80	1-50	.1-20	1-70	5-100	10-100	5-20
5°	.05-200	.07-200	.01-100	.05-250	.2-350	.3-300	.3-120
Price (10-49)							
Model TMO	$5.95	$6.25	$6.25	$5.95	$4.95	$6.25	$6.25
Model T	$3.95	$4.25	$4.25	$3.95	$2.95	$4.25	$4.25

	TMO-series	T-series
Primary Impedance: 50 ohms	.25 cu. inches	.02 cu. inches
Total Input Power: ¼ watt	.07 ounces	.01 ounces

Designers Kit Available

(TK-1) — 2 transformers of each type T1-1, T2-1, T4-1, T9-1, T16-1 **$32.00**

(TMK-2) — 2 transformers of each type TMO1-1, TMO2-1, TMO4-1, TMO9-1, TMO16-1 **$49.50**

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CIRCLE NUMBER 3

Electronic Design® 10

VOL. 25 NO. 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10,1977

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by William S. Porter, courtesy of Hewlett-Packard.

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The 2900 Family: Two years later.

1975. Advanced Micro Devices introduces the world's best 4-bit microprocessor slice, the Am2901, along with a few support circuits.

1977. It's a whole new family. Now there's an Am2901A just like the Am2901, only better. Now there are 18 support circuits, two or three second sources and all the software you'd ever want. The 2900 family has become the family of the future. Here's why:

The first family.

The Am2900 family is the first group of products designed specifically for microprogrammed machines. Microprogramming is rapidly becoming the most popular way to design medium- and high-performance systems, to reduce development time, make changes easily, and conveniently add new features.

Less weight, less size.

With the Am2900 family, it's not uncommon for entire boards to be eliminated. You'll shrink system size and weight, increase overall reliability and reduce manufacturing costs.

Time goes by, price goes down.

In July 1975, we told you we'd reduce the cost of the Am2901 by 30% per year. We've done it twice. Once in April 1976 and once in March 1977. The Am2900 family gets less and less expensive all the time.

We're so popular, we're the industry standard.

The Am2900 family is the most widely used Bipolar LSI family in:

- Minicomputers: For emulators, high-performance CPU's and add-ons by eight out of the top ten U.S. manufacturers.
- High-performance controllers: For discs, tapes, floppy discs and universal controllers.
- Communications: For PBX systems, central exchanges, multiplexers and modems.
- Military: For radar processors, display systems and the Navy's new standard avionic computer, the AN/AYK-14.

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Across the desk

Varactors do cost, but are indispensable

The statement, "In TV it's PLL vs varactor tuning" (ED No. 1, Jan. 4, 1977, p. 50), is very misleading. The technical truth is that in order to achieve digital (or analog) PLL in TV, varactor tuning is *indispensable.* The old-fashioned mechanical TV tuners do not lend themselves to PLL.

Another error is to believe that the varactor-tuning systems are "less expensive." They are more expensive than mechanical tuners for three reasons:

1. Varactors have a poor "Q" particularly in the uhf range, and these deficiencies have to be compensated by extra circuitry.

2. Varactor tuners require peripheral circuitry that is *not* cheap, such as stabilized tuning voltage supplies up to 30 V at temperatures from 0 C to +75 C.

3. The customer controls of varactor tuners can be costly, depending on the degree of sophistication, and are often very delicate (such as control potentiometers and switches that wear out easily).

P. H. Anrooy

QUASAR Electronics Corp.
Electronic Tuning Systems
9401 W. Grand Ave.
Franklin Park, IL 60131

Think positive

I adamantly object to the continually negative attitude in *every* editorial I have ever seen issued by ELECTRONIC DESIGN. How about some positive mental material leaking into your writings? All your theoretical companies slip into degradation (George saw it coming!) when, in fact, thousands of successful companies do exist. Why not depict the rise and growth of these *factual* companies?

Hugh T. Vidovic/MSEE

General Diesel & Equipment, Inc.
3603 E. Beltline
Hibbing, MN 55746

Misplaced Caption Dept.

Harder Jack, the spec says 2500 g.

Sorry. That's Francisco de Goya y Lucinentes' "The Forge," which hangs in the Frick Collection in New York City.

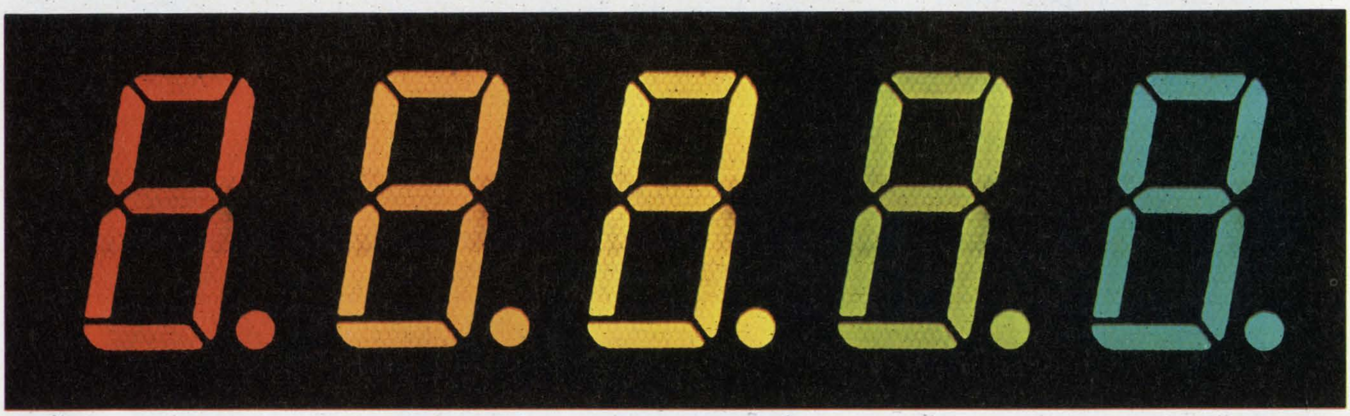
Memory cycle time upped thousandfold

The item, "NDRO Core Memory Protects Data from Noise," in News Scope, Feb. 15, 1977, said that the read or write-cycle time of the memory was 1 ms. The actual cycle time is one microsecond.

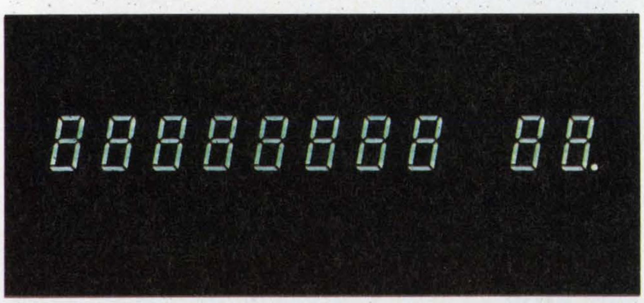
Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

LEDs, make

For most displays, they're up to 8 ways better.



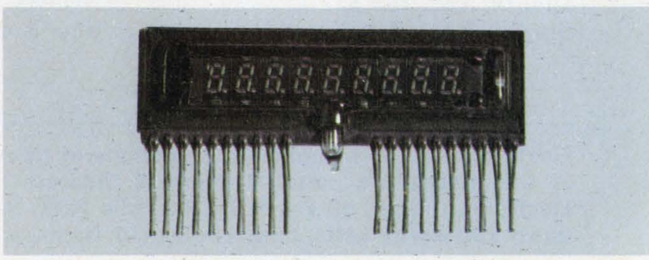
You've seen their bright, large, eye-pleasing characters in inexpensive calculators. They're called, technically, "Vacuum Fluorescent Indicator Panels" or, for short, **FIPs**. Actually, **FIPs** are modern developments of very old technology, that of the vacuum tube. In fact, they're triodes, complete with plate (anode), cathode, and grid, but with the addition of a phosphor on the segmented plate so the characters will glow. Brightly.



THE CHART TELLS THE STORY. Even though NEC is among the world's largest producers of both LEDs and gas discharge (plasma) displays, we see **FIPs** rapidly taking over for most applications—such as calculators, data & POS terminals, clocks, radios, car dashboards, microwave oven controls, instruments, CB, TV, etc. For obvious reasons, that are summarized in the chart at far right.

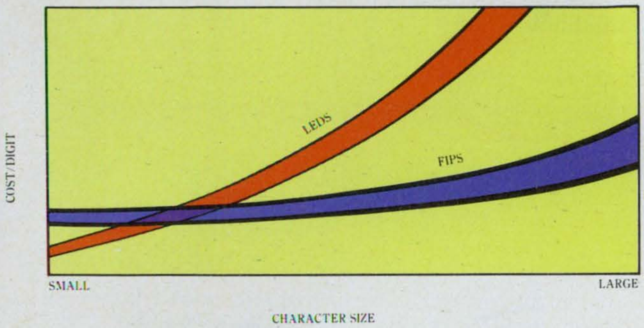
Typical Red LED

AND THERE ARE OTHER GOOD REASONS, SUCH AS RELIABILITY & LONG LIFE. The tremendous variety of uses that **FIPs** can be put to calls for very high acceptance standards. NEC has developed what may be the most rigorous QA and QC in the world. In a recent, routine test cycle, a total of 1085 **FIPs** of various models were put through a total of 15 grueling tests...with a single failure. The tests, and their standards, are described in the new **FIP** Selector Guide, available by mailing the coupon in this ad.

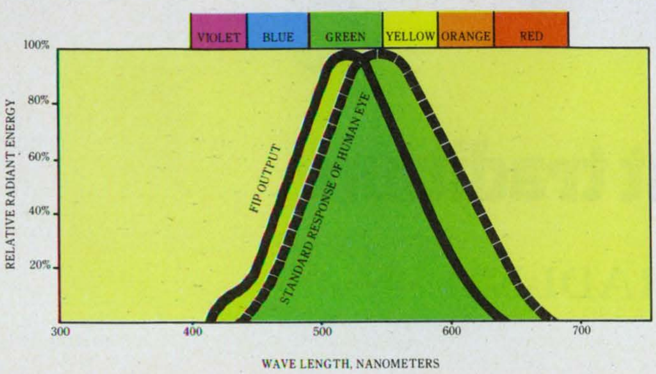


way for FIPs.*

ONE GLANCE TELLS THE COST/PERFORMANCE STORY. The larger the character size, the better the direct savings. That doesn't take into account the additional indirect savings from such things as simpler circuitry, fewer failures, and easier assembly. Check this graph, to get the idea.



THE STORY ON BRIGHTNESS AND LIGHT BANDWIDTH. FIPs' phosphors are selected to be extremely efficient converters of electrical energy to light energy, minimizing power input. In addition, the light is spectrum-wide, from red to violet, and can thus be filtered to provide any single hue desired. The light predominates in the blue-green area, which overlaps the standard curve of human eye response (see graph), so the viewer perceives the maximum of brightness for the minimum of power input. And—the gentle, soothing blue-green glow is considered to be much less fatiguing to the eye than red and orange colors.



LED/GAS DISCHARGE/FIP COMPARISON CHART

	LED	GAS DISCHARGE	FIP
VOLTAGE	~1.7-5V	~150-200V	~10-40V
POWER/CHARACTER	high	low	low
CURRENT	high	low	low
MOS IC DIRECT DRIVE	no	no	yes
THIN & FLAT	yes	yes	yes
VIEWING ANGLE	wide	wide	wide
BRIGHTNESS	moderate	moderate	high
MOUNTING EASE	good	good	good
COST/PERFORMANCE	fair	good	excellent
READABILITY	fair	fair	outstanding
COLOR CHOICE	limited, fixed	red, limited	many—filterable

33 TYPES AVAILABLE IN HIGH VOLUME—HOW TO SELECT YOURS? Easy. Send for our just-off-the-press FIP SELECTOR GUIDE. It tells everything you need to know to select exactly the **FIP** for your application. Then, mail the postpaid return card bound into the guide, and we'll send you the data sheets you require, with the comprehensive specifications. Make sense? Then we hope to hear from you soon. Mail coupon, or telephone us at (408) 738-2180, Telex 34-7475.

NEC

NEC America, Inc.

CLIP THIS TO LETTERHEAD FOR FAST RESPONSE.

NEC America, Inc., Electron Devices Div.
3070 Lawrence Expressway
Santa Clara, CA 95051
Send me that 8-page FIP Selector guide.
My application is (or will be) ____________.
☐ Call me for immediate requirement at (_____) _____-_______, extension ______.

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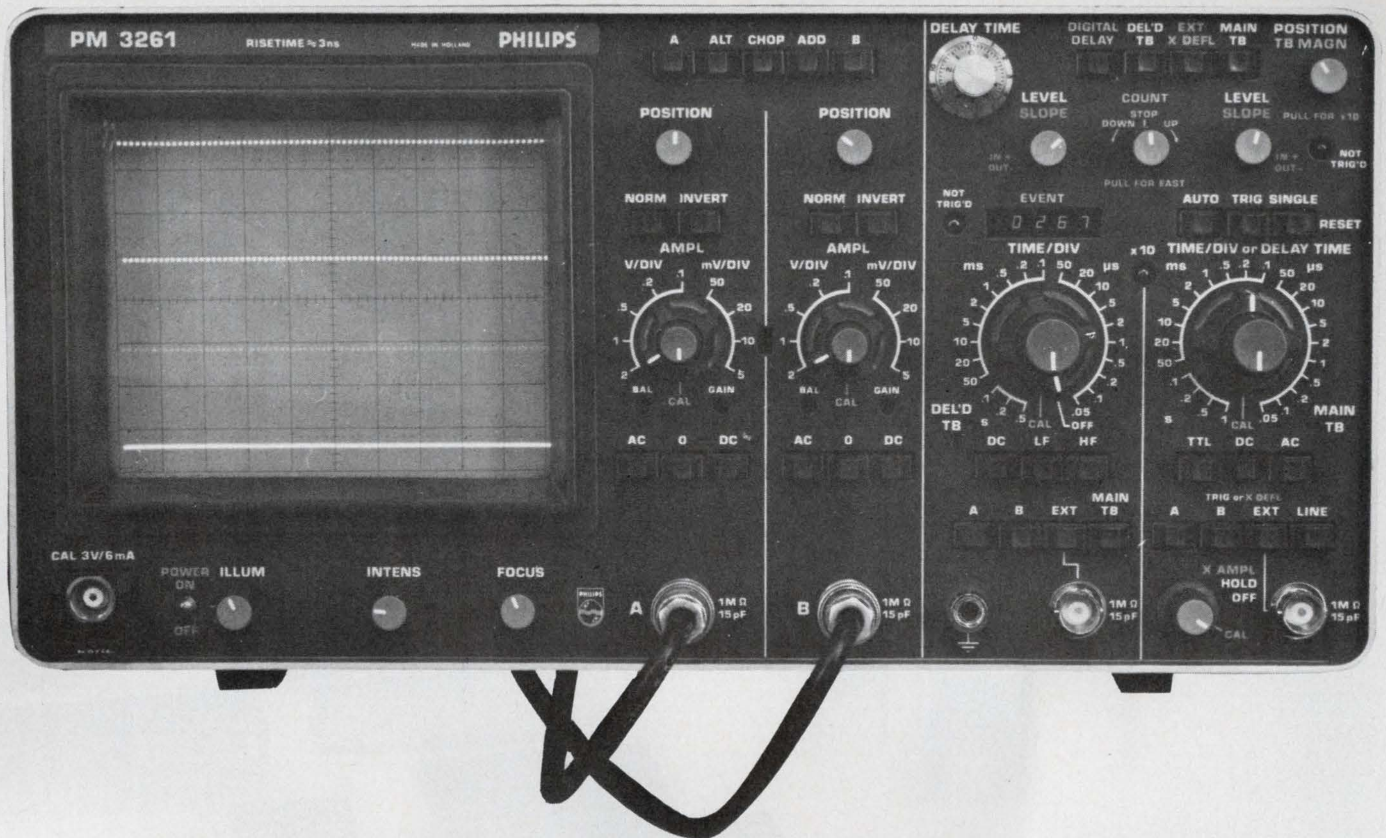
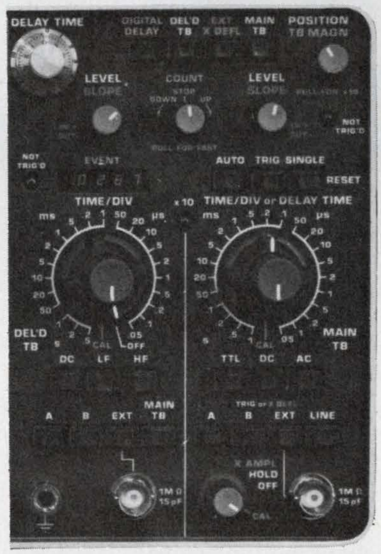
CIRCLE NUMBER 6

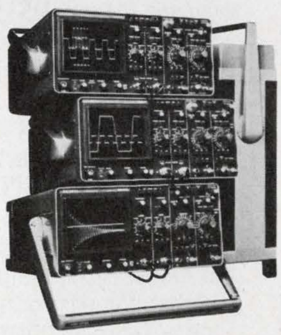


DISPLAY THE 267th BIT
and be sure it's not the 268th or 269th...



Finding the 267th bit takes quite a while, and then you're not sure you have the right one. The solution is programmed digital delay. On the Philips PM 3261, you can program the delayed timebase to start on the nth bit. By means of an internal variable-speed clock, the events counter can be preset from 1 to 99,999 events, with complete trigger level setting control.

Another addition to the Philips family of HF portable oscilloscopes, the 120 MHz PM 3261 adds easily programmable digital delay to the already completely separate delayed timebase control section found on its predecessors.



Special TTL triggering selection allows the PM 3261 to react just as logic does - a TTL level window prevents false triggering on rising or falling edges.

The PM 3261 list price is only $ 2595.00*

For further information contact, Philips Test & Measuring Instruments, Inc.

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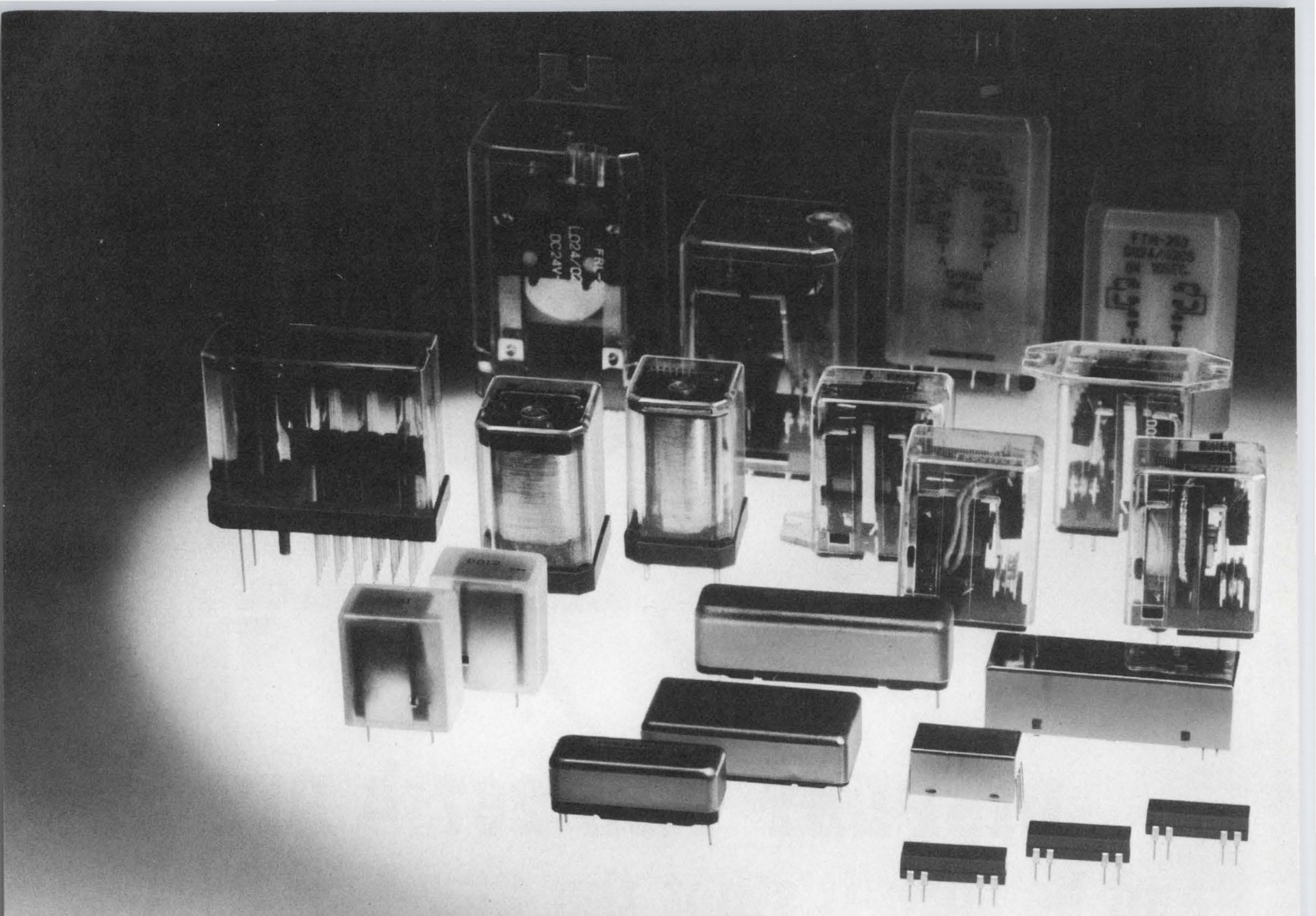
PHILIPS

PHILIPS

CIRCLE NUMBER 8



Make the switch to Fujitsu high

When it's time to put solid "switching power" into your equipment, it pays to select relays with proven performance and top quality. And that's just what you get when you specify Fujitsu relays. The wide-coverage Fujitsu relay lineup is here now ready to fill your total relay needs, from space-saving flat package units to powerful 10-amp general purpose models. Each and every Fujitsu relay is built to the quality standards that are synonymous with the name Fujitsu, and all feature proven performance that guarantees thousands of hours of failure-free operation. Here are just some of the features in store for you when you choose the name Fujitsu for your demanding relay needs.

Fujitsu flat package relays

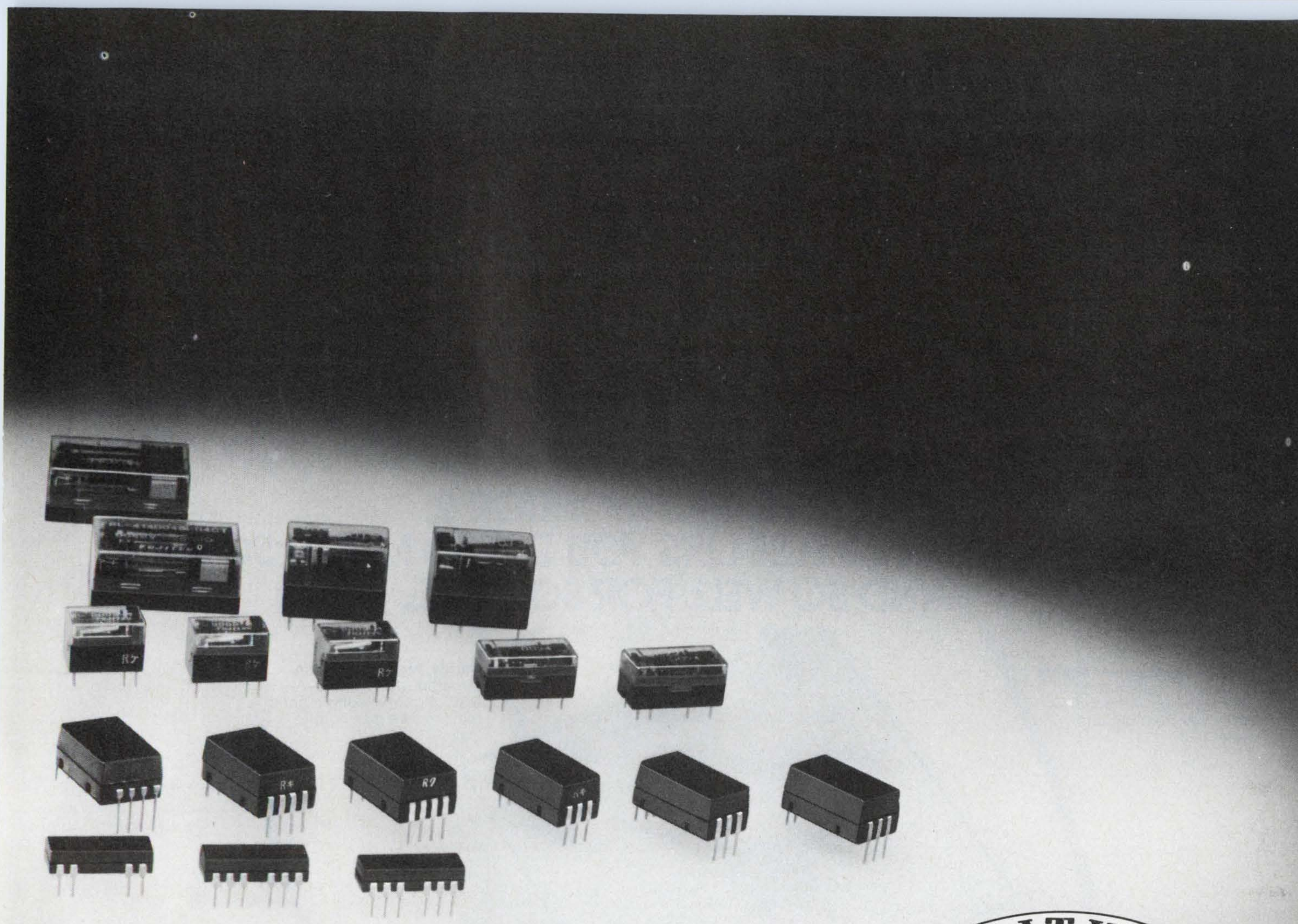
The Fujitsu lineup of flat package relays offers exceptional coverage and the advantages of flux-contamination-immunity. Within the lineup are our FRL 410-series low-profile and our BR-series miniature GP models. The former are available in both DPDT and 4PDT contact arrangements and coil voltage ratings to 48V DC enabling the widest selection to meet demanding applications including those for communications. And our BR-series models offer you similar wide choice including 0.5A ultra-miniature models that enable exceptional component densities for solid savings in both equipment size and cost.

CIRCLE NUMBER 111

Fujitsu general-purpose relays

With a wide model choice, including units capable of handling loads to 10 amps, the Fujitsu general-purpose relay lineup is a winner. Most models are available in both DC-and AC-rated coils, and with a solid selection of mounting configurations. You also get solid load handling and a choice of contact material to meet your exact operation requirements. Contact arrangements available are from SPDT to 6PDT, depending on models, with 12PDT or 18PST available on special order with our 491-series miniature models. Yes, whether compact or high load, the Fujitsu GP relay lineup is solid to meet your total switching needs. And for special applications, Fujitsu relays with fixed, knob-adjustable, or driver adjustable time delay are also available.

CIRCLE NUMBER 112



quality relays

QUALITY • RELIABILITY • FUJITSU

Fujitsu reed relays
Featuring Fujitsu-built reed switches of exceptional quality, the Fujitsu reed relay lineup is the unbeatable choice for today's high-speed, low current switching applications. As standard features, you get low contact resistance, compact size, a wide choice of contact arrangements and coil ratings, the availability of shielding and other features, and models including a built-in latching function via the Fujitsu MEMOREED® switch. You even have a choice of mounting grid patterns when you pick the FRL 640-series, low-profile reed switches. Full-featured and available in a wide range of models, Fujitsu reed relays are the solid choice for today's demanding data processing and control applications.

CIRCLE NUMBER 113

Fujitsu mercury wetted-contact relays
Built to provide exceptional reliability for a variety of equipment applications, Fujitsu mercury wetted-contact relays are top performers. Among the advantages of our mercury wetted-contact models are freedom from contact bounce, low and stable contact resistance, wide load-handling capabilities (from micro-ampere levels to a full 2 amps), low unit profile, and the capability for being driven by ICs. In our five-model lineup, you can choose coil ratings to 24V DC, with all models guaranteeing at least 10×10^9 operations.

CIRCLE NUMBER 114

The Fujitsu relay lineup. It's full coverage and high quality for unbeatable performance, and at prices that will make you wonder why you didn't think Fujitsu before. So, join the growing number of makers who specify Fujitsu quality products. Call or write now for additional information. You'll be glad you did.

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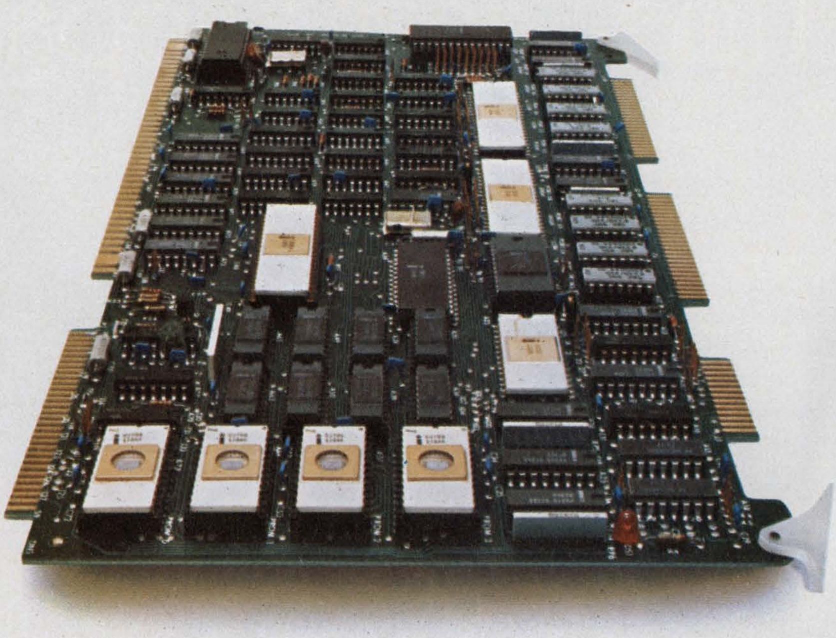

Intel delivers real time microcomputer multiprocessing. The new SBC 80/20 Single Board Computer.

SBC 80/20 delivers system throughput and design flexibility previously unobtainable on a Single Board Computer. Like our low cost industry standard SBC 80/10, the SBC 80/20 has everything you need—CPU, EPROM, RAM and programmable parallel and serial I/O—all on a single 6.75" x 12.0" board. And because the SBC 80/20 also has dual bus architecture, multiprocessor bus control, programmable eight level vectored interrupt and programmable timers, it is your best choice for real time multiprocessing and other high performance applications.

SBC 80/20 increases system throughput and improves system reliability by allowing tasks to be segmented in a true parallel processing configuration. Operate up to sixteen SBC 80/20 systems simultaneously without tying up the system bus when using on-board memory and I/O. And when access is required to resources sharing the system bus, onboard multiprocessing logic provides the necessary bus priority control.

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To protect data integrity, the SBC 80/20 includes an auxiliary memory power bus and all the logic necessary for implementation of a battery back-up system.

Ask for our new 24-page brochure describing the entire family of Intel® SBC 80 Single Board Computers, System 80 packaged systems and expansion boards. For your copy or for a demonstration contact your local Intel representative, use the reader service card or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California, 95051.

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ROSITE® moldings are presently being used by thousands of engineers in many innovative and masterful designs. Inside this XEROX 3100 copier there are 12 different ROSITE glass polyester moldings. They replace die-cast aluminum and other metal fabrications effecting economy and weight reduction helping make the 3100 copier a better product.

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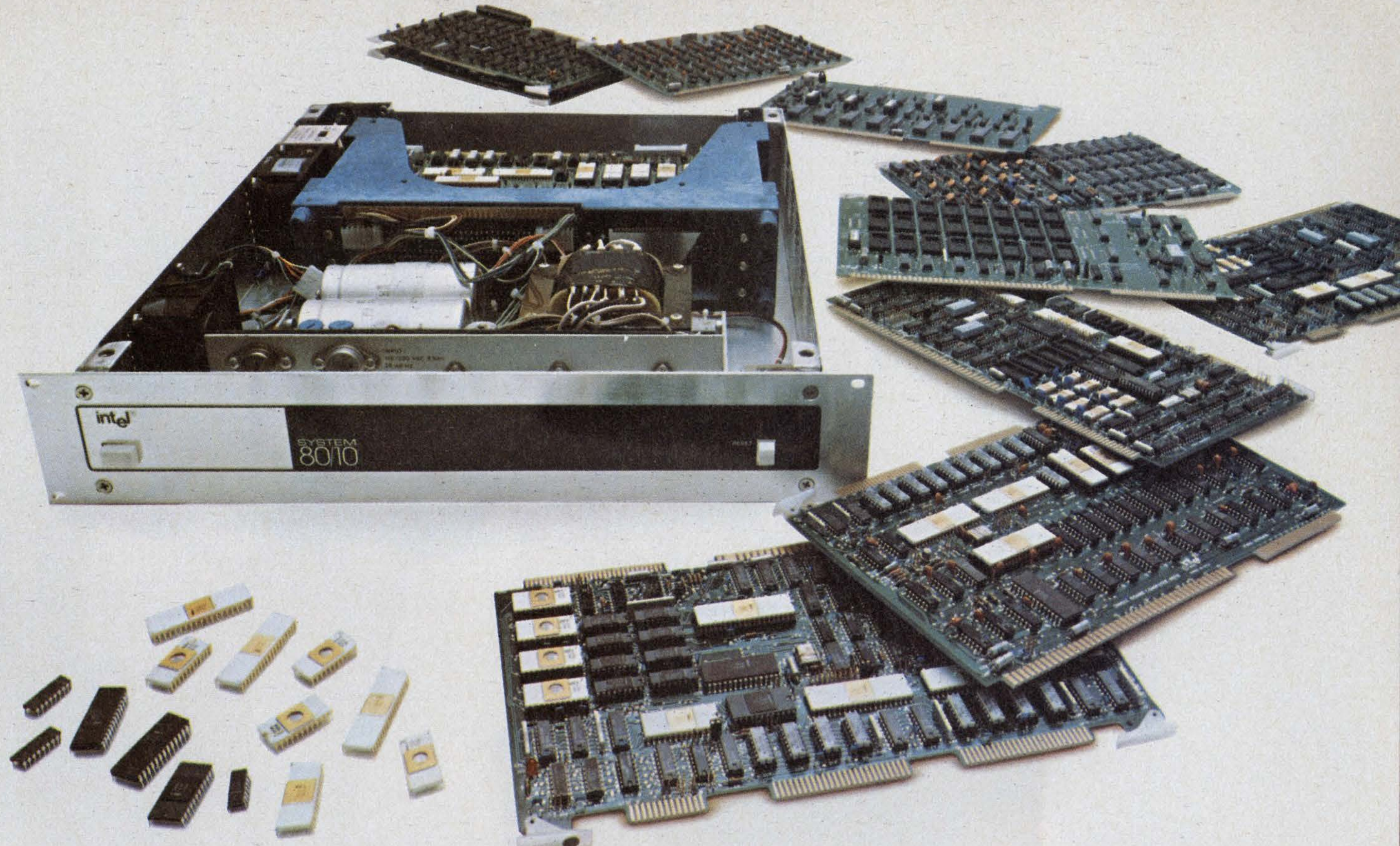

Intel delivers microcomputer systems that take the risk out of becoming successful.

Intel takes the risk out of becoming successful by providing economic, flexible and reliable microcomputer hardware and software solutions for your moderate and high volume requirements.

For most moderate volume microcomputer applications, it makes economic sense to buy an assembled and tested microcomputer system. That's why we offer two Single Board Computers (SBC 80/10, SBC 80/20) and two packaged systems (System 80/10, System 80/20). When you decide it's more economical to do the job "in-house," we'll make arrangements for you to use our bill of material, fab and assembly drawings, and artwork. And since we manufacture *all* the essential components—CPU, EPROMs, ROMs, RAMs, programmable I/O, and other LSI devices in volume, you can order the components from us and continue to take advantage of quantity discounts. *No penalty for success.*

Intel® microcomputer systems are flexible and easily configured to your specific needs. Expanding your system or reconfiguring the I/O is easy. All Intel microcomputer systems are supported by a complete line of I/O and memory expansion boards, diskette and DMA controllers, power supplies, card cages, and accessories. And since I/O, communications, timer and interrupt control functions are programmable, you can reconfigure the system to match your application by altering a few bytes of memory instead of redesigning system hardware.

And Intel delivers more than microcomputer systems that give you the cost/performance advantage. In addition we provide Intellec® Microcomputer Development System support to get you to market sooner. Intellec resident PL/M, the high level microcomputer language, can cut man months off your software development schedule. Intellec ISIS-II Diskette Operating Software, with linkage and relocation capabilities, will save more programming time. Develop programs in small manageable modules—then link them together or link them with general purpose subroutines from a software library. Reduce system integration and checkout time with the Intellec resident ICE-80™ In-Circuit Emulator. Develop, symbolically debug and execute high level and assembly language programs directly on your System 80 or SBC 80 based prototype.

From hardware and software development all the way through production, Intel gives you the competitive advantage. For a copy of our new 24-page brochure or a demonstration contact your local Intel representative, use the reader service card, or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

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How to turn a computer into a disk jockey.

The μPD372 Floppy Disk Controller.

Now you can turn almost any micro or minicomputer into a genuine floppy disk jockey with the help of just one small chip.

Our μPD372 Floppy Disk Controller. Or if your computer prefers playing tapes, we also have the μPD371 Tape Cassette Controller.

Either one can take the place of from 50 to 60 TTL packages to save you space as well as money. The 372 is completely compatible with IBM, Minifloppy,™* and other formats and controls up to 4 floppy disk drives. The 371 controls up to 2 tape cassette drives. They come with complete documentation and—best of all—they're available now.

The μPD372 and 371 are just part of our complete family of microprocessor products including 8080As, dynamic and static RAMs, ROMs, Electrically Erasable PROMs, and 8212, 8214, 8216, 8224, 8228/38, 8251, 8255 and other support chips. All backed by full documentation, applications support, and software.

The μPD372. The μPD371.

And the hits just keep on comin'.

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NEW BURROUGHS' 480-CHARACTER GAS PLASMA DISPLAY:

It's a space saver!
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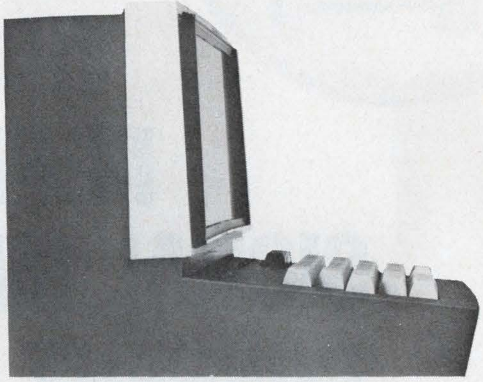
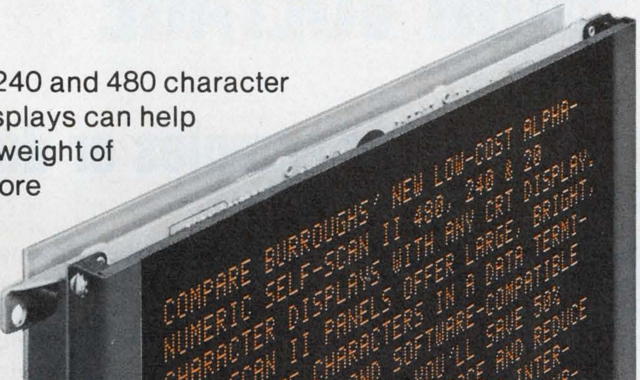




Burroughs low-cost 40, 240 and 480 character SELF-SCAN® II panel displays can help you reduce the size and weight of your data terminals by more than 50%. You'll reduce costs as well. And, at the same time, obtain excellent display readability under all operating conditions — indoors or out, day or night. Characters are uniformly bright, free of jitter and flicker with no fuzziness, distortion or loss of linearity at the display's edges. Character-to-background contrast is better than ever. And, the SELF-SCAN II panel's 40-character line is compatible with popular software.

Other significant advantages include direct digital address, easy interface to microprocessors, thin cross-section and rugged construction for long service life under all operating conditions.

Give your data terminals a bright new outlook; call or write for complete information. Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Plainfield, New Jersey 07061. Telephone (201) 757-5000. SELF-SCAN® displays are available nationwide through our distributors, Hamilton/Avnet and Cramer Electronics.

You can see the difference
Burroughs

CIRCLE NUMBER 15

News scope

MAY 10, 1977

Nonvideo games pit man vs microprocessor

The widespread attention lavished on electronic video games has overshadowed another fast-growing sector —nonvideo, microprocessor-based games.

For example, the $200 Chess Challenger by Fidelity Electronics, Ltd., Chicago, is a "board game." A player tries to beat a Nippon Electric 8080A μP programmed to respond to the standard moves and rules of chess. The initial version, introduced at the Winter Consumer Electronics Show in January, is programmed so that an average player can beat it as often as 70% of the time. But the next version, to be available in June, will be able to pit its wits against better players with a smarter ROM programmed to be more competitive.

Meanwhile, Bally Manufacturing, Chicago, has produced the first μP-based home version of its arcade pinball games. The $800 Fireball is controlled by an F-8 microcomputer that includes the CPU and 11 peripheral chips. Up to four persons can play together, and scoring appears on LED readouts.

Should the Fireball malfunction, the user can check all the moving parts and bulbs by actuating a built-in diagnostic program with a switch. The program checks only as far as the computer-board level. At this point, the owner can remove the IC board and send it to a service center for repair. The arcade version has an extended diagnostic program that permits a serviceman to check all the way down to components on the board.

Fireball sales have encouraged Bally to ready two more consumer pinball games for introduction next month—Captain Fantastic and Evel Knievel.

Interactive games needn't be elaborate or expensive. Two battery-operated, hand-held games—Auto Race ($25) and Football ($30) by Mattel, Inc., Hawthorne, CA—contain small, dedicated microprocessors and special LED displays (see photo).

To win the auto race, a player must

Two electronic games from Mattel are Auto Race (left) and Football.

beat two other "cars"—actually small moving bars of red light. He steers his car to avoid collisions and races the other cars against a built-in digital timer. A four-speed gear shift is provided along with a loudspeaker and racing sounds.

To score in the football game, a user/challenger must run through μP-controlled opponents (represented by bars of LED light) by keying in his own through-the-line or end runs. A digital LED scoreboard gives the down, yards to go, and the position of the ball on the field.

Calculator games are also making their presence felt in the marketplace. The first to be designed with six games programmed into it is the Mathemagician by APF Electronics, New York City. For games like Lunar Lander, Baseball, Gooey Gumdrop and Arithmetic, overlays are placed over LED readouts.

For the Lunar Lander game, for example, an overlay is used that indicates the speed of the rocket ship's landing, its altitude, and the quantity of fuel used. The object of the game is to touch down without crashing, which is indicated by a "Contact" LED. Less perfect landings are signaled by other LEDs: "Repairable," "Crash," and "Stranded."

The growing popularity of "man-against-machine" games has led Hewlett-Packard to program a $35 magnetic card of popular games. Many of the games in Pac I are large-computer games submitted by HP-65 and 67 programmable-calculator owners to the HP Users' Program Library.

The programs of submitted games have been refined to provide the highest programming efficiency, says Ken Newcomber, HP program applications engineer at Corvallis, OR. The games in Pac I may be played by one, two or more participants. Six of the games—Sub Hunt, Artillery, Super Bagel, NIM_k, Golf and Hexapawn—have variable difficulty. Two games—Dice and Slot Machine—rely totally on chance for the outcome. The other games are 21, Tic-Tac-Toe, Wari, Racetrack, Teaser and The Dealer.

Assembly problems? A NASA team may help

Electronics manufacturers with assembly problems can contact a NASA-sponsored team of experts for custom-tailored help. On request, the team will visit a plant, examine difficulties, and try to plug in solutions that NASA, or one of its contractors, has already developed for an aerospace program.

"We want to hit assembly operations more than device-production lines," says John D. Meyer, director of the manufacturing-applications teams. "We might be interested in companies building instrumentation devices for process control and other industrial applications."

A contract, set up for one year with options to extend, will be carried out by the Illinois Institute of Technology Research Institute (IITRI), Chicago, under the direction of NASA's Marshall Space Flight Center, Huntsville, AL.

A good example of NASA's technological wealth is conformal coatings for PC boards that create an environmental seal. Conformal coating materials developed by the NASA flight center have thermal expansion characteristics that match the devices they're used on.

IITRI plans to work through industry associations whenever possible. The Electronic Industries Association, for example, has just started a new manufacturing committee headed by Dale Hartman, director of manufacturing technology at Hughes Aircraft. Meyer's group plans to give one of its first presentations at the committee's meeting in May. "We hope to visit 40 companies the first year," Meyer says, adding, "We already have requests from 20."

Companies interested in IITRI's personalized counseling can contact John D. Meyer at IITRI, 10 West 35th St., Chicago, IL 60616. Telephone: (312) 567-4609.

Jitter and drift cut in Trapatt oscillator

Using light from a laser diode to control a Trapatt oscillator not only reduces jitter up to 60% but also gets rid of more than 85% of the frequency drift associated with conventional Trapatt circuits.

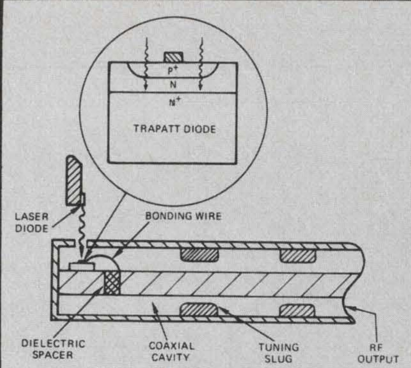
A Trapatt (trapped-plasma, avalanche-triggered transit) diode is mounted at the end of a slug-tuned coaxial cavity so that its active layer can be illuminated with a gallium-arsenide laser diode. The circuit was developed by Richard A. Kiehl and Errol P. EerNisse of Sandia Laboratories' Solid State Device Physics Division in Albuquerque, NM.

Trapatt devices are simpler and less expensive than multicomponent, chain-amplifier transmitters used in such high-frequency applications as pulsed radars. However, their use has been greatly limited by jitter in the leading edge of the rf pulse, sensitivity of jitter to circuit tuning, bias, and temperature, and frequency drift, due to heating, during each pulse. In conventional Trapatt devices, start-up jitter—the interval between bias application and oscillator start-up—can vary from 50 to over 100 ns.

The optically controlled Trapatt diode cuts jitter to 20 to 40 ns and makes jitter far less sensitive to circuit tuning, bias and temperature than conventional Trapatts. In addition, frequency drift, which averages about 1.4 %/μs in unilluminated diodes, drops to 0.2 %/μs in the optically controlled device. In fact, adds Sandia, by steadily increasing the intensity of illumination during the bias pulse, frequency drift can be virtually eliminated.

Trapatt oscillators incorporate semiconducting diodes mounted in a coaxial resonating cavity. When biasing current is applied to the diode, high-frequency waves are reflected back and forth within the cavity, and some of the energy escapes as rf output.

In the optically controlled oscillator,



LASER ILLUMINATED TRAPATT OSCILLATOR (EXPERIMENTAL CONFIGURATION)

photons from the laser pulse create electron-hole pairs by penetrating about 20 microns into the Trapatt's active region. These carriers aid in avalanche multiplication, which in turn aids in triggering the rf output.

Short laser pulses produce sharp frequency-change spikes on the rf output signal form timing marks that are easily detected when the signal is reflected back to the receiver. These signals may be of value in extremely precise phase-tracking radars, radar altimeters, proximity fuses, perimeter surveillance devices, and high data-bit-rate phase coding for transponders. As a result, says Sandia, systems with peak pulse outputs of several hundred watts at frequencies from 500 MHz to 10 GHz should soon be possible.

Stereo cartridge holds up to 1 Mbyte of data

The familiar 8-track stereo cartridge has been adapted to store digital data instead of music. Like a floppy-disc drive or a cassette-tape drive, the 8-track digital-tape cartridge can record data on removable media and reproduce it reliably. But in addition, the cartridge can also hold a full Mbyte of data—much more than standard floppy discs and cassettes—and reportedly puts more data storage on line per dollar.

The cartridge is called a "floppy tape" by its developer, Intelligent Systems Corp. of Norcross, GA, because its bit-serial data format is a simpler version of the floppy-disc format. A photo-sensed foil segment at the splice in the tape loop replaces the index hole used on floppy discs. The gaps, track-and-sector addresses, 128-byte data blocks, and check sums are like those of soft-sectored floppy discs.

With the same construction and tape path as the standard audio cartridge, the digital-data cartridge can store an endless loop of recirculating tape on a single hub. Tape slips out of the center of this reel to go to the heads, then wraps back on to the outside of the reel. The eight data tracks are accessed by a four-head assembly. Track switching takes only 1 μs if head motion is not needed—10 ms if the head assembly must move. The synchronous motor drive with read/write electronics, control electronics and a 4800/9600-baud RS232 asynchronous interface costs $100 in large-quantity orders, according to C.A. Muench, ISC marketing vice president.

Cartridges loaded with a specially lubricated 3M digital tape cost about $4 in quantities of 25 and up.

Circle No. 318

TI data terminals contain bubble memory

The first commercially available magnetic bubble memory was announced a couple of months ago—the TBM 0103 by Texas Instruments. Now two data terminals, incorporating the memory, have been announced by TI.

While a cassette system can take up to several minutes, both terminals can access any indexed records in memory in less than 15 ms. What's more, if the data location in either the 763's or the 765's memory is not indexed, their character-string search speed is 1000 characters per second—about four times faster than a cassette search. And the terminals' record-access time is more than 10 times faster than a floppy disc's, although their total data-transfer rates are lower.

Both members of the "Silent 700" series, the portable (17 lb) Model 765 and the larger table-top Model 763 come with 20,000 bytes of bubble-memory storage, expandable to 80,000 bytes in 20,000-byte increments. Each terminal is a fully capable 30-cps unit with a full ASCII keyboard, a built-in numeric cluster, a virtually silent thermal printer and an acoustic coupler. The portable 765 is equipped with a carrying case, as well as such traditional ASR functions as playback and record control with USAC USASCII commands, without additional cost.

Both terminals will be demonstrated at the National Computer Conference in Dallas, June 13 to 16.

Circle No. 319

LM140/340: Better Specs At The Same Price

Our LM140 series of three-terminal voltage regulators now offers a combination of features that gives you a higher-performance part, but with no increase in its price.

For example, our LM140 boasts superb low-frequency ripple rejection under load—to 80 dB, typ., depending on the output voltage level; excellent high-current load regulation at high input voltages—0.60%/A; line regulation, 0.06%/V; output current capability in excess of 1 A (with an adequate heat sink for the TO-3 package); and very low thermal feedback effects. Of course, internal thermal overload protection, internal short-circuit current limiting, and output transistor safe area protection are also included.

Now look at our brand new LM340. We're the first manufacturer to offer this commercial part with line and load regulations identical to the MIL version, yet priced the same as competing, less-tightly-spec'd devices.

And we've made both the LM140 and the LM340 very easy to use—they need very few external components, and are available in a wide range of fixed outputs between 5 V and 24 V. Ask too, about our LM140A and LM340A; these feature tighter output voltage tolerances and even better line/load regulation than the LM140/340.

Protected CD4000's

Not all CD4020/40/60 CMOS counters have Schmitt triggers on the clock inputs. Ours do. And these Schmitts eliminate the problems commonly encountered on clock inputs in the competition's devices.

The CD4020B and CD4060B are 14-stage ripple-carry binary counters; the CD4040B is a 12-stage version. All advance one count on the negative transition of each clock pulse, reset to the zero state with a logical '1' at the Reset input (independent of the clock), operate between 3 V and 15 V, run at 8 MHz (at V_{DD} = 10 V), and are low-power-TTL compatible (fan-out of 2 driving 74L, of 1 driving 74LS).

Support Circuits, Faster 8080A's Added

Less than one year ago we entered the 8080A marketplace with our INS8080A—a pin-for-pin, function-for-function replacement for you-know-who's MPU. But that was only the start. Since then we've added two more versions of that microprocessor, as well as a complete family of support circuits.

The new versions of our original 2-μs cycle time INS8080A are the INS8080A-1, which has a 1.3-μs cycle time, and the INS8080A-2, with a 1.5-μs cycle time.

In addition to the faster 8080A's, we now offer ten types of interface circuits to support 8080A system design.

- DP8212 is an 8-bit I/O port that you can use to implement all major peripheral and MPU I/O system functions.
- INS8255 is a programmable peripheral I/O interface that features direct bit set/reset capability.
- DP8301 is a microprocessor interface latch element (MILE) with on-chip status flags for 'handshake' control and interrupt generation. It drives TTL, NMOS, PMOS, and CMOS circuitry.
- DP8224 is a crystal-controlled clock generator and driver, which also provides a status strobe and oscillator outputs for external circuits.
- DP8228/8238 are system controller and bus driver circuits that generate all needed read/write control signals, provide drive and isolation for the 8080A's bidirectional data bus, and a user-selected single-level interrupt vector.
- DP8304 is an 8-bit bidirectional bus transceiver with high active outputs to both ports, a Tri-State® chip enable control, and transmit/receive control.
- INS8251 is a universal communications interface (USART) for data communication in 8080A and other bus-structured systems. (Available in April.)
- DP8216/8226 are I/O buffer drivers (4-bit parallel transceivers) suited to both 8080A and general MPU applications. (Available in April.)

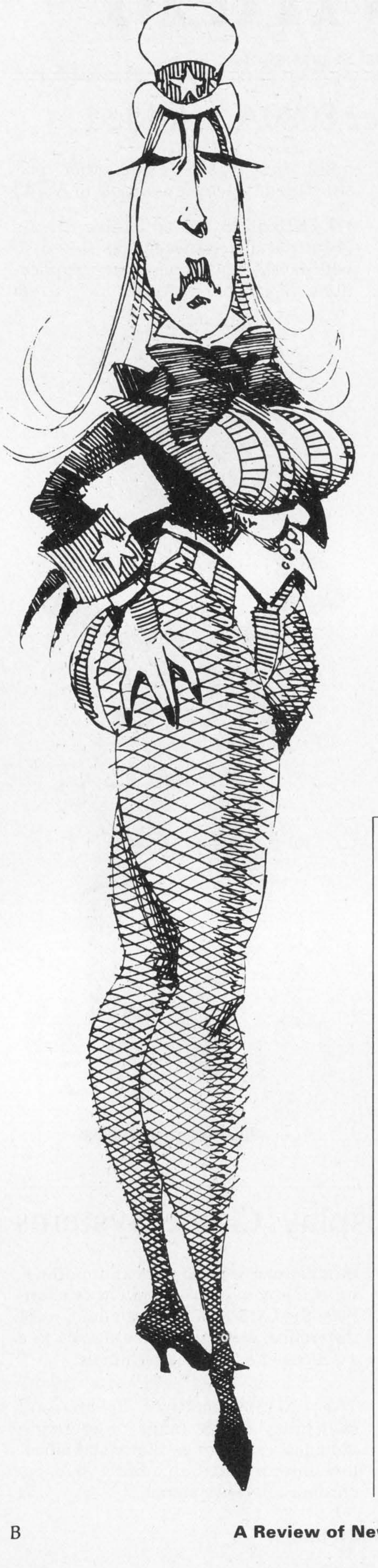
Video Modulator for Display, Game Systems

Our LM1889 lets you display video information—from VTR's, games, test equipment, etc.—on any standard black-and-white or color television receiver, and also lets you encode composite video. In addition, the LM1889 together with our MM57100 and MM53104 form a complete video game system.

Consisting of sound and chroma subcarrier oscillators, quadrature chroma modulators, rf oscillators and modulators for any two low-band vhf TV channels, the LM1889 interfaces audio, color difference, and luminance signals to a TV receiver's antenna terminals.

The LM1889 features dc channel switching, a wide range of operating voltages, excellent oscillator stabilities, low intermodulation, and a 5-V_{pk-pk} chroma reference signal.

Not Just Another Pretty Shift Register



We've added two National-proprietary circuits to our line of digital products—the DM86LS52 and DM86LS62 shift registers. But if you're thinking, "Ho hum, just another shift register," you're wrong. For in each 18-pin package there are two registers—an 8-bit serial type in parallel with an 8-bit I/O type.

Such a device is called an 8-bit dual-rank shift register. And what that means is that each package gives you a bidirectional circuit designed to interface parallel and serial bus lines. Thus, you can transfer 8-bits-wide parallel data to a serial line, and vice versa.

The DM86LS52 lets you synchronously clear the registers, while the DM86LS62 lets you simultaneously transfer data between the serial and parallel registers.

To duplicate such functions with standard components would require about 13 packages; a single DM86LS52 or 62 does it all, and at about half the cost.

Specifics of these new bus-oriented registers include edge triggering on the positive transistions of the clock; pnp transistor inputs; input disable dominant over output disable; Tri-State® buffered, 8-bit common I/O pins; n-bit cascadability; 36-MHz (typ.) shift frequency; and 305 mW (typ.) power dissipation.

Second-Source 8-Bit D/A Converters

Our LMDAC08 and LM1508/LM1408 monolithic D/A converters are direct replacements for the DAC-08 and MC1508/MC1408, respectively, and carry very low prices in 100-up quantities.

These current-output D/A's feature high-speed operation (typical settling times to within ±½ LSB are 100 ns for the LMDAC08 and 150 ns for the LM1508/LM1408); full-scale current matching to ±1 LSB; and typical full-scale drifts of ±10 ppm/°C (LMDAC08) and ±20 ppm°C (LM1508/LM1408). Excellent reference-to-full-scale current matching eliminates current trims.

Both the LMDAC08 and LM1508/LM1408 interface directly with DTL, TTL, CMOS, etc., logic levels. They operate between ±4.5 V and ±18 V, and dissipate only 33 mW, typical, at ±5 V.

8-Bit-Wide Tri-Safe™ PROMs Increase Memory Density

The DM74S470 (open collector) and DM74S471 (Tri-State®) PROMS are Schotty-clamped, 2048-bit memories organized 256 x 8. The DM74S472 (Tri-State) and DM74S473 (open collector) PROMS are also Schottky clamped, but are 4096-bit parts organized 512 x 8.

Although the word width is 8 bits—which, by the way, is ideal for MPU applications—these memories are housed in 20-pin DIPS only 0.3-inch wide. And this means that you get the increased memory density of 0.6-inch-wide designs, but at the better packing density of older, 4-bit-word designs in 0.3-inch-wide packages.

The combination of National's Tri-Safe™ programming and advanced, low-voltage titanium-tungsten fusing assures you of extremely high programming yields and the most reliable long-term stability you can buy.

The DM74S470/471 feature address access times of 60 ns (max.), while the DM74S472/473 have address access times of 65 ns (max.). The enable access time for all these parts is 30 ns, maximum.

BI-FET[tm], Integrating A/D Analog Building Block

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APPLICATIONS CORNER

How to Build a Digital Thermometer

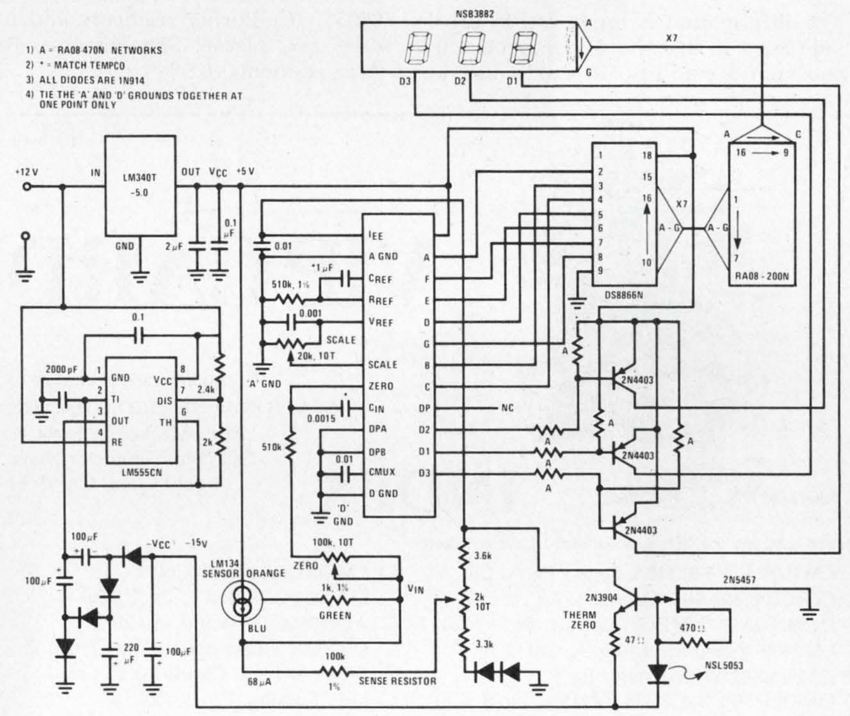
Analog electronic thermometers have been available for some time, but they are generally difficult to read and, besides, are relatively fragile. Digital thermometers, on the other hand, are both easy to read and rugged.

The digital thermometer described here uses a ADD2500 2½-digit DPM chip for A/D conversion and display decoding. The LM134 programmable current source operates here as the temperature sensor, and the LM555 timer as a dc/dc converter. The DS8866 and the pnp transistors drive the NSB3882 display.

The LM134 makes an excellent temperature sensor: it has a constant temperature coefficient of +0.30%/°C (0.167%/°F); and its noise immunity and current programmability make it ideal for remote sensing use. Output-current flow through a sense resistor scales the LM134's output voltage—in this case, to 10 mV/°F, which is one count of the DPM or 1°F displayed.

Besides a +5 V input, the ADD2500 draws 18 mA from a negative supply. This comes from the dc/dc converter (at −15 V) as a regulated current via the 2N5457 FET, the LED, and the 2N3904. The negative supply of the ADD2500 is internally Zener regulated; it, together with the two diodes and the resistor string between ground and I_{EE}, establish a low-drift offset voltage for the LM134's sense resistor.

The finished thermometer requires only a single, unregulated +12 V supply, and operates from −29°C to +60°C (−20°F to +140°F).



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A great amount of general design data are also included, and the material covers the instruction set, addressing modes, I/O capabilities, interrupt structures, and other applications-related features.

The *SC/MP Microprocessor Applications Handbook* costs $5.00 per copy. Send your check or money order—no cash, please—to Marketing Services M/S 520, National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051. (California residents add 6% sales tax, please; San Francisco Bay Area residents, 6.5%.)

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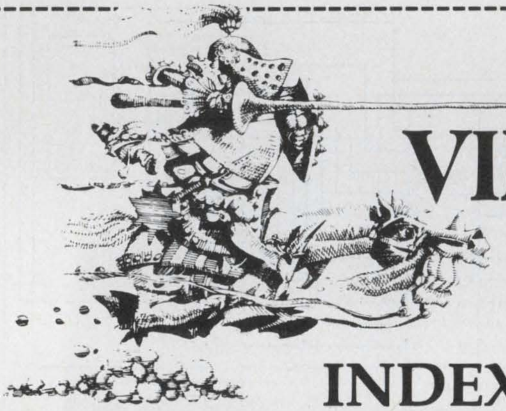

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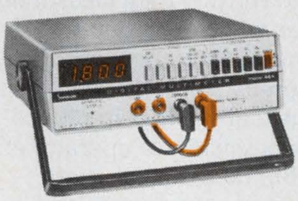

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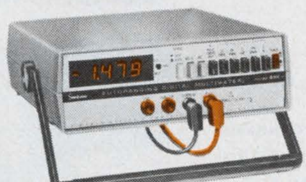

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CIRCLE NUMBER 17

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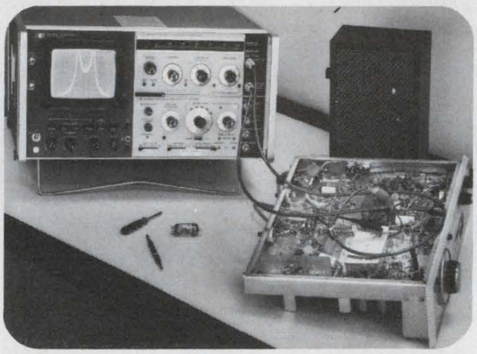

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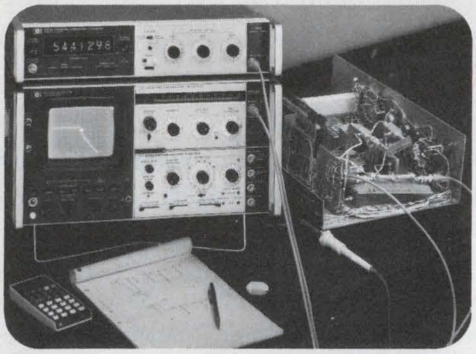

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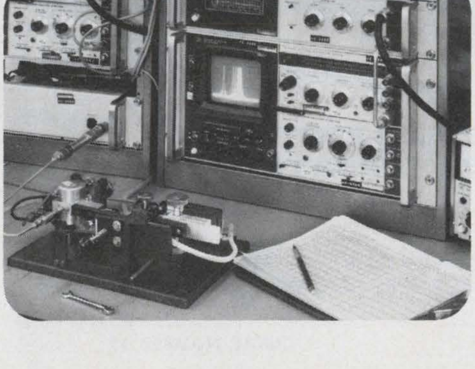

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CIRCLE NUMBER 21

Peripheral chips add functions —and problems—to μP systems

Peripheral chips are becoming more and more important to microprocessor systems because they provide the interface circuitry and hardware to perform functions the μP can't handle, extending the capabilities of the CPUs themselves. In fact, over the next few years, the peripheral chips' share of the market for microprocessor-system components will grow as the CPU and memory shares decline (see graph). But as the influence and complexity of peripheral chips grow, so do the problems of testing and deciding when—and when not—to use the devices.

Running benchmarks

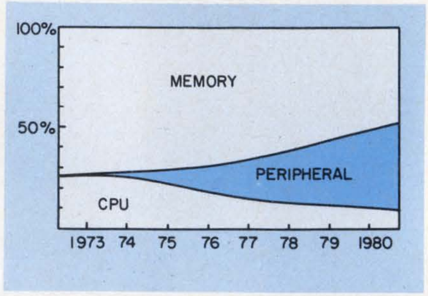
For one thing, it is becoming increasingly difficult to employ standardized benchmark tests to select a microprocessor. Rather than consider a CPU's features alone, many engineers are concerned with specific tasks and how easy or difficult it is to apply the microprocessor and its peripheral chips. So the peripheral chips available with one CPU may make that CPU seem more desirable than a superior CPU without the peripherals. "You can't just run a microprocessor through its paces and say it's the best," says Dan Abenaim, engineering manager of GenRad Inc.'s Electronic Instrument Division in Concord, MA.

Peripheral chips are also making it much more difficult to test microprocessor-based printed-circuit boards, says GenRad engineer Mark S. Mayes. "Peripheral chips can be more complex than processors, and there are often more of them on a board." While an 8080A CPU chip has fewer than 5000 transistor equivalents, a floppy-disc controller or a synchronous-data-link controller has the equivalent of over 22,000 transistors on a chip, says David House, marketing manager at Intel's Microcomputer Division in Santa Clara, CA. In addition, a CRT controller contains about 15,000 transistors per chip, and even a relatively simple keyboard/display controller has about 6000, says House.

Searching for sources

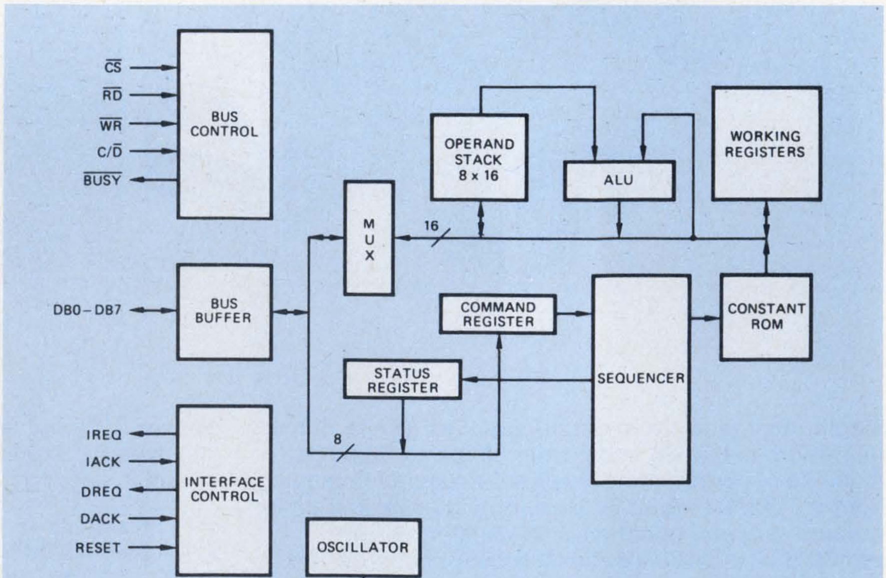
Moreover, a CRT controller may represent 25 to 30 SSI and MSI chips, according to Art Gruszynski, product manager at National Semiconductor in Santa Clara, CA, which leads to another problem—alternate sources.

"We're talking about large-scale systems on a chip," says Gruszynski. "The more you do that, the more the buyer becomes dependent on the supplier." As a result, buyers are unwilling to commit to designs that use peripheral chips available from only one source.



Microprocessor peripheral chips are getting so important, they will account for more than 40% of the dollar volume in μP-system sales by 1980.

"There's still a considerable resistance in peoples' minds to buying a sole-source product," says David F. Millet, microprocessor product manager at NEC Microcomputers Inc., Lexington, MA. While NEC is the only source for some of its peripheral chips, the firm is negotiating for alternates.



Plugging in a peripheral chip can add calculatorlike functions to a microprocessor-based system. This AMD circuit calculates trigonometric and logarithmic functions without tying up a lot of CPU time.

Andy Santoni
Associate Editor


0300
1200
12•12 DATA MODEM
POWER
ORIGINATE
SELF TEST
ANSWER
NORMAL
REMOTE
LOOPBACK
ANALOG
TEST
OH/RI
CARRIER DETECT
ERROR
XMIT DATA
RCV DATA

And Texas Instruments is negotiating for alternate sources for its 9900-series devices.

Trading software for hardware

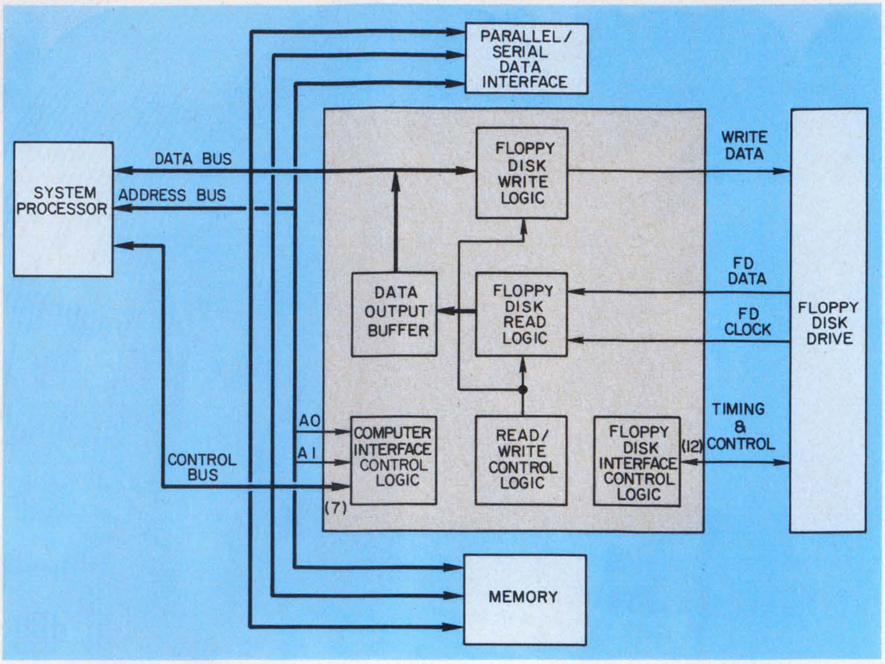
But sometimes peripheral chips aren't needed at all. "A microprocessor can do any job without sophisticated I/O chips, if it has enough time," says W.J. Dennehy, microprocessor-product marketing manager at RCA Solid State Division in Somerville, NJ. Peripheral chips are needed only when the CPU isn't fast enough to perform a specific task, or when there isn't enough time in the microprocessor's program to perform the function in software, says Dennehy. On the other hand, when high speed is demanded, or when the CPU has too many other tasks to perform, a universal asynchronous receiver/transmitter (UART) should be used, not software, according to Dennehy. In other cases, code conversion and formatting can be written into software. Storing a UART program in ROM costs about 32 cents —a good deal less than the cost of an additional chip, according to NEC's Millet.

If a minicomputer's CPU devotes just half its time to assigned tasks, that's too much, Dennehy says. Because the computer is employed in general-purpose systems, other, often unforeseen demands must be satisfied in the time remaining. But since, by and large, microprocessor CPUs aren't used in general-purpose applications, over 90% of the CPU's time can be dedicated to specific tasks, says Dennehy. Since operations can be handled in software, additional chips are unnecessary.

"If you're going to build a lot of something, you want to get your chip count down to nothing," Dennehy adds. That requires putting as much into software as possible.

Signetics' Weissberger agrees that some functions could be done in software, but complex tasks like synchronous data link control demand too much of a microprocessor's time and are best left to external hardware. "It takes a lot of overhead, and even the fastest bit-slice microprocessors can't do it," he says.

"The tendency is to use more and more the intelligence you're building into the system," says National's Gruszynski, so anything that can be off-loaded from the CPU should be performed elsewhere. For example, the microprocessor can scan a keyboard, but such a burden is better left to special-purpose peripheral chips.



Peripheral chips tie peripherals to microprocessor systems, too. This National/Western Digital circuit interfaces a floppy-disc drive to a multiplexed three-state data bus.

Adding functions

Indeed, peripheral chips are often called upon to extend the capabilities of the CPU itself. For example, the Am9511 arithmetic processor unit from Advanced Micro Devices Inc. of Sunnyvale, CA, adds a number of calculatorlike mathematical functions to processor-oriented systems, which reduces the software necessary to perform these functions.

Besides the four basic arithmetic functions—add, subtract, multiply, and divide—the 9511 can perform trigonometric and inverse trigonometric calculations, square roots, logarithms and exponentiation and can store such constants as pi and e. Its operating mode can be either fixed point, with single or double precision (16 or 32 bits), or floating point, with single, 32-bit precision.

Like other peripheral chips, CPU extensions take some of the burden that system software would otherwise have to handle. And by quickly performing functions in hardware, they increase time in the CPU for other functions.

Without external arithmetic processors, even relatively simple operations like multiplication would be time-consuming for most microprocessors, which perform multiplications by adding and shifting data. Some microprocessors, like Texas Instruments' TMS 9900, have built-in facilities for single-instruction multiplication, but must handle more complex calculations in software.

On the other hand, the 9511 takes data from the microprocessor, performs a function, and returns the result over an 8-bit bidirectional data bus. The device can be connected to the system through a conventional programmed I/O port, or through a faster direct-memory-access (DMA) controller.

Gaining access

The DMA controller is itself a useful peripheral device. By transferring data between memory and outside devices without passing the information through the CPU, a DMA controller, like Mostek's MK3854 for the F8, can take over some of the CPU's tasks, again leaving the microprocessor available for other operations.

In the IM6102 from Intersil Inc., Cupertino, CA, a DMA controller is incorporated with memory extension and interval-timer circuitry. A silicon-gate CMOS device that interfaces with the IM6100 microprocessor through the data bus and handshake lines, the IM6102 operates from dc to 8 MHz and

requires a single, 4 to 11-V supply.

The IM6102's real-time clock circuitry can be used to accurately measure and count intervals or events, as required by data acquisition and data processing systems. Similar functions can be added to 6800-based systems with the MC6840 programmable timer from Motorola Semiconductors, Austin, TX.

The 6840 has three 16-bit binary counters, three corresponding control registers and a status register. The counters are under software control and may be used to generate system interrupts as well as output waveforms.

For 9900-based systems, Texas Instruments offers the TMS 9901 programmable systems interface, which includes a real-time clock, interrupt-control circuitry, and I/O ports. An n-channel, silicon-gate device, the 9901 operates from a single, 5-V supply and has TTL-compatible inputs and outputs.

The 9901's clock consists of a 14-bit counter that functions as an interval timer by decrementing to zero, issuing an interrupt, and restarting at the programmed start value. The clock can also function as an event timer since, whenever the device is switched to the clock mode, the current value of the clock is stored in a register.

Six dedicated and nine programmable interrupt inputs are sampled and gated with their respective mask bits. If an interrupt input is active and enabled by its mask bit, the signal is passed to a priority encoder, which converts the highest priority signal to a 4-bit binary code. The code and the interrupt request are fed to the CPU at the proper clock time.

Communicating with peripherals

Besides extending CPU functions, microprocessor peripheral chips can interface the processor with external circuits and devices. These interface chips are either communications-oriented devices or circuits to interface microprocessors to such peripherals as floppy-disc drives and cassette recorders.

An example of the latter type is the FD1771 floppy disc formatter/controller from Western Digital Corp., Newport Beach, CA. An alternate source for the device is National Semiconductor Corp., Santa Clara, CA. As a formatter, the 1771 divides a disc according to IBM 3740 standards, with sector lengths of 128, 256, 512, or 1024 bytes. Discs can also be divided into non-IBM sector lengths from 16 bytes to 4 kbytes in 16-byte increments.

As a controller, the 1771 seeks any track, restores to track zero, steps ±1 track, reads and writes single or multiple sectors, and reads the identification field. The chip is programmed by the system's software, which—along with data, status, and control information—is transferred over a three-state bidirectional bus.

A similar floppy-disc controller, the μPD373, is available from NEC Microcomputers Inc., Lexington, MA, along with the μPD371 tape-cassette controller, which contains the circuitry needed to read data from, write data into, and control the motion of a digital cassette recorder. The μPD371 also converts data from 8-bit parallel to phase-encoded format, and vice-versa, as well as generates and detects cyclic-redundancy check (CRC) codes.

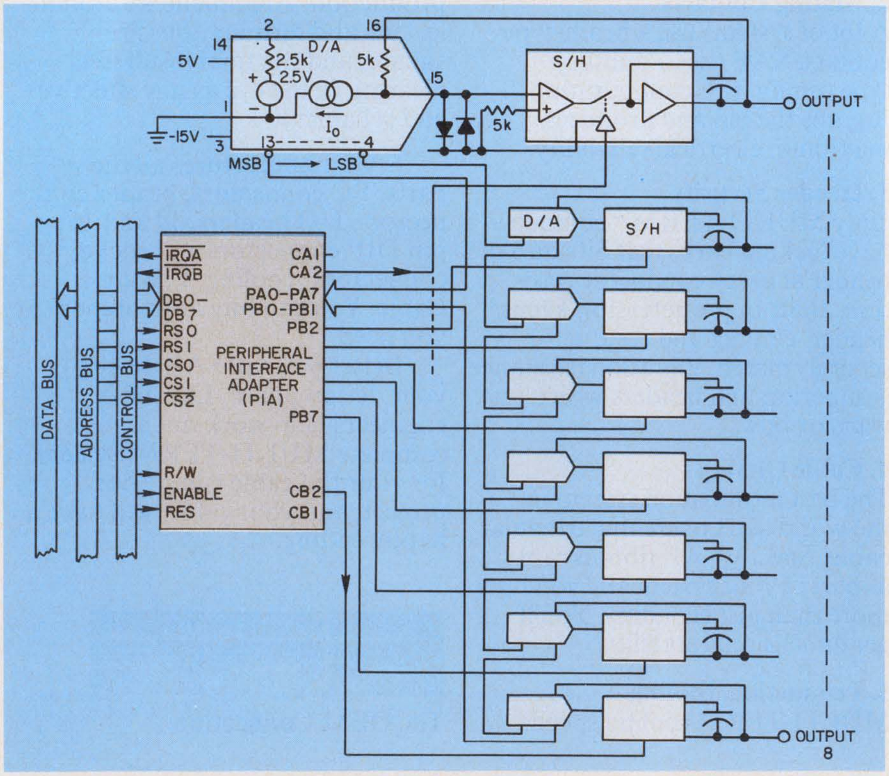
Chips by type, too

Some peripheral chips complement particular microprocessor types. Intel offers a line of devices for its microprocessors, Motorola for its 6800, Zilog for the Z-80, Fairchild for the F-8, and Mostek for its versions of the Z-80 and F-8. Other chips can be used with any microprocessor, or at least with any that has an 8-bit bidirectional data bus. And some more general-purpose products, like analog-to-digital and digital-to-analog converters, can be considered microprocessor peripheral chips when they are applied in μP-based systems.

Many of the latest converters are designed with microprocessor-based systems in mind, among other systems, says Ivar Wold, director of systems development at Analog Devices, Norwood, MA. The converters' digital-data terminals have three-state, byte-addressable configurations to minimize interface circuitry by permitting direct connection to the bidirectional data bus of the microprocessor.

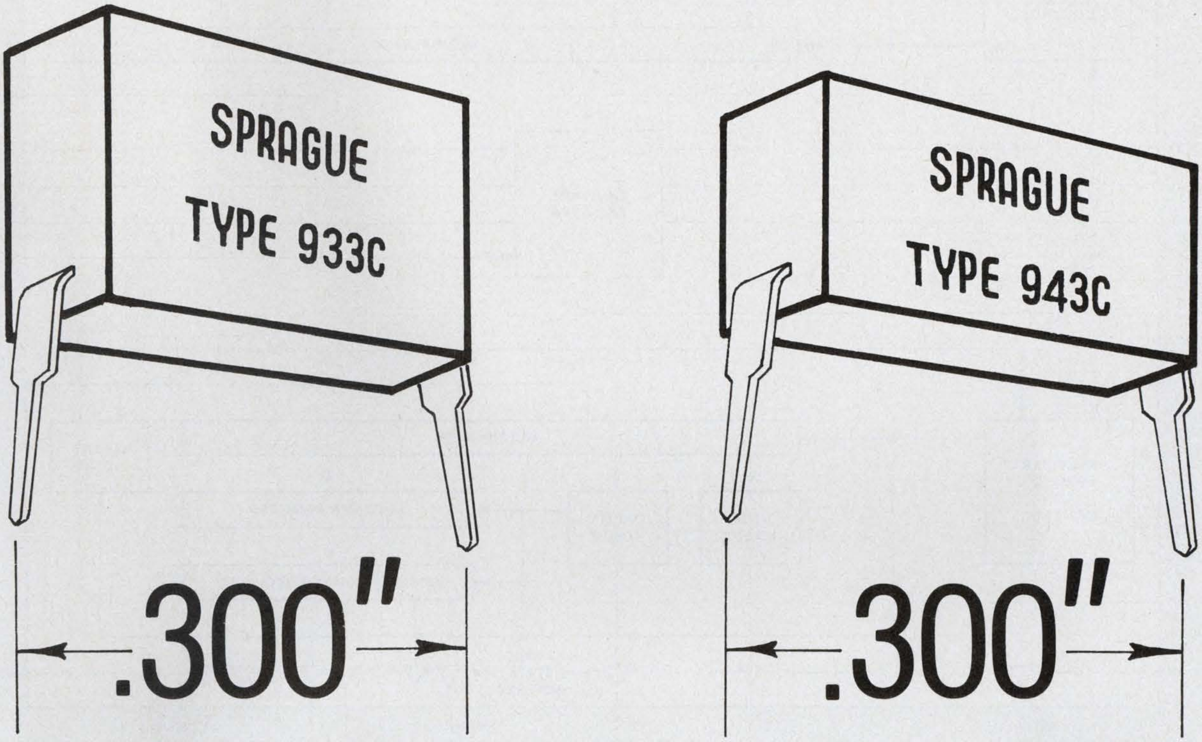
Even where multiple converters are necessary, interfacing can be simplified with a peripheral-interface adapter (PIA) like the MC6820 from Motorola, says Dave Kress, product-marketing specialist at Analog Devices Semiconductor in Wilmington, MA. As shown in the figure, eight d/a converters can be interfaced to a 6800-type microprocessor through a single PIA.

Where digital data are to be transmitted to other devices, such as CRT terminals, a common approach is to process signals from the microprocessor through a UART. Asynchronous systems are simpler than synchronous systems, especially when a UART is employed. "A UART saves



Talking to the analog world is simplified by feeding μP digits through a peripheral interface adapter to as many as eight digital-to-analog converters.

COMPATIBILITY!



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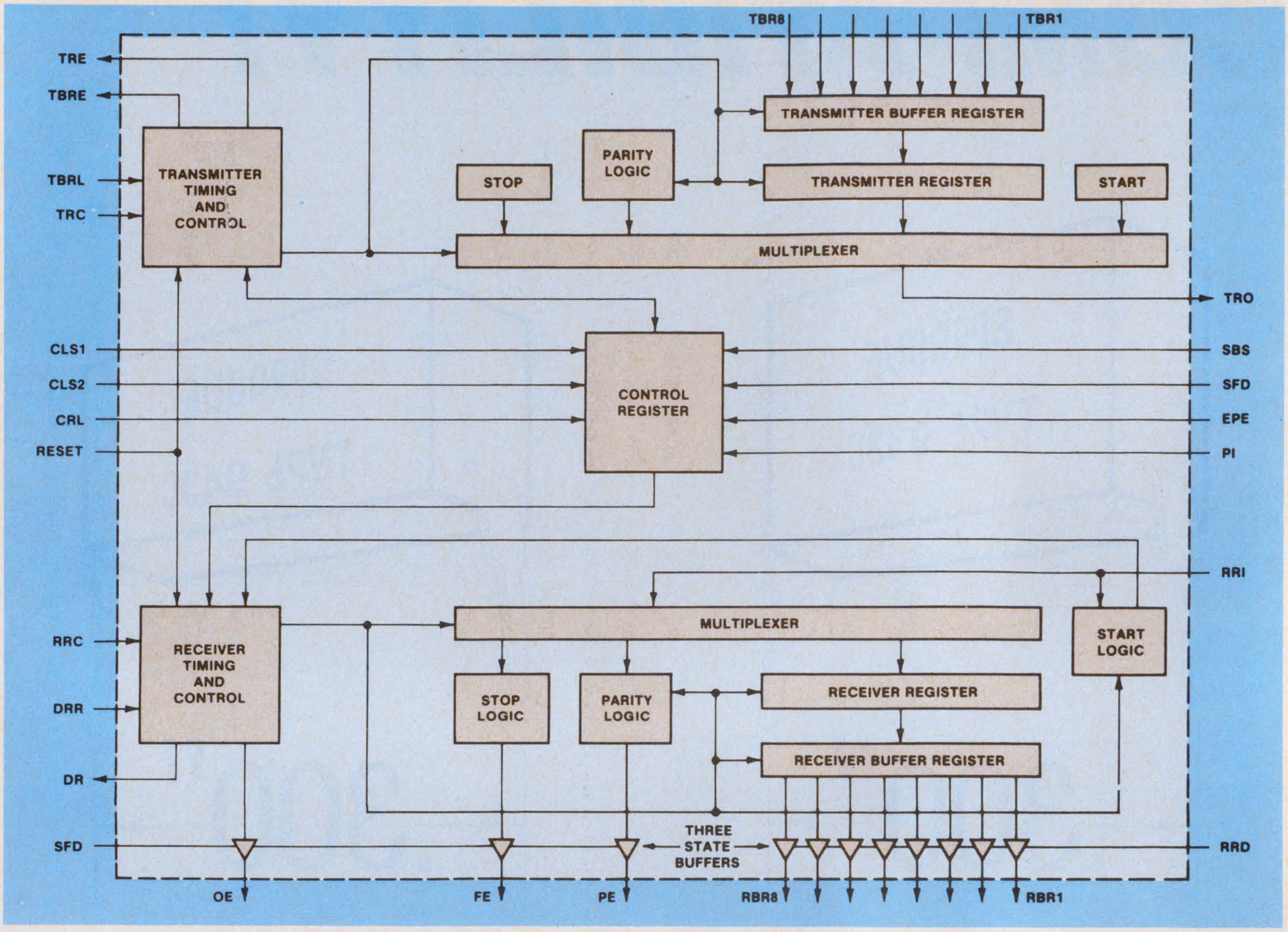


When digital data are transferred from one system to another, as from a CRT terminal to a microcomputer, the number of lines needed can be cut by employing an asynchronous receiver/transmitter such as the HD-6402/HD-6403 from Harris Semiconductor, shown here, to convert from parallel to serial and back.

logic cost," explains Ed Zander, product manager for the Micro Nova line at Data General Corp., Southboro, MA.

Pin-compatible synchronous and asynchronous control devices represent Texas Instruments' approach to receiver/transmitters. Instead of using a serial interface with the processor, the TMS 9902 asynchronous and TMS 9903 synchronous controllers interface directly to 8-bit buses and operate from single, 5-V supplies. Because the 9902 is housed in an 18-pin package and the 9903 in a 20-pin package, a board design that leaves space for 20 pins can accept either device. So by simply changing one IC and the program, a designer can change from synchronous to asynchronous links. This can be less expensive than incorporating a universal synchronous/asynchronous receiver transmitter, with its 40-pin package, into a system, says Tom Miller, TMS 9900 program manager at TI in Houston, TX.

Even the latest microprocessors, like Intel's single-chip 8085, have peripheral chips available. For CPU functional expansion, Intel offers timer, direct memory access, and interrupt controller chips. There are general-purpose I/O devices, universal synchronous/asynchronous receiver/transmitters (USART), and memory interfaces.

Aiming at common needs

In addition, Intel has just begun production of peripheral chips that perform "the four functions we found most prevalent," says Intel's House. The 827X peripheral series includes the 8271 floppy-disc controller, the 8273 synchronous data link controller, the 8275 CRT controller, and the 8279 keyboard and display controller.

The 8271 can control two single-sided for one double-sided drive in an IBM 3740 soft-sectored format. If the sectors are assumed to have no faults, the 8271 can drive four units. Programmable functions include record length, step rate, settle time, head-load time, and head-unload index count.

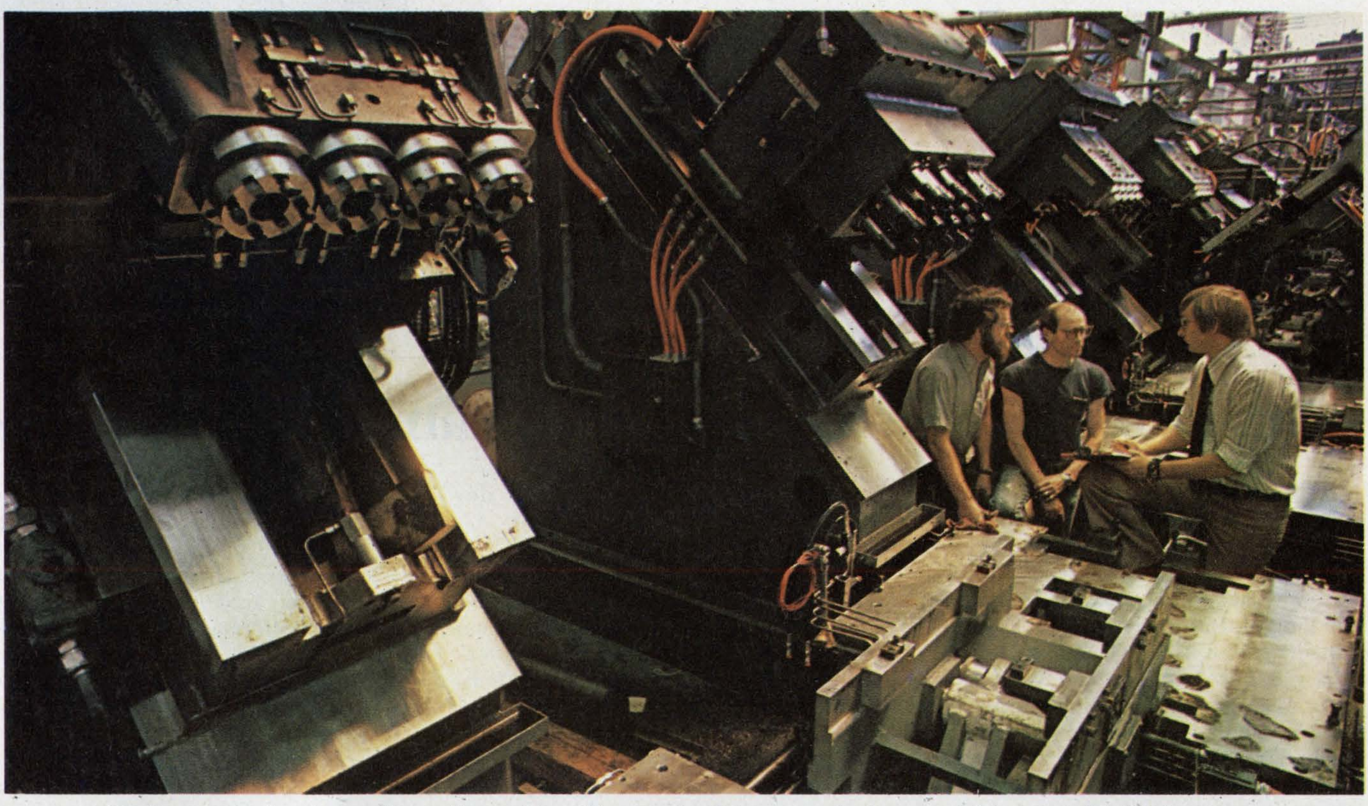
The 8275 CRT controller has screen and character formats that can be programmed by feeding data into the device's registers. The registers appear to the microprocessor as if they were memory locations. In addition, the controller can detect light-pen outputs for changing data on the CRT screen.

Among the peripheral chips available for the Z-80 microprocessor, from Zilog and Mostek, are the Z80-PIO parallel I/O controller and Z80-CTC counter-timer. The interrupt control logic for these devices is included on the chip, so a separate interrupt controller chip is not always necessary when they are employed.

The latest Z-80 peripheral chips include a serial I/O controller and a direct memory access circuit. The DMA chip controls data transfers between two ports, which may be either system memory or peripheral I/O devices. The circuit can also search a block of data for a particular byte, with or without a simultaneous transfer. ■■

DP Dialogue

Notes and observations from IBM that may prove of interest to the engineering community.



Work stations of an Ingersoll transfer machine. The transfer slides are at the bottom of the picture. Visible here is part of one section of a large machine which will make transmission cases.

Simulation Makes Giant Transfer Machines More Efficient

Computer simulation is helping huge transfer machines achieve as much as 15 percent higher productivity.

Robert Callahan, president of Ingersoll Manufacturing Consultants, attributes recent gains to an IBM computer program called General Purpose Simulation System V (GPSS V). It can be used in modeling a broad range of business activities, including manufacturing, physical distribution and transportation.

Callahan's group is a subsidiary of Ingersoll Milling Machine Company, Rockford, Ill., and is separate from that company's machine tool business. It helps manufacturing clients around the world to increase their return on investment and reduce costs.

Transfer machines finish rough castings into complex pieces such as engine blocks. They are named for the transfer mechanisms which automatically move the workpieces through successive 'stations' where cutting is done.

"If a line were built as a single straight-through train of work stations," Callahan says, "every stoppage would quickly bring the entire machine to a halt. So we lay it out in several sections, each supplied from a 'bank' of workpieces which can be drawn upon when upstream sections are stopped. How close a line comes to its production potential is determined by such factors as the number of sections and the size and placement of the banks.

"It is vital," he adds, "to design the section split and the banks correctly before the line is built. But there is no straightforward analytical way to calculate performance in advance. Simulation by computer is the ideal tool for this kind of problem; with a GPSS model of the entire line, we can test proposed layouts quickly and easily."

Callahan's group runs its simulations on an IBM System/370 Model 145 operated by the parent company.

"In designing a line," he adds, "we manipulate the computer model to work our way toward the best configuration. We trv different layouts, section splits, banking arrangements and tool placements. GPSS lets us model the characteristics of each tool in detail; the resulting model behaves remarkably like the real transfer line."

Computing Power for Engineers

Design engineers can now access the computer directly through terminals in their offices to test tentative structural configurations, run simulations and develop improved designs. A growing number of companies are raising engineering productivity with IBM interactive computing facilities.

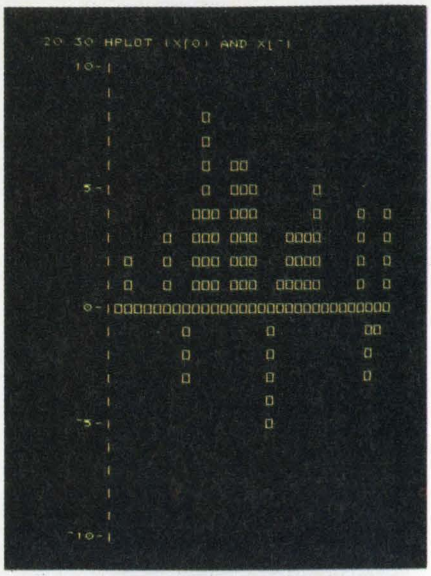
A user at a terminal can activate a previously prepared program stored in the computer. Or he can create a problem-solving routine to meet the need of the moment, using one of the simple-to-learn but powerful programming languages.

Facilities exist for presenting a computation as a curve, bar chart, histogram or frequency distribution on the screen of an IBM 3277 Display Station. In lengthy computations, intermediate results can be displayed, allowing the user to watch the trend and terminate an unpromising trial.

Often, the user of the computer finds that a calculated result suggests further trials with new parameter values, approaching an optimum solution iteratively. With interactive computing, the user can obtain multiple job "turnarounds" in a short time, rather than one or two a day.

Programs can be written for one-time use or to be kept in direct-access storage and invoked whenever needed. Such programs can be as large as a complex system simulation or as small as the evaluation of a simple expression. The computing power is always on tap, whenever it can be useful.

Facilities available from IBM bring interactive computing capability to any System/370 installation.



Simple instructions can specify graphic display (above, bar chart) of interactive computing results.

Computer Cuts Water Use More Than 30% for Farmers

Irrigation is vital to crop production in the Great Plains. The more water applied, the greater the production—up to a point. After that, water and energy are wasted and nutrients are leached out of the soil. Intuitive methods of scheduling irrigation usually lead to over-watering—or, in some cases, underwatering.

"With the help of a computer, a growing number of farmers in this area are achieving water and energy savings of 30 to 40 percent," says Paul Fischbach, extension irrigationist at the University of Nebraska.

These farmers are using one of more than 100 programs available in AGNET (Agricultural Computer Network), a remote-access computer service developed at the university.

They obtain assistance through terminals in many locations throughout the state. When a farmer enters the word 'Irrigate' an IBM computer in Lincoln responds by requesting current information on his field. He enters daily temperatures, rainfall, amount of irrigation applied and soil moisture readings since the previous update.

When the farmer has keyed in all the requested weekly data, the computer uses up-to-date weather statistics for the region and the stored characteristics of the farmer's field to determine a suggested irrigation schedule.

Nebraska farmer Kenneth Bruns takes a reading of soil moisture, one of the variables considered by AGNET in the calculation of an optimum irrigation schedule.

At the university's Institute of Agriculture and Natural Resources, James G. Kendrick, professor of agriculture economics and Thomas L. Thompson, professor of agricultural engineering, lead the continuing development of the online AGNET system, implemented on an IBM System/370 Model 158 at the Nebraska State Department of Administrative Services.

Another AGNET program helps livestock growers calculate optimum feed mixes or formulas. For maximum growth rate, the nutrition requirements are different for various species and change as the animal grows. For example, AGNET identifies 13 different nutritional balances for beef cattle.

To develop a minimum-cost mix of cattle feed that meets nutritional and palatability requirements, the computer asks what ingredients are to be considered, and at what prices. The farmer enters his own prices or uses those in the AGNET data base.

He can ask the computer "what if" questions, test his decisions against hypothetical price and cost fluctuations, and calculate the total costs of crop production under different management techniques. A financial program analyzes investment in capital equipment, using any desired cost and performance assumptions. Other programs recommend pest control schedules, make fertilizer recommendations based on soil analyses and simulate the growth of livestock.

"The computer," Kendrick notes, "is becoming an important tool for improving the economics of farming in this area."

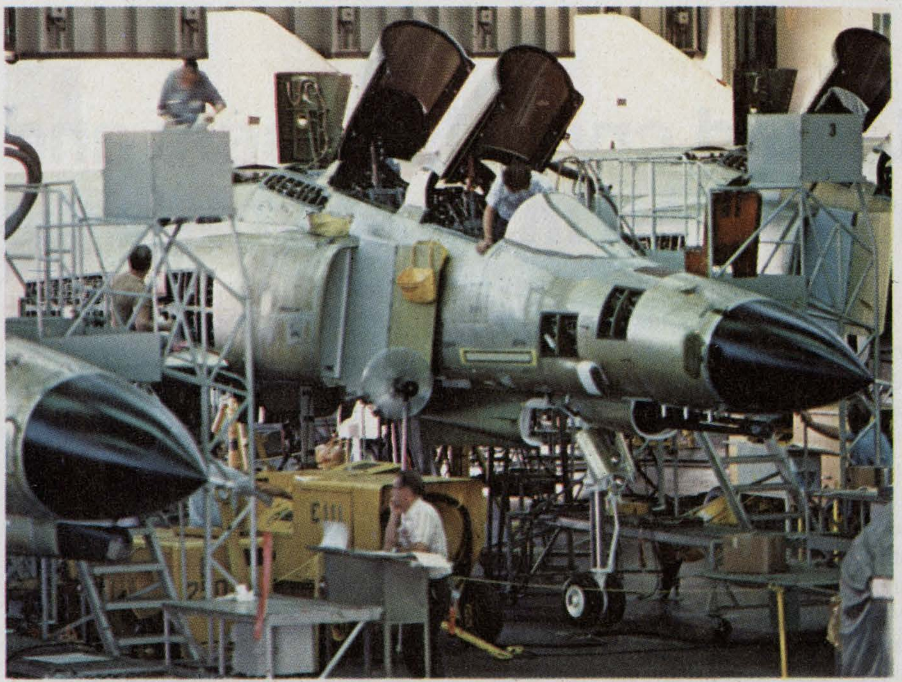
Designing Supersonic Aircraft with a Light Pen

The complex shape of a supersonic aircraft fuselage appears in crisp white lines on a CRT screen. The design engineer seated at the terminal presses a few keys and the image of the craft's landing gear unfolds into the extended position.

But the engineer observes some interference between the landing gear and the fuselage. Swiftly he touches keys and moves a light pen across the surface of the screen. As he works, the shape of the fuselage alters slightly, and when the landing gear descends again it is clear of all obstructions.

The scene is McDonnell Aircraft Company, where the engineer and his colleagues design high-performance aircraft. He is seated at one of 30 IBM 2250 Graphic Display Terminals in the St. Louis headquarters of the McDonnell Douglas Corp. subsidiary, using a graphics processing computer program called Computer Aided Design and Drafting (CADD, pronounced "caddy"). Created by McDonnell, CADD runs on two IBM System/370 Model 168 computers.

"We can sometimes identify engineering productivity gains of ten to one or more," says Stanley LaFavor, director of computer-aided technology. "In one instance, our engineers solved in two days a problem in landing gear placement which we couldn't have solved manually in six months.



McDonnell Douglas engineers design structural components of these high-performance aircraft, working interactively with the computer at graphic terminals.

"Overall, we see an average engineering productivity gain of six to one," LaFavor adds, "and we are accomplishing many engineering tasks with CADD today that couldn't be done any other way. Formerly, with these difficult design problems, we had to take the first solution that would work; now we can find the best one."

A remarkably sophisticated graphics processor, CADD permits the engineer to display sight lines (indicating, for example, the unobstructed view from the pilot's seat), or to display any desired cross section of any geometric shape he has defined to the computer. Not only landing gear but any articulated part—hinged doors in compound-curved surfaces or an in-flight missile launching system—can be displayed and its motion in space delineated and checked for interference.

CADD displays three-dimensional shapes in trimetric projection, a type of perspective frequently used in drafting. The system can rotate a projection around any selected axis, move it in any direction or change its scale. The user defines a geometry and commands system functions by means of the light pen, the keyboard of the 2250, and a set of pushbuttons which control powerful graphics functions in the CADD program.

CADD permits structural components of the aircraft to be designed in detail at the terminal. To configure a fuselage bulkhead, for example, the engineer asks the computer to display the desired cross-section of the fuselage and to subtract the skin thickness to arrive at the exterior shape of the bulkhead. He then works out the machined shape—webs, flanges, lightening holes—using the light pen and the keyboards.

In addition to its graphics capabilities, CADD serves as the core component of a related set of computer programs supporting all aspects of structural design of an aircraft. These subsystems are linked to one another by the CADD data base, in which all details of the aircraft are accumulated as design progresses. One subsystem generates loft lines; others perform structural analysis and calculate the weight and structural dynamics as the detailed components of the craft take shape. A third calculates the operational performance of the hypothetical aircraft.

"We've eliminated much that is time-consuming and repetitive in engineering," says LaFavor. "Our major thrust has been to improve the flow of data from engineering to manufacturing, saving downstream dollars."

IBM Interactive Languages for Engineers

Three IBM programming languages are designed specifically for problem-solving by engineers and other non-data processing professionals:

1. VS APL A broadly applicable interactive language, simple to learn, yet uniquely powerful for scientific and mathematical problems.

2. VS BASIC Powerful for a wide range of problem-solving, and flexible without sacrificing simplicity.

3. VSPC FORTRAN Permits problem-solver to create and invoke FORTRAN programs directly. The user enters data and receives results at the terminal.

For more information on these languages, write to the address on the right.

DP Dialogue is designed to provide you with useful information about data processing applications, concepts and techniques. For more information about IBM products or services, contact your local IBM branch office, or write Editor, DP Dialogue, IBM Data Processing Division, White Plains, N.Y. 10604.

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Liquid crystals, lasers and μPs reflected in tomorrow's displays

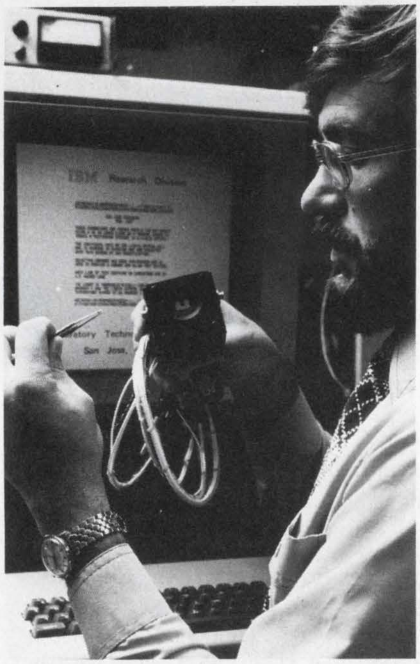
"Innovative" is the key word to describe a host of new displays at the recent Society of Information Display's International Symposium in Boston. Prototype systems discussed incorporate the latest technological developments—lasers, liquid crystals, magnetic and electrical particles, microprocessors and so on. Key developments include

- A 2000-character thermally addressed liquid-crystal projection display, which avoids the use of bulky, liquid-cooled lasers and inefficient transmission-type cells by substituting a room-temperature gallium arsenide laser and an efficient reflective-type liquid-crystal cell.
- Rotating-particle panels, which have an inherent memory and require low operating power, and are appearing as either electrostatically or electromagnetically operated devices.
- Multiple displays on a terminal, an emerging design trend that reflects the increasing processing power being incorporated in terminals through powerful microprocessor architecture.

Experimental liquid-crystal displays have been developed that have cooled solid-state lasers that scan patterns on transmissive liquid-crystal screens. But an experimental 2000-character, laser-driven display developed by IBM incorporates two improvements: a room-temperature, gallium-arsenide laser and a reflective liquid-crystal cell. The room-temperature laser simplifies system design. And scanning the liquid-crystal cell's aluminum reflective layer provides maximum absorption of laser power.

The IBM system can display 20 characters per second. Cell data can be bulk-erased by applying a 200-V, pk-pk ac field, and selectively erased by combining a 50-V, pk-pk ac field with laser scanning.

Jim McDermott
Eastern Editor



Gallium arsenide laser (in tweezers) mounts on heat sink inside laser module for IBM's liquid-crystal projection display system.

The cell is constructed with smectic crystals sealed between two glass plates, with the reflecting aluminum coating deposited on the inside rear plate. The internal surfaces of the glass plates are treated with plasma-deposited silicon dioxide, according to Dr. Anthony G. Dewey, staff member at IBM, San Jose, CA. This treatment aligns the individual liquid-crystal molecules, shaped like cigars, parallel —not perpendicular—to the glass-plate surfaces.

The liquid crystal is a mixture of octyl cyanobiphenyls. To prevent changes in the laboratory ambient that would alter cell characteristics, the cell is stabilized at 60 C.

In experiments, the parallel alignment of the liquid crystals proved most sensitive to the energy in the laser beam, which was focused on the rear, internal aluminum surface of the cell. A pair of X-Y galvanometer mirrors scan the focused beam across the cell in a top-to-bottom raster.

Fabricated at the IBM Yorktown Research Laboratory, the gallium-arsenide laser is a double-heterostructure device with a junction width of 12 μm. The laser and its drive circuitry are contained in a vacuum inside a laser module (see photo). Heat-sink temperature is maintained at 8 C (46.5 F) by a thermoelectric cooler.

Power density in the laser-beam spot is 1.1×10^{-4} W/cm^2. The spot on the aluminum surface struck by the beam heats up, which scatters the crystals and changes the contrast at that point. The contrast ratio obtained from the cell itself is measured at 40:1. Because the optics used for the IBM setup were not designed for the project, only 2 to 3 mW from a 15 to 25 mW laser output can be focused into a 3×15-μm spot on the aluminum surface. The picture elements of the cell itself are 10 μm square, and the field of the laser system is about 7 mm. The result is a square picture of 500×500 elements, or 40 rows of 50 characters.

With a writing rate of 20 characters/s, only 35% of the time is used for actual writing, while 65% is used for flyback to give a picture-element-area scan of 280 μs. But since the laser is pulsed during this period for 120 μs of "on" time, the laser is being used only 15% of the total time.

The writing rate strongly depends on the laser power. But Dewey points out that refinements to the present system can increase the rate to 100 characters per second. What's more, using multiple lasers to write separate lines at 1000 characters per second is feasible, Dewey insists.

The laser beam is applied to the rear of the cell, and light from a 500-W tungsten projection bulb is focused on the front of the cell (see Fig.). The image is produced by the on-axis system. Black characters are presented on

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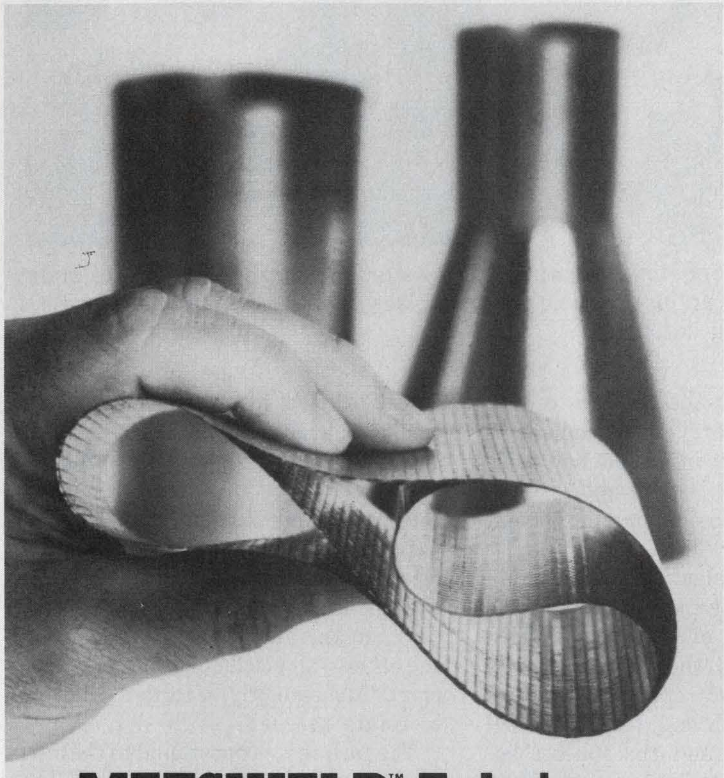

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a white background by using an off-axis telecentric Schlieren lens.

The image of the liquid crystal cell can be combined by interposing a slide in the projection system. A relay lens creates an image of the liquid-crystal cell in the plane of the overlay slide. The combined image is then projected at 25-X magnification onto a rear-projection screen. The slide image is 10-in. square and has high resolution and full color. The dynamic liquid-crystal cell information appears as a central 5-in.-square image with black characters. The 40:1 contrast ratio of the cell is reduced to 8:1 by a combination of the f/7 Schlieren system and scattered and reflected light reaching the screen with the present setup. Maximum screen brightness is 45 ft L.

An M6800 microprocessor modulates the laser-drive current and the selective erase field, and also drives two d/a converters to provide inputs to the galvanometer servos. Some 750 bytes of control program are stored on two EPROMs, and 1 kbyte of RAM stores the alphanumerics. ASCII code from the keyboard of a RAM controls a sampled ROM to give the correct bit sequence for any of the sixty-four 7 × 9-dot characters.

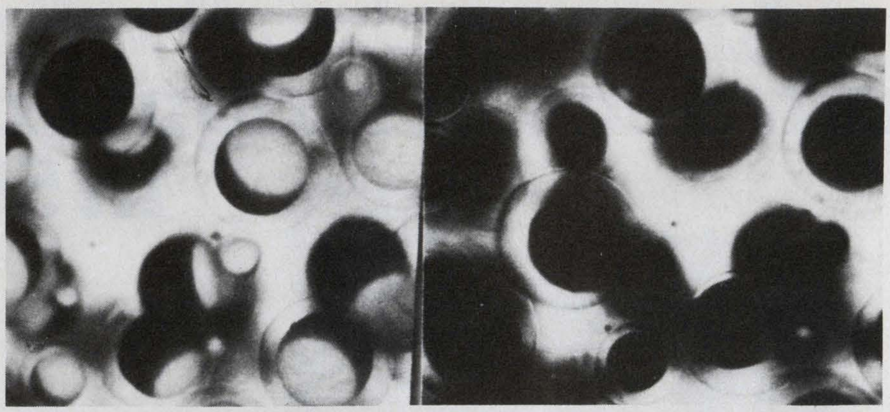
Electric field drives display

Meanwhile, a number of other methods have been explored to produce ambient-light displays changing color or reflectivity. A new one, the Gyricon, developed at the Xerox Research Center, Palo Alto, CA, uses an electrical field to rotate dielectric balls encapsulated in a thin sheet of silicone elastomer. Hemispherically colored black and white balls are contained in individual, oil-filled cavities.

The Gyricon display, which promises to be both reliable and inexpensive, has a memory: Once the balls are rotated by the field, they remain in that position when the field is removed. Power consumption is limited to the capacitive displacement current associated with the switching of the display.

To fabricate the display, white glass balls are made by melting titanium dioxide—one of the whitest substances known—into the surfaces of the micron-sized glass spheres. Halves of the spheres are then coated with a proprietary black dielectric layer put on by vacuum deposition.

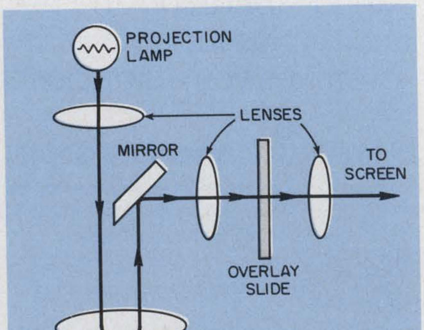
The spheres are then mixed with an uncured elastomer, like silicone. But organic elastomers can be used as well, points out Nicholas K. Sheridon, principal scientist at the research center. The elastomer carrying the spheres is spread out into a thin sheet and heat-cured. The sheet is then immersed in a dielectric liquid—an organic solvent or an oil.



Hemispherically coated microspheres of Xerox' Gyricon system rotate under the influence of an electric field to give a black or white display. Spheres float in encapsulating liquid.

Acting as a plasticizer, the liquid swells the rubber sheet typically to more than 50% of its original cured volume. Although the elastomer swells isotropically and spherical cavities form around each ball, the cavities fill with plasticizer and the spheres become free to rotate in the liquid. When the spheres are rotated by electrical charges, the liquid also serves to dampen the oscillation of the spheres about their equilibrium positions.

The titanium dioxide and the black hemispheres have different contact potentials with respect to the dielectric plasticizer. And liquid ionic double layers develop with different surface-charge densities and/or signs associated with the two hemispherical surfaces. Part of the charge resides in the liquid and part on the spherical particle, Sheridon explains. When an electric field is applied, the charge on the surface starts moving in one direction and the particle starts moving in the other—an electrophoretic phenomenon. Consequently, a torque develops to rotate the ball.



Laser beam strikes rear surface of liquid-crystal cell in IBM display. Projection lamp bounces light off front of cell, and optics project cell data onto screen.

The torque is proportional to the sine of the angle between the pole of the ball. The direction of the electrical field orients the ball so that either the light or dark hemisphere faces an observer. Reversing the field reverses the orientation of the ball.

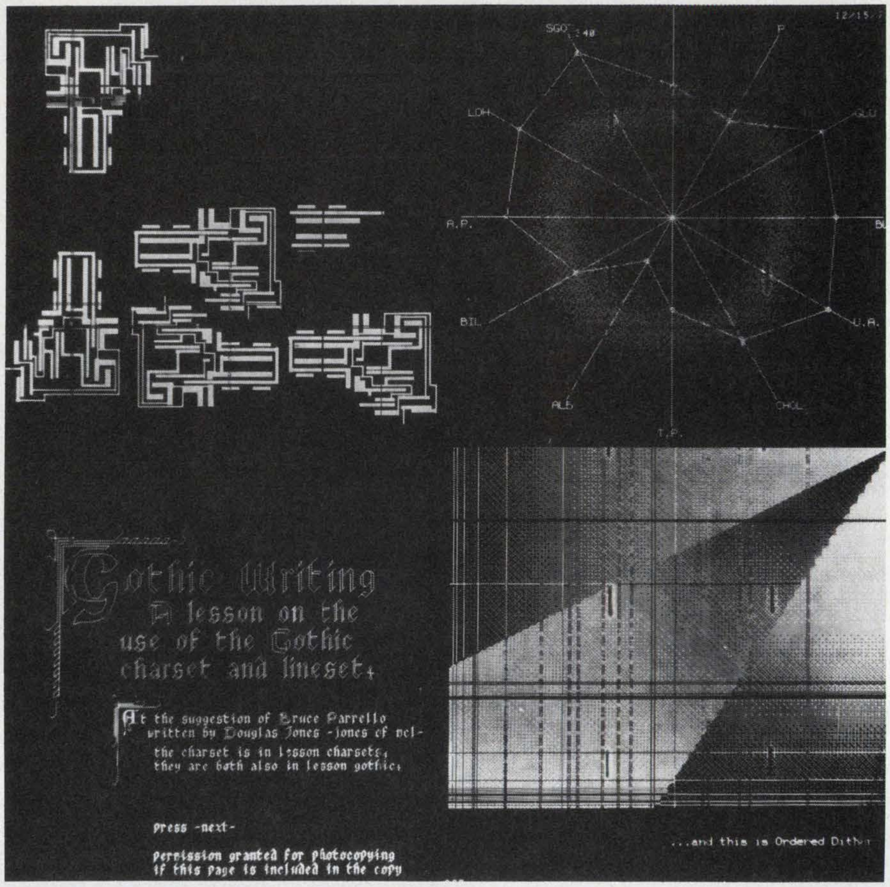
Both particle diameter and applied voltage influence switching time. After switching, the balls retain their orientation within the cavities for days. An X-Y grid of conductors can provide the switching medium.

Because plasticizing with a low-volatility liquid is permanent, it is not necessary to seal a display cell further. This method lends itself to low-cost manufacture.

Rotating spheres give images

Another flat-panel display that produces images by the rotation of hemispherically colored black-and-white microspheres is the Magnetic Particles Display being developed by Magnavox, Fort Wayne, IN. The magnetic display is a matrix-addressable device with free-moving magnetic spheres, each of which is a tiny permanent magnet (see photo). The amount of ambient light reflected by the particles is a function of particle orientation, which is controlled by a magnetic field.

The latest panels developed by



The first prototype display to use a 1024 × 1024 plasma panel, by Science Applications, can present separate graphics in each of its quadrants and can also combine all quadrants for a single display.

Magnavox require only 10 gauss to rotate the particles, reports Lawrence L. Lee. The first displays required 100 gauss to generate an image. And since the latest display uses but a single loop of No. 36 wire for addressing each row and column. It may be fabricated with photo-etching or screen-printing techniques. Previous displays required 5½ turns of No. 31 wire around each row and column.

The Magnavox panel has a 10 × 15 matrix, each element of which is formed by a group of 40 to 50-μm spheres encapsulated in liquid in a clear epoxy panel. The rotation of the particles in the individual elements is controlled by the magnetic state of a memory plane, which contains a 14 × 15 matrix of magnets.

μPs power multipanel displays

Not only are ubiquitous microprocessors putting more intelligence and computing power into shrinking display terminals, but they are also establishing a new trend: multiple screens for the terminal user. The first graphic terminal to use the Owens-Illinois 1024 × 1024-dot ac plasma display panel has a large-screen, 12.5 × 12.5-in. display that, under the control of an LSI-11, can present independent graphic information in four 6.25 × 6.25-in. quadrants. Each quadrant is equivalent to a standard 512 × 512 plasma-panel display and has 83 picture elements per inch.

The quadra-display terminal also incorporates 32 × 32-element touch-input matrices in the quadrants, adds Patrick FitzHenry, chief engineer, system development Science Applications, Inc., Urbana, IL. As a result, the system can be accessed simply by touching that panel. Moreover, the system can simulate a Plato terminal, which is a university-education system through which a user interacts with the computer via the touch panel.

In fact, the user-programmable quadra-terminal can communicate with a variety of host systems by simulating several types of commercially available graphic terminals. Able to operate as a stand-alone computer with display, it can run commercial operating systems and higher-level languages.■■

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So OEM's are dancing in the streets, that's so what. At least the pros are.

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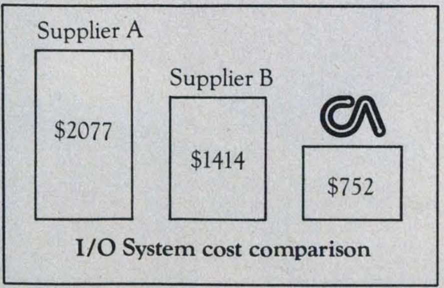
One reason is that interfaces are generally long on duplication and short on common sense. Most interfaces, for example, faithfully repeat half or more of the circuitry on all the other interfaces. And with multiple interfaces, that gets to be a pretty expensive proposition.



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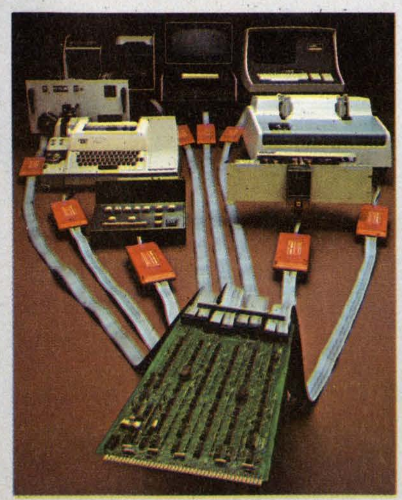

The Distributed I/O System

This arrangement allows much smaller computer packages, since only one I/O board is housed inside the computer cabinet.

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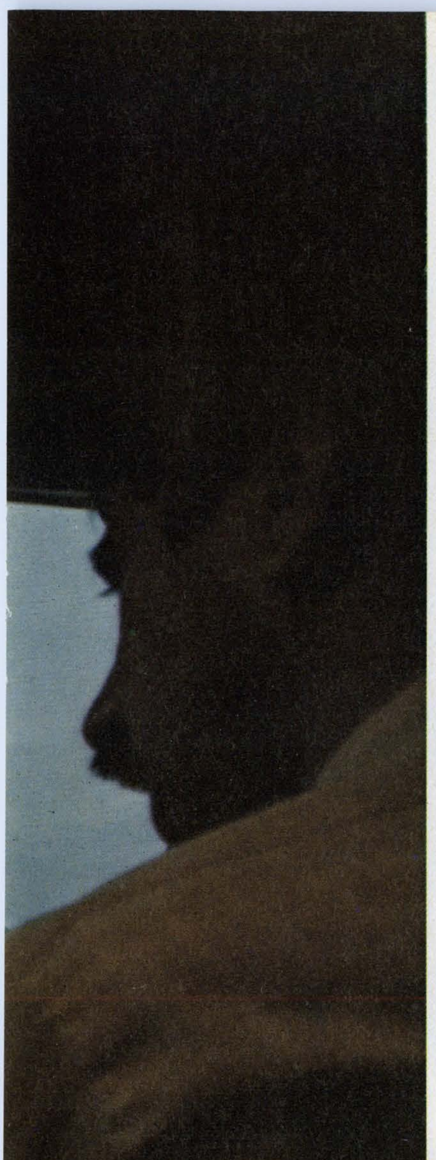

We build CPC's out of tough, durable high-grade thermoplastic. They're 50 percent lighter than comparable metal connectors. And recognized under the component program of the Underwriter's Laboratories for 250-volt service. They are also CSA certified and FAA accepted.

And in case you're not familiar with AMP technical support, you will be, because it comes with every AMP product. It's based on AMP's long-held conviction that professional engineers are entitled to expert technical support, both before and after the sale.

CPC connectors accommodate a variety of pins and socket contacts, including coax. They are part of the AMP Multimate concept. Their contacts are interchangeable with those in several other AMP connector families. And they all can be assembled with the same application tooling. For you, that means substantial production and inventory savings.

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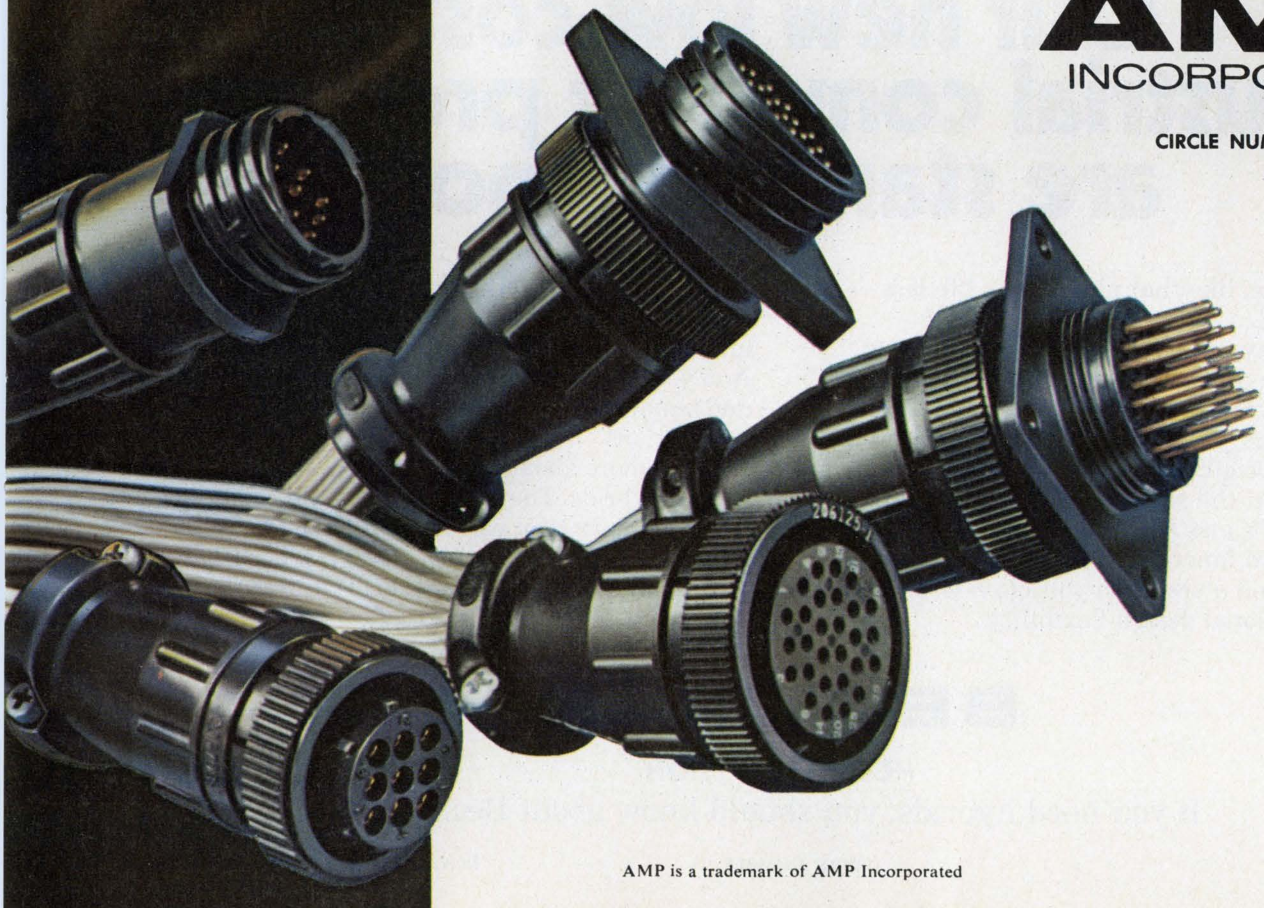
CIRCLE NUMBER 29

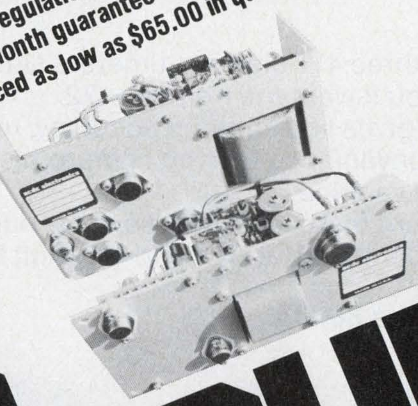


7037

The unique demands of microprocessor-based systems and their increasing popularity has resulted in the development of a special breed of low-cost power supply.

- Designed to power a wide range of micros, including the popular 8080A
- 0.1% regulation on all models
- 24 month guarantee
- Stock delivery
- Priced as low as $65.00 in quantity

INTRODUCING ACDC'S NEW LINE OF MICRO-PROCESSOR POWER SUPPLIES



INPUT	105-125/210-250 VAC at 47-63 Hz. Derate 10% at 50 Hz.			
OUTPUT	Nominal Adj. Output Range Voltage ±V	Ratings (Amps) Maximum Current 40°C	55°C	70°C
MP 301	+ 5 0.25	3.0	2.25	1.50
	+12 0.5	0.5	0.38	0.25
	− 5 0.25	0.85	0.50	0.43
MP 401	+ 5 0.25	6.00	4.50	3.00
	+12 0.5	1.00	0.75	0.50
	− 5 0.25	1.00	0.75	0.50
	All outputs are isolated from line and ground.			
REGULATION	0.1% +5mV NL-FL; ±0.1% ±5mV for a ±10% input change.			
RIPPLE	2mV RMS max, 20mV P-P max.			
STABILITY	Typically 10mV for eight-hour period after initial warm-up.			
TRANSIENT RESPONSE	Output voltage returns to within regulation limits within 50 microseconds in response to a 50% load step.			
OUTPUT IMPEDANCE	DC-1KHz: 0.005 ohm max. 1KHz-100KHz: 0.5 ohm max.			
TEMPERATURE COEFFICIENT	0.02%/°C max.			
REMOTE SENSING	Terminals are provided to maintain regulation at the load, compensating for up to 0.25 Volt loss in the load cable.			
AMBIENT TEMPERATURE	Operating: 0 to 70°C Storage: −55 to 85°C			
OVERLOAD PROTECTION	Inherently protected against overload and short circuit by a foldback type characteristic. Recovery is automatic.			
OVERVOLTAGE PROTECTION	The unit can be furnished with overvoltage protection on any or all of the outputs. The output will be crowbarred in the event of a rise in the voltage of between 1 to 2 Volts or 10 to 20% (whichever is larger) above maximum adjustable output voltage. This protection circuit is completely independent of the supply and is adjustable. The addition of overvoltage protection does not add to the outline dimensions of the supply.			
CONSTRUCTION	Integral aluminum chassis and heatsink. Sides are open to allow unobstructed ventilation, easy inspection and accessibility.			
DIMENSIONS (Shown as inches/mm)		Wide	High	Long
MP 301		4.03 / 102.36	2.70 / 68.58	8.03 / 203.96
MP 401		3.20 / 81.28	4.88 / 123.95	9.00 / 228.6
PRICES				
MP301	$ 79.00 (1-9); $72.00 (25-49); $71.00 (100-249); $65.00 (250 and up)			
MP401	$100.00 (1-9); $95.00 (25-49); $89.00 (100-249); $85.00 (250 and up)			

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CIRCLE NUMBER 32

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The 172 gives you superior accuracy, resolution and convenience with no compromise—at a competitive price.

If you want more evidence, send for our detailed "Comparative Guide to 4½-digit DMMs."

The Keithley 172 rates best—not on every factor, but on most.

If you want hands-on proof, put our 172 side-by-side with the Fluke 8600A, HP 3465A, or any other 4½-digit DMM. The Keithley will stand alone.

Check the chart below or make your own comparison, you'll pick the Keithley 172.

Fluke 8600A

HP 3465A

Keithley 172

	Fluke 8600A	HP 3465A	Keithley 172
Functions & Ranging:			
dcV	Auto/Manual	Manual	Auto/Manual
acV	Auto/Manual	Manual	Auto/Manual
dcA	Manual	Manual	Auto/Manual
acA	Manual	Manual	Auto/Manual
ohms	Auto/Manual	Manual	Auto/Manual
Basic Accuracy (dc volts @ 25°C ambient)	±0.02% reading + 1 digit	±0.02% reading + 1 digit	±0.01% reading + 1 digit
Full Range Display (Counts)	19999	19999	29999
HI/LO Ohms	No	No	Yes
Ohms Configuration	2 terminals	2 terminals	2 or 4 terminals
Lighted Function Indicator	No	No	Yes
Price	$549	$510	$525

Comparison based on manufacturers' published specifications. Prices are domestic U.S. for ac line-operated instruments.

It's easy to make your own comparison. Use coupon. Or call (216) 248-0400.

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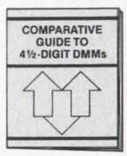
- ☐ Send specs on the Keithley 172. I'll make my own comparison.
- ☐ Send "Comparative Guide to 4½-digit DMMs." I need more proof.
- ☐ Bring in a Keithley 172 so I can make a side-by-side comparison.



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CIRCLE NUMBER 35

More electronics sought for F-16 fighter

Additional electronics equipment will be installed on the Air Force's F-16 air combat fighter if the principal user of that aircraft, the Tactical Air Command, has its way.

Although the Air Force Aeronautical Systems Div., which is developing the aircraft, has specified external electronic countermeasure pods (the Westinghouse ALQ-131), TAC has requested internal ECM to improve the aircraft's aerodynamic performance and to leave space on the wings for weapons.

TAC is also asking for equipment that would enable the aircraft to use the proposed joint Tactical Information Distribution System (JMDS) secure-data link and the Navstar global positioning satellite, according to a report to Congress on the F-16 program prepared by the General Accounting Office.

The Air Force is reluctant to add any more equipment because the program unit cost of an F-16 has risen from $9.2-million to $9.91-million (including inflation) in the past year even though the quantity was increased from 650 to 1388 ("Washington Report," ED No. 6, March 15, 1977, p. 43). Total cost of the enhancements is expected to be at least $1-million per aircraft.

IR warning systems planned by Air Force

In response to a growing threat from surface-to-air missiles that can home in on the infrared spectral signatures of aircraft engines, the Air Force is launching a three-year development program to outfit its slow, low-flying aircraft with a new infrared warning receiver.

The receivers, which would give a pilot enough time to take evasive action, may be installed on at least 700 helicopters and transport aircraft. Cost should run at least $60,000 per aircraft.

Aerojet Electrosystems, Azusa, CA, and Cincinnati Electronics were selected by the Air Force Aeronatical Systems Div. and each given $2-million and one year to develop a prototype. One will then proceed with full-scale development. Losing bidders were Hughes Aircraft, Loral and Texas Instruments.

Navy to complete LAMPS ASW helicopter team this month

The Navy has completed its avionics subcontractor team on a new anti-submarine warfare (ASW) helicopter, the Light Airborne Multi-Purpose System Mark III, and expects to choose the airframe and engine contractors later this month.

Avionics subcontractors include Control Data, its AYK-14 standard airborne computer; Texas Instruments, with its APS-124 search radar; and Raytheon, with the ALQ-142 electronic stores management system—an airborne version of that firm's shipboard Design to Price Electronic Warfare System (DFEWS). Other avionics subs are Collins Radio, Bendix, Hazeltine, GE, Sperry Rand and Honeywell.

A prime contractor for systems integration has already been named—IBM Federal Systems Div., Bethesda, MD. For the first time in Pentagon history, the avionics supplier, rather than the airframe producer, has been designated the prime contractor.

Competing for the airframe are the Sikorsky Aircraft Div. of United Technologies Corp. and the Vertol Div. of the Boeing Co. The engine will go to General Electric or Avco Lycoming Div. The winning firms will receive 54-month development contracts to produce six prototypes, the first of which is expected to make its initial flight in December, 1978. The production phase calls for 204 helicopters at a cost of $2.7-billion, or about $13.4-million each (including projected inflation).

Two under-secretary defense posts proposed

The Defense Department has asked Congress to establish two new under-secretary posts—one for research and engineering, the other for policy.

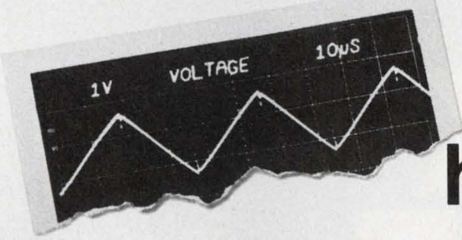
In submitting the proposed legislation to both the House and the Senate, Defense Secretary Harold Brown announced that he expects to leave five or six of the assistant-secretary positions vacant. There are currently 22 assistant secretaries in the Pentagon—three for each service and 13 in Brown's office.

The under secretary for research and engineering will be former electronics executive Dr. William Perry, who has already been appointed the Pentagon's director of research and engineering ("Washington Report," ED No. 8, April 12, 1977, p. 50). As an under secretary, Perry will oversee all the Pentagon's R & D and procurement activities, and is expected to be named the department's principal acquisition executive, as required by Office of Management and Budget Circular A-109.

The under secretary for policy, as yet unnamed, will be responsible principally for international affairs.

Capital Capsules: **NASA is "now at a crossroads and entering a new era** in which the tremendous technological capabilities of the Space Shuttle can be used," according to Dr. Frank Press, President Carter's nominee for science advisor, at his Senate confirmation hearing. The MIT geophysics professor did not comment directly on the proposed space station ("Washington Report," ED No. 9, April 26, 1977, p. 49), but did indicate support for a space telescope, and Landsat and planetary probes. . . .The Air Force hopes **to counter possible jamming of its Navstar global positioning satellite** ("Washington Report," ED No. 8, April 12, 1977, p. 50) with highly directional signals in the 1 to 2-GHz frequency coupled with a pseudorandom noise-signal structure. . . .The Navy must look at **satellite communications using blue-green laser light sources at optical wavelengths around 0.5 micron** as an alternative to its proposed Seafarer ELF communications system for submerged submarines. The House Armed Services Committee, which issued the order, has voted $5-million for initial studies.

If you're only measuring voltage, you're only getting half the picture



Current is the other half of the picture. And you can measure current accurately and efficiently with a TEKTRONIX Current Probe like the P6302/AM503. You'll find many uses for its 1 mA to 20 A current measurement range and its DC to 50 MHz bandwidth—such as plotting the current characteristics of a transformer, balancing an SCR circuit, or measuring the dc and ac peak current load on a power supply.

A current probe is also a helpful companion for your voltage probe when measuring signals at high impedance points in a circuit. The low circuit loading characteristic of a current probe means less signal attenuation and less rise time loss.

Tektronix offers a wide selection of general purpose and specialized probes to meet your current and voltage measurement needs. These include a number of active and passive voltage probes as well as logic probes.

The first step to an accurate, meaningful oscilloscope measurement is choosing the right probe. And your Tektronix Field Engineer can help you make the proper selection.

Once you get the whole picture, save it with a scope camera. It's still the most efficient and least expensive means of saving measurement results from your oscilloscope or waveform monitor.

With a camera you can record waveforms for publication in technical papers and journals. Prints can be kept as a permanent record in your engineering notebook, or used to support your position in a design meeting.

The low cost C-5A fits all TEKTRONIX Laboratory Oscilloscopes, 400-Series Portables and the new T900-Series. At $250* you can afford a C-5A for your own test bench. You no longer need to share one camera with all the engineers in your group.

Other TEKTRONIX Cameras give you automatic single-shot control for transient recording, and photometer aided exposure setting for clear, no-fuss photography of even the dimmest displays.

For more information about the complete selection of TEKTRONIX Probes and Cameras, contact your local Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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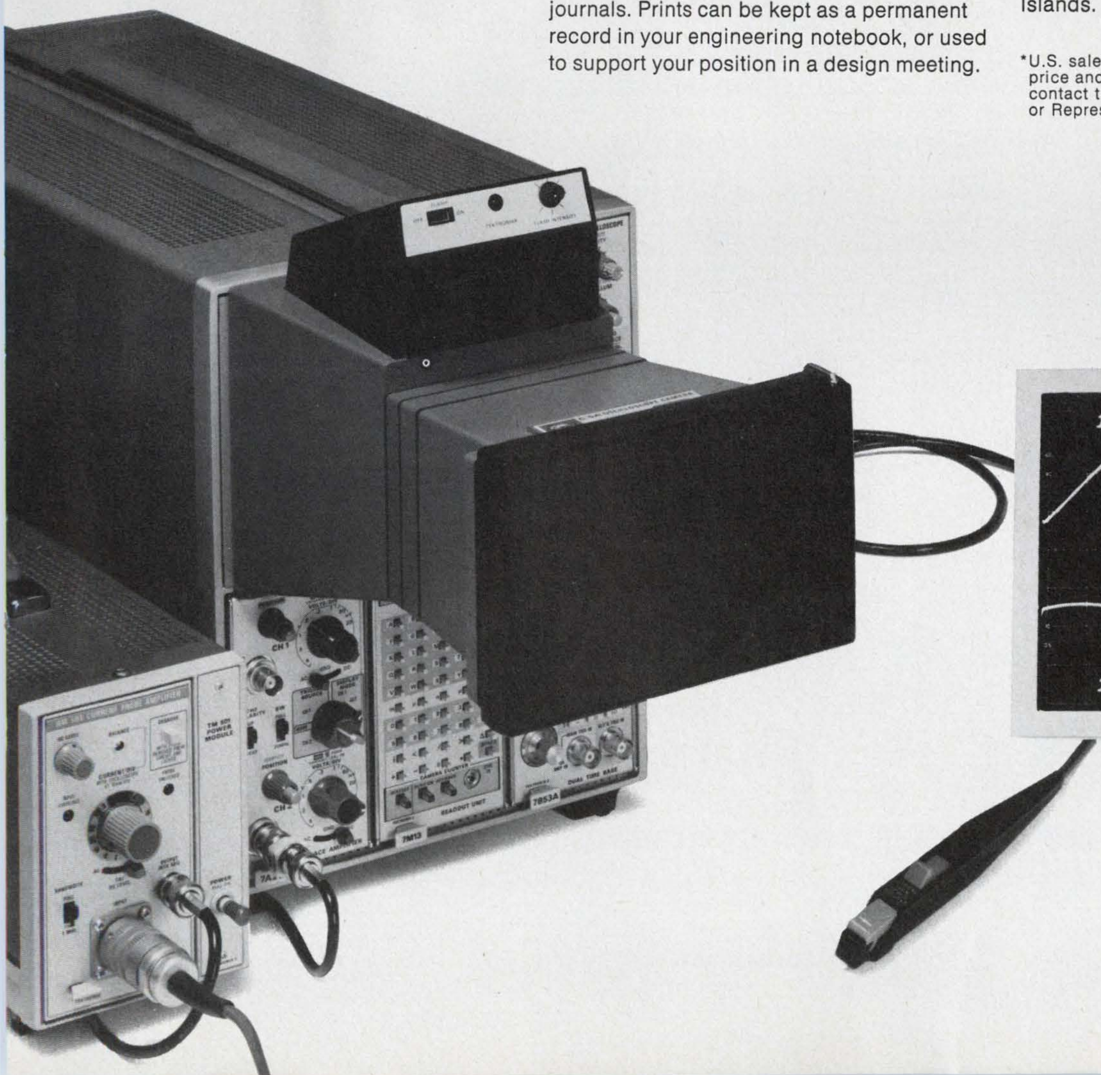
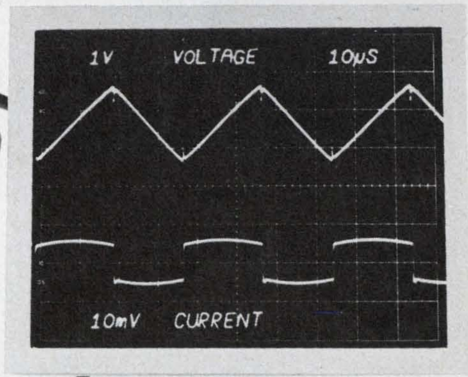
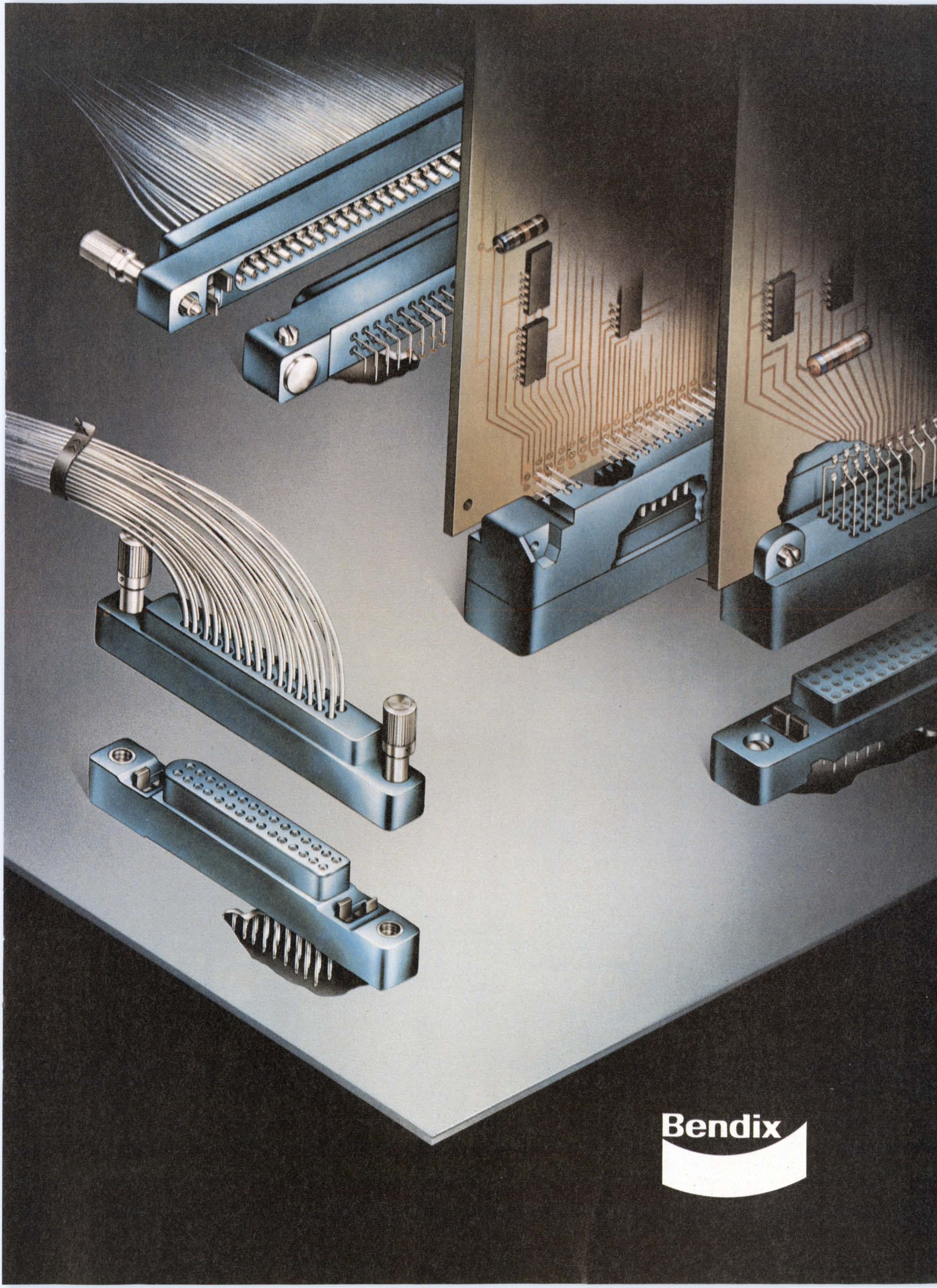




Once you get the whole picture, save it with a scope camera

FOR TECHNICAL DATA CIRCLE #33
FOR DEMONSTRATION CIRCLE #34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FEATHERWEIGHT MINIATURE PANEL MOUNT THERMAL PRINTER!!

Datel's new model DPP-7 Digital Panel Printer uses only 2 moving parts for OEM reliability. At only 2.3 Lbs, (1,1Kg) it is one of the lightest panel-mounting recording instruments available.

Includes all electronics.
The $475* single quantity price includes everything required for full parallel BCD/TTL data inputs *plus* an input storage register for multiplexed bus applications *plus* an AC power supply! There are no extra boards to design or bulky cables and power supplies needed. The DPP-7 is ready to use.

Thermal printing means no messy inks, banging hammers or twirling print-wheels. Nothing to jam or run out of ink.

Use the miniature DPP-7 for simple data logging systems, automatic test fixtures or with a digital panel meter for accurate unattended data measurement.

The **small size** of the DPP-7 makes it ideal for panel-mounting in analytical instruments and compact data systems. Up to six digits and sign may be printed to identify channel number and data.

The DPP-7 uses +5VDC power in a very short 6.2" (158mm) deep version or 100, 115 or 230 VAC or +12V or +28VDC power in an 8.7" (221mm) deep version.

DPP-7 QUICK SPECS

Printing Rate:
3 lines per second

Inputs
Full parallel BCD
TTL logic inputs, selectable positive or negative true

Printouts:
Six digits and sign, 99±9999, ±999999 or 9±99999
(Hexadecimal optional)

Input Storage
BCD data must be valid only 1.5 microseconds during print command

Data Capacity
9000 lines on 150 foot x 1.75 inch (44.5mm x 45m) thermal paper rolls

Power Supply:
Choice of: +5VDC, +12VDC, or +28VDC, or 100, 115 or 230VAC, 47 to 440 Hz.

Size Case:
4.50" wide x 2.72" high
(115mm x 69mm)

Depth:
5V Models
6.2" (158mm)
28V, 12V, or
AC Models: 8.7"
(221mm)

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CIRCLE NUMBER 36

Editorial

Learning sensitivity

"Dammit, Jack, where the hell is that report I asked you for yesterday?"

"Well, sir," Jack replied to his boss, "you also asked me to find out why so many instruments were dying on the production line. It took me a long time to discover that somebody had substituted a cheap component for a better one I had specified."

"Look, Jack, when I ask for something, I want it done. Period. I don't want excuses."

"Yes, sir," Jack replied, but that's not what he really meant. He really wanted to say that he couldn't take on two simultaneous projects. He wanted to tell Charlie, too, that Charlie was the one who had ordered cheaper components. Charlie was the one who had caused the crisis on the production line. But Jack couldn't say those things because Charlie was very sensitive. Such words might have hurt his feelings. And Jack didn't want to hurt Charlie's feelings.

In fact, most of his colleagues shared Jack's concern for Charlie's feelings. However sharply or imperiously Charlie addressed anybody, the reply was always courteous and considerate. One reason was that Charlie's feelings had a marked effect on people's paychecks and job security.

Deep down, Charlie probably sensed the difference between the way people spoke to him and the way he spoke to them. He knew he could vent his inner anger on subordinates, while they had to swallow their anger and take it home. But that's the way business runs, Charlie told himself. You mustn't let underlings talk back. You can't get things done unless you wipe out insubordination. And he did.

Unfortunately, he also wiped out a lot of people. There was staggering turnover among the people who worked for him and everybody knew it. So it was difficult for him to hire replacements—especially good ones.

As a result, the quality of his staff declined and, with it, the quality of his products. This wreaked havoc with sales and profits, which made him angrier, which made him more difficult to work for, which increased his staff turnover, which further reduced the quality of his products.

In time, he was no longer boss. With practically no experience at it, poor Charlie had to learn how to be sensitive to other people. Especially his boss.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

Stretch your test instrument budget

Does a scope always have to be expensive to meet your needs? At B&K-PRECISION we don't think so. B&K-PRECISION offers a full line of scopes that give you the performance and features you need, at substantial cost savings...plus the advantage of immediate delivery and 10-day free trial through local distributors.

B&K-PRECISION to high-priced

B&K-PRECISION has taken a no nonsense, cost-effective, approach to oscilloscope design. All our scopes will trigger at frequencies typically 50 to 100% beyond their rated band-width. They are rugged, dependable instruments, designed to match the features and performance of far more expensive scopes, without matching their high price. An important part of our approach is that you shouldn't have to buy more scope than you need to get the features you want. Before making your next purchase, compare the features and performance you require with what we have to offer. You'll discover that your budget is a lot bigger than you first thought!

30MHz Dual-Trace 5″ Triggered Scope with Signal Delay

For the engineer who requires a full-feature 30MHz scope

- Built-in signal delay line permits viewing of high-frequency pulse risetimes
- Triggers on signals up to 50MHz
- Rise time 11.7nS
- 20 calibrated sweeps – 0.2 μS/cm-0.5S/cm
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- Illuminated graticule
- TTL compatible intensity modulation
- X-Y capability using matched DC amplifiers
- P31 blue phosphor
- Internal .5Vp-p ±1% calibration source
- 5mV/cm horizontal sensitivity.

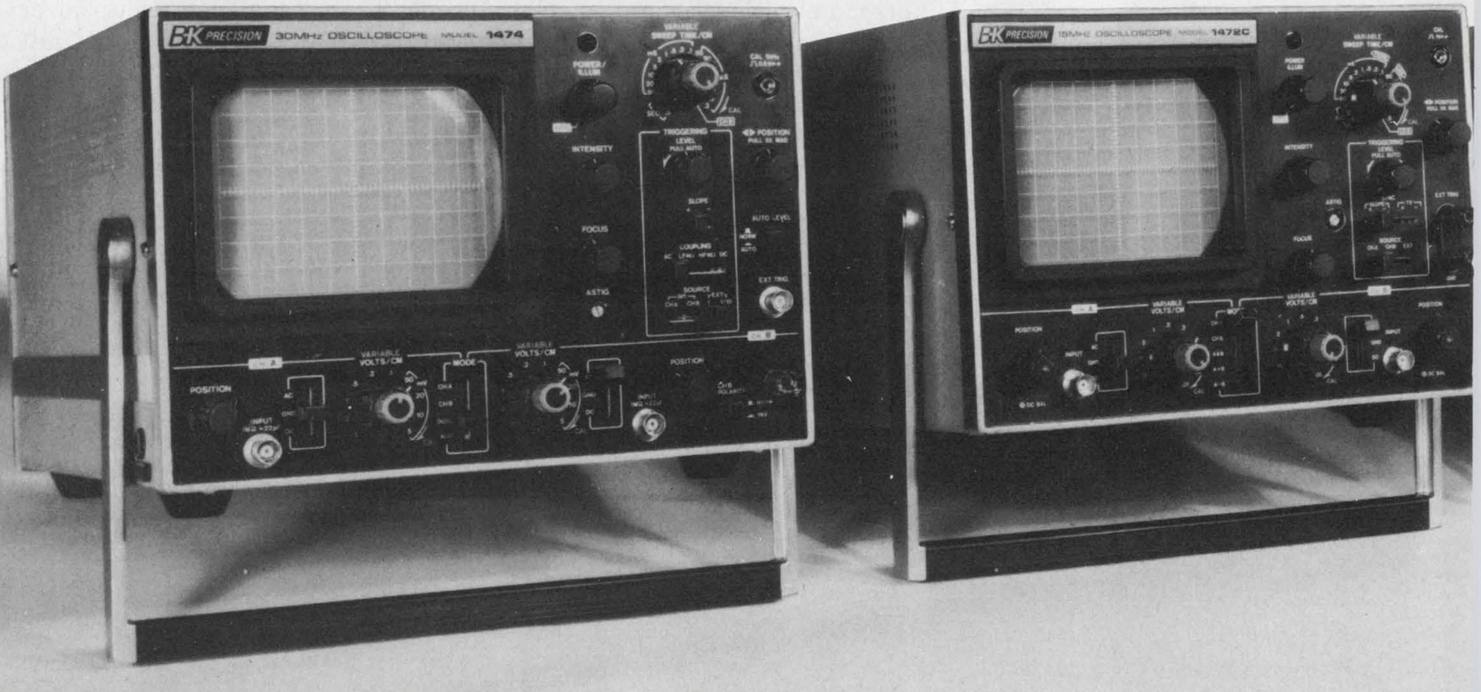
Model 1474 $930 (including two 10:1/direct probes)

15MHz Dual-Trace 5″ Triggered Scope

Premium features and performance in a 15MHz dual-trace scope

- Ultra – flat in-band response with smooth rolloff past 15MHz
- Triggers beyond 27MHz
- 24nS risetime
- 19 calibrated sweeps – .5 μS/cm-0.5S/cm
- 10mV/cm vertical sensitivity
- Algebraic addition and subtraction
- Illuminated graticule
- X-Y capability using matched DC amplifiers
- P31 blue phosphor
- Internal calibration source
- Built-in TV sync separator
- For fast setup, mode automatically shifts between CHOP and ALTERNATE as you change sweep times.

Model 1472C $720 (including two 10:1/direct probes)



Use 4-bit slices to design powerful microprogrammed processors. The 2900 family of circuits lets you build machines with cycle times of 110 ns.

Though not the first 4-bit bipolar bit-slice family, the 2900 series of processor circuits probably offers the most flexibility of any bit-slice family. What's more, with bipolar-Schottky execution speeds of 90 to 200 ns per instruction, the circuits combine to build computer systems with any word size (Fig. 1).

The basic family developed by Advanced Micro Devices consists of the 2901 4-bit arithmetic and logic unit (ALU) and the 2909 microprogram sequencer (Fig. 2). With up to 64 possible input and ALU-function combinations, the 2901 provides more than twice the capability of other ALUs. And cycle times of 120 ns for the 2901 and 90 ns for the 2901A give you a wide choice of performance levels.

Many direct-support circuits developed by AMD and other companies can be added to your design repertoire. Some of these are the 2902 look-ahead-carry generator, the 2913 interrupt expander, the 2914 vectored-interrupt controller, the 29803 16-way branch control for the 2909 and the 29811 next-address-control unit.

Some other circuits, still in development, promise to make designing a high-performance system even easier: the 2910, a sequence controller that can do the job of three 2909s; and the 2930, a program-control unit (PCU) that is sort of a cross between a 2901 and 2909—it contains the address circuitry of a 2909 and a simple ALU. (A summary of the major support circuits is shown in Table 1.)

Analyze the circuits first

Before you design a computer, though, you should understand each of the major circuit building blocks. The 2901 contains the actual processing circuits—ALU, associated scratchpad memory and control logic (Fig. 3). Control is done via nine function lines, I_0 to I_8, which are split into groups of three.

The first group, I_0 to I_2, controls the inputs to the ALU (Table 2)—they determine whether the ALU is fed by an external input, the on-chip scratchpad RAM or the internal Q register. Lines I_3 to I_5 determine the actual ALU function (Table 3)—from three arithmetic and five logic operations. The other three lines, I_6 to

Jim Clymer, Engineering Manager, Systems and Applications, Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086.

Table 1. 2900-series support

Part number	Description	DIP size	100-up price
Am2901	Four-bit CPU slice (120 ns)	40-Pin	$14.70
Am2901A	Four-bit CPU slice (90 ns)	40-Pin	17.85
Am2902	Carry-lookahead	16-Pin	2.65
Am2905	Bus interface (open collector)	24-Pin	6.75
Am2906	Bus interface (open collector)	24-Pin	7.45
Am2907	Bus interface (open collector)	20-Pin	5.40
Am2909	Microprogram sequencer	28-Pin	5.95
Am2910	Sequence controller	40-Pin	*
Am2911	Mini-micro-program sequencer	20-Pin	3.95
Am2913	Interrupt expander	20-Pin	2.53
Am2914	Vectored interrupt controller	40-Pin	29.95
Am2918	One-by-two port register	16-Pin	3.08
Am29LS18	Low-power one-by-two port register	16-Pin	2.60
Am2919	One-by-two port register	16-Pin	3.10
Am2920	Eight-bit register	22-Pin	2.88
Am2921	One-of-eight decoder	20-Pin	2.55
Am2922	Eight-input multiplexer	20-Pin	*
Am2930	Program control unit	28-Pin	*
Am2931	Mini program control unit	20-Pin	*
Am29700	16 × 4 RAM (open collector)	16-Pin	3.75
Am29701	16 × 4 RAM (three-state)	16-Pin	3.75

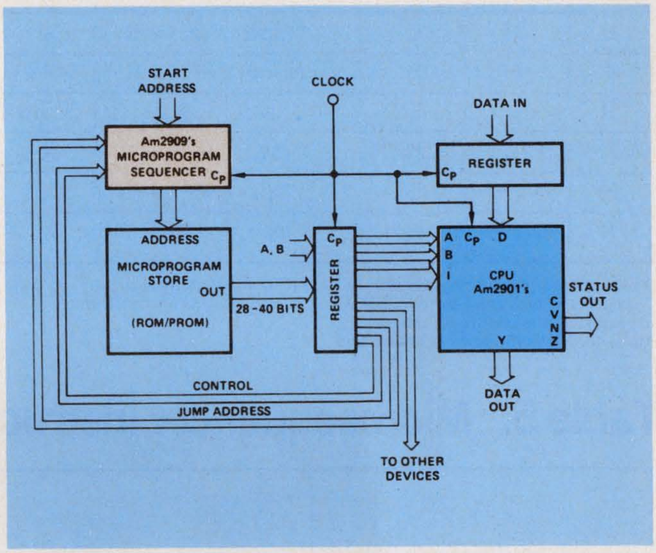
I_8, determine whether the ALU dumps its output (Table 4) onto the Y_0-to-Y_3 output lines, or into the Q register or the scratchpad RAM. These three lines also control the RAM and Q register.

Of the 27 remaining pins on the 2901, 12 are used for the A and B word addresses and the direct-data input (four for each). So two pins are left for power, one for the clock input, one for the three-state output control, four for left or right shifts and seven for mathematical carry and overflow indicators.

The other key element of the 2901 is the two-port scratchpad RAM. Up 16 four-bit words can be held in the RAM and read from either the A or B ports, depending on the A and B-address inputs and lines I_6 to I_8. When the RAM is enabled, new data are always written into the location specified by the B-address lines. Three-input multiplexers are used on the RAM inputs to permit data to be shifted left or right before

Part number	Description	DIP size	100-up price
Am29704	16 × 4 two-port RAM (open collector)	28-Pin	10.50
Am29705	16 × 4 two-port RAM (three-state)	28-Pin	10.50
Am29720	256 × 1 open-collector RAM	16-Pin	3.35
Am29721	256 × 1 three-state RAM	16-Pin	3.35
Am29759	32 × 8 open-collector PROM	16-Pin	3.00
Am29760	256 × 4 open-collector PROM	16-Pin	4.50
Am29761	256 × 4 open-collector PROM	16-Pin	4.50
Am29803	16-way branch control for Am2909	16-Pin	4.95
Am29811	Next-address control unit	16-Pin	3.25
Other support			
Am2900K1	Evaluation and learning kit (containing one 2901 ALU, one 2909 and all necessary support circuits	9 × 11 in. board	$289
AMDASM	Mnemonic programming language available on CSC time-sharing network	Mag. tape	$2500
Second sources			
Motorola, Raytheon, Signetics, Sescosem, National Semiconductor, Fairchild			

*To be announced.



1. **By combining the 4-bit 2901 ALU sections** and 2909 microprogram sequencers, you can build a high-performance computer that can handle any word size.

Table 2. ALU-operand control bits

Microcode			ALU source operands	
I_2	I_1	I_0	R	S
L	L	L	A	Q
L	L	H	A	B
L	H	L	O	Q
L	H	H	O	B
H	L	L	O	A
H	L	H	D	A
H	H	L	D	Q
H	H	H	D	O

Table 3. ALU-function control bits

Microcode			ALU function	Symbol
I_5	I_4	I_3		
L	L	L	R plus S	$R + S$
L	L	H	S minus R	$S - R$
L	H	L	R minus S	$R - S$
L	H	H	R OR S	$R \vee S$
H	L	L	R AND S	$R \wedge S$
H	L	H	$\overline{R}$ AND S	$\overline{R} \wedge S$
H	H	L	R EX-OR S	$R \veebar S$
H	H	H	R EX-NOR S	$\overline{R \veebar S}$

Table 4. ALU-destination control bits

Microcode			RAM function		Q-reg function		Y output	RAM shifter		Q shifter	
I_8	I_7	I_6	Shift	Load	Shift	Load		RAM_0	RAM_3	Q_0	Q_3
L	L	L	X	None	None	F → Q	F	X	X	X	X
L	L	H	X	None	X	None	F	X	X	X	X
L	H	L	None	F → B	X	None	A	X	X	X	X
L	H	H	None	F → B	X	None	F	X	X	X	X
H	L	L	Down	F/2 → B	Down	Q/2 → Q	F	F_0	IN_3	Q_0	IN_3
H	L	H	Down	F/2 → B	X	None	F	F_0	IN_3	Q_0	X
H	H	L	Up	2F → B	Up	2Q → Q	F	IN_0	F_3	IN_0	Q_3
H	H	H	Up	2F → B	X	None	F	IN_0	F_3	X	Q_3

X=Don't care. Electrically, the shift pin is a TTL input internally connected to a three-state output which is in the high Impedance state.
B=Register addressed by B inputs.
Up is toward MSB, Down is toward LSB.

Table 5. Microsequencer instructions

Microcode				TC	Instruction	TCEN	OPREQ*	HLTRQ*	ZERO*	S_1	S_0	PUP	FE*
A_4	A_3	A_2	A_1	A_0		O_7	O_6	O_5	O_4	O_3	O_2	O_1	O_0
0	0	0	0	0	RESET	0	1	1	0	X	X	X	1
0	0	0	0	1	RESET	0	1	1	0	X	X	X	1
0	0	0	1	0	EXECUTE	0	1	1	1	0	0	X	1
0	0	0	1	1	EXECUTE	0	1	1	1	0	0	X	1
0	0	1	0	0	EXECUTE	1	1	1	1	0	0	X	1
0	0	1	0	1	JUMP-THROUGH-REGISTER	1	1	1	1	0	1	X	1
0	0	1	1	0	EXECUTE	1	1	1	1	0	0	X	1
0	0	1	1	1	JUMP DIRECT	1	1	1	1	1	1	X	1
0	1	0	0	0	EXECUTE	1	1	1	1	0	0	X	1
0	1	0	0	1	JSB-THROUGH-REGISTER	1	1	1	1	0	1	1	0
0	1	0	1	0	EXECUTE	1	1	1	1	0	0	X	1
0	1	0	1	1	JSB DIRECT	1	1	1	1	1	1	1	0
0	1	1	0	0	EXECUTE	1	1	1	1	0	0	X	1
0	1	1	0	1	RETURN	1	1	1	1	1	0	0	0
0	1	1	1	0	LOOP	1	1	1	1	1	0	X	1
0	1	1	1	1	RETURN	1	1	1	1	0	0	0	0
1	0	0	0	0	PUSH	0	1	1	1	0	0	1	0
1	0	0	0	1	PUSH	0	1	1	1	0	0	1	0
1	0	0	1	0	EXECUTE	1	1	1	1	0	0	X	1
1	0	0	1	1	BRANCH AND POP	1	1	1	1	0	1	0	0
1	0	1	0	0	LOOP	0	1	1	1	1	0	X	1
1	0	1	0	1	LOOP	0	1	1	1	1	0	X	1
1	0	1	1	0	EXECUTE AND POP	1	1	1	1	0	0	0	0
1	0	1	1	1	LOOP	1	1	1	1	1	0	X	1
1	1	0	0	0	POP	0	1	1	1	0	0	0	0
1	1	0	0	1	POP	0	1	1	1	0	0	0	0
1	1	0	1	0	EXECUTE	1	1	1	1	0	0	X	1
1	1	0	1	1	HALT	1	1	0	1	0	0	X	1
1	1	1	0	0	EXECUTE ASYNC.	0	0	1	1	0	0	X	1
1	1	1	0	1	EXECUTE ASYNC.	0	0	1	1	0	0	X	1
1	1	1	1	0	EXECUTE AND FETCH	0	1	1	1	1	1	X	1
1	1	1	1	1	EXECUTE AND FETCH	0	1	1	1	1	1	X	1

they are stored in the RAM. To eliminate any possible race conditions during write operations, both the A and B RAM outputs are held in latches when the clock line goes low.

The multiplexing scheme used on the ALU inputs permits any of the A, B, D, and Q inputs, or none of them (all zeros), to be selected source operands for the ALU. When taken two at a time, these five inputs produce 10 possible combinations of source-operand pairs, of which eight are actually used in the 2901 (see Table 2 for I_0 to I_2 lines).

The D input is a 4-bit-wide direct-data input to the ALU that is used to insert all data into the working registers or modify any of the internal-data files. The Q register is a 4-bit register primarily intended for use with multiplication and division routines, but it can also be used as an accumulator or holding register.

When several 2901s are cascaded, the carry-generate and carry-propagate ($\overline{G}$ and $\overline{P}$) outputs can be used with such carry-look-ahead generators as the 2902 or the 74LS182 to speed up the final results. Carry-output (C_{n+4}) and carry-input (C_{in}) signals are also available to help cascade sections. The ALU has three other status outputs, the F_3, F=0 and overflow (OVR) lines.

Without enabling the three-state output lines, the F_3 signal lets you determine the most-significant (sign) bit of the ALU. The F=0 line can be used to detect an all-zero condition. The overflow output indicates when any arithmetic operation exceeds the available 2's-complement number range.

Access instructions via a sequencer

Instructions for the 2901 bit slice come from a microprogram memory, which you can access with the 2909 microprogram sequencer (Fig. 4). Its main circuits are a cascadable 4-bit microprogram counter, a 4 × 4 register file with stack pointer and push/pop control for nesting, and an internal-address register.

The 2909 can select an address from four sources:

1. A set of external direct inputs (D lines).
2. External data from the address-register inputs (R lines) stored in an internal register.
3. A four-word-deep push/pop stack.
4. A program-counter register (which usually contains the last address plus one).

The address selection is controlled by two input lines, S_0 and S_1, which determine the multiplexer output. Of the 28 pins on the 2909, four are used as direct-address inputs, four as address-register inputs, four as OR inputs for the multiplexer output, and four as the final address output. Two other lines form the multiplexer control, and two more are for power and ground. So eight lines are left for timing and control.

Of those eight remaining lines, one is used as a clock input, one enables the address-register inputs, and one enables the three-state output address. Two other lines are used for carry-in and carry-out when sequencers are cascaded, another line controls access to the stack, and another controls the direction of data flow in the stack (push or pop). The eighth line can be used to force the address outputs to zero, which permits the 2909 to jump or branch to another address.

A second version of the 2909, called the 2911, is housed in a 20-pin DIP. Aside from the D and R lines being paralleled to squeeze down the pin connections, and no OR inputs, the 2911 is the same as the 2909.

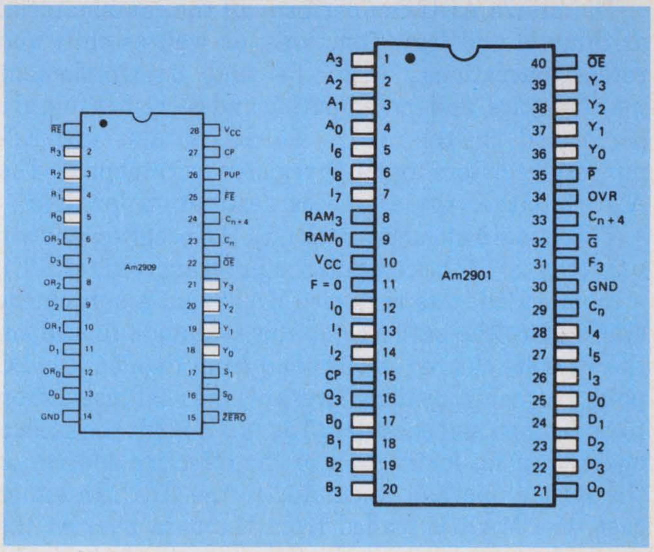
Depending on the size of the control microprogram's memory, many of the 2909s can be cascaded in much the same way as the 2901s. A detailed arrangement for a high-performance microprogram controller is shown in Fig. 5.

Combine the controller and ALU

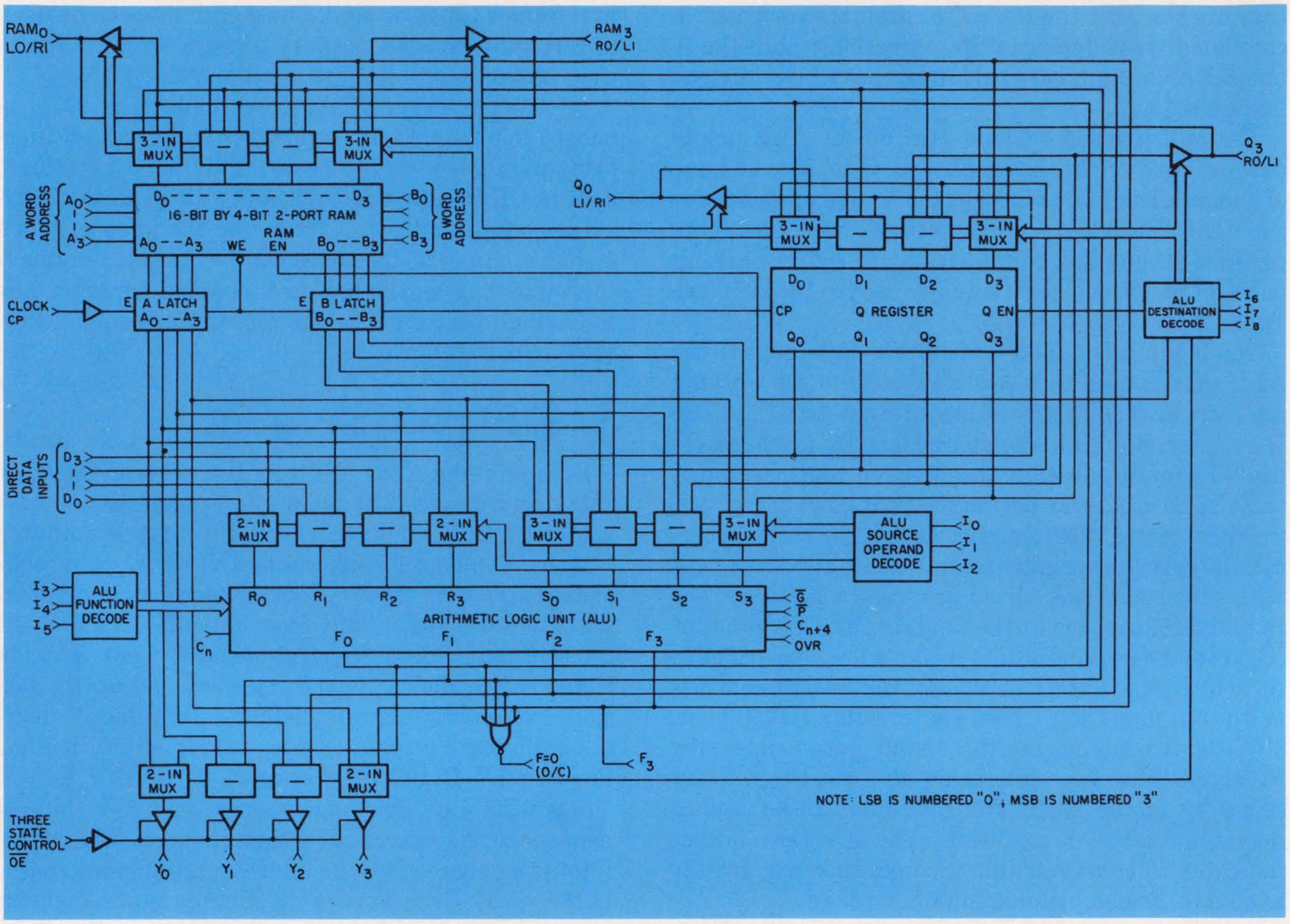
By combining four 2901 ALUs, several 2909s or 2911s, or a single 2910 and a microprogram memory, you can form a rudimentary 16-bit digital computer (Fig. 6). For better performance, however, add look-ahead carry with the 2902 look-ahead carry generator. A central processor built from four 2901s and three 2909s or 2911s has 16 general-purpose registers made from the paralleled 16 × 4 registers and up to 4096 words of microprogram memory. (For more about basic microprogramming, see "A Primer on Bit-Slice Processors," ED No. 3, February 1, 1977, p. 52.)

Each 2909 or 2911 can supply only four bits of address to the microinstruction memory. And, when n units are cascaded, the addressing range increases to 16^n words. Each word of the microprogram memory can have as many bits as necessary to perform the desired function—a 40-bit word is not uncommon.

To see how the 2909/2901 combination can be microprogrammed to function as a minicomputer, examine a design example of a 16-bit minicomputer whose architecture and operation is similar to that



2. **Housed in a 40-pin DIP,** the 2901 ALU offers up to 64 different operating modes under the direction of nine control lines (right). The 2909, in a 28-pin DIP, provides the address-control logic that pulls instructions from the microprogram memory (left).



3. **The eight-function ALU** built into the same chip as a 16-word RAM combines forces with various registers and multiplexers in the 2901 to make a versatile logic processor for any computer system.

shown in Fig. 7. The processor has an address bus and a data bus. Since both buses use three-state logic, expanding the system is very easy. A third bus within the processor is used only for internal control and cannot be accessed like the other two.

The mini's ALU can perform all the combinatorial arithmetic and logic functions, as well as shift and rotate operations. Also, 1's and 2's-complement mathematics, and incrementing and decrementing are performed in the ALU, which contains general-purpose registers and a Q register (scratchpad). The ALU is either the source or destination for data.

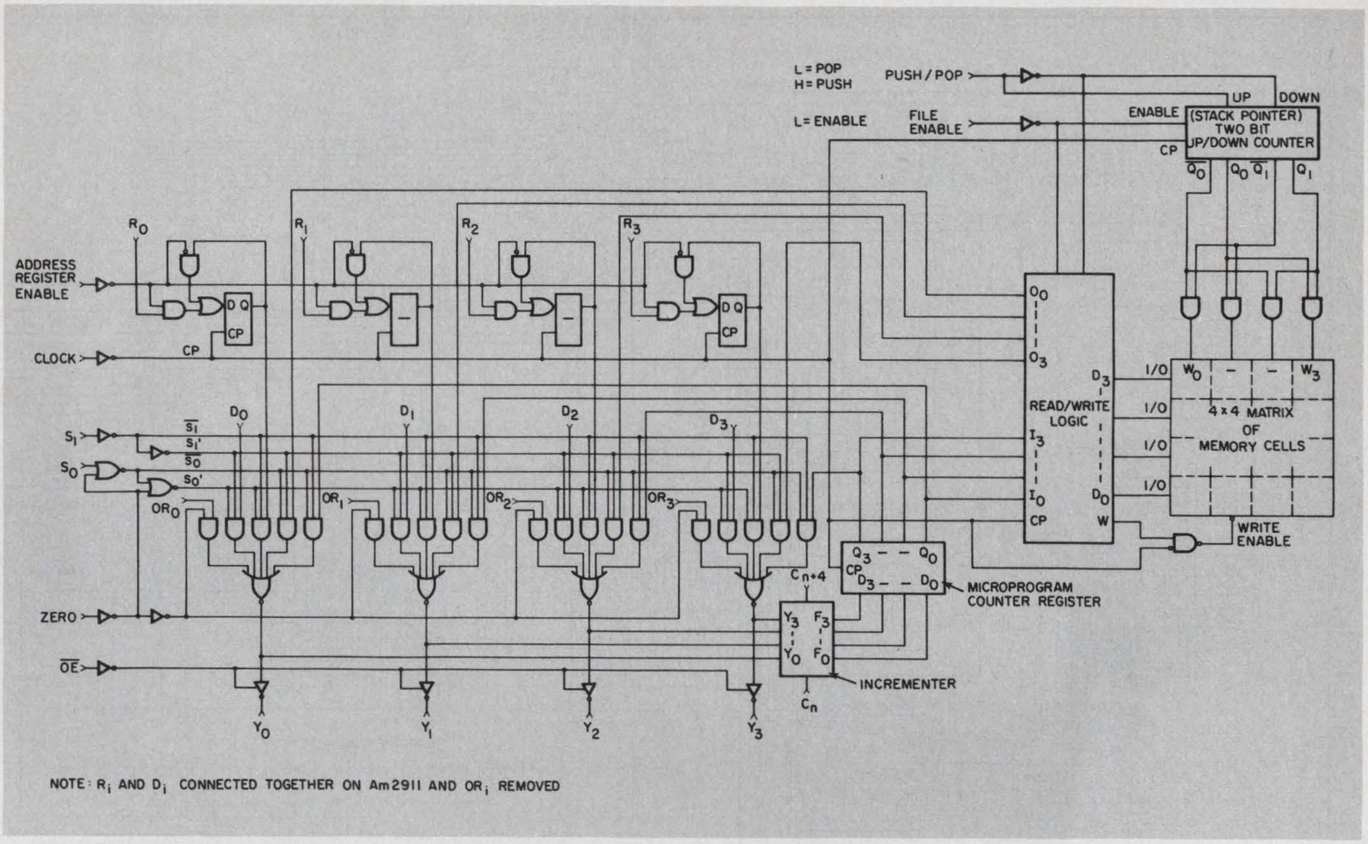
Three main elements make up the program-control unit (Fig. 6) of the computer: a program counter (PC), a memory-address register (MAR) and a subroutine stack. Once the entire computer system is turned on, the PC gets cleared to 0000 and from then on, the PC points to (contains the address of) the next instruction to be fetched and executed. The MAR holds the second operand of an instruction or the effective address of the second operand calculated in the ALU. In either case, the MAR is loaded from the data bus. At the start of any memory cycle, the contents of either the PC or the MAR are enabled onto the data bus. Either the 2930 or its mini version, the 2931 can be used to build the PCU. Addressing 65,384 words of memory requires four 2930s.

Of course, the computer system contains a memory that holds the program to be executed and the data to be operated on. The memory can be either synchronous or asynchronous.

The two other sections of the mini are the interrupt-control unit (ICU) and the computer-control unit (CCU). Handling interrupt requests from peripheral controllers, the ICU provides masking and clearing operations under program control. What's more, a minimum interrupt level can be set with an instruction. And, the highest-level interrupt wins any contention race and produces a 4-bit interrupt vector.

When an interrupt is received, the CCU grants the interrupt at a convenient point in the microprogram sequence. An interrupt-acknowledge signal is then sent back to the requesting peripheral; the current state of the processor must be saved in a stack. The 2914 is specially designed to handle interrupts.

The CCU consists of the instruction register and all the circuitry necessary to hold the microprogram for the ALU and system logic, including the clocks. The output of the instruction register feeds a PROM or programmable logic array that decodes the op code from the instruction register. The decoded output then feeds the sequencer array of 2909/11s, which in turn accesses the microprogram memory that controls the ALU and the rest of the computer.



4. **Auto-incrementing logic** as well as a 4 × 4 register file are included in the 2909 microprogram sequencer. Also included on the same chip are the stack pointer and a cascadable output bus.

The 16-bit computer operates with a main memory of 65,384 16-bit words. Data are formatted in 2's-complement integer form with the least-significant bit as bit 0 and the most-significant bit as bit 14. Bit 15 is reserved for the sign. Operations on the words held in the memory can be performed on either entire words or half-words (bytes). The lower byte is held in bit positions 0 to 7, the upper in 8 to 15.

Machine instructions consist of one or two main-memory words, which in turn are defined by sequences of microinstructions stored in the CCU memory. There are two formats for single-word instructions: register-to-register (RR) and special-function (SF). Double-word instructions also have two formats: register-indexed (RX) and register-immediate (RI).

The operation to be performed by the computer's current instruction is defined by a memory word's upper byte. The rest of the word and the next word (if it's a two-word instruction) are used as the operand. (Operands provide data, addresses or data-source and destination information.)

Machine instructions are divided into seven general function classes: arithmetic, logic, shift, data-movement, program-control (branch), input/output, and executive. The four different addressing modes already defined—RR, SF, RX and RI—must also be put into one or two-word formats (Fig. 9).

For the RR mode, the second byte of the 16-bit word defines the two registers used for the source and destination. The SF mode looks similar to the RR mode, except that the F field uses the lowest four bits of the instruction to define any of 16 special tests.

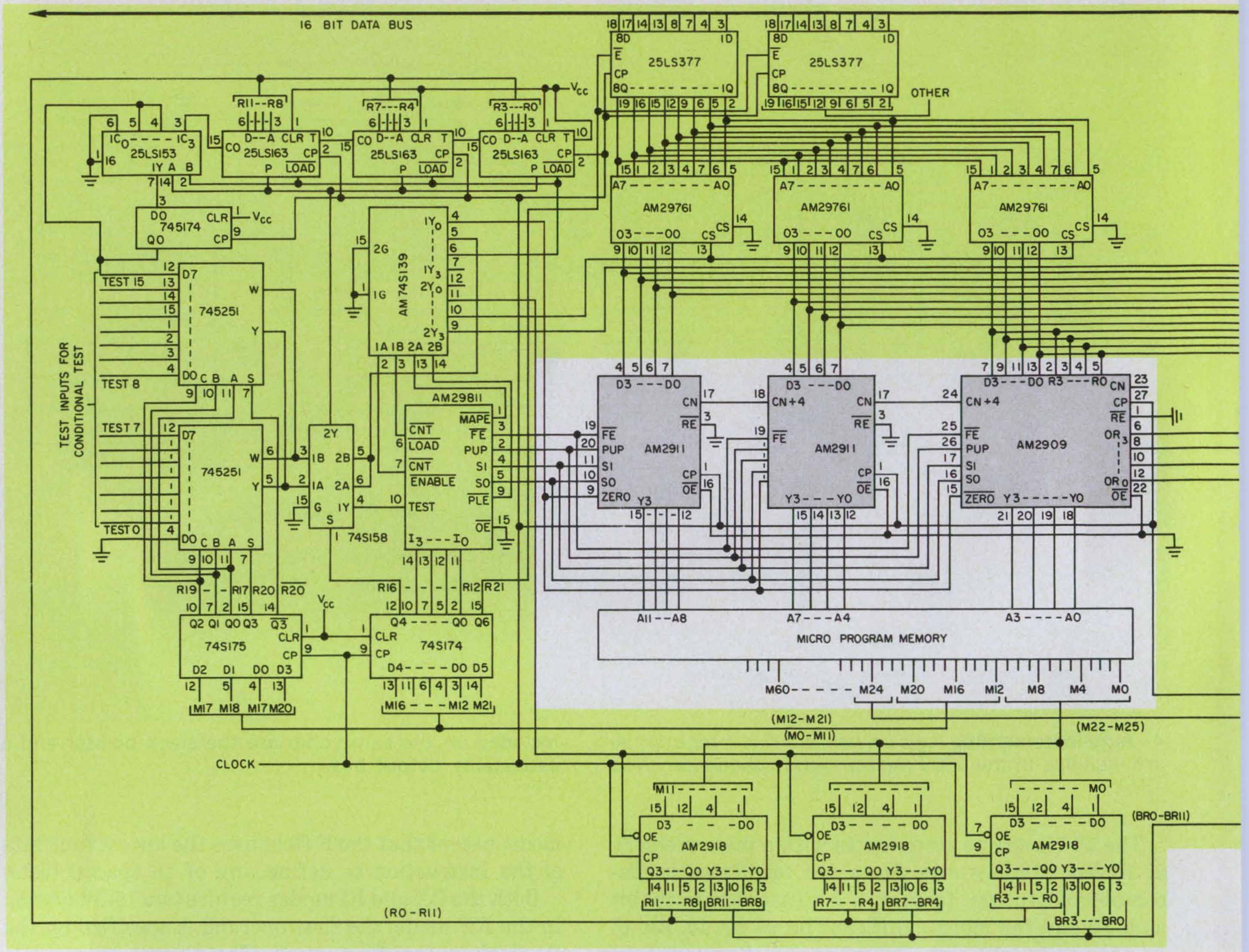
Both the RX and RI modes require two 16-bit words. In the RX mode, the first operand is specified by the R_1 field in the first word. The second operand is specified by the sum of the second word and the contents of the general-purpose register selected by the X field of the first word. However, if the zero register is specified, the contents of the second instruction word's address field becomes the effective address of the second operand.

The RI mode is very similar to the RX mode. The second operand is contained in the second word of the instruction. To get the actual operand, the second operand must be added to the contents of the register specified by the X field in the first word.

All four of these addressing modes and the normal next-instruction addressing are performed with a program counter and push/pop stack in the PCU, and a set of program-control instructions held in the memory. Since the program-control instructions—jump, jump-to-subroutine, and return-from-subroutine—control either the PC or the stack, they all affect the next instruction address.

Define the microinstruction features

As already mentioned, the CCU controls all the operations of the computer once an instruction is pulled in from the main memory (Fig. 5). This instruc-



tion is routed into the CCU's instruction register. The op-code portion is fed into a mapping PROM or PLA, which in turn feeds the microsequencer.

The microsequencer determines the portion of the microprogram PROM or ROM that must be accessed to perform the operation specified by the op code. The number of bits of microprogram memory depends on the number of functions to be performed simultaneously. For the operations to be performed by the 16-bit computer under design, the microprogram memory is 64 bits wide and as many as 4096 words deep.

CCU operation is very straightforward—once the starting address reaches the microsequencer, the microprogram ROM gets addressed. A short time later, the ROM outputs the instruction code to the microinstruction register (often referred to as the pipeline register). Meanwhile, inside the microsequencer the original address is being incremented so that the next address can be rapidly accessed.

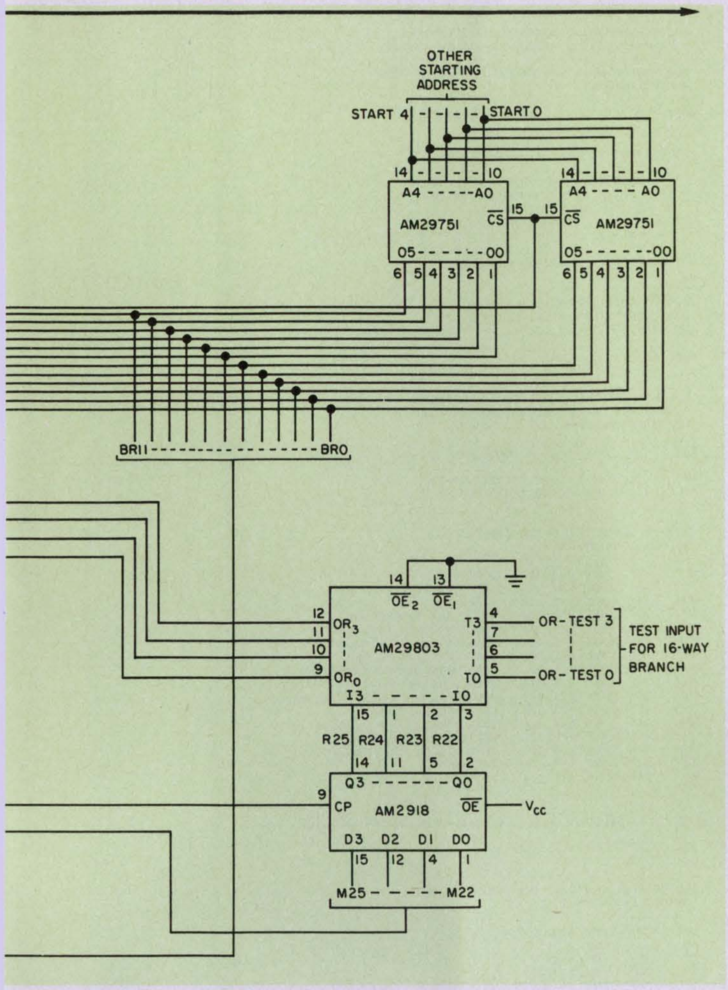
Another part of the CCU, which performs all the ancillary timing, synchronization and control must be used to coordinate all operations. The jobs performed by this logic section include initialization upon power-up, generation of the system clock, decoding of both micro sequencer and condition instructions, and synchronizing asynchronous operations.

Operation of the PCU, which controls the computer's access to main memory, is also straightforward (see Fig. 8). Upon command, any information on the data bus can be strobed into the input register of the 2930, manipulated, then fed out of the Y bus onto the address bus.

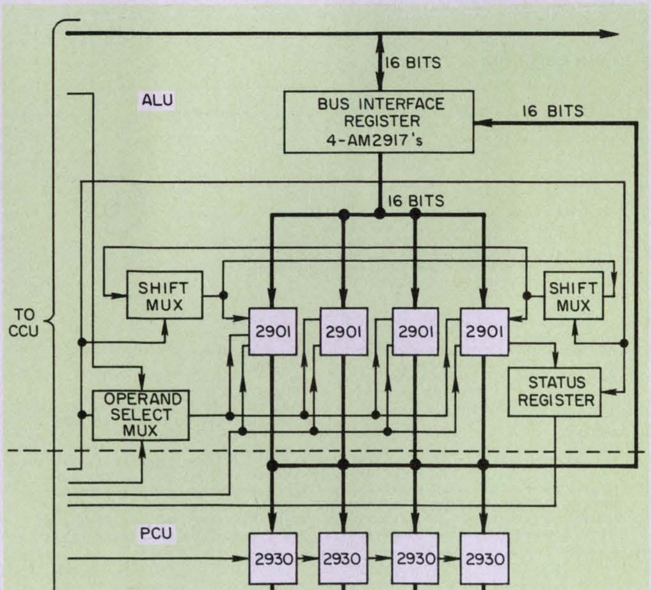
Set up the microinstructions

Now that you know what to use, you can develop the actual microinstructions to carry out the main-program commands. Start by assigning fields to each microinstruction. The 64-bit word used in the minicomputer is split into two major sections: 26 bits determine the operation and addressing function of the CCU circuits, and the other 38 bits take care of the rest of the computer.

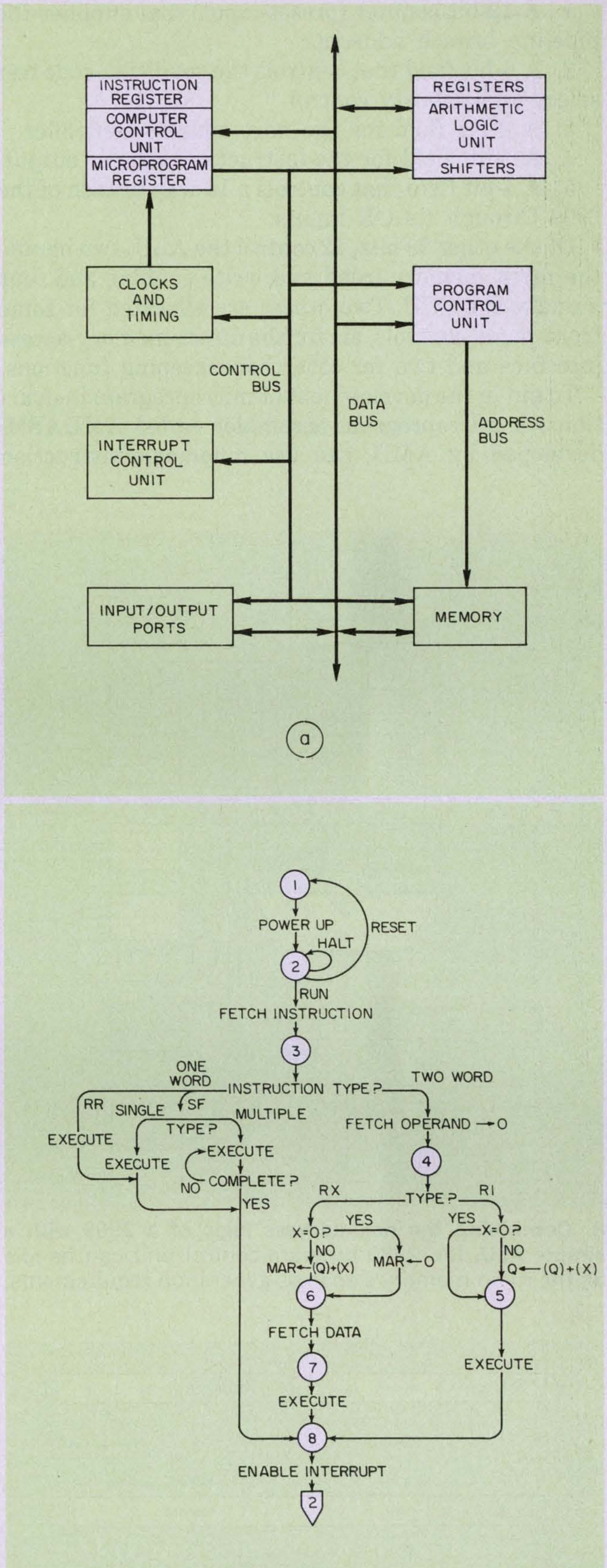
A flexible, high-performance CCU can be built by combining one 2909, two 2911s, a 29803, a 29811 and the necessary holding registers, multiplexers and counters (Fig. 5). To control these circuits, the 26-bit section is subdivided into five main fields:



5. **By cascading two 2911 sequencers and one 2909,** as well as adding the necessary registers, multiplexers and memory circuits, you can build a complete high-performance computer-control unit.



6. **A basic 16-bit minicomputer** can be assembled by combining four 2901s for the ALU, four 2930s for the program control unit, the CCU of Fig. 5, and appropriate memories and registers.



7. **Breaking a 16-bit minicomputer into its various function blocks** permits you to take advantage of the diverse circuits in the 2900 series (a). Computer operation can be shown very simply if a state-transition diagram is used to map the flow of an instruction.

1. A 12-bit counter (preset-input) that supplies the pipeline branch address.

2. A 5-bit field that controls the condition-code test select and polarity control.

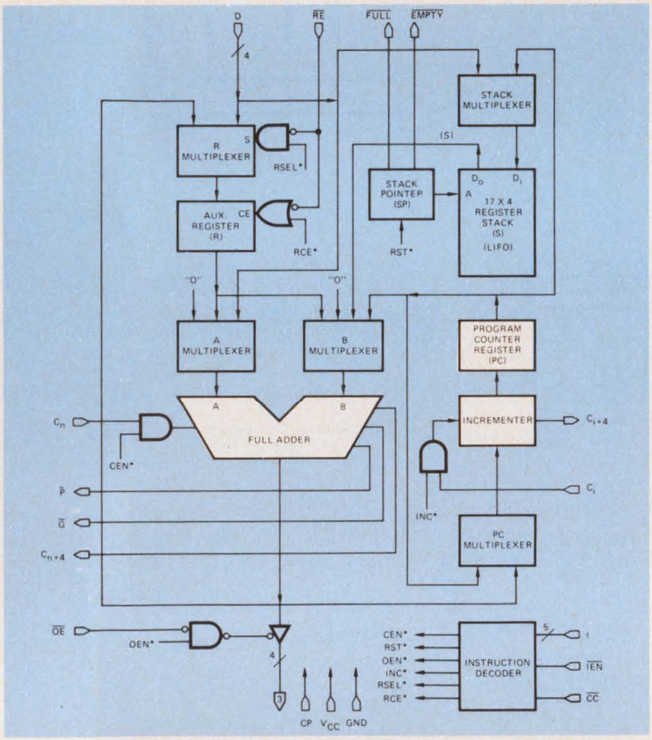
3. A 4-bit field for the next address controller.

4. A 1-bit field for the instruction-register output.

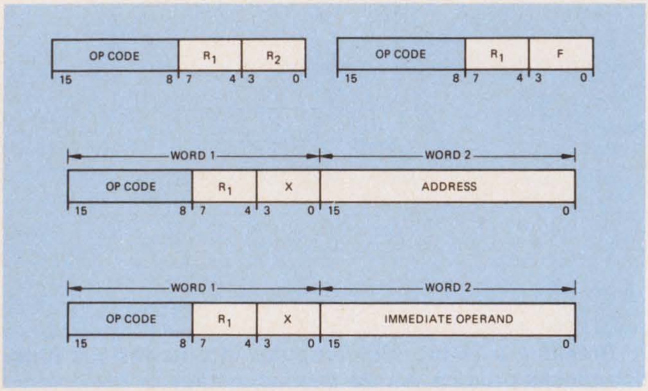
5. A 4-bit field that controls a 16-way branch of the 2909 through its OR inputs.

Of the other 38 bits, 22 control the ALU, two handle the main memory (read and write enable), and four manage the PCU. Two others are allocated for some front-panel controls, six for the direct-memory-access interface and two for other housekeeping functions.

To aid in the development of microprogram instructions, a microprogram assembler called AMDASM, developed by AMD, can use mnemonic-instruction



8. **Combining the next-address logic of a 2909 with a simple ALU,** the 2930 program-control unit can handle all the main memory's address-generation requirements.



9. **Different-sized instruction types**—two that are one word long and two that are double-word commands—provide the computer with four addressing modes.

(a)

```
THIS IS AN AMDASM MICROPROGRAM ASSEMBLY EXAMPLE.
AMDASM REQUIRES TWO PHASES; DEFINITION AND ASSEMBLY.

FOLLOWING IS THE DEFINITION PHASE AND THE DEFINITIONS
REFER TO FIGURE 11.

WORD    64                    ; DEFINE A 64 BIT MICROINSTRUCTION

THI. FIVE MAIN CCU FIELDS ARE AS FOLLOWS:

        M0 -M11:  A 12 BIT NUMERICAL FIELD USED TO
                  SUPPLY THE PIPELINE BRANCH ADDRESS
                  OR COUNTER LOAD VALUE.
        M12-M15:  THE AM29811 INSTRUCTION
        M16 M20:  CONDITION CODE TEST SELECT & POLARITY CONTROL
        M21    :  INSTRUCTION REGISTER READ IN
        M22 M25:  THE AM29803 INSTRUCTION

DEFINE THE DEFAULT PIPELINE BRANCH FIELD.
IT WILL FORCE THE MICROPROGRAM TO THE HIGHEST
MICROPROGRAM MEMORY LOCATION IF LEFT IN DEFAULT FORM.

NUMB:   DEF   52X, 12V%Q=7777

DEFINE THE CONDITIONAL TEST SELECT FIELD AND POLARITY CONTROL
DEFAULTS ARE: NONINVERTED AND UNCONDITIONAL.
TESTS ARE ACTIVE LOW!

TEST:   DEF   43X, 4V%:D=0, 1VB=0, 16X

CNTR:   EQU   15        ; COUNTER ZERO TEST SELECT
INV:    EQU   B=1       ; POLARITY CONTROL

DEFINE THE AM29811 NEXT ADDRESS CONTROL UNIT
INSTRUCTION MNEMONICS.

JZ:     DEF   48X, H=0, 12X   ; JUMP ZERO
CJS:    DEF   48X, H=1, 12X   ; CONDITIONAL JUMP SUBROUTINE
JMAP:   DEF   48X, H=2, 12X   ; JUMP MAP
CJP:    DEF   48X, H=3, 12X   ; CONDITIONAL JUMP PIPELINE
PUSH:   DEF   48X, H=4, 12X   ; PUSH/CONDITIONAL LOAD COUNTER
JSRP:   DEF   48X, H=5, 12X   ; COND JUMP SUBROUTINE REGISTER/PIPELINE
CJV:    DEF   48X, H=6, 12X   ; CONDITIONAL JUMP VECTOR
JRP:    DEF   48X, H=7, 12X   ; CONDITIONAL JUMP REGISTER/PIPELINE
RFCT:   DEF   48X, H=8, 12X   ; REPEAT FILE LOOP ON COUNTER .NE. ZERO
RPCT:   DEF   48X, H=9, 12X   ; REPEAT PIPELINE ON COUNTER .NE. ZERO
CRTN:   DEF   48X, H=A, 12X   ; CONDITIONAL RETURN
CJPP:   DEF   48X, H=B, 12X   ; CONDITIONAL JUMP PIPELINE & POP
LDCT:   DEF   48X, H=C, 12X   ; LOAD COUNTER & CONTINUE
LOOP:   DEF   48X, H=D, 12X   ; TEST END LOOP (CONDITIONAL LOOP ON FILE)
CONT:   DEF   48X, H=E, 12X   ; CONTINUE
JP:     DEF   48X, H=F, 12X   ; JUMP PIPELINE

THE DEFAULT FOR DATA BUS READ IN OF INSTRUCTION REGISTER IS DISABLE

DB:     DEF   42X, 1VB=1, 21X
IN:     EQU   B=0

DEFINE THE AM29803 16-WAY BRANCH CONTROL UNIT
INSTRUCTION MNEMONICS.

NOT:    DEF   38X, H=0, 22X
T0:     DEF   38X, H=1, 22X
T1:     DEF   38X, H=2, 22X
T01:    DEF   38X, H=3, 22X
T2:     DEF   38X, H=4, 22X
T02:    DEF   38X, H=5, 22X
T12:    DEF   38X, H=6, 22X
T012:   DEF   38X, H=7, 22X
T3:     DEF   38X, H=8, 22X
T03:    DEF   38X, H=9, 22X
T13:    DEF   38X, H=A, 22X
T013:   DEF   38X, H=B, 22X
T23:    DEF   38X, H=C, 22X
T023:   DEF   38X, H=D, 22X
T123:   DEF   38X, H=E, 22X
T0123:  DEF   38X, H=F, 22X

END                   END OF DEFINITION PHASE

BEGIN ASSEMBLY PHASE
```

(b)

```
A DIVISION ROUTINE. ASSUME F=0 OF THE ALU IS CONNECTED TO
TEST-12 (AND F3 TO TEST-13 AS BEFORE), AND SIXTEEN
DIVISION STEPS ARE REQUIRED. IF THE FINAL REMAINDER IS NEGATIVE, IT MUST BE
RESTORED BY ADDING IT TO THE DIVISOR. THE VECTOR INPUT IS SET UP
FOR THE ERROR ROUTINE. NOTE USAGE OF THE AMDASM CONVENTION
"$" TO DENOTE THE CURRENT PROGRAM COUNTER.

0001 ORG Q=1000
0002 DIVIDE:  LDCT & TEST, INV & NUMB D=14%.     ;(ALU OUTPUTS DIVISOR)
0003          TEST 12, INV & CJV                 ;IF=0: ERROR
0004          RPCT & TEST CNTR, & NUMB $         ;LOOP
0005          TEST 13, INV & NUMB $+2 & CJP      ;IF R<0, CORRECT
0006          TEST, & JMAP                       ;EXIT TO MAP
0007          TEST, & JMAP                       ;ALU ADDS REMAINDER TO DIVISOR, EXIT MAP
0008 END

0200 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX00001 1100111111110001
0201 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX11001 0110XXXXXXXXXXXX
0202 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX11110 1001001000000010
0203 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX11011 0011001000000101
0204 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX00000 0010XXXXXXXXXXXX
0205 XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXX00000 0010XXXXXXXXXXXX
```

10. **To simplify microprogram development,** AMDASM, a mnemonic programming language available on time-sharing networks, lets you define instructions and constants before writing the programs (a). When actually writing a 2900-series program such as this divide routine, you can overlay microcode instructions to produce a compact microprogram (b).

equivalents for the instruction codes of the 29811 or ALU. Available on CSC time-sharing services, the program is used in two steps. Step 1 defines the microprogram word size, its fields, and the instruction mnemonics. Step 2 uses the mnemonics and permits you to write a program overlaying the different fields to arrive at the final microinstruction. A typical example of this definition stage is shown in Fig. 10a.

Once you're ready to develop the software, you should already have done most of the hardware definition and determined the microinstruction word size. The first thing you do with AMDASM is define the microword size and each of the fields that will be used (block ⓐ of Fig. 10). Next, define some mnemonic instructions. The command NUMB, for instance, is a 64-bit microword whose first 52 bits are don't cares (52X). The next 12 bits form a variable field (12 V) with all bits substitutable—all 12 or just a few (%). If no 12-bit field is specified, the octal number 7777 is put in the NUMB field (Q#7777).

The next instruction definition follows an almost identical format. The command TEST is defined as a 64-bit microword whose first 43 bits are don't cares (43X). The next four bits are a variable field (4V), with all four bits substitutable (%). And if more than four bits are supplied, truncation will occur at four bits (:). If no variable field number is supplied, AMDASM will substitute a decimal value of 0 (D #0).

The definition continues past the comma stating that the next bit is a variable field (1V). If no number is supplied, a binery zero will be substituted (B#0). And past the comma, the last 16 bits of the word are defined as don't cares (16X).

Now the program is used to equate mnemonics CNTR and INV with numeric values 15 and binary 1, which are used to select test input 15 and set the polarity control. Next, the instruction mnemonics of the 29811 are defined. Each of the 16 instructions is represented by a microword, the first 48 bits of which are don't cares; the next four bits represent a hexadecimal number (H#0 to H#F), and the next 12 bits are don't cares (12X).

Once the mnemonics are defined, they can be put into adjacent words and ORed (overlaid) with other words to form a composite microword. A typical example of the necessary CCU instructions is shown in Fig. 10b. Here, a division example illustrates how instructions are overlaid. The & symbol indicates an overlay operation, and the * indicates an inverse function (14* = 85). For example, the first instruction after the ORG command (set program counter to 1000_{octal}) combines several mnemonics into one microword: the LDCT, TEST, INV and NUMB instructions.

Should your design end up using too many bits of microword width, don't be too concerned. The extra memory won't cost very much, and will probably even keep the over-all design time down. ■■

Previous articles in this series discussed the 8080, F8, 6800, 2650, 1802, 6100, PACE, SC/MP, and Series 3000. The next article will describe the 10800 series.

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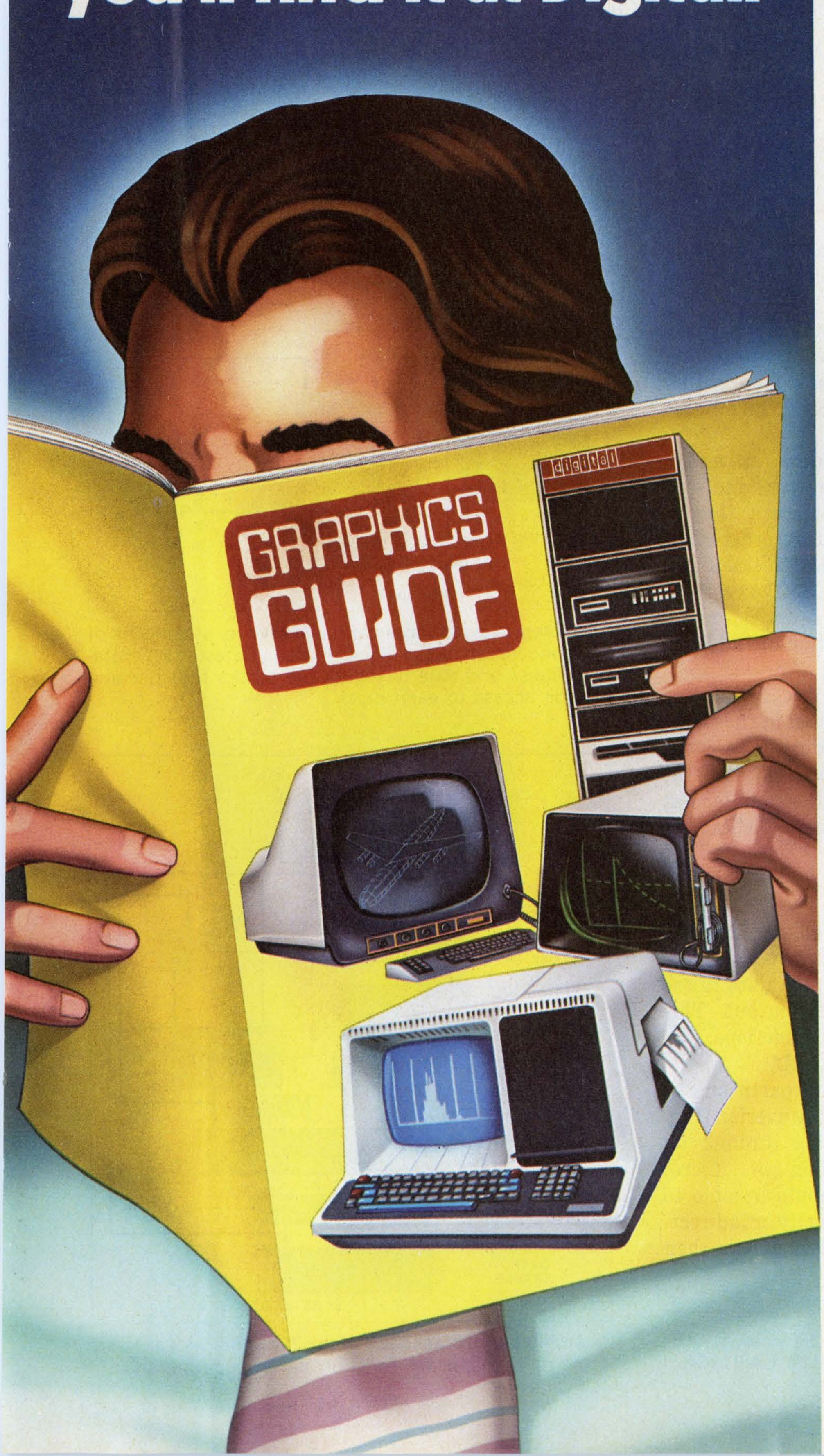

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Wring out 4-bit μP slices with algorithmic pattern generation. You will be able to pinpoint faults in both hardware and software.

Testing the 2901 and other 4-bit μP slices demands better methods. A bit slice must be thought of as a complex, sequential logic structure, and not simply as a few gates or an LSI memory. One fairly new testing approach writes test sequences in a microprogram, or algorithm, and a generator produces the required bit patterns.

The technique contrasts with the bulk of automatic testing today, in which bit sequences are generated by a computer program held in mass memory, then transferred first to a RAM, and second, in a burst, to the device under test.

A true and meaningful test requires an understanding of the slice hardware architecture and software functionality. Hardware architecture, that is, the internal organization, consists of an ordered set of modules, such as the register stack, accumulator and arithmetic logic units (ALU). Software functionality is the arrangement of ordered microinstructions that monitors the operation of the hardware modules.

Once both areas are mapped out, you can develop an ordered set of test sequences, written in the slice's own instruction set, to test each module one by one. Algorithmic pattern generation follows. Although the 2901 is a good example for describing the modular test approach, the technique applies to all μP slices.

Slicing up the slice

In general, a μP slice has two buses. One bus addresses both the external and the internal scratch-pad memory. Another bus supplies input data to the processor and processed data to the output. This second bus also links the internal functions, the scratch-pad memory, registers and ALU.

The first step in slice testing is to partition the device into modules, some of which may overlap (Fig. 1). Each module should be accessible through its input/output bus by the execution of microinstructions. In other words, you should be able to apply data to the slice input either directly or indirectly with the μP instruction set. The data should then propagate to the output.

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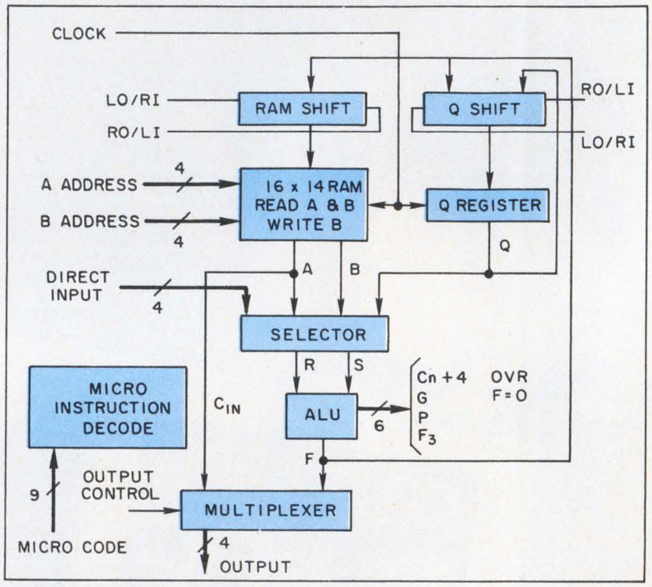
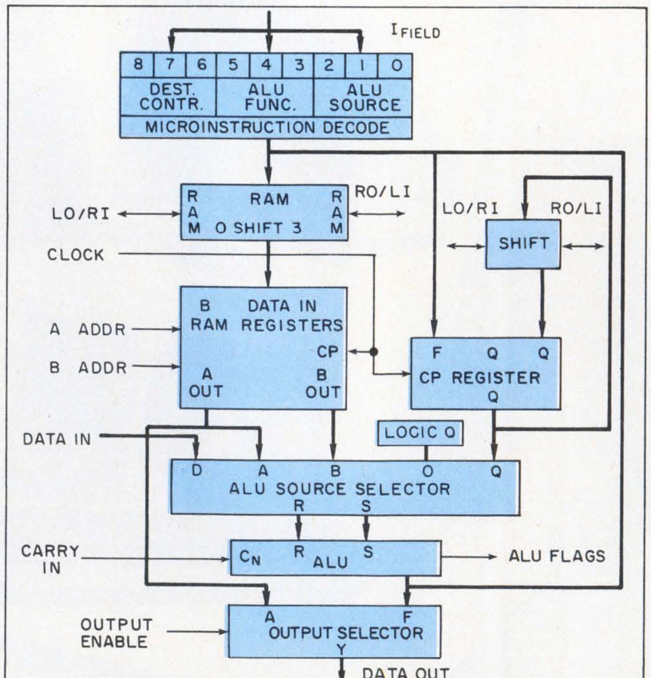


1. **Microprocessor slices** can be viewed as assemblies of independent functional blocks that can be tested separately. Address and data buses tie the blocks together and provide access to each block.



2. **Architectural breakdown of the 2901:** modular analysis is the most important function in developing tests.

A test is generated for each module of the slice so that a worst-case test pattern is run on each one. Sensitivity to the pattern can be determined with yet another pattern consisting of galloping ONEs and ZEROs.

While you test the first module, a set of instructions should be executed. As you proceed towards the second module, another set of new instructions is executed. This process continues until all instructions within the set are used in testing each module.

The diagnostic information gained has dual value. First, if a failure occurs, the faulty module is pinpointed. Convenient breakpoints inherently exist in such a module-by-module approach. Second, a set of microinstructions is executed in conjunction with each module, so if a fault occurs, the specific instructions can be isolated and identified.

The 2901 lends itself to the modular test approach because of its hardware and microinstruction architecture (Fig. 2). Notice that the device can be divided into the following modules: RAM, Q register, ALU, ALU source-decode multiplexer, RAM and Q-register right/left shift logic.

Start with the ALU

Since the 2901 has an ALU section, you should first test those areas that supply data to the ALU. Start with the RAM, and then do the Q-register module. Once these have been tested, they can serve as reliable data sources for the ALU-module test.

After the RAM and Q register, a typical test flow for the 2901 proceeds to the ALU source-decode multiplexer, the ALU and flags, and ends with the RAM and Q-register right/left shift logic (Fig. 3). During the test flow, all microinstructions are used.

Once you determine the necessary bit pattern, you have to create the pattern. The most common implementation on automatic testers today, the stored-pattern method, suffers from major drawbacks: inflexible programming, a large, expensive memory, long transfer periods and lack of fault isolation. Algorithmic generation can solve these problems.

In the algorithmic method, the defined sequence of patterns is created by a high-speed pattern generator controlled by a microprogram control. A variety of distinct patterns is possible, and you can modify with ease. Each module is tested by a sequence of generated stimuli that simulates the actual μP instruction. The device's true output response is controlled by the pattern generator.

The algorithmic technique can also solve the problem of overhead-data-transfer time. Since algorithmic generation occurs at true device speed, a substantial amount of the overhead time inherent in stored-patterns is eliminated.

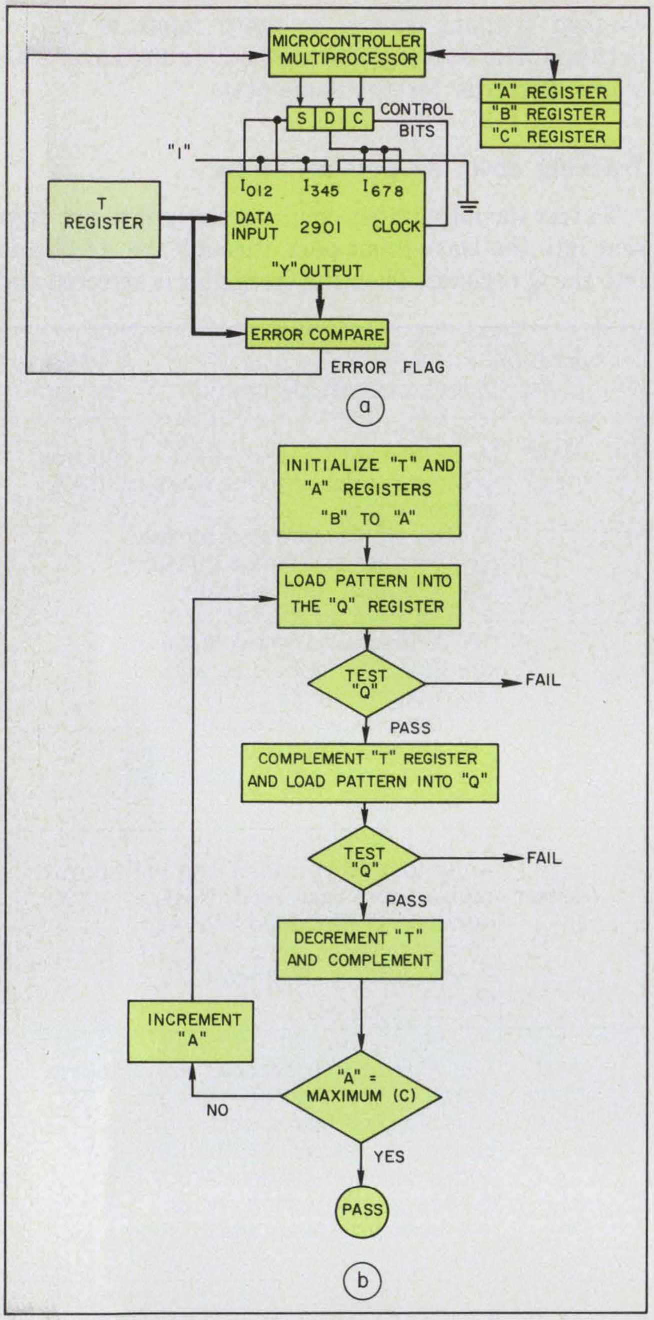
Tests on the 2901 Q register and the right/left shift operation on the RAM illustrate the advantages of testing with algorithmic generation. In both cases, all operations are tested, and all number combinations checked without having to store input or output patterns. The conventional method requires over 8000 stored patterns for the same test.

Tracking down all possible faults

To test for all number combinations, data are first sent into the Data-input port, through the ALU, and into the Q register. Then the Q register is selected and

Test flow chart	Functional-test description	Test pattern
RAM test	A galloping ONE and ZERO pattern is applied to the RAM in combinations. 1. The RAM addressed by the "A" address and tested through the Y output port directly. 2. The RAM addressed by the "A" address and tested through the ALU. ALU is held at a fixed instruction. 3. The RAM addressed by the "B" address and tested through the ALU. ALU is held at a fixed instruction.	Approx. 3000
Q register	A number 15 is loaded into the register and then read. Next, a number "0" is loaded and read. This is followed by a 14, 1, 13, 2, etc., until a "0" then a 15 is loaded.	Approx. 100
ALU source decode	The ALU source decodes are tested to see if all decodes are possible. The test is performed by loading values into the RAM and Q register and selecting all decodes while testing for any interaction between bits or sections.	Approx. 50
ALU	A series of numbers is loaded into the RAM and Q register. These numbers are then used as inputs to the ALU. At the same time, all outputs and flags from the ALU are monitored while incrementing the operations the ALU can perform.	Approx. 1000
RAM and Q register right/left shift MUX	All numbers from 0 to 15 are shifted through the RAM and Q register. While the RAM section is being tested, all locations are tested. After each shift, all possible number combinations are delivered to the output latch, without clocking the latch, to see if there is any latch sensitivity.	Approx. 8200

3. **Each functional module of the 2901 slice is isolated** and a test flow established for each module. All microinstructions should be used in the tests.



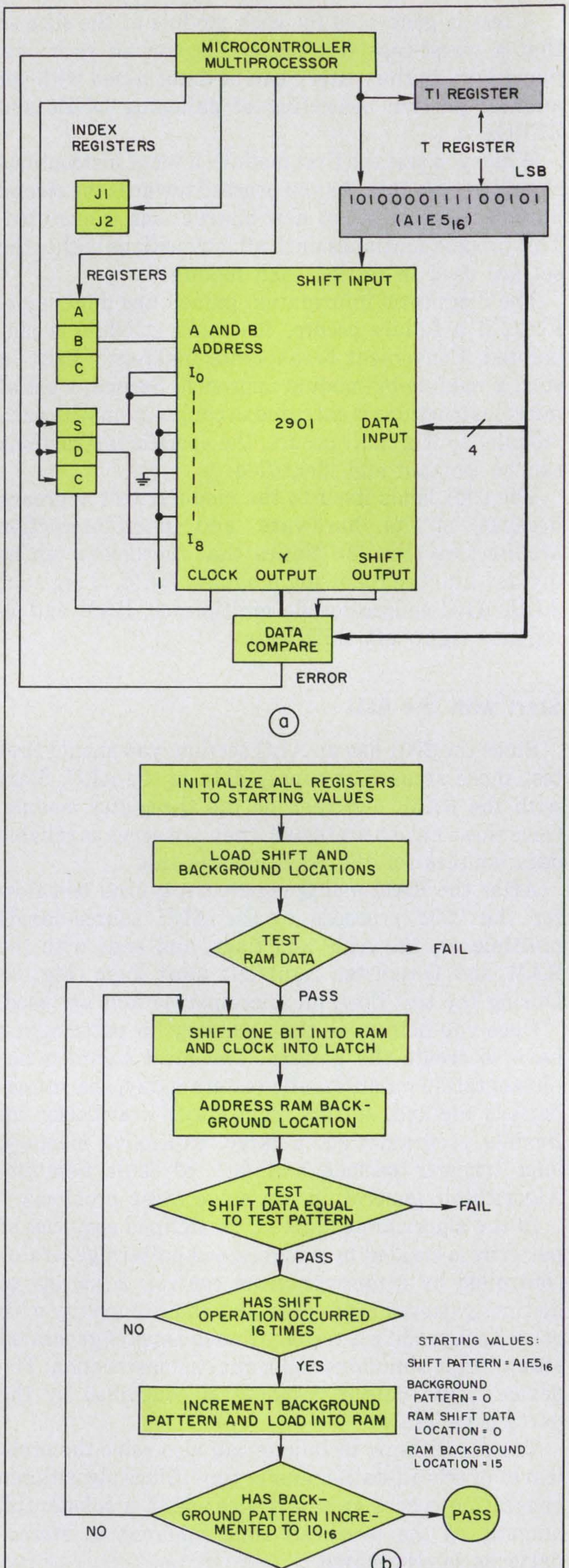
4. **The Q register is tested** for all numerical combinations with a register that provides inputs and compares output and input data (a). The test flow chart is shown in (b).

its contents tested (Fig. 4). All that is required is a register to keep track of the input and output data, another to keep track of the test cycles, and three bits to control the microinstructions and the μP clock.

As shown in Fig. 4, a 4-bit test register supplies that data input and compares output and input data. The A register keeps track of the test cycles performed, the B register stores the starting count, and the C register the ending count.

The S bit selects the ALU data sources, and the D bit picks the ALU data's destination. The C bit clocks the device. Finally, a microcontroller multiprocessor controls all registers and control bits, and tests for an error in the compared data.

As illustrated in Fig. 4b, a simple test run on the



5. **Testing the right/left shift operation** of the 2901 RAM requires a more elaborate arrangement (a). The test flow checks the data latches as well (b). Two locations in RAM store shifted and background data.

register checks that all possible number combinations and complements are loaded. Data enter through the input port, pass through the ALU, and are clocked into the Q register. The ALU source is selected to octal-code, 7 (R=D, S=O), and the ALU function is selected to octal 3 (R or S) throughout the test.

Keeping the ALU function in R *or* S allows you to isolate faults easily: Only one path is used through the ALU. After the Q-register operation is loaded, the sequence selects the Q-register and tests it for the correct value. The Q-register position is selected through the ALU selector (octal-code 2) and the ALU destination set to octal-code zero to transfer the Q register to the Y output.

The test vector is then complemented and the selection operation repeated. Upon completion, the test vector is decremented and complemented, and the same test performed again until all combinations are tested: 0, 15, 1, 14, ..., 14, 1, 15, 0.

Testing the right/left shift operation of the RAM calls for a more complex test pattern. The shift test must test the right/left operation of the RAM completely, and the RAM data-output latches. Two locations in RAM are used. The first stores the shifted data, the second the background pattern delivered to the latch after the shifted data have been clocked into the data latch.

Additional hardware is required to perform the shift test (Fig. 5a). First, both the shifted and the background data values need to be stored. The shifted data are stored in the previous-test register (T), and the background data in register (T_1).

Two other features are added to the T register: a circular shift of the most-significant bit to the least-significant bit and a bidirectional 16-bit transfer path between the T and T_1 registers.

Two index registers, (J_1 and J_2), keep track of each shift operation and each incrementation of the background value. All operations are controlled by the microcontroller multiprocessor.

In the final test, checking the RAM's shift operation, the algorithm is not really as complex as it appears in the flow chart (Fig. 5b). Two locations in RAM store the test-shift background data. The test loads the two and then shifts pattern $A1E5_{16}$ through the RAM.

After each shift, the shifted data are checked and the background addressed. The output is again tested to see that the latch's state is unchanged. With $A1E5_{16}$, all number combinations will be shifted through the RAM. After all 16 bits of the pattern have shifted through, the background word is incremented and the test repeated.

The algorithm of Fig. 5b is repeated on all RAM addresses, with the complement of the background pattern acting as the test-pattern address. ■■

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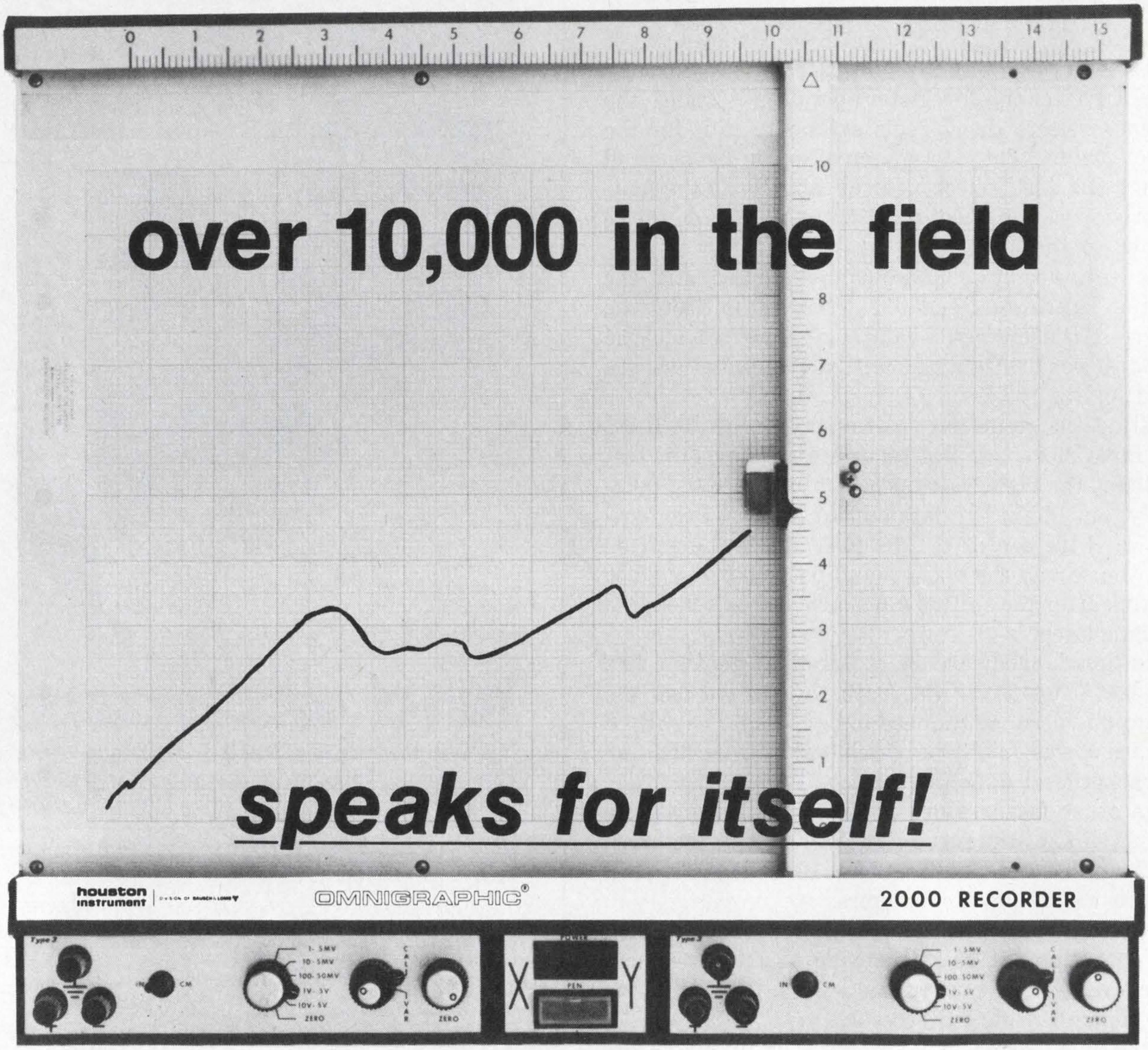

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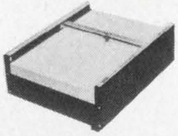
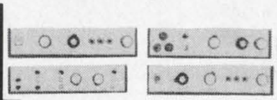
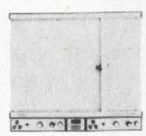
1  **+1**  **= 3** 

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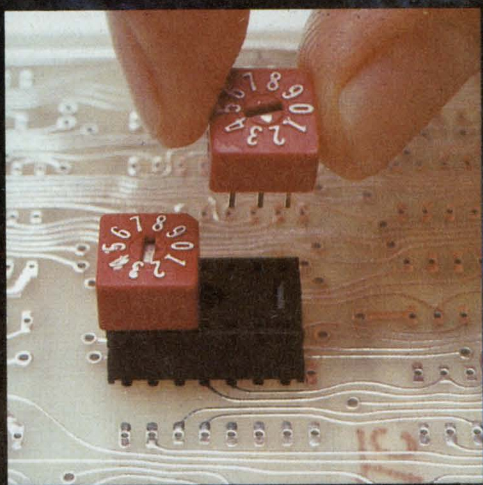

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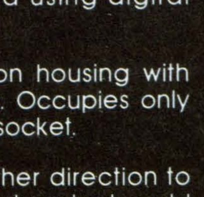

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Real-time systems often use interrupts

to service I/O devices in order of importance. And blocks of data can be moved quickly by direct memory access.

Microcomputers are often used in dedicated control operations where inputs occur at unpredictable intervals. Process control systems that affect motor speeds, flow rates, machine operations, or process parameter variations must be sensed and controlled in real time. Program-controlled I/O (Part 5, ED No. 9, Apr. 26, 1977, p. 70) must therefore be supplemented by device-controlled interrupts.

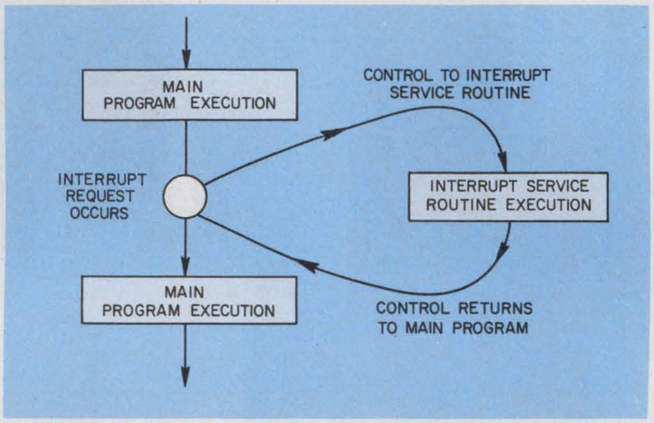
An interrupt may occur at any time during program execution. In response to an interrupt, control is transferred to an interrupt-service routine after the current instruction is completed. When the service routine has processed the interrupt, it returns control to the main program. If all goes well, the main program continues execution without adverse effects. But only if you carefully consider, both in software and hardware, all interrupt phases: initiation, acceptance, service and return.

In its simplest form, the computer receives a single interrupt, finishes the current instruction, and calls the fixed memory location that contains the interrupt service routine (Fig. 1). The service routine performs the data transfers and returns control to the main program. Because the single-interrupt routine address is fixed by hardware, it is called a fixed (or single-level) interrupt.

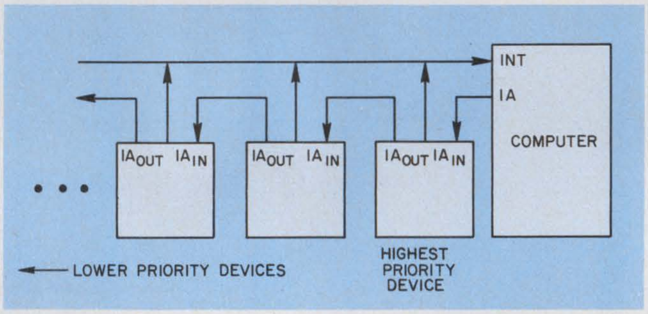
Polling requires more logic

A single interrupt line can be shared by several external devices if you apply the "polling" technique. Logic must be added to the interrupt service routine to read the status of each interrupting device and determine which one requires attention. The result of the poll is used to transfer control to the proper I/O routine. If there are many interrupting devices, polling can be very slow and inflexible.

Vectored (or multiple-level) interrupts are faster and more flexible, but require more hardware. The computer then responds to an interrupt by sending out an interrupt-acknowledge signal when it has completed the current instruction or routine. The interrupting device then supplies the CPU with the



1. **A single interrupt stops execution** of the main program whenever it occurs. Once the interrupt service routine is executed, control returns to the main program.



2. **The daisy-chain priority-interrupt system** acknowledges interrupt requests only when all upstream devices have been serviced.

address of its service routine, and control is transferred directly, without polling or decoding. You may combine vectored, polled, and fixed interrupt schemes in your system architecture to obtain the desired response characteristics.

When your system contains several interrupting devices, you must establish a pecking order. The highest-priority devices may always have to be serviced on demand, while lower priority devices wait —or are ignored altogether.

A simple priority scheme for microcomputer systems is the daisy chain (Fig. 2). All interrupting devices share the common interrupt line, but the interrupt-acknowledge line is routed to the highest

Robert W. Ulrickson, President, Logical Services Inc., 711 Stierlin Rd., Mountain View, CA 94043.

priority device first, and then passed through to consecutively lower-priority devices. Until it has identified itself and been serviced—or has, in turn, been interrupted by a higher priority device—the interrupting device suppresses transmission of the acknowledge signal to lower-priority devices.

For a more sophisticated priority-interrupt scheme, LSI devices such as Intel's 8259 provide "hardware-priority" encoding, so that you can enable and disable specific devices under program control. In most systems you can completely disable interrupts during such critical program segments as timing loops. But you must be sure that only expendable data are lost when an interrupt request is disregarded.

Before enabling any interrupts, the system control program requires initialization—i.e. you must set up all data values that the interrupt-service routines will need. Normally, an interrupt-service routine is executed once each time a device interrupts. Because you don't know when the interrupt may occur, it is vital that the interrupt-service routine restore all registers and flags that it modifies during I/O processing, before it returns control to the main program. If any other interrupts are automatically disabled by the first interrupt, the service routine must re-enable them before execution continues.

How do you like your eggs?

Many microcomputer systems perform tasks for a fixed time interval—for example, cooking an egg to your preferred consistency—which requires translating elapsed time into a form that is usable by the program. Suppose you have a clock outside your system than can generate an interrupt once every second. By assigning some memory location as a counter, your system can count these interrupts and know how much time has elapsed (Fig. 3).

If you want to use this counter to time a three-minute egg, you need a 360-second delay, or 360 counts. If the counter is at, say, 600 when you start the egg timing routine, your program has only to monitor the counter until it reaches 960, then turn off the stove or ring a bell. For such simple elapsed-time tasks interrupt initialization consists of clearing the counter location and enabling interrupts. A routine that uses this timer simply reads the current value of the counter, adds the desired number of counts to that value, saves the sum, and continues until the counter reaches the sum (Fig. 4).

To implement this routine with an 8080A system, assign the timer two memory locations labeled TIME and set up an external clock to generate an "RST5" for service (see box). Program sections for the timer routine, initialization and service routines follow:

```
;INITIALIZE TIMER
        LXI H,Ø     ;CLEAR TIMER
        SHLD TIME
        EI          ;ENABLE INTERRUPTS
        .
        .
        .
        LHLD TIME   ;GET INITIAL TIME
        ADD L       ;ADD COUNT TO HL
```

(continued on page 82)

The 8080A restart instructions

The 8080A provides an 8-level vectored interrupt system. When an interrupt is acknowledged, the interrupting device may place one of eight single-byte RST instructions on the data bus. The RST instructions behave as subroutine calls to a fixed block of addresses low in memory:

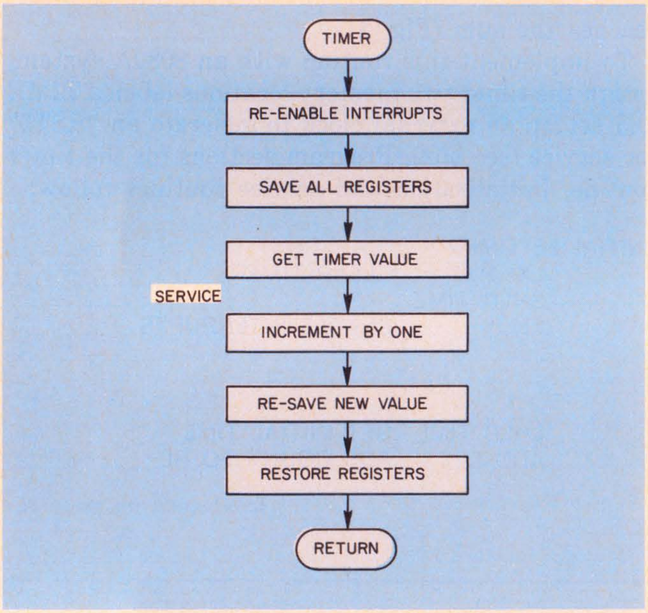
INSTRUCTION	ADDRESS CALLED
RST 0	0
RST 1	8
RST 2	10H
RST 3	18H
RST 4	20H
RST 5	28H
RST 6	30H
RST 7	38H

Each restart area consists of eight bytes, and if an interrupt service routine requires more, use a jump instruction to continue it elsewhere in memory.

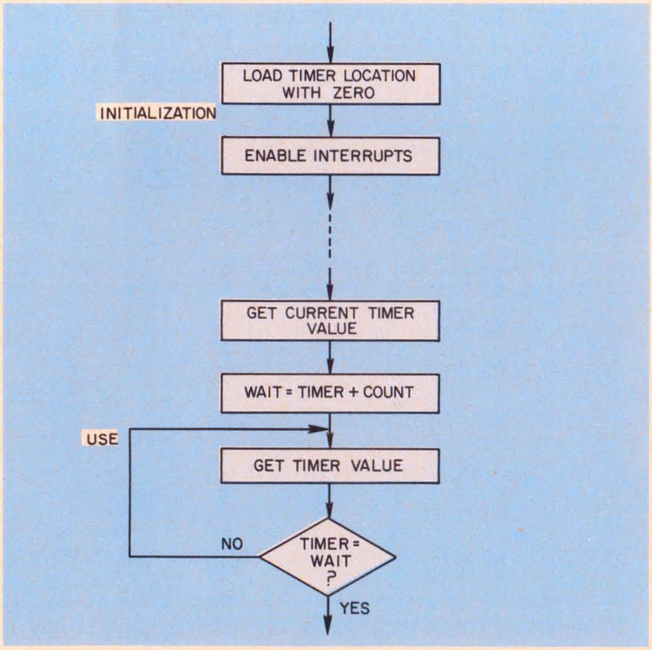
(continued from page 81)

```
         MOV L,A
         MOV A,H
         ACI Ø
         MOV H,A
         XCHG        ;MOVE VALUE INTO DE
TLOOP:   LHLD TIME   ;GET CURRENT TIME
         MOV A,E     ;SUBTRACT FROM VALUE
         SUB L
         MOV A,D
         SBB H
         JNZ TLOOP   ;WAIT UNTIL THEY MATCH
         .
         .
```

```
         ORG 28H     ;RST 5
TIMER:   EI          ;RE-ENABLE INTERRUPTS
         PUSH H      ;SAVE HL
         LHLD TIME   ;GET TIMER
         JMP TCONT   ;CONTINUE ELSEWHERE
         .
         .
         .
TCONT:   INX H       ;INCREMENT TIMER
         SHLD TIME   ;RE-SAVE
         POP H       ;RESTORE
         RET
         .
         .
         .
```



3. **This timer flow chart** is an example of an interrupt service routine. The time count is only correct if the interrupt is serviced promptly.



4. **Interrupt service routines,** like the timer routine, interface with an initialization segment and a use routine in the main program.

Note that, since the timer service routine is longer than the eight bytes provided by RST5, it is continued in another part of memory. In this case, you don't have to save and restore the program-status word (PSW), because the INX instruction does not affect any flags.

When you design software to process asynchronous interrupts, erroneous changes in the execution of the

What is a checksum?

In a commonly used method for checking data validity, a checksum is formed by keeping a running sum of all data bytes in the record. After all the data bytes have been written, the two's-complement of the sum is formed and written on the tape as the checksum. When the tape is read back, the sum of all read data is formed again, and the checksum added. If the data have been read back correctly, the result is zero. For example, consider writing six data bytes as follows:

Data: 0,1,2,3,4,5
Sum: $0+1+2+3+4+5=0F_H$
Two's-comp. checksum: $0F+1=0F0_H+1+0F1_H$

On readback, the sum of all data on the tape is formed again, and the checksum added:

$$0+1+2+3+4+5+0F1_H=100.$$

Ignoring carries, the sum is zero, which indicates that the data have been read correctly.

Checksums can be formed differently, but it is common to use the "checksum modulo w," where w $= 2^n$ and n is the number of bits in the computer's basic data word. The modulo function produces the "integer remainder" of the division of one number into another. Thus, the number 11 evaluated in modulo 5 becomes 1, because $11/5 = 2$ with an integer remainder of 1. The checksum is easily evaluated in modulo w by simply forming the sum of the data bytes and ignoring any carries. With an 8-bit microcomputer, checksums are evaluated modulo 256 ($2^8 = 256$), so that only a single-byte checksum is needed, regardless of how many data bytes are written.

main program can result, unless you pay close attention to memory and register usage. Occasionally, detailed timing analysis may be required.

Want to move data wholesale?

At times you may have to interrupt processor operation, or dedicate the processor temporarily to the transfer of a block of data between an external device and a reserved block of memory. Block transfers are used typically for interfacing magnetic tape or disc units, which have a very high data-transfer rate for blocks of data, but can't be easily started and stopped to transfer a single byte.

Memory areas reserved to store such blocks of data are called buffers. The most common type of buffer is a FIFO (first in, first out) stack. Data transferred into a FIFO are made available in the same order in which they are entered. FIFO stacks may be implemented by software in main memory, or by special-purpose hardware for very high-speed applications. In either case,the FIFO buffer matches the data-transfer rate to the rate at which the processor generates or uses the data.

To illustrate block-data transfers, suppose you have interfaced your computer to a magnetic tape unit. Now you wish to transfer blocks of data to and from tape.

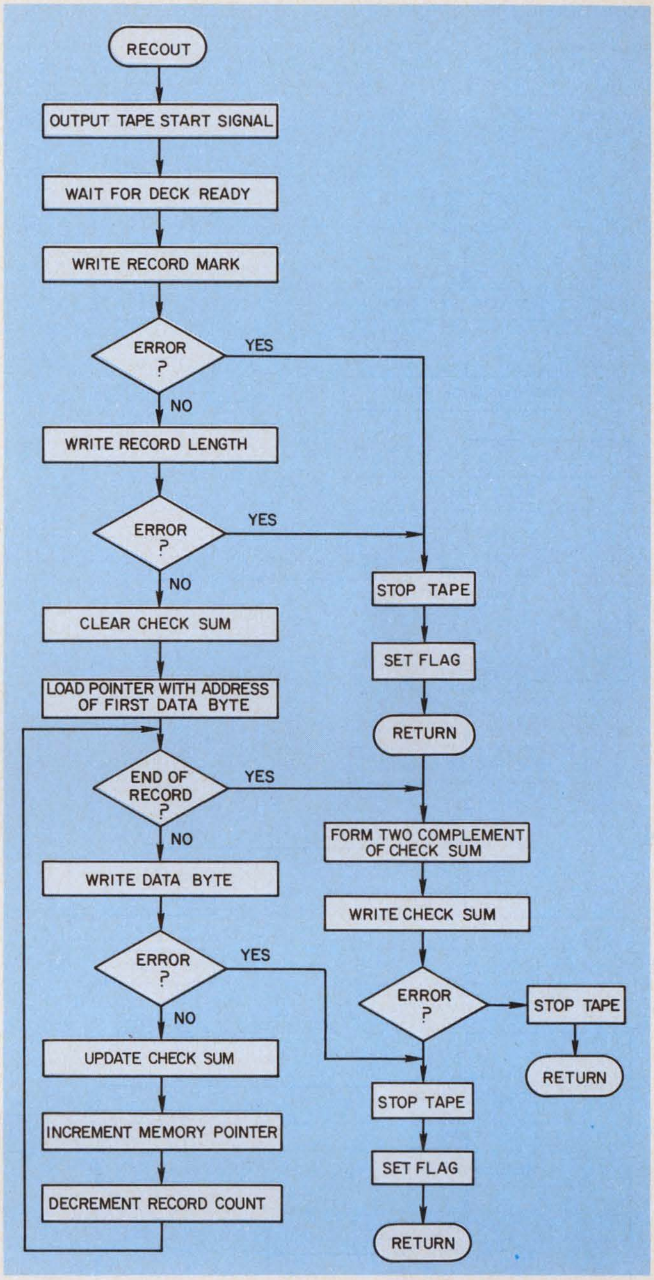
A block of data on tape is called a "record." Each record contains a leading record mark, the data block itself, and a trailing record mark. The leading record mark usually contains the record length and special identifying information. The trailing record mark contains data-checking information.

Records are usually separated by gaps long enough for the tape to start and stop. The details of the record marks vary with the hardware you select. A typical record format uses a single-character record mark, a single-byte record length (which limits the record to 256 data bytes), and a single-byte "checksum" (see box), followed by a gap.

Strictly for the record

The program logic for a record-output processor shown in Fig. 5 is set up as a general purpose subroutine. The calling programs supply the record length and the memory address of the first data byte to be transferred. The processor routine then turns on the tape-write hardware and waits for the deck to reach operating speed. The time delay can be provided by control signals from the tape deck, or by software timing loops. Once the deck reaches operating speed, the routine outputs the record mark, record length, data and checksum. A zero-length record is often used to mark the end of a group of records, sometimes called a "file."

Fig. 6 shows the logic of a record-input processor. Calling programs pass-in the memory address where the data are to be loaded. The routine executes the transfer and returns with the number of bytes trans-



5. **The program logic for record-output** is set up as a subroutine. The checksum serves as an error detection device for data transfers.

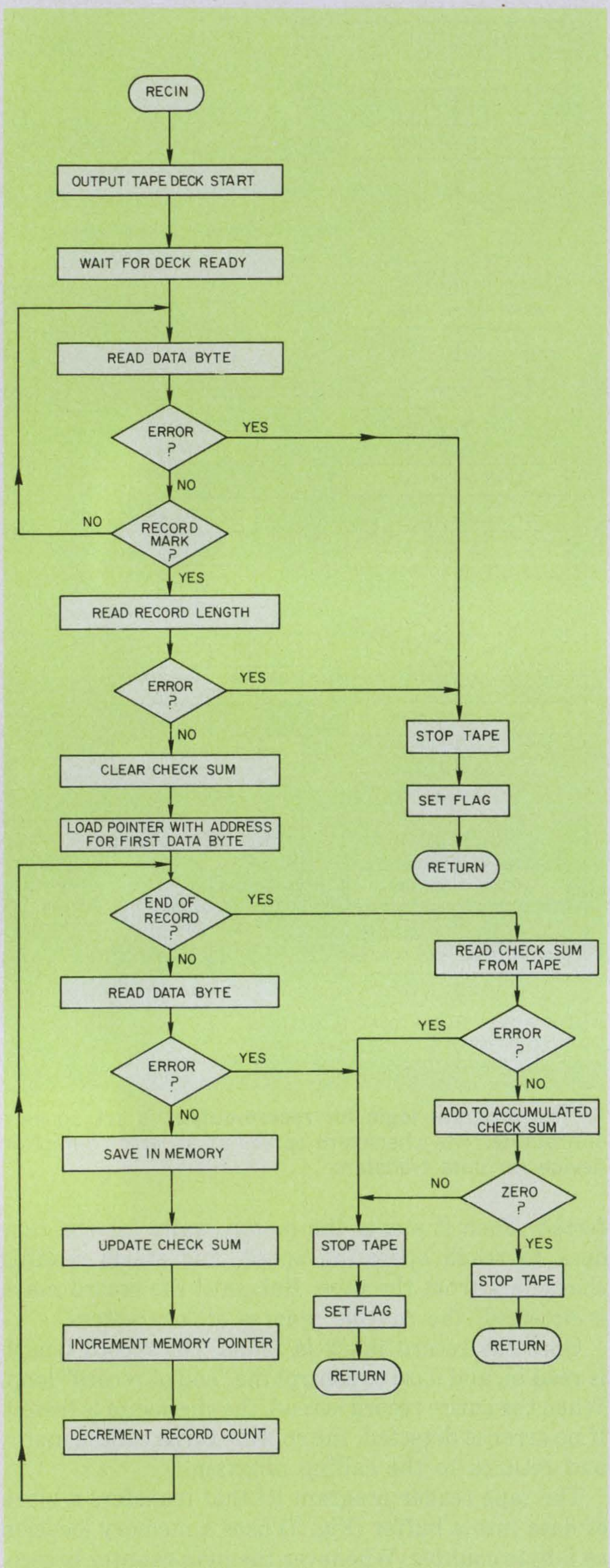
ferred. Then it starts the motor, waits for the tape deck to reach operating speed, and starts reading characters from the tape. But until the record mark is detected, the routine ignores all characters.

Once the record mark is found, the record length is read in, and used to control the "end of record" loop. When the entire record is read, the checksum is tested. If no error is detected, the routine turns off the motor and returns to the calling program.

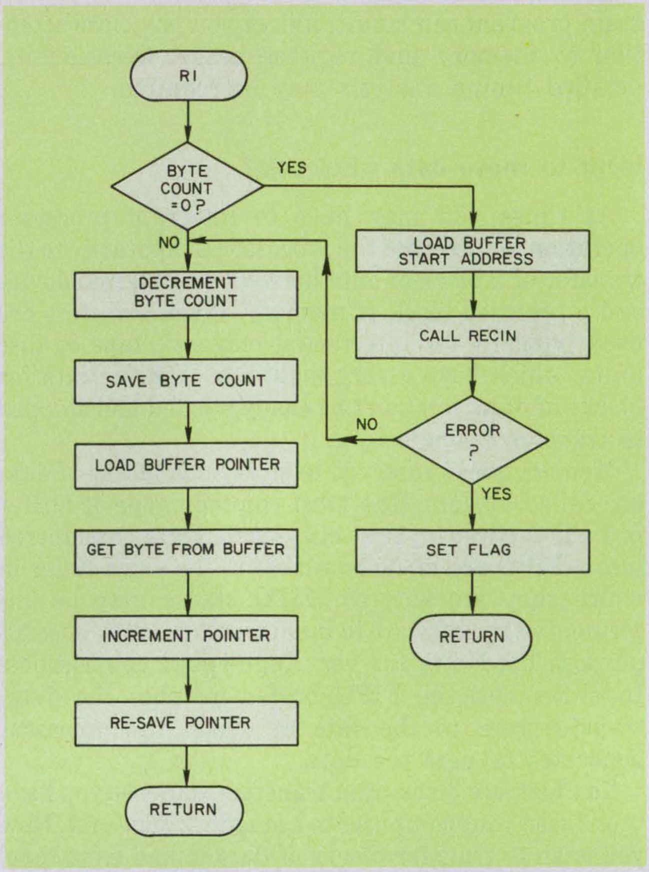
The tape reader program RI that transfers a block of data into a buffer (Fig. 7) uses a memory location as a byte counter. Whenever the byte counter is zero, a new block of data is transferred. The main program must initialize the byte count to zero before the first call to routine RI. After that, RI automatically

(continued on page 84)

(continued from page 83)



6. **The record-input logic** closely resembles that for record-output. But it ignores all incoming data until the record mark is found.



7. **To transfer a block of data into the buffer,** the reader-input program uses a memory location as a byte counter, which counts down to zero.

transfers data blocks from the tape whenever the byte count is zero.

The location of the next character is maintained by saving a pointer in memory and incrementing it every time a character is taken from the buffer. The byte counter and the buffer pointer form a FIFO stack.

A powerful prescription: DMA

By combining block-data transfers with a sophisticated method called "direct memory access" (DMA), data can be transferred in or out of main memory without involving the processor. "Smart" I/O devices are mandatory for DMA which treats main-memory buffers as if they belong to a processor within the accessing I/O device. In fact, they usually do. First, the main processor is put to sleep, or under local anesthesia, so that the host processor can't affect buffer-memory areas assigned to the accessing I/O device. A separate processor in the I/O device then takes control, transfers data into or out of main memory buffers, and returns control to the main processor. DMA is often used for block transfers to high-speed mass memory devices such as magnetic discs.■■

The next article in this series will appear in the June 7 issue, and will cover the important topics of program testing, debugging, and documentation.

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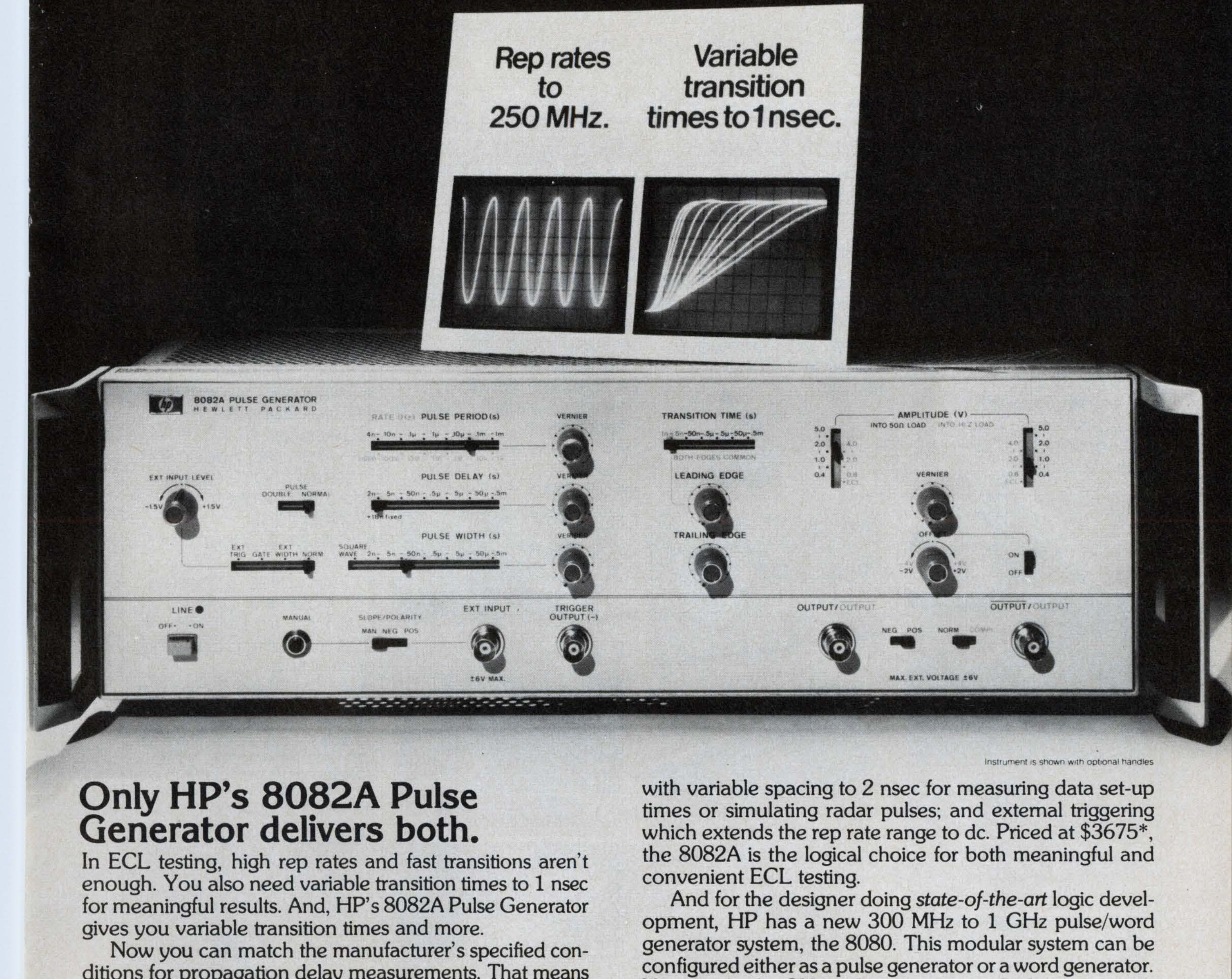

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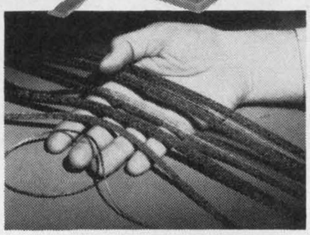
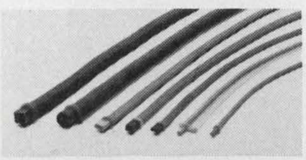
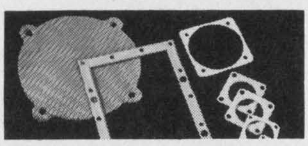

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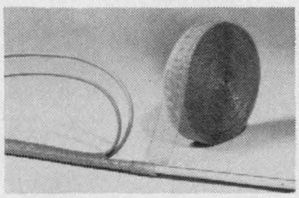
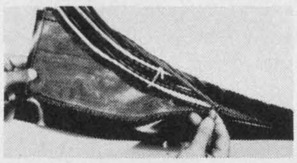
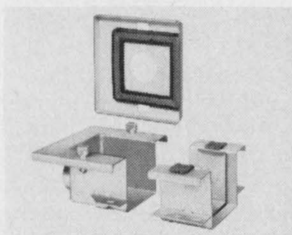
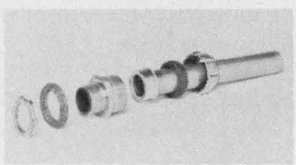

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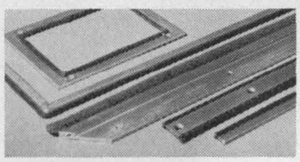
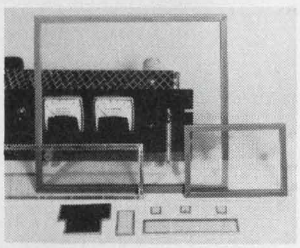
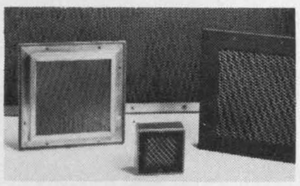
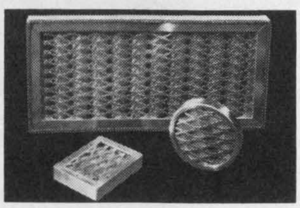

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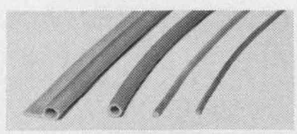
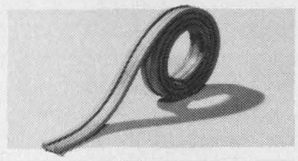
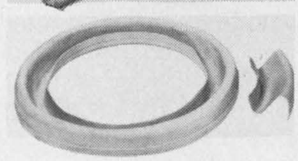

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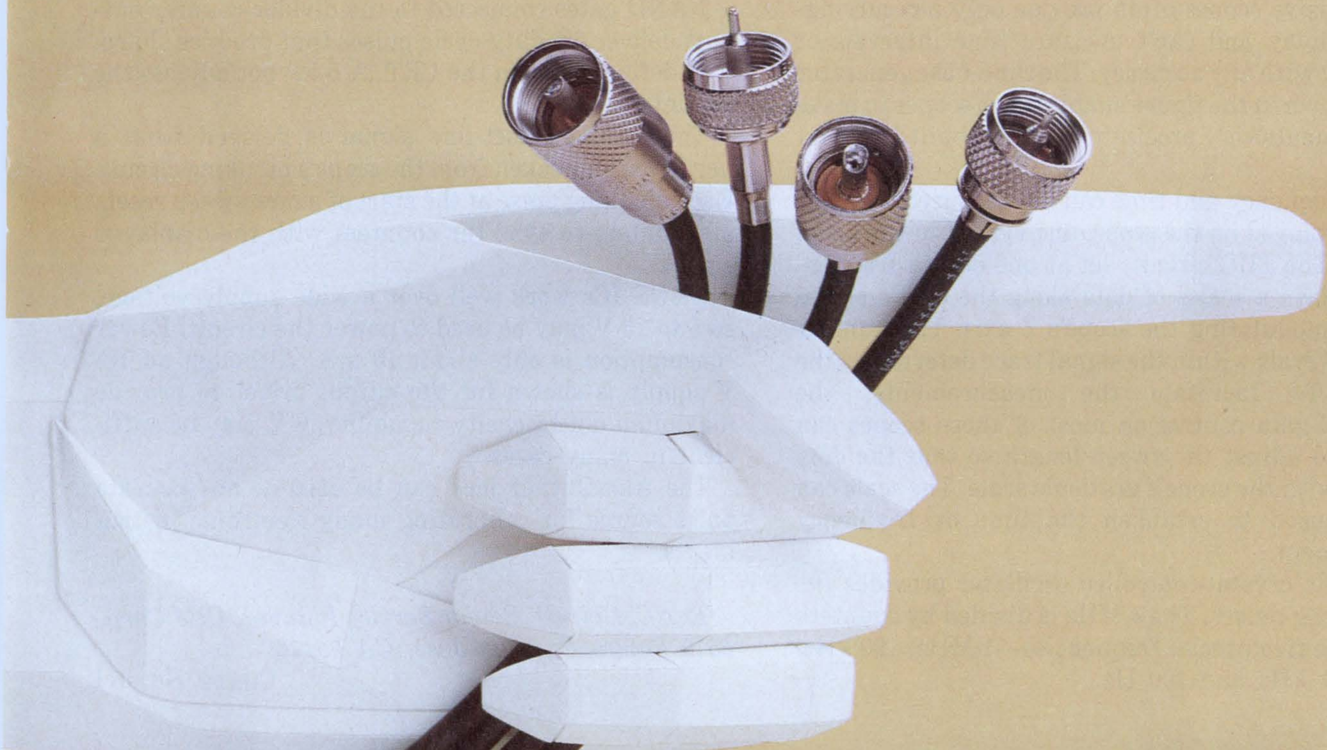

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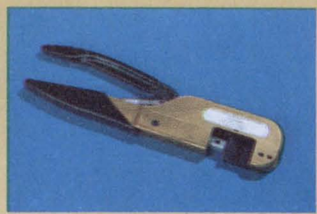

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Crystal-controlled time-base generator measures frequency/time in low-cost scopes

Inexpensive scopes often provide only a recurring-sweep display and can't measure time intervals or frequency with any accuracy. The time-base generator (TBG) shown in the figure enables such scopes to make measurements very precisely. It can be built for about $15.

Both frequency and time can be measured with the signal displayed on the scope, and synced in the usual manner. The TBG circuit, set at one of five frequencies, displays a series of dots along the CRT's signal trace by modulating the scope's Z axis. The number of dot intervals within the signal trace determines the timing. To facilitate the measurements, the horizontal-gain control on most of these scopes can be used to adjust the sweep length so that the dots coincide with the scope's graticule scale. The scale can then be used to establish the time or frequency measurement.

A 4-MHz crystal-controlled oscillator provides the basic timing pulses. The 4 MHz is divided by counters to produce five precise frequencies—1 MHz, 100 kHz, 10 kHz, 1 kHz and 100 Hz.

NAND gates connected to the divider-counter outputs deliver 5% duty-cycle pulses that produce sharp, well-defined dots on the CRT. A 5-kΩ pot adjusts the dot intensity.

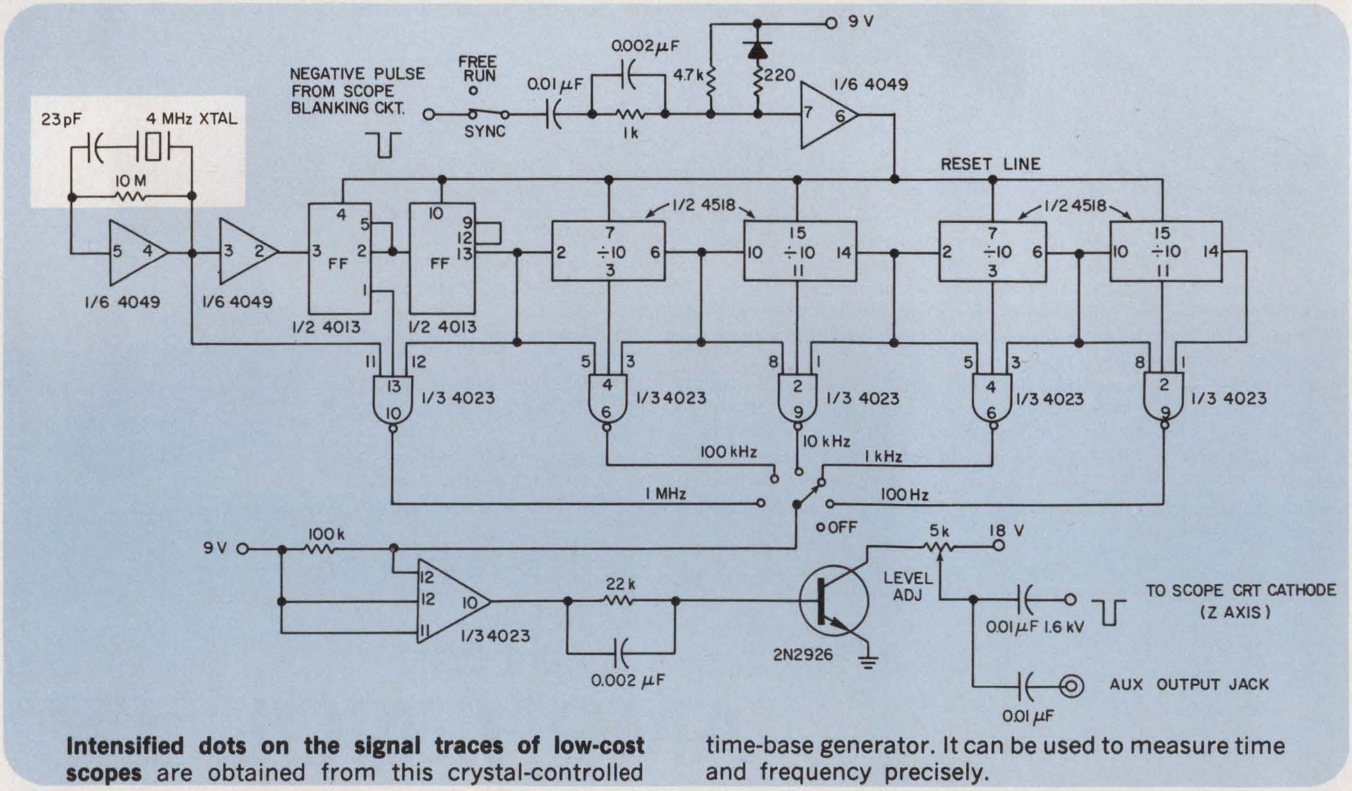
The counter reset-line signal is derived from a negative pulse taken from the scope's blanking circuit. Each blanking pulse at the start of a new sweep resets all counters to sync the counters with the displayed signal.

CMOS ICs work well over a wide supply voltage, so 5 to 15 V may be used to power the circuit. Power consumption is only about 10 mA. Although an 18-V supply is shown for the output driver to provide maximum dot-intensity capability, 9 V may be sufficient in many cases.

The Aux-Output jack can be used as an accurate pulse source for calibrating many electronic instruments.

Rex C. Geivett, Senior Service Planner, IBM Corp., 6519 Pajaro Ct., San Jose, CA 95120.

CIRCLE No. 311



Intensified dots on the signal traces of low-cost scopes are obtained from this crystal-controlled time-base generator. It can be used to measure time and frequency precisely.

A 60-MHz power oscillator generates a low-noise output

The 1-W oscillator in Fig. 1 can very effectively serve as a variable-frequency oscillator (VFO) for broadband transmitters that must produce low broadband-noise outputs. Operating at 60 MHz, it produces noise as low as 145 dB below the carrier level for a 30-kHz bandwidth. Noise is lowered by the high degeneration in the emitter circuit.

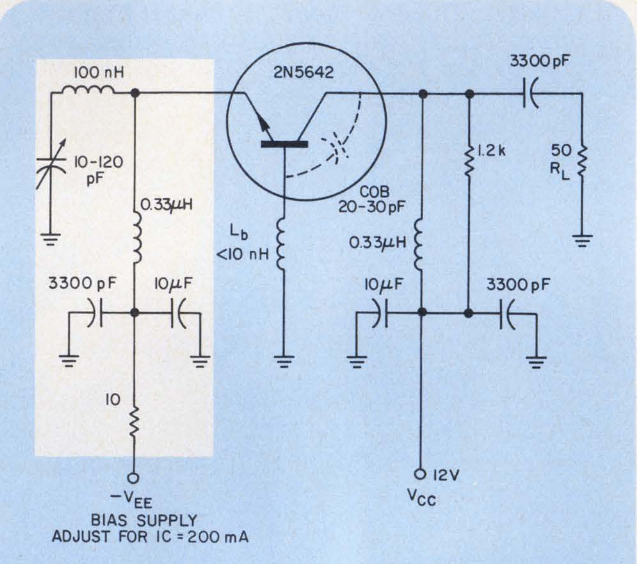
The noise power, P_n, delivered to the load comes mainly from collector-current shot noise, i_c. Accordingly,

$$P_n = \overline{i_c^2} R_L = (2eI_c BS^2) R_L$$

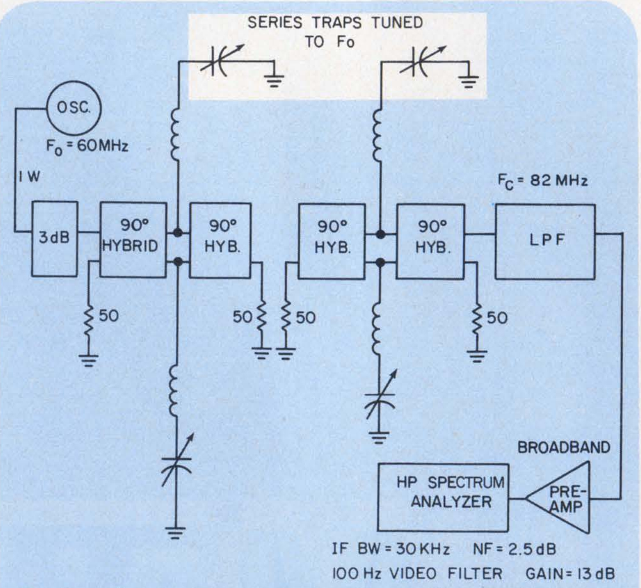
where e is the charge on an election, I_c is collector current, B is bandwidth and S is a space-charge reduction, or smoothing factor. For a 2N5642 transistor,[1] S^2 is 0.017. Thus, with I_c (average) = 0.2 A, B = 30 kHz, and R_L= 50 Ω, then P_n = −118 dBm, close to a measured value of −115 dBm.

Oscillation is produced by feedback via the collector-base junction capacity, C_{ob}, and the small base-lead inductance, L_b. Since X_{cob} is much larger than X_{Lb} for the frequencies of oscillation, the feedback current leads the collector voltage by 90 degrees. The base voltage developed by this current, in turn, leads the current by another 90 degrees and establishes the correct phase condition for oscillation. The oscillation frequency is determined by the series-tuned circuit in the emitter.

A noise measurement setup (see Fig. 2) was used to test the oscillator. Two sections of quadrature hybrid couplers with series-tuned traps produce a total notch of 60 dB for the carrier. A low-noise preamp with a 13-dB gain effectively lowers the noise floor of the spectrum analyzer. The 3-dB pad provides a proper load impedance for the oscillator, and a low-pass filter prevents the oscillator's second harmonic output, which is 30 dB below the fundamental's amplitude, from overloading the preamp.



1. **High negative feedback in the emitter circuit** reduces the noise output of this 1-W power oscillator to very low levels.



2. **A noise measurement setup** with carrier-suppression circuits was used to establish that the oscillator noise output is 145 dB below the carrier.

Reference

1. Lohrmann, Dieter R., and Son, Kyung S., "Reduce the Noise Output of Linear rf Amplifiers," *Electronic Design*, Sept. 27, 1976, p. 84.

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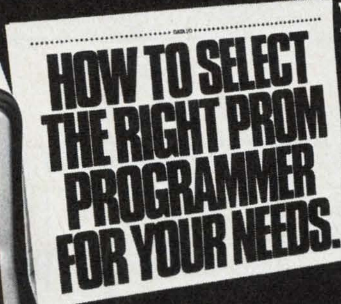

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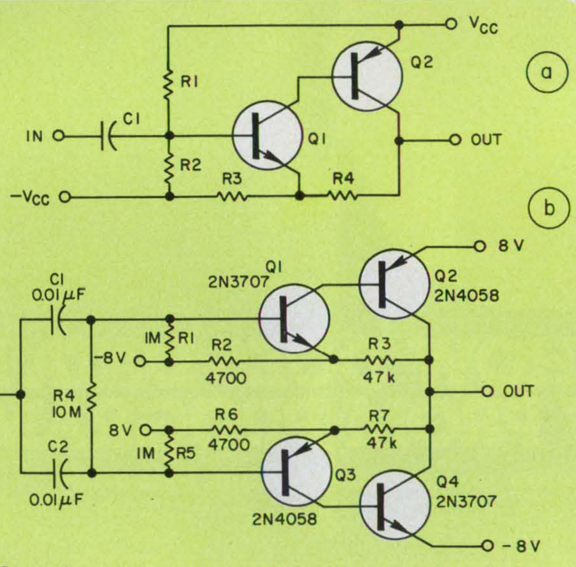
Complementary amplifier improved by double-ended symmetrical configuration

The principal virtue of the well known complementary amplifier of Fig. 1a is its ability to yield an output swing whose peaks nearly span the supply voltage. But the circuit has two grievous drawbacks: First, the achievable gain is limited by its dependence on supply voltage. The optimum ratio of R_4/R_3 to hold output voltage halfway between $-V_{cc}$ and $+V_{cc}$ is $R_1/2R_2$. Choosing a larger R_4/R_3 ratio to get more gain makes the operating point of Q_2 shift disproportionately with changing supply voltage. Second, the circuit is inefficient, because Q_2 is a single-ended class-A amplifier. And to drive a low-impedance load requires that collector resistors R_3 and R_4 have low values. The resultant high quiescent current then needed to establish the operating point of Q_2 results in poor efficiency.

Both disadvantages can be overcome by the symmetrical arrangement shown in Fig. 1b. Even though output transistors Q_2 and Q_4 are operating in class A, their push-pull action allows higher efficiency. Since the feedback-resistor pairs R_2, R_3 and R_6, R_7 don't carry power-output current, they can have high values with a corresponding reduction in quiescent current.

In the symmetrical amplifier, bias is supplied by voltage dividers R_1, $R_4$and R_5. Because this network is common to both inputs, the effect of varying V_{cc} on one half of the circuit cancels its effect on the other half. Hence, the output voltage tends to remain halfway between $+V_{cc}$ and $-V_{cc}$ —or at zero volts, if tracking plus and minus supplies are used. Ratios R_3/R_2 or R_7/R_6, therefore, may be made as large as required to obtain the desired gain. Of course, these ratios must be kept within limits dictated by the matching of complementary parts and the amount of distortion that can be tolerated.

Dale Hileman, Sphygmetrics, Inc., 6311 J De Soto Ave., Woodland Hills, CA 91367. CIRCLE NO. 313



1. **Complementary transistors in a single-ended amplifier arrangement** (a) have severe design limitations. The problems can be alleviated by a symmetrical double-ended configuration (b).

IFD Winner of January 4, 1977

Max W. Hauser, Engineering Associate, Plasma Research Laboratory, Cory Hall, University of California, Berkeley, CA 94720. His idea "Keyboard for 64-key ASCII Code Features Very Low Power Consumption" has been voted the most Valuable of Issue Award.

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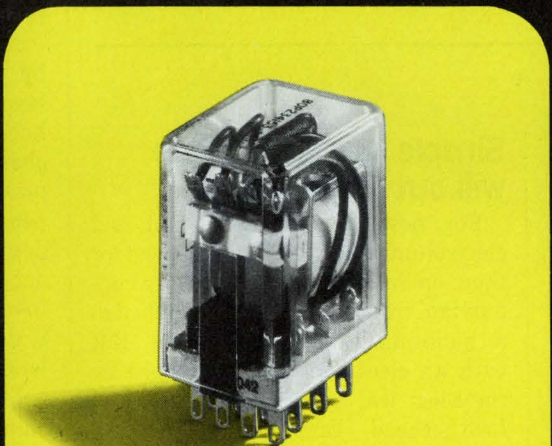

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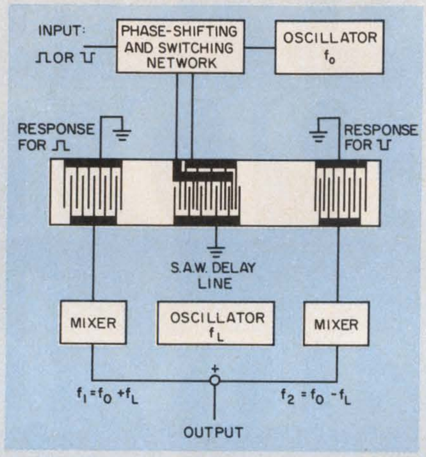
Frequency shifts keyed with SAW-based device

Based on surface acoustic waves, a novel frequency-shift keying device developed at Japan's National Defense Academy in Yokosuka uses a three-phase interdigital transducer (see figure).

A surface acoustic wave, excited by a central transducer, propagates to the left or the right, according to the polarity of a dc pulse applied to a phase-shifting and switching network. Two biphase interdigital transducers on either side of the three-phase transducer detect the excited signals.

The detected signals are balance-modulated with a 1.6-MHz signal and then filtered. Digital coding is accomplished by assigning positive and negative pulses to the ONEs and ZEROs of binary logic.



Formed on piezoelectric ceramic, the devices are 52-mm long × 13-mm wide × 4-mm thick and polarized normal to the free surface. For each of the outer transducers, there are 19 evaporated aluminum-electrode fingers, and 13 for the central transducer. The three transducers occupy about 30 mm and have a center frequency of 2.7 MHz.

Semi die, wire bonders don't need our help

Microcomputer-controlled automatic semiconductor die and wire bonders can operate continuously without human supervision. Developed by the Tokyo Shibaura Electric Co., the machines have solid-state cameras that automatically detect such errors as defective components and faulty positioning, chip mounting and wiring.

Pattern-recognition algorithms executed by the microcomputer analyze the camera outputs and discriminate between good and defective chips, and check the chip's positioning.

The die bonder's solid-state camera has 50 × 50-bit resolution.

Because of the elaborate functions incorporated, each die bonder requires its own microcomputer. The wire bonder, however, does not require the same degree of intelligence. One microcomputer can control up to five of them.

Simple electrode paste will cut display costs

For now, both liquid-crystal and electroluminescent displays depend for their operation on an electrically conducting, transparent coating applied to a high-quality glass substrate. But with an electrode paste developed by the Electrical Research Association in Leatherhead, England, an ordinary window glass may be used for the substrate—which should reduce the manufacturing costs of both displays substantially.

What's more, says ERA, the printing and firing operations used to apply the new electrode material are much simpler than currently used methods and much more suitable to volume production.

Currently, a two-stage process is used to apply and form the conventional coating into electrodes that have the shapes of the characters to be displayed. First, a thin layer of conducting material, such as tin oxide, is deposited on the glass with sputtering or hydrolysis techniques. The electrode pattern is then obtained with photolithography.

The ERA electrode material, an organic paste containing metal compounds, is screen-printed onto the glass, which is then fired. The heat decomposes the paste, and leaves a firmly adhering oxide film. Tests have shown that the electrodes thus formed work well with field effect LCDs.

Optocouplers protected from serious degrading

The destructive effects of excessive voltage and temperature on optocoupler transistors have been overcome in a fabrication technique developed by Siemens, West Germany. The new method allows optocouplers to function at 100 C and 1000 V dc—without this technique, a voltage of 220 V dc at 80 C can damage a phototransistor irreversibly in just a few days.

Normally, the transistor is protected by silicon-dioxide or silicon-nitride layers. But these insulating layers can become positively or negatively charged due to ion migrating in the plastic at elevated temperatures. Depending on the charge and the type of doping, the ion migration can create enhancement or depletion regions, or inversion layers—all of which seriously degrade the optocoupler's characteristics.

Siemens' solution is to apply an insulating ion screen to the surface of the transistor chip. The screen thickness is matched to the LED-radiation wavelengths for negligible light absorption. The screen prevents charging effects due to ion migration and also prevents the electric field from penetrating the semiconductor crystal.

Optocouplers consist of a LED and a phototransistor mounted 0.5 to 1 mm apart and coupled by a thin plastic section that conducts the LED radiation. Internal electric fields in the devices can be considerable. For example, a 1000-V drop between LED and transistor produces a field of 10^4 V/cm.

The big 32K ROM! Newest discovery in ROM Country

Sure it cuts your parts count and saves money — but that's only the beginning of what the big ROM offers.

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CIRCLE NUMBER 51

How fast can you measure rise time, fall time and pulse width?

Your way.

(About 5 minutes.)

1. Connect signal to scope. **2.** Adjust trace intensity. **3.** Adjust focus. **4.** Select VOLTS/DIV range. **5.** Select TIME/DIV range. **6.** Adjust vertical gain to fill screen for location of 10% & 90% points. **7.** Locate 10% point. **8.** Locate 90% point. **9.** Determine horizontal displacement between 10% & 90% points. **10.** Multiply displacement by horizontal scale factor.

That's RISE TIME. Only 9 more steps and you've got PULSE WIDTH and FALL TIME.

Our way.

(About 5 seconds.)

1. Connect signal. **2.** Push [rise] button for RISE TIME. **3.** Push [pulse] button for PULSE WIDTH. **4.** Push [fall] button for FALL TIME.

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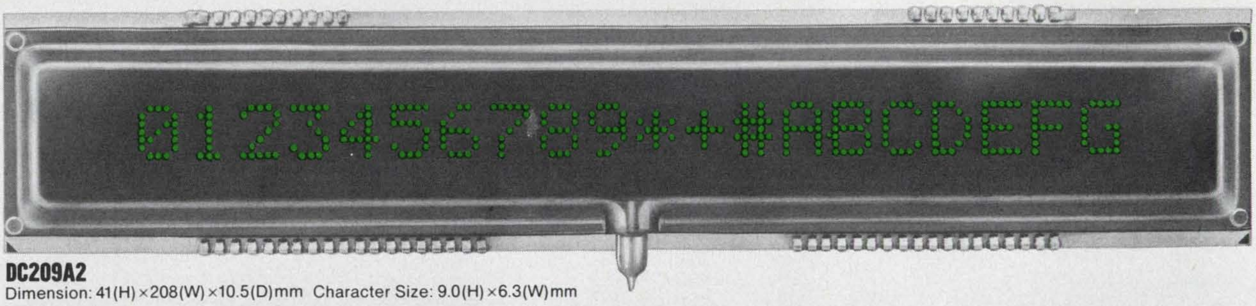
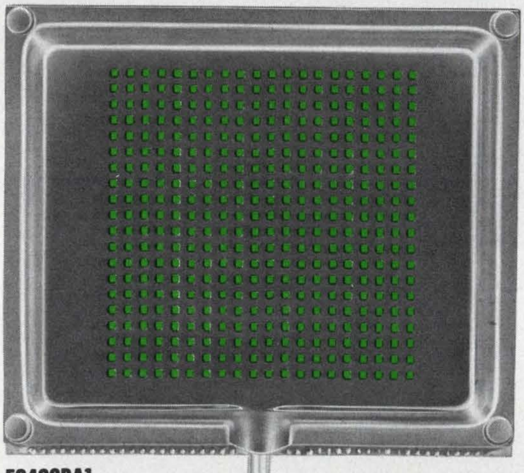
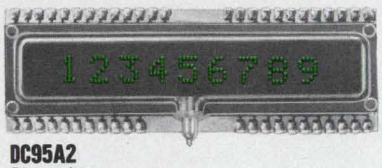


DC209A2
Dimension: 41(H)×208(W)×10.5(D)mm Character Size: 9.0(H)×6.3(W)mm

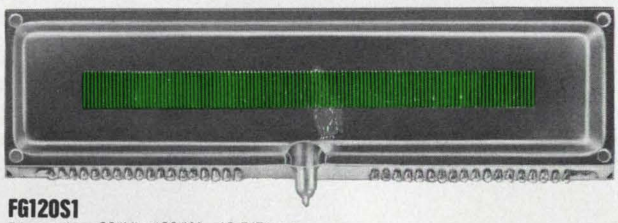


FG400DA1
Dimension: 114(H)×130(W)×17(D)mm



DC95A2
Dimension:
24(H)×75(W)×7.2(D)mm
Character Size:
5.05(H)×3.55(W)mm

FG48D6
Dimension:
25.5(H)×56.5(W)×7(D)mm
Character Size:
8.0(H)×4.2(W)mm



FG120S1
Dimension: 39(H)×138(W)×12.5(D)mm

FG209M2
Dimension: 41(H)×208(W)×10.5(D)mm Character Size: 9.0(H)×5.4(W)mm

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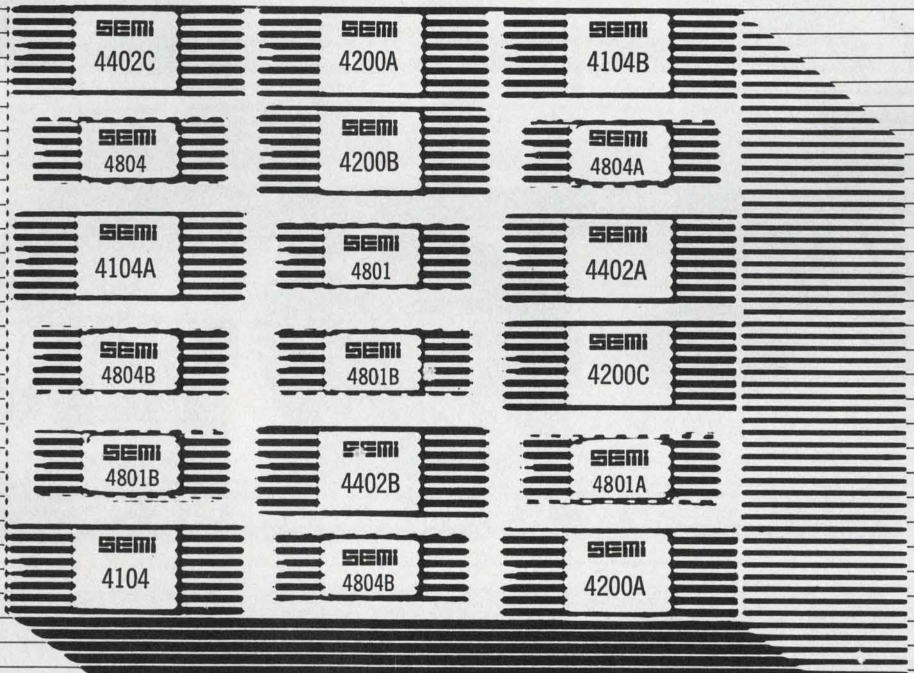

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And the AD561 joins the industry's 12-bit IC DAC standard, AD563.

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JUNE 21
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The sixth installment of *Electronic Design's* 1977 FOCUS series will appear in the June 21 issue. The topic: Multipin Connectors.

Connectors are as crucial to a successful electronic system as the more exotic components. Associate editor Morris Grossman takes an in-depth look at round and rectangular multipin units, including rack/panel types. The report examines zero-insertion-force (ZIF) connectors, mass-termination connectors, and multiple-lead fiber-optic connectors.

As with all FOCUS reports, emphasis is placed on the significant specs readers should watch for and how to avoid pitfalls in connector selection and use. More than 61,000 *Electronic Design* subscribers specify or authorize purchase of connectors. If you're one of them... mark June 21 on your calendar. It's a report you'll want to keep for months to come.

FOCUS ON MULTIPIN CONNECTORS

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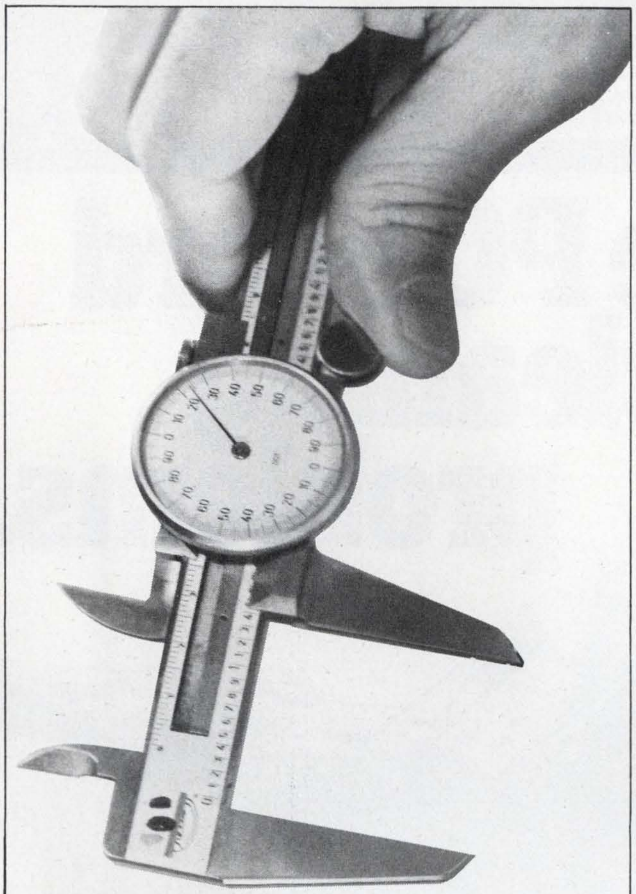

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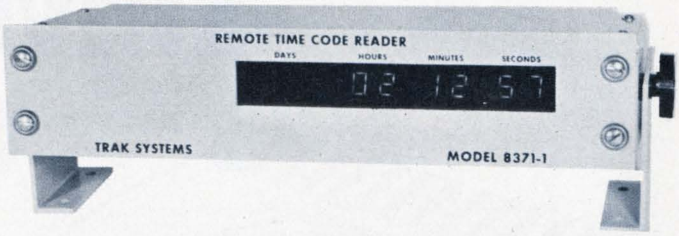

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The Model 8371 Remote Time Code Reader accepts a serial time code input on 100, 250, or 1000 Hz carrier and displays time of day in hours, minutes, and seconds. An additional three digits displaying day of year are optionally available or may be added in the field merely by plugging in three display digits and three integrated circuits. The input code is also provided as an output to allow "daisy-chaining" of units. Brackets are provided to allow mounting of the unit from the top or bottom with an adjustable tilt of 45°.

SPECIFICATIONS

Code Input
Formats: IRIG B, IRIG E, NASA 36BIT, XR3, 2137 (specify)
Impedance: 150K ohms
Level: 0.5 to 10.0 Vpp without adjustments
Modulation Ratio: 2:1 to 6:1
Carrier Frequency: 100 Hz (IRIG E), 250 Hz (XR3), 1000 Hz (others)
Connector: BNC

Code Output
Same as input

Synchronization
Display updates within ±5 ms of "on-time" (once per second)

Display
Type: Seven-segment LED's
Color: Red
Height: 0.5 inches
Reading distance: 30 feet
Viewing angle: 60° minimum

Power Requirements
Voltage: *110 or 220 VAC 10%
Frequency: 50 to 400 Hz
Power: 15 Watts nominal
Switch: Rear-panel On-Off power switch

PHYSICAL
Weight: 4 pounds
Height: 3.0 inches
Width: 14 inches
Depth: 5.0 inches (excluding ¾" heat sink)

*Unit is delivered with internal jumper strapped for 110 Vac operation. This strapping may be changed in the field to convert the unit for 220 Vac operation.

Price: $585, quantity 10. Add $75 for days display

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CIRCLE NUMBER 53

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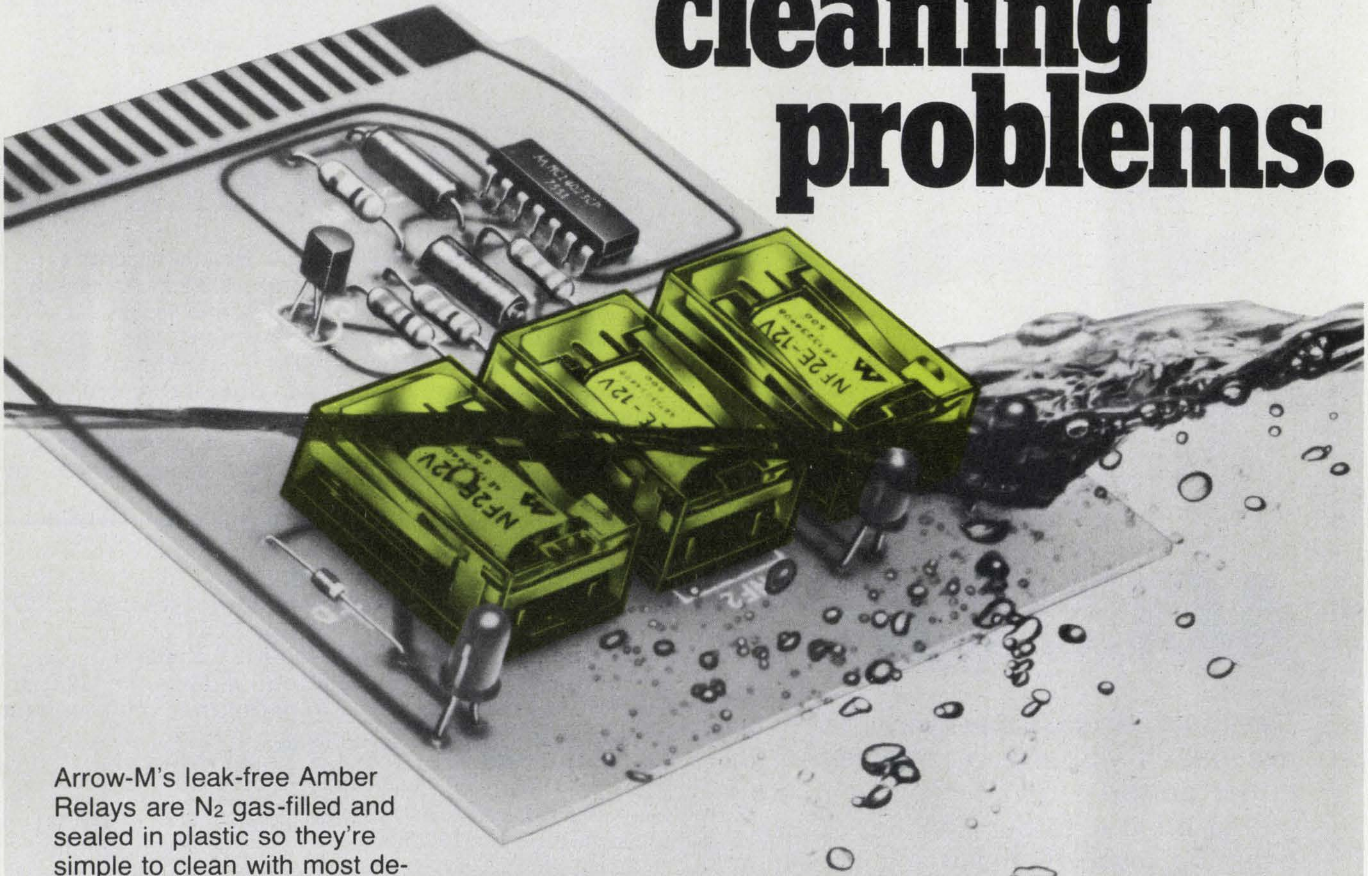
solve PC board cleaning problems.



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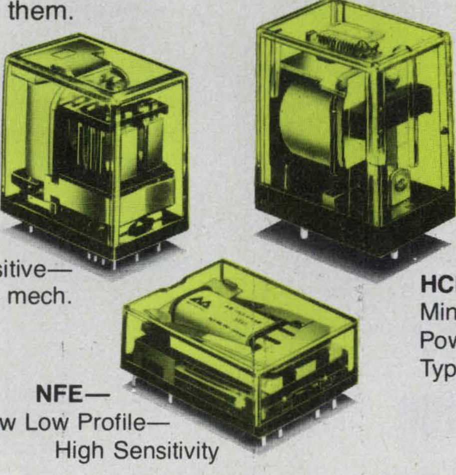

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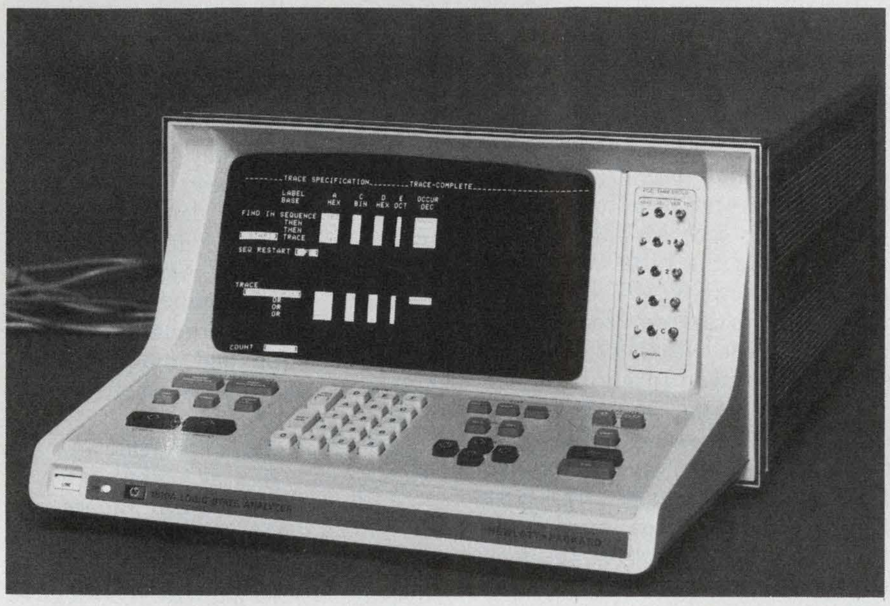
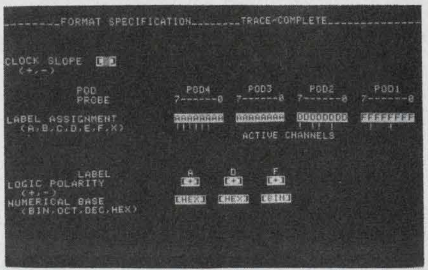
CIRCLE NUMBER 55

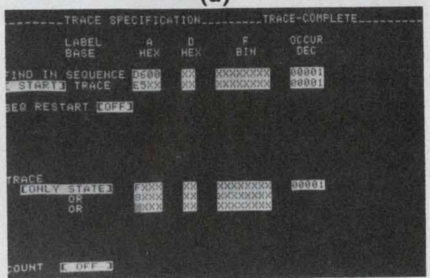
New products

Logic analyzer traces nested loops to 7 levels with state sequences and 'menu' control

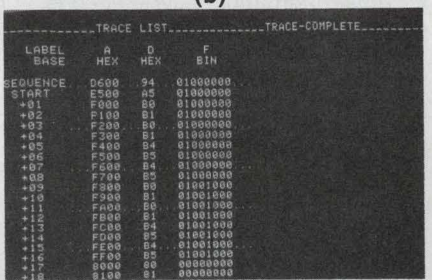




(a)



(b)



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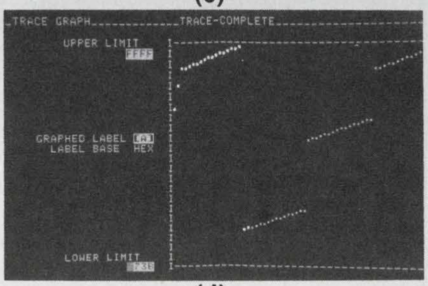


(d)

Select your format from an on-screen menu (a), and tailor the HP 1610A to almost any application. Choices include clock slope, logic polarity and radix. In this **trace-specification display** (b), the 1610A is told to find one occurrence of hex data D600 before capturing 64 words starting at E5XX. The **trace-list display** (c) shows results in a 20-line listing. You can scroll to see all 64 words. A state count or time between states can also be shown. **The trace graph** (d) gives an overview by plotting words as binary magnitudes vs time.

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. P&A: See text.

Just when you think you understand logic analyzers, along comes one with original features and terminology, and the most extensive troubleshooting power yet. Suddenly, you've got to start learning all over again. Getting to know HP's 1610A is well worth the effort: No other analyzer gives you as much.

With the 1610A, you can pull out and trace a given subroutine, even if the routine is buried within seven nested loops. You can require each of those loops to go through as many as 65,536 iterations. You can logically OR the capture criteria to follow μP system operation from as many as seven different locations. And you can use as few as one or as many as 32 input bits to define the capture point.

Those capabilities put the 1610A well ahead of available analyzers. And the barely one-year-old HP 1611A dedicated unit may look like it, but the similarity ends right there. The general-purpose 1610A does much more.

Instead of the "trigger," "delay" and "map" of previous analyzers, you must now think in terms of "trace position and selective trace," "state occurrence," and "graph." The differences aren't merely semantic.

The 1610A is HP's first menu-controlled instrument. With many modes implemented in software, the video screen, in effect, doubles as both a display and control panel. Press a button, and the screen presents one of two specification menus: a format specification, which defines the relationship between the input channels and the display, or a trace specification, which defines the conditions under which the test data will be captured. An operator-controlled cursor identifies various fields in each menu.

In the format-specification mode, which appears on power-up or at the touch of a key, you put the various inputs together in some logical manner (photo a). For instance, bits that behave as a unit can be grouped. The inputs are sensed synchronously (to 10 MHz) with 32 variable-threshold probes, fanning out of four 8-bit pods. An arbitrary label can be assigned to each group—perhaps an "A" to identify a μP's address bus, a "D" for the data bus and so on. Six different labels, A

(continued on page 100)

(continued from page 98)

through F, are available.

After the labeling, all input data are gathered at a clock transition and treated as one parallel state. In subsequent "trace" measurements, occurring state values are collected.

While still in the format mode, you then assign a radix of 2, 8, 10 or 16 to each label. You may want to consider the address lines in octal, the data lines in hex and the status and interrupt lines in binary. Or, you can choose decimal notation. Finally, you choose either positive or negative-true logic polarities for each assigned label.

Having told the 1610A how to present a μP's activity, you tell it which information to capture. Press a button, and the screen clears for the trace-specification menu (photo b).

The key to the 1610A's troubleshooting power lies in the trace-specification mode. Here, you define a qualifying sequence of data patterns—up to 32 bits wide and seven words deep—that must be matched by the input stream before system activity is captured.

Each of the 64 captured 32-bit words is called a "state." A reference point, called the "trace position," can be assigned as the "start," "center," or "end" of the 64 captured words.

Measurement then proceeds in two phases. First, the 1610A locates the trace position in the input data. Second, it performs a selective trace—it captures the 64 words in a specified manner. Both position and selective-trace specs are given in terms of hex, octal, decimal, binary or don't care conditions on any or all of the 32 bits.

If you select "start" for the trace position, the selective-trace states come after on the screen. Select "center," and the selective-trace states show up before and after. Select "end," and the states are displayed before.

The state sequence you have assigned—up to seven state conditions—must be found in the specified order. States that don't satisfy the sequence are ignored.

With state sequences, you can directly locate branched, looped or nested forms (or sections) of state flow. Since you can specify each state condition to "occur" up to 65,536 times, you can locate the nth pass of a loop, beginning at a given state.

In effect, both selective trace and trace occurrence compress information flow by leaving out unnecessary states and obviating the need for a deeper, costlier, internal memory.

Count measurement, another test mode, provides even more analyzing potential. With it, you count states or measure the time between states, in either a relative (state-to-state) or absolute (referred-to-trace-position) mode. Counts can go beyond 4×10^9, and time to 429.4 s, with a resolution of 100 ns and an accuracy of 0.01%.

To look at the captured data, take your choice of three trace presentations: "list," "graph" or "compare."

In the list display, the one you'll probably use the most, 20 traced states are presented in order of occurrence (photo c). Roll keys will let you see the remaining 44 states. Along with a line number and the captured data, which are alphabetically formatted into the assigned labels and radix, you get either the accumulated counts or timing information.

The graph display presents an overview of data in a new way: as a plot of the integer binary magnitude of each state versus time (photo d). This display mode does what the mapping displays in other analyzers do—it gives a "big picture" of over-all system activity.

With the compare mode, you get a tabular listing of the differences between a current measurement and one that's been stored. Identical bits are displayed as ZEROs, dissimilar bits as integers. For example: Octal 03, which translates to binary 000 011, indicates dissimilarity in the two right-hand bits.

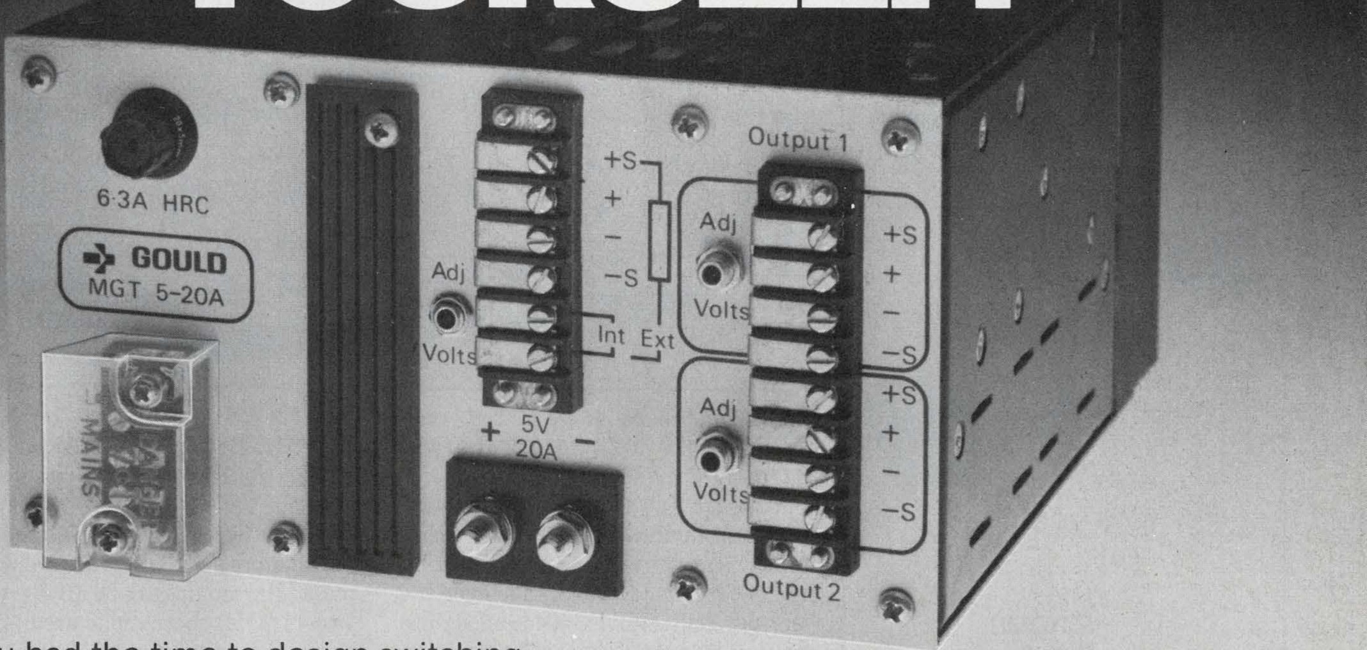
The compare mode furnishes an additional capability. You can rerun a measurement continuously until current and stored data are equal. Or you can set up the analyzer to tell when the current measurement doesn't equal the stored data—handy for tracking down frustrating intermittents.

As if the 1610A's measuring capabilities weren't enough, the unit also diagnoses itself. Simply touch a self-test button, and the unit exercises and verifies the operation of internal memory, the display, the keyboard, the input pods and other portions of the circuitry. Self-test displays are presented, and an internal verification program guides you through the test via the display.

The 1610A will sell for $9500. The first units will be available in July, 1977.

Circle No. 304

YOU'D THINK YOU DESIGNED IT YOURSELF.



If you had the time to design switching power supplies, we think your design, like ours, would reflect this basic design precept: achieve greatest efficiency in the least amount of space at a cost comparable to linear supplies.

That's one important reason why over the past four years more than 20,000 Gould units have quietly found their way into the designs of systems engineers all over the world.

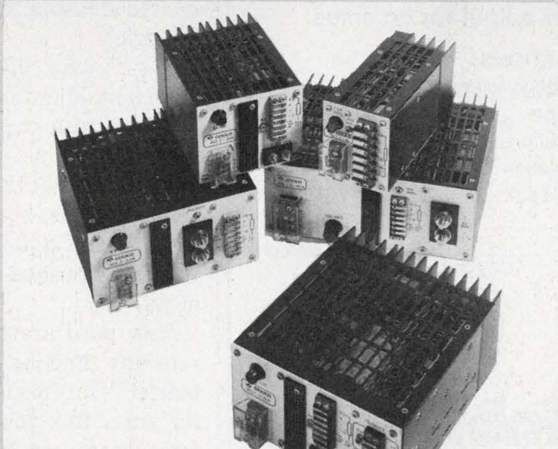
Of course there are other important reasons:

- 36,000+ hours MTBF
- Switching at 33,000Hz
- 0.1% line/load regulation
- less than 50mV peak-to-peak ripple
- full output rating at 50°C ambient
- standard remote sensing and programming

There are still more reasons, but we think you get the idea. Show a good design to a good design engineer and it'll speak for itself. So let us demonstrate to you the smallest and most efficient OEM power supplies yet designed.

For more information contact Gould Inc., Power Supply Dept., 3631 Perkins Ave., Cleveland, Ohio 44114.

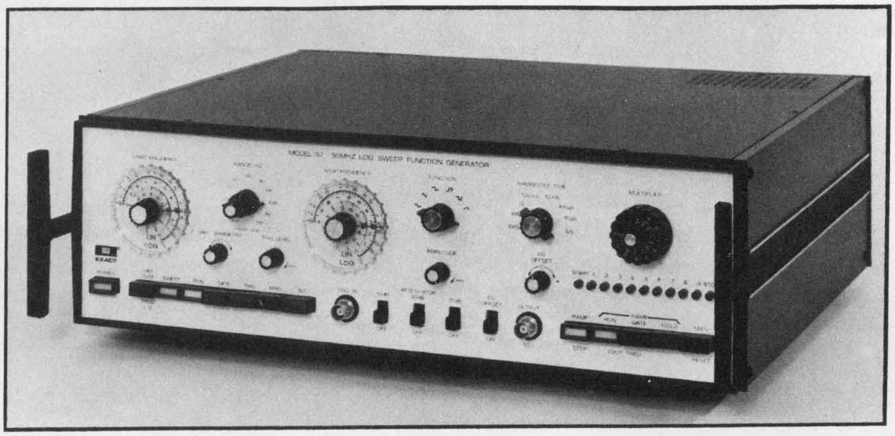
For brochure call toll free at (800) 325-6400 Extension 77
In Missouri: (800) 342-6600



GOULD
The product development company

CIRCLE NUMBER 57

Function generator breaks 50-MHz output barrier



Exact Electronics, 455 S.E. 2nd Ave., Hillsboro, OR 97123. (503) 648-6661. $1450; 30 days.

Although the 50-MHz 757 function generator by Exact Electronics doesn't exactly leave its rivals in a trail of dust, its 25% frequency advantage over the year-old Tektronix FG504 is enough to make it the world's fastest function generator. At least for now.

With frequency boosts in function generators coming ever more frequently—after Wavetek's 30-MHz 160 held the top spot for so long—a question arises: Have designers finally hurdled the barriers that can make a 30, 40 or 50-MHz waveform look more like a melted sinusoid than a square wave or triangle?

"Yes," says Jerry Foster, Exact's president. Microwave techniques in the 757 make it a true 50-MHz generator, Foster explains. Sinusoids, squares and triangles at the top frequency look like sinusoids, squares and triangles. The 757 isn't a 10-MHz unit that's been somehow pushed to 50 MHz, Foster notes.

How good are the 757's waveforms—or any function generator's, for that matter? Only your oscilloscope knows for sure. But you can get some idea from specs for sine-wave distortion, square-wave aberrations and triangle nonlinearity.

In the 757, distortion products from 100 kHz to 50 MHz are 30 dB down, aberrations stay under 5% (no frequency specified), and linearity is within 1% of a "best" straight line—but only to 100 kHz. Beyond 100 kHz, no spec is given, at least in the preliminary sheets.

In the Tektronix FG504, the same parameters get slightly different treatment: Harmonics are 20 dB down from 1 to 40 MHz, aberrations are under 5% pk-pk plus 30 mV into a 50-Ω load, and triangular linearity is within 10% from 4 to 40 MHz, measured between the 20% and 80% points on the waveform.

Two clearer advantages of the 757 are the split arrangement of its frequency dials, and the operating versatility offered by two generators in one, each with its own set of controls. Built around a Kelvin-Varley divider, two independent dials let you set sweep-start and sweep-stop frequencies with 10-turn-type resolution.

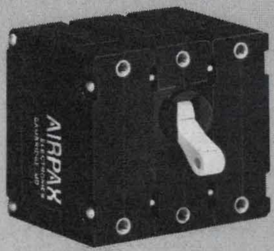
A start or stop frequency can be dialed in either linearly or logarithmically over a 1000:1 range, from 1/100 to 10 times the frequency-range setting. LEDs peeking through the start-stop dials indicate the scales and settings and flash on and off in invalid modes.

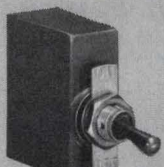
With the 757's second built-in source not only can you sweep the output, you can step through 11 different frequency levels. LEDs indicate which level is at the output. And like the main generator, the ramp/step can not only free run but also be triggered or gated—either manually or externally.

Exact Electronics	**Circle No. 301**
Tektronix	**Circle No. 302**

AIRPAX MAGNETIC CIRCUIT BREAKERS

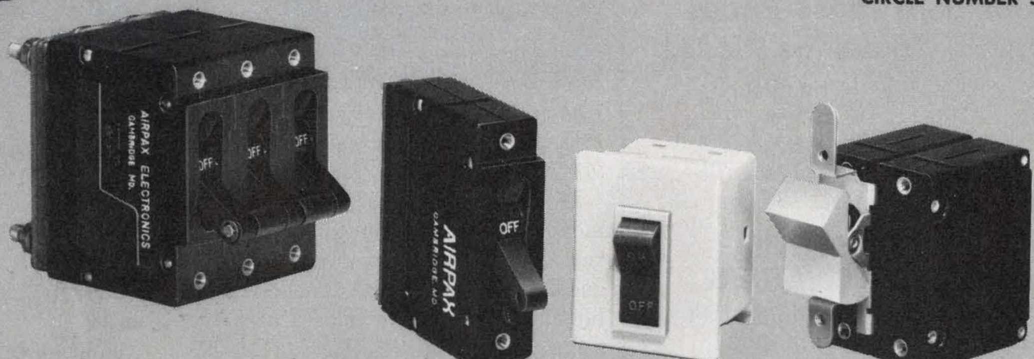
meet U.L., C.S.A., and military requirements.





The choice of a protective device for any application involves voltage, current, trip time delay, and short circuit ratings. Such mechanical variables as number of poles, termination, mounting, size, and type of actuation are also involved. Before final selection is made, however, be sure to consider applicable U.L., C.S.A., and military requirements. Chances are that Airpax has the magnetic breaker you need . . . qualified, recognized, or listed for your specific requirements. **Other Advantages.** Airpax magnetic circuit breakers have accurate trip currents. They are not sensitive to ambient temperatures, can be used as ON-OFF switches, and come in single or multipole packages. Some even have a pilot light in the handle and snap-in mounting. **Full Details Available.** For further information on the full line of Airpax circuit breakers, plus U.L., C.S.A., and military listings, request Short Form Catalog 2013 from your local Airpax representative, or contact Airpax Electronics, Cambridge Division, Cambridge, Maryland 21613. Phone (301) 228-4600. Telex: 8-7715. TWX: (710) 865-9655. Other factories in Europe and Japan. European Sales Headquarters: Airpax S.A.R.L., 3 Rue de la Haise, 78370 Plaisir, France.

CIRCLE NUMBER 59



AIRPAX™

THE PRO IN PROTECTION

Junction-to-case thermal resistance can be 'measured'

Sage Enterprises, 1080 Linda Vista Ave., Mountain View, CA 94043. Bernie Siegal (415) 969-5111. $5750 plus test fixture; 60 to 90 days.

The Theta 210 from Sage is the first instrument to "measure" the junction-to-case thermal resistance (Θ_{JC}) of transistors. The instrument completes the test in 6 s—which far surpasses home-brewed equipment that takes 15 to 30 min. per transistor and requires hand calculations.

The 210 doesn't measure junction temperature directly—it averages many pulsed-heating cycles, and extrapolates junction temperature from changes in base-emitter voltage.

A digital readout shows Θ_{JC} in °C of junction temperature rise per dissipated watt. Accuracy on the 0-to-19.99 C/W scale is ±6% of reading ±0.04 C/W. Accuracy on the 0-to-199.9 C/W scale is ±6% of reading ±0.4 C/W. These worst-case errors include the ±2% tolerance in the collector voltage and current supplied by the tester. Voltage can be selected from 1 to 99 V in 1-V steps; current goes from 10 to 990 mA in 10-mA steps. Since either polarity is available, both npn and pnp transistors can be tested.

Thermal resistance is important because for every 12-C rise in junction temperature, a transistor's life expectancy is cut in half. The quality of the bond between the transistor chip and the case determines thermal resistance and, according to Sage president Bernie Siegal, "Mounting and bonding chips is still a black art."

One limitation of the 210 is that a different test fixture is required for each case type. Sage supplies some for popular cases at $200 to $300. Or you can build your own to Sage guidelines.

CIRCLE NO. 305

DPM reads rms, true and decibels, too

Analog Devices, Rte. 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. $225 (100s); stock.

Model AD2033 3-1/2-digit DPM measures both the true-rms value and the decibel value of complex ac or ac+dc waveforms, and functions as a bipolar dc meter. The unit features five separate input ranges (199.9 mV, 1.999 V, 19.99 V, 199.9 V, 600 V rms full scale) and 500 mV, 5 V, 50 V, 500 V, 625 V rms for decibel readout. No external components are required. The line powered DPM features accuracy to 0.1% of reading ±0.5% full scale ±1 digit.

CIRCLE NO. 309

Build your own function generator

AE Corp., 65 Wellesley Ave., Needham, MA 02194. (617) 449-3142. $79.95, kit; $124.95, wired.

Model 12 function generator comes as a kit or wired. Featured are external frequency-control VCO from dc to 1 MHz; remote frequency-shift keying; frequency modulation; remote tone burst and simultaneous sine, triangle and square waves. Also included are continuously adjustable amplitude and dc offset.

CIRCLE NO. 310

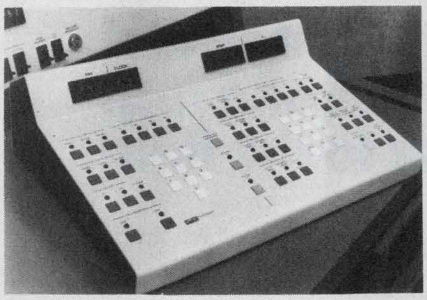
Spectrum analyzers get a memory, I/O interface

Polarad Electronics, Nelson-Ross Electronics Div., 5 Delaware Dr., Lake Success, NY 11040. (516) 328-1100. $8850 to $10,600.

A digital memory with interface capability is incorporated into the compact N-R 600 Series rf/microwave spectrum analyzers, working from 100 kHz to 40 GHz. The memory provides nonfading flicker-free display storage, and retains data for recall at will. Precise on-screen comparisons can be made between incoming signals and stored reference displays. An input/output memory interface is provided for use with data storage and signal processing accessories. The I/O is adaptable for use with an IEEE-488 format data bus.

CIRCLE NO. 421

Logic tester aimed at μP PC boards



Fluke Trendar, P.O. Box 43210, Mountlake Terrace, WA 98043. (206) 774-2211. $60,000 to $95,000; 8 wks.

Model 3040A (Logictester) digital logic board tester is specifically designed to test μP boards. The Logictester can apply user-defined test sequences at rates up to 1,500,000 input words per second. At the same time, the 3040A can also run automatic sequences at rates up to 5 MHz. The 3040 applies the technique of cyclic redundancy checks to digital board testing. Long used for error checking in data transmission applications, CRC signatures can now be used for go/no-go tests as well as nodal diagnostics.

CIRCLE NO. 422

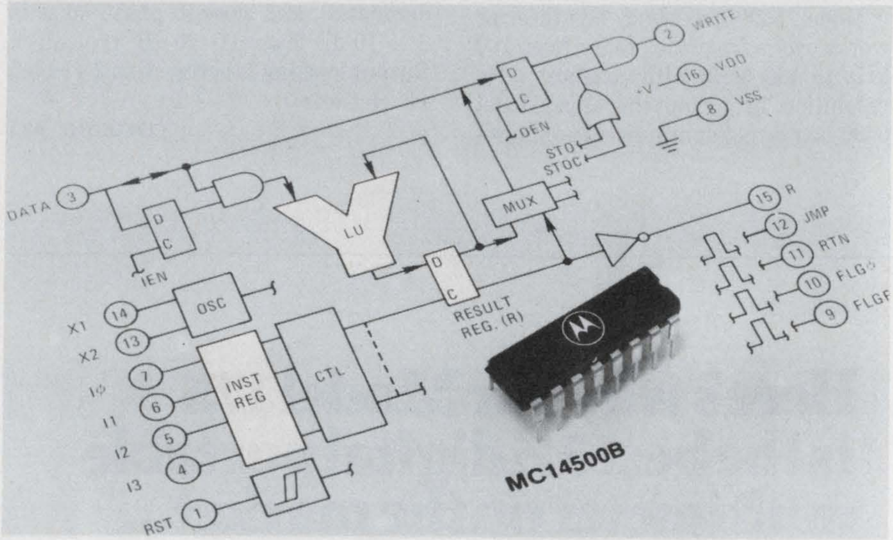
Synthesizer resolves 1 Hz throughout range

Rockland Systems, 230 W. Nyack Rd., West Nyack, NY 10994. (914) 623-6666. $4975. Stock-30 days.

Model 5600 frequency synthesizer works over a frequency range from 100 kHz to 160 MHz with constant 1-Hz resolution throughout the range. Model 5600 is a direct synthesizer (no phase-locked loops) and is therefore faster than the older indirect phase-locked VCO designs; typical switching time is 20 μs. Spurious harmonic outputs are said to be 10 to 15 dB lower than in indirect designs (> 35 dB below fundamental), and close-in phase noise is 6 to 10 dB lower (> 70 dB, typically). Output leveling is better than 2:1 ($\pm$0.5 dB flatness).

CIRCLE NO. 423

Single-bit μP avoids overkill



Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85008. (602) 244-6900. P&A: See text.

To eliminate 4 and 8-bit processor "overkill" in many low-end applications, Motorola has developed the first commercial microprocessor with a one-bit word length. And because the MC14500B is built with CMOS technology, its dissipation is just a few μW.

A small, but flexible repertoire of 16 instructions includes five logic operations performed on the contents of the result register and the data held on the bus, four instructions to transfer data, five commands to manipulate programs and two commands to enable either output or input. Unlike bit-slice circuits, the μP includes a clock oscillator, registers, ALU and power-on reset circuit.

With a crystal or resistor between the timing pins, the 14500B operates at clock frequencies up to 1 MHz with a 5-V supply. However, the unit can function over a 3 to 18-V supply range.

The circuit comes in a 16-pin DIP, with the following pin allocations: four pins for instruction inputs, two for the timing circuit, one for a reset, one for a data input, two for a data output, two for power and ground and four for program control.

External circuitry required to operate includes one-of-eight decoders (MC14512) and 8-bit latches (MC14599) to select data and perform I/O operations. A program counter is needed to provide the memory addresses; a simple ripple counter does the job.

The MC14500B can resolve decision-based questions with one instruction per logic element. Most microprocessors require three or more instructions per logic element.

Prices for the 1-bit processor are \$7.58 (100-999) and \$4.88 (1000-4999) and quantity deliveries will be available in June. **Circle No. 303**

ROM holds 32-k and accesses in 350 ns

Electronic Arrays, 550 E. Middlefield Rd., Mountain View, CA 94043. John Lipnisky (415) 964-4321. $35.06 (100-up); 4 to 6 wks.

A 32,768 bit ROM, the 3210/20, offers a 350-ns access time and 25-mW typical standby power. There are two versions: the 3220 uses a 12-V clock for compatibility with MOS systems, and the 3210 has a TTL-level clock. Operating power is 500 mW, typical, or 15 μW per bit. The ROMs come in 28-pin ceramic DIPs.

CIRCLE NO. 320

Rf power FETs provide 10-dB gain at 200 MHz

Siliconix, 2201 Laurelwood Rd., Santa Clara, CA 95054. Jim Graham (408) 246-8000. $13.97 (100-up); stock.

The VMP 4, a Mospower FET, is claimed to be the first commercial rf power MOSFET. The device has no thermal runaway or secondary breakdown, withstands any VSWR, offers a 10-dB minimum gain at 200 MHz and a 35-W maximum power dissipation. It is an n-channel enhancement-mode MOSFET packaged in a 380SOE flange-mount, ceramic stripline case. The maximum voltage of the VMP 4 is 60 V in the drain-source direction and 20 V for the gate-source. Transconductance (g_m) of the VMP 4 is typically 280 millimhos. In continuous operation, the VMP 4 provides power outputs to about 14 W with inputs of less than 1 W. Saturated power outputs range up to over 20 W with power input of 1 W. The typical small-signal noise figure is 2.5 dB at 150 MHz and the two-tone, third-order intermodulation intercept point is +46 dBm.

CIRCLE NO. 321

One-chip microcomputer compatible with F8

Fairchild Camera and Instrument Corp., Micro Systems Div., 1725 Technology Dr., San Jose, CA 95110. Gordon Daggy (408) 998-0123. Under $10 (large qty.).

A one-chip version of the F8 microprocessor, called the F8 MicroMachine, provides all the functions of the earlier two-chip F8 system consisting of the 3850 CPU and the 3851 PSU.

CIRCLE NO. 322

ICs & SEMICONDUCTORS

Magnetic bubble memory holds 92 k on one chip

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. (214) 238-2011. $200 (unit qty.); stock.

Capable of nonvolatile storage of 92,304 bits of data, the TBM0103 magnetic bubble memory chip comes housed in a 1 × 1.1 × 0.4-in. package. The bubble chip is made of a gadolinium-gallium garnet substrate upon which a magnetic epitaxial film is grown. Device architecture is a major loop/minor loop structure. Data bits are written into and read out of the major loop; data bits are transferred to minor loops for storage. Housed in a 14-pin dual-in-line module the chip is surrounded by two orthogonal coils that provide the rotating magnetic field, a permanent magnet set and a magnetic shield to protect data from external fields. Performance specifications at 100 kHz operation include an access time of 4 ms for the first bit, cycle time for the 144-bit page of 12.8 ms and an approximate power consumption of 0.5 W for continuous operation. Operating range is initially 0 to 50 C with a nonvolatile storage range of −40 to 85 C.

CIRCLE NO. 323

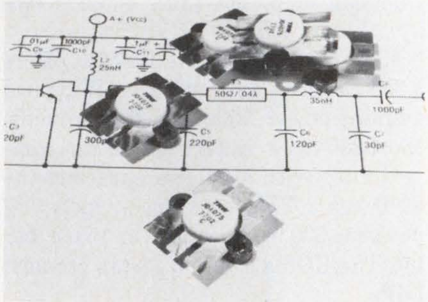
Premium d/a converter settles in 135 ns

Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. Donn Soderquist (408) 246-9222. $9.95 (100-up); stock.

A high-performance grade unit for the DAC-08 series 8-bit multiplying DAC, the DAC-08H, offers significantly improved performance over other converters in the series. Settling time is 135-ns max., nonlinearity is ±0.1 (±1/4) LSB max., and the output current is matched to the reference input current within ±1 LSB to eliminate the need for calibration. Complementary current outputs with a −10 to +18 V compliance allow conversion to a voltage without an external op amp. Direct interface to TTL, DTL, NMOS, CMOS, and MECL logic is accomplished using a voltage-programmed, logic threshold control pin. Specified over 0 to 70 C, the DAC-08H consumes 33 mW with ±5-V supplies and 135 mW with ±15-V supplies.

CIRCLE NO. 324

Rf transistor handles 75 W



TRW RF Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. (213) 679-4561. $15.80 (1000 up); stock to 4 wks.

A vhf transistor, JO 4075, for land-mobile radio-transmitter applications provides 75 W of output power across the 136-to-175-MHz band at 12.5 V dc. The minimum gain at 75 W is 6.2 dB and at 70 W, 6.9 dB in Class A or AB power amplifiers. Features include a patented input-matching technique, diffused ballast resistors and a passivated-gold metalization system for greater reliability. The units are 100% tested to overstress conditions of infinite VSWR at the collector with 18 W of rf input and 15.5 V dc applied.

CIRCLE NO. 325

Electronic piano circuit senses key velocity

General Instrument, Microelectronics Div., 600 W. John St., Hicksville, NY 11802. Sol Gertzis. (516) 733-3107. $6.25 (100-up); stock.

Developed for use in electronic pianos the AY-1-1320 circuit detects the speed of each key depression and then generates a corresponding volume signal to the sound circuitry. This produces a note that decays in amplitude in a manner similar to a keyboard instrument. And, the sound of an electronic piano can be adjusted to simulate the honky-tonk piano, the harpsichord and the clavichord by altering the character of the voicing filters. The output from each keying circuit is a square wave of the required fundamental frequency, which is then shaped by external voicing circuits. The Ay-1-1320 contains 12 separate frequency keying circuits, one for each note in an octave. Thus, a five-octave instrument would require only five 40-pin plastic devices. Each package requires 25 to 29 V at 6 mA max.

CIRCLE NO. 326

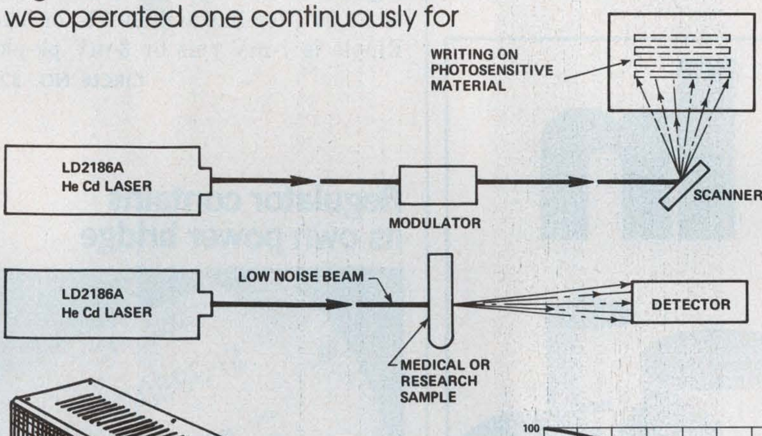
Opening new frontiers with electro optics

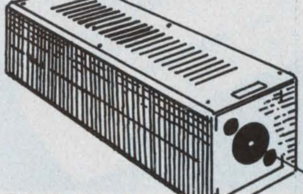
RCA Helium-Cadmium lasers offer long life: we ran one for more than 12,000 hours.

If you need 20 mW typical output in the blue region (441.6 nm), you get that and a lot more in RCA's Helium-Cadmium Laser System LD2186A.

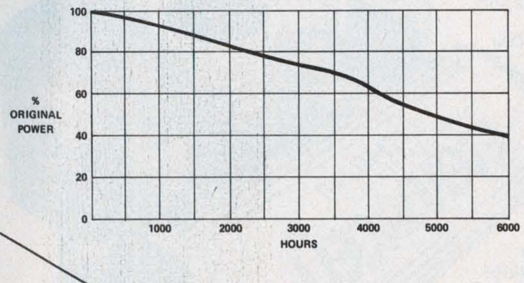
You also get excellent long-term stability: ±1% typ. Low noise: 0.7% rms typ. (10 Hz to 10 MHz). Convection cooling: no fans or water. And — very important — long life.

As the graph shows, typical life is greater than 6,000 hours — but we operated one continuously for more than 12,000 hours. A helium reservoir plus an innovative recirculating cadmium system are what make the LD2186A a reliable, long-life system for facsimile, COM, phototypesetting, pollution monitoring, video recording and non-impact printing. LD2186A is available from stock. For UV applications, we also offer a version with 325 nm output.





Circle 141

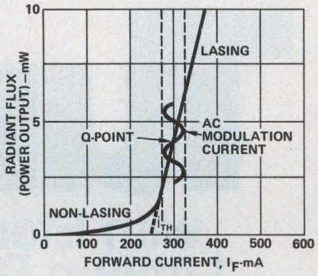


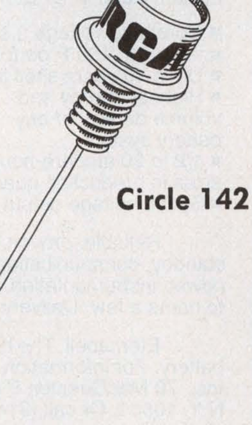
If electro optics can solve your problem, remember: EO and RCA are practically synonymous. No one offers a broader product spectrum. Or more success in meeting special needs. Call on us for design help or product information. RCA Electro Optics, Lancaster, PA 17604. Phone 717-397-7661. Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste.-Anne-de-Bellevue, Quebec, Canada; Belo Horizonte, Brazil; Hong Kong.

RCA

Solid state laser breakthrough: CW output at room temperature!

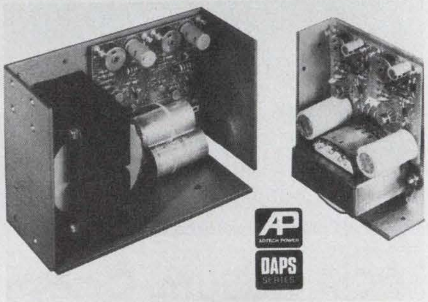
You get at least 5 mW of continuous lasing in a solid state package. RCA's new AlGaAs CW injection lasers have a rise time of less than 1 ns — allowing modulation rates beyond 100 MHz. This plus small source size (13 x 2 μm typical) and 820 nm wavelength make the C30130 and C30127 well suited to optical communications, facsimile, fiber-optic transmission, document reading, flying spot scanning.





Circle 142

Dual outputs power μCs and op amps



Adtech Power, 1621 S. Sinclair St., Anaheim, CA 92806. (714) 634-9211. $35.80 to $47.60 (100 qty).

Any two of the common voltages for μCs and IC op amps (±5, ±12, and ±15 V dc) are available from the DAPS series of power supplies. The units are constructed on an open aluminum chassis with 20% more heat-sink area than competing supplies. Fasteners are available for mounting in various orientations. You can choose either separate or combined overvoltage protection for the two outputs. For reliability, the supplies use metal packaged regulators and transistors. Regulation is ±0.05% for line and ±0.1% for load. Ripple is 1-mV rms or 3-mV pk-pk.

CIRCLE NO. 327

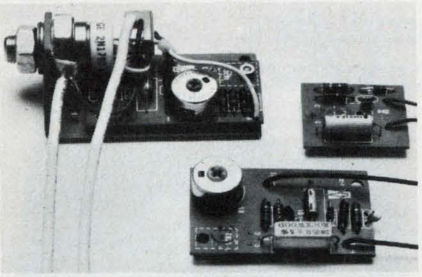
Regulator contains its own power bridge

Energy Electronic Products, 6060 Manchester Ave., Los Angeles, CA 90045. (213) 670-7880. $6.10 (100 qty); stock.

The SI-20506, a hybrid regulator that passes 5 V at 2 A, contains its own power-rectifier bridge. The unit made by Sanken in Japan features overload and short circuit protection. The device operates from −20 to +80 C and is 2.4 × 1.6 × 0.4 in.

CIRCLE NO. 328

Overvoltage protectors span wide range

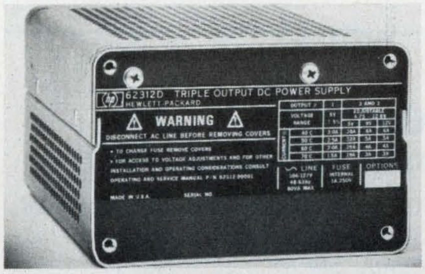


Standard Power Inc., 1400 S. Village Way, Santa Ana, CA 92705. (714) 558-8512. From $6 to $37 (unit qty); stock.

Overvoltage protectors of the OVP series come on a PC card with a mounting bracket and are compatible with most regulated power supplies. The 16 models of the series operate from 5 to 75-V-dc inputs at from 8 to 60-A continuous, and 25-A to 1-kA instantaneous. They are available in three voltage ranges: fixed, 5 to 32 V dc adjustable and 25 to 75 V dc adjustable. They weigh from 1 to 8 oz and range from 1.5 × 1.5 × 0.5 to 4 × 2 × 1.5 in.

CIRCLE NO. 329

Vary all three μC supply outputs



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. M. Fournell (415) 493-1501. $116 (100 qty); 2 wks.

The fully enclosed HP 62312D provides three adjustable outputs that will power most μCs. The primary output is rated at 4.75 to 5.25 V at 3 A, while the other two each range from 4.75 V at 0.38 A to 12.6 V at 0.6 A. The supply operates fully rated up to 40 C and up to 70 C with derating. Regulation for line or load is 0.1%. PARD is 1-mV rms or 3-mV pk-pk from 20 Hz to 20 MHz. Remote programming of the 5-V output is standard. The supply operates from inputs of either 104 to 127 or 208 to 250 V ac at 48 to 63 Hz. Protection features include: fused ac; fixed, foldback, current limiting; and overvoltage limiting on the main 5-V output (optional on the other two outputs).

CIRCLE NO. 330

Dual outputs crammed into tiny module

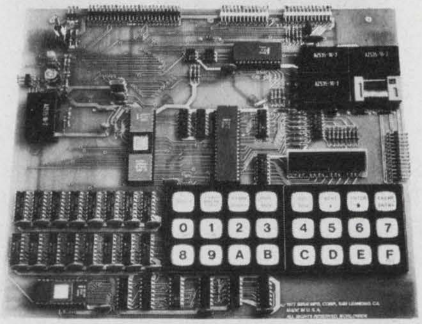
Calex Mfg., 3305 Vincent Rd., Pleasant Hill, CA 94523. (415) 932-3911. $29; stock.

Supplying ±15 V at 50 mA, the Model 22-40 regulated dc supply is just 1 × 1.75 × 2.25 in. The 6-oz unit offers line and load regulation of ±0.1% and noise and ripple of less than 1 mV. Along with pins, it also has a molded-in threaded insert for firm PC-board mounting. The module operates from 1.5 V ac over −25 to +70 C. Short-circuit protection by foldback current limiting is standard.

CIRCLE NO. 331

Single-board control computer uses 8748/8048 microprocessor

Imsai Manufacturing, 14860 Wicks Blvd., San Leandro, CA 94577. Michael Stone (415) 483-2093. From $249 (kit form), $299 (assembled); stock.



The first single-board microcomputer to use the 8748/8048, the 8048 control computer made by Imsai offers built-in interfaces for many applications. Included on the board with the 8748 μP is a cassette interface, an RS-232 or current loop input, 1 kbytes of PROM, room for 1 kbytes of RAM and five relays capable of handling 2 A at 220 V or 3 A at 110 V.

Capable of operating with a 2.5-μs instruction cycle, the 8.5 × 10-in. board requires just a 5-V supply. Features of the board include 2 I/O lines, an internal timer/counter, on-chip oscillator and clock circuit, built-in reset and interrupt circuits and BCD arithmetic capability. Also included on the board is a 24-key keyboard and a nine-character LED display.

There are two versions of the board available: One version has the system monitor programmed into the μP itself, the other version uses a separate 8716 EPROM. The monitor program permits code to be entered into program memory, data to be entered into both internal and external memory, examination of any location, execution of a program, insertion of breakpoints, and store or read from cassette tapes or paper tapes.

CIRCLE NO. 306

Packaged microcomputer based on SBC 80/20

Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Wayne Gartin (408) 246-7501. $1895; stock.

The System 80/20, a completely packaged microcomputer, is tailored specifically for distributed computing and multiprocessor control. Based on the Intel SBC 80/20 single-board computer, the System 80/20 offers a dual bus architecture with multi-processor bus arbitration logic. Two programmable interval timers, eight levels of priority interrupt and programmable communications interfaces are available. The System 80/20 contains a comprehensive ROM-resident system monitor to aid in loading, executing and debugging programs. Packaged in a 3.5-in. high housing compatible with standard 19-in. RETMA rack mounting, the System 80/20 contains cardcage and backplane assembly for up to three additional boards, and includes a power supply and cooling fans.

CIRCLE NO. 332

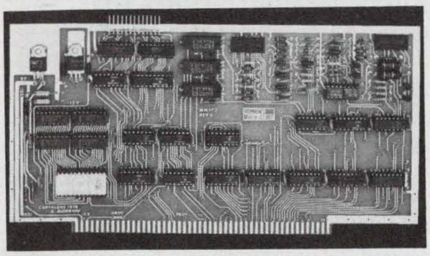
Complete μC system uses 8080-based CPU

Vector Graphic, 717 Lakefield Rd., Suite F, Westlake Village, CA 91361. Carole Ely (805) 497-0733. From $349 (kit); stock.

Based on the 8080, the Vector 1 computer comes with an 18-slot motherboard with six connectors, and an 8 V at 18 A and ±16 V at 2 A power supply. Housed in a custom cabinet, the computer has a whisper fan, card supports and guides for six cards and all hardware. The 8080-based CPU board has eight-level vector priority interrupts, current-status register, and a dual-mode, real-time clock. A PROM/RAM board with 1024 bytes of RAM and room for 2048 bytes of 1702A PROM is available. A 512-byte monitor program for use with audio cassettes and Altair, Imsai, or Polymorphic I/O boards is also available. The Vector 1 requires an I/O board and terminal or video display board, keyboard and monitor.

CIRCLE NO. 333

Cassette interface handles three drives

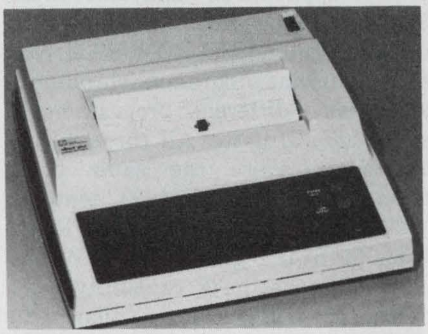


Morrows Micro-Stuff, Box 6194, Albany, CA 94706. (415) 527-7548. $120 (kit), $165 (assembled); stock.

Fully compatible with the Altair Microcomputer bus and the "Kansas City" standard cassette data recording format, a serial interface board developed by the company can link a computer to three inexpensive audio cassette machines for mass memory applications. Another serial port allows simultaneous communication with a teletypewriter incorporating reader control, as well as any RS-232 serial device (such as a modem or video terminal). Also on the board is an 8-bit parallel port with handshaking signals. The board has firmware in 500 bytes PROM, which contains all routines needed for cassette interfacing, UART simulation, and data transfer between the microcomputer's memory and the 500 bytes of onboard RAM. Buffers isolate internal data paths from the bus and onboard regulation simplifies power requirements.

CIRCLE NO. 334

Receive-only terminal prints at 30 cps



Texas Instruments, P.O. Box 1444, Houston, TX 77001. D. Fullerton (713) 494-5115. $1195; 30 days.

A receive-only version of the Silent 700 thermal-printing terminal, the 743, uses a microprocessor-controlled, buffered print mechanism. It prints at 30 char/s and accepts EIA RS-232-C and TTY current loop interfaces. Only two front-panel switches are available: a paper advance switch and a baud-rate switch to change from 110 to 300 baud.

CIRCLE NO. 335

Flexible disc drives go four to a controller

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $4200 (12732A), $2600 (12733A); stock.

Two disc drives, the 12732A and 12733A, are compatible with all systems using any of the firm's current real-time executive operating-system software. Both units, the 12732A with controller cards and the 12733A slave, have an average transfer rate of 46,000 bytes/s and an average access time of 267 ms. Recording is double-density with 67 tracks per disc, 30 sectors per track, and 256 bytes per sector. One 12732A drive with controller can handle three additional slave units. A stand-alone self-test is available at the touch of a button; any malfunction is indicated by a red light.

CIRCLE NO. 336

Microcontrollers offer designers third choice

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Orville Baker (408) 737-5000.

The gap between general-purpose microprocessors and dedicated custom circuits is now filled by the COPS series of four-bit microcomputers. These calculator-oriented processors, the MM5781 and 5782 chip set and the MM5799 or 57140 controllers, contain all that's necessary for most dedicated control applications—and cost under $10. Each PMOS controller comes with clock generator, CPU, ROM, RAM, parallel inputs and programmable outputs and many different programmable single-bit I/O ports. All three microcontrollers share the same basic architecture. The MM5799 contains 1536 eight-bit instructions in its ROM, holds 96 BCD digits in its RAM, has seven-segment drive capability, and cycles through each instruction in 10 μs. Both the 5799 and 57140 controllers have fixed-size ROMs and cannot be expanded. However, the 5782 controller uses off-chip ROM and can access 2 k (MM5781), 4 k (MM57129) or up to 16 k instructions. All controllers operate from 7.9-to-9.5-V supplies and come in 24 or 28-pin DIPs. Development time from customer definition to prototype-circuit delivery is estimated to be less than 16 weeks for most applications.

CIRCLE NO. 337

Bipolar μP handles MIL temps & 3-MHz clocks

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. (214) 238-2011.

Able to operate over the full MIL temperature range, the SBP 9900 16-bit microprocessor developed by Texas Instruments offers all the features of the TMS 9900 and more. The SBP 9900 is an I^2L circuit, and even though it requires only a single-phase clock, all operations are fully static. Clock frequencies can range now from dc to 3 MHz, but higher operating speeds should be available soon. What's more, just one dc power supply is necessary to power the TTL-compatible SBP-9900. The speed-versus-power performance is variable and, by limiting the supply current, can be adjusted over several decades. Like the TMS 9900, the SBP 9900 is supplied in a 64-pin ceramic DIP and offers separate 16-bit address and data buses. The microprocessor is also compatible with instructions in the 990 minicomputer series. For the full MIL temp version (−55 to +125 C), the SBP 9900 costs $386 in 100-unit quantities. Delivery is from stock.

CIRCLE NO. 338

Microprogram controller handles 16 commands

Motorola, P.O. Box 20294, Phoenix, AZ 85036. (602) 244-6900.

By responding to a set of 16 instructions, the MC10801 microprogram controller can efficiently manage the microinstruction memory of 10800-series bit-slice processors. The ECL LSI circuit, a member of Motorola's 10800 MECL processor family, controls the sequence of microprogram instructions with 16 jump and branch commands. On the chip are five 4-bit I/O ports that handle memory-address information. Eight 4-bit master-slave registers in the 10801 hold the current microprogram address cycle as an index counter for repeats, store op codes and flag conditions, and reset subroutines in a 4 × 4 last-in, first-out stack. A "next address" logic section, when used with the 16 instructions, determines the next memory address. The controller is compatible with all MECL 10,000 components and requires −5.2 and −2-V supplies. Operation is specified from −30 to +85 C. The unit is housed in a 48-pin quad-in-line package. The MC10801 costs $50 in 100-unit quantities and is available from stock.

CIRCLE NO. 339

Microcomputer card includes its own software

Microcomputer Associates, 2589 Scott Blvd., Santa Clara, CA 95050. Manny Lemas (408) 247-8940. $575; stock.

A "Super Jolt" microcomputer card that measures only 4.25 × 7 in. contains its own resident assembler and debug programs. The card carries a 6502 8-bit μP, 1 kbyte of static RAM, 32 bidirectional and programmable I/O lines, a 1-MHz crystal clock, an interval timer, four interrupts, three serial interfaces (20-mA current loop, RS-232 and TTL) and 5120 bytes of ROM. With the resident single-pass assembler, the Super Jolt can function as a single-card development system, and its programs can be debugged with the Demon debug monitor program. If a higher-level language is required, a subset of Basic, called Tiny Basic, is available on the board.

CIRCLE NO. 340

Floppy/computer combo has one or two drives

GNAT Computers, 7895 Convoy Ct., Unit G, San Diego, CA 92111. Frank Adams (714) 560-0433. $2895 (with one drive); 30 days.

Available with either a single or dual minifloppy disc drives, the System 8 microcomputer has the works in a 5.25-in.-high cabinet. Included in the unit is a 1.3-μs 8080A processor, minifloppy disc drive with controller and interface, 16-k/64-k RAM module with 16-k RAM, serial-parallel I/O, and front panel for control and display. Software included consists of a resident PROM monitor and a complete disc operating system with file management, editor, assembler and dynamic debugger. PLM, Basic, Fortran and other high-level languages are available.

CIRCLE NO. 341

PROM programmer mates to microcomputer

MITS, 2450 Alamo S.E., Albuquerque, NM 87106, (505) 243-7821. $4.56; stock.

Designed to work with the Altair 8800 microcomputer systems, the 88-PROM Programmer will program standard 1720A (256-byte) erasable PROMs in less than three minutes. The programmer consists of a separate chassis (10.6 × 4.2 × 11 in.) with a 24-pin, zero-insertion-force socket. The unit connects with the 8800 through its own interface card, which plugs into the computer bus. To function, the programmer requires an 8800 a or b computer with an 88-PMC (PROM memory card), an SIO or 2SIO serial input/output card and a terminal. The 88-PMC card is necessary because the software driver for the programmer is supplied in PROM form. All the programmer timing is controlled by the 8800 through its software driver. The PROM is programmed with a 256-byte block transfer from the 8800 memory (RAM or PROM) to the programmer.

CIRCLE NO. 342

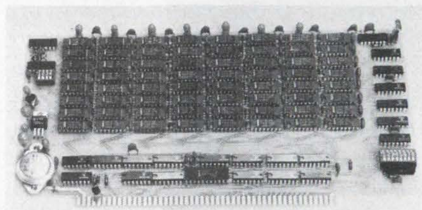
High-level language speeds programming

RCA, Route 202, Somerville, NJ 08876. (201) 685-6423.

Developed to reduce the time necessary to write programs for the CDP1802 microprocessor, microForth executes 10 to 100 times faster than Basic and other similar microcomputer languages. The high-level language requires only 8 kwords of storage space in a microcomputer system—and that includes a 2-kword user workspace. Since a large host computer is not needed, program-development costs should be much cheaper, say RCA officials. With microForth, the user can work on a resident or direct basis with the CDP1800 development system. The language's interactive nature is flexible enough to permit, for example, programmer-defined words to represent entire functions. MicroForth programs run on RCA's CDP1800 development system, which is equipped with a floppy-disc option. Support for microForth includes assembler, compiler, cross compiler, and inner and outer interpreter programs. The program costs about $1000 when purchased in disc form.

CIRCLE NO. 343

RAM board holds 65 k, including refresh

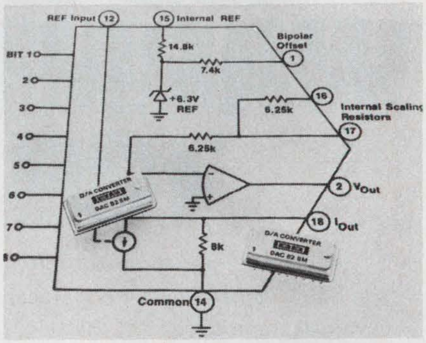


Extensys Corp., 592 Weddell Dr., Sunnyvale, CA 94086. Ed Hartnett (408) 734-1525. $1495 (65 k), $895 (32 k); stock.

Holding all the memory a microprocessor can directly address, a 65 kbyte RAM board developed by the company can mate with buses in Altair, Imsai and other bus-compatible microcomputers. Up to 1,048,576 bytes can be used in a bank-switching arrangement. The 5 × 10-in. board includes the decoding hardware for bank switching and also allows memory addresses to be set in 8-k increments. A hardware write-protect capability in 16-k increments is also available. The board requires +12 V at 300 mA, +5 at 750 mA and −5 V at 1 mA, has a cycle time of 500 ns, and a 400-ns access time.

CIRCLE NO. 344

This d/a converter also multiplies



Burr-Brown, International Airport Industrial Park, P.O. Box 11400, Tucson, AZ 85734. J. Santen (602) 294-1431. From $19.25 (100-249); stock.

DAC 82 is a multiplying d/a converter that provides ±1 LSB accuracy at 20 C without adjustments, and ±1/2 LSB linearity over the full temperature range. The 8-bit converter can be used with either its internal reference or with an external reference for multiplying. The reference input works with any positive voltage and an appropriate input resistor. A BM version is specified from −25 to +85 C and an SM version covers the −55 to +125 C range. Features include: voltage-output settling time (±0.2% of full scale) of 2 μs; current-output settling time of 250 ns; selectable voltage-output ranges; and gain drift better than ±50 ppm/°C. Both versions of the device are hermetically sealed in metal packages.

CIRCLE NO. 345

Plug your Zilog Z80 into the analog world

Signal Laboratories, 202 N. State College Blvd., Orange, CA 92668. D. Flagg (714) 634-1533. From $495 (1-9); stock.

The MAD card provides the Zilog Z80 microcomputer with analog-I/O capability. The multiplexed converter module features a commutating memory to increase system throughput by over 25%. The unit performs a/d conversion in 20 μs. In addition to a/d and d/a converters, the system includes a programmable-gain amplifier with gains of 1, 2, 4 and 8; and an on-board Zilog interface chip. Options include 32-channel analog input capability (16 std.); dual d/a output capability; four discrete (one-bit) outputs; 5-V power operation.

CIRCLE NO. 346

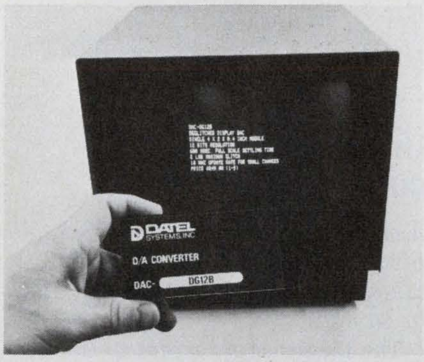
12-bit a/d spans full temperature range

Beckman Instruments, 2500 Harbor Blvd., P.O. Box 3100, Fullerton, CA 92634. (714) 871-4848. $185 (100 qty); stock.

Hermetically sealed in a 24-pin DIP, Series 873-15 offers 12-bit resolution and ±1/2-LSB linearity from −55 to +125 C. Gain drift is typically less than +10 ppm/°C. Gain drift and offset error are externally adjustable to provide accuracy of ±0.012% of full-scale ±1/2-LSB quantizing error. Conversion speed is 30 μs. The units operate from 15 and 5-V-dc power. The successive-approximation device accepts inputs of 0 to 10, −10 to +10 or −5 to +5 V. All models offer complementary straight-binary (CSB) and complementary offset-binary (COB) codes for both parallel and serial data output.

CIRCLE NO. 347

Small fast d/a nails spikes to 2 LSB

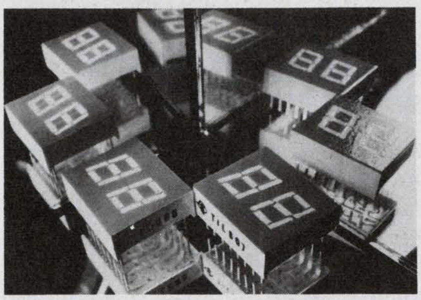


Datel Systems, 1020 Turnpike St., Canton, MA 02021. E. Zuch (617) 828-8000. $249 (1 to 9 qty); 4 wks.

Output glitches of the DAC-DG12B, a 12-bit d/a, are held to ±2 LSB. Voltage × time area for spikes in 250 mV × ns, at the 4 × 2 × 0.4 in. unit's output. The output can zip through a 10-V change with 1-LSB accuracy in 600 ns and to 1% in 250 ns. Changes of ±4 LSB take 100 ns (update rate of 10 MHz). Output ranges of 0 to −10, +5 to −5 or +10 to −10 V are pin selectable. Output current is ±10 mA with short-circuit protection. One model accepts complementary-binary and complementary-offset-binary coding while the other accepts complementary two's-complement coding. Gain tempco is ±35 ppm/°C max from 0 to 70 C. Power requirement is +15 V dc at 50 mA, −15 V dc at 35 mA and +5 V dc at 230 mA.

CIRCLE NO. 348

Dual characters shine brightly



Texas Instruments, P.O. Box 5012, M/S 308, Dallas, TX 75222. B. Alexander (214) 238-3940. $2.88 (100-999); stock.

Dual, direct-drive, seven-segment displays feature a high brightness of 500 microcandelas per segment at 20 mA. The TIL807 display has a common anode; the TIL808 has a common cathode. The 0.3 in., red, two-digit displays have a lead-frame construction with bottom pins. Pin spacing is 0.08 in., for insertion in mounting hole rows on 0.5 in. centers. The package height and width are 0.6 and 0.7 in.

CIRCLE NO. 349

Sampler peak-detects and holds forever

Hybrid Systems, Crosby Dr., Bedford Research Park, Bedford, MA 01730. W. Peacock (617) 275-1570. $115.50 (1-9 qty); stock to 4 wks.

The SH755 peak detector stores an analog input voltage indefinitely without droop of the stored value, regardless of the duration of the holding period. The unit can be programmed by pin connections for operation as either a peak-detector or a sample-and-hold. The device has a tracking rate of 0.25 V/μs as a peak detector, and an acquisition time of 40 μs, plus a sampling rate of 25 kHz as a sample-and-hold circuit. The module accepts 0 to +10-V signals.

CIRCLE NO. 350

VCO in a double DIP has crystal stability

Greenray Industries, 840 W. Church Rd., Mechanicsburg, PA 17055. (717) 766-0223. $50 (1000 qty); 8 to 10 wks.

In just a 1.4 × 0.8 × 0.4-in. 24-pin double DIP, the Model ZN-7414, a voltage controlled crystal oscillator, offers up to ±0.05% frequency deviation. The hybrid unit comes with any base frequency from 50 Hz to 20 MHz with a stability of ±0.004% over 0 to 70 C. The base frequency can be modulated up to 15 kHz. The unit operates from +5 V dc ±5% and drives 10 TTL loads.

CIRCLE NO. 351

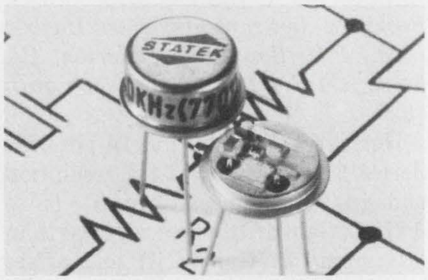
Digital transducer connects simply to μP

Siltran Digital, P.O. Box 437, Silverado, CA 92676. M. Hordeski (714) 649-2704. $225 (1-24 qty); 30 days.

The 8-bit output of series DPT-005 pressure transducers can be connected directly to the 8255 or 6820 interfaces for 8080 or 6800 μPs. To mate a μP with the transducer you instruct the μP to treat the interface connections as inputs. The transducer outputs are unclocked and available for sampling at any rate defined by main-program control. Power input is +5 V dc or 110 V ac and pressures up to 30,000 lb/in^2 are available.

CIRCLE NO. 352

Tiny ELF oscillator draws low power



Statek, 512 N. Main St., Orange, CA 92668. (714) 639-7810. $27 (100 qty); stock.

Generating a standard 1-Hz or nonstandard frequencies in the 1-Hz-to-10-kHz range, the TO-5 mounted DQXO-3 boasts 100-ppm precision and consumes only 150 μA from a 5-V supply. Aging during the first year is 10 ppm at 25 C. The extremely low-frequency oscillators are controlled by the company's unique three-lead crystals. These laser-trimmed crystals have low capacitance, high Q (65,000 typically) and low-power consumption.

CIRCLE NO. 353

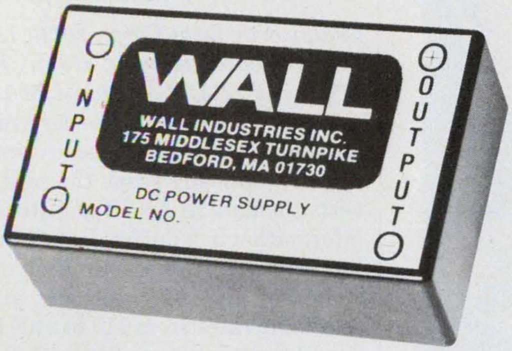
Unit converts low currents to frequency

Analog Technology, 3410 E. Foothill Blvd., Pasadena, CA 91107. (213) 449-8440. $995 to $1795 singles; stock to 60 days.

The 150 series of current-to-frequency converters accepts bipolar input current 3×10^{-14} to 5×10^{-6} A from low-level current sources and produces a pulse-train output whose frequency is proportional to the input current. The converter operates in three selectable sensitivity ranges, 10^{-14}, 10^{-13} and 10^{-12} AHz, and each range operates linearly in frequency up to 5 MHz. Used as an interface between a current-source device and any standard digital-data-handling equipment, the converter furnishes frequency information that varies linearly over a continuous five-million-to-one dynamic range without range switching. Pulse-position transient response is less than 1 μs, and the transient time for 100%-frequency settleout is twice the new period. Signal-output formats of pulse train, parallel binary, parallel BCD and range-switched-analog are available.

CIRCLE NO. 354

POWER SUPPLIES



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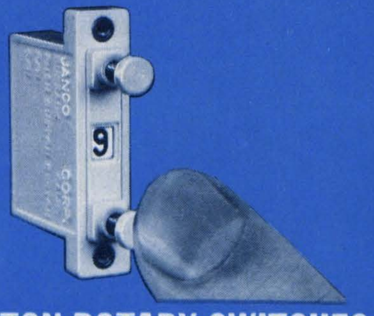
CIRCLE NUMBER 84

Right on the button!



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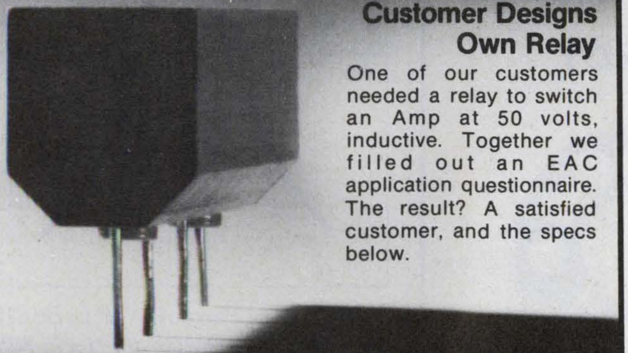
CIRCLE NUMBER 86

Special Relays — *QUICKLY*



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One of our customers needed a relay to switch an Amp at 50 volts, inductive. Together we filled out an EAC application questionnaire. The result? A satisfied customer, and the specs below.

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5, 6, 12, 24, or 48 volt DC coil voltage
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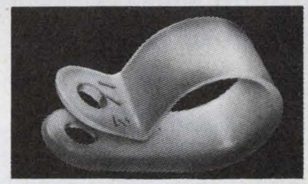
CIRCLE NUMBER 85

New Heyco® Nylon Cable Clamps



New from Heyman Manufacturing—nylon clamps for standard and heavy duty cable applications. Tough, lightweight nylon resists abrasion, aging and most chemicals. And provides excellent insulation. Standard clamps range from 1/8" thru 1/2" in 7 sizes. Heavy duty clamp holds 19 different diameter cables, from 1/8" thru 1 1/2". Both have standard locking holes. Both have full radiused inside edges that won't cut into wire insulation—and are open ended for easy entry. U.L. recognized. **FREE SAMPLES on request from:**

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HEYCO®

33D

CIRCLE NUMBER 87

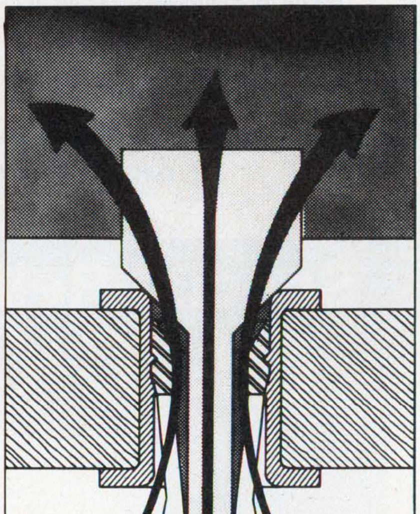
This mark reader scans both sides at once

Chatsworth Data Corp., 20710 Lassen St., Chatsworth, CA 91311. Frank Lefkowitz (213) 341-9200. $3500.

Model 4800 mark sense card reader, capable of reading both sides simultaneously, optically scans the card, converts the data to ASCII and stores the information in a buffer. Data from the top side are strobed out first over a standard RS232C interface, at five selectable rates from 110 to 2400 baud. Card length can vary from 5-7/8 to 14 in. Options include command-controlled card feed, code converters (EBCDIC and binary card image), and dual output ports.

CIRCLE NO. 355

Precision contact turns plated hole into socket



Augat Inc., 23 Perry Ave., P.O. Box 779, Attleboro, MA 02703. (617) 222-2202.

The precision-machined Holtite contact is press-fitted into plated-thru holes. It uses the existing space within the board, allowing the plated-thru hole to become the socket. The outer conical shape of the contact sizes the plated-thru hole when pressed into place, and the geometry of the contact accepts the displaced solder without damaging the hole, or affecting performance. The open contact design permits air flow through the board.

CIRCLE NO. 356

WHO SAYS ENGINEERS ARE SQUARES?

Here are the comments we received recently from *Electronic Design* reader Gottlieb Dändliker, then a project leader at SODECO-SAIA, SA (public telephone toll systems) Geneva, Switzerland:

"Being the responsible for the design of electronic equipment and the leader of several research projects, I am depending on up-to-date information regarding trends in technology and design.

"Among the multitude of publications, I consider it expedient to concentrate on a few ones, and I have chosen *Electronic Design*.

"I especially appreciate the concise articles taking into account the interest and needs of equipment designers and also the clear manner in which you regularly report on various special fields.

"I always peruse all the advertisements too.

"The photo shows me for once, not working but gliding, my favorite hobby."

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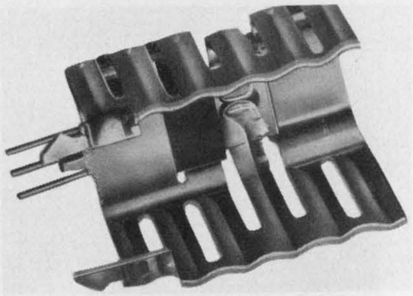
Cool it with these stand-up heat sinks



Wakefield Engineering, 77 Audubon Rd., Wakefield, MA 01880. (617) 245-5900. $0.05 (large qty).

Stand-up heat sinks Model 297-V1-130 for cooling TO-202 and TO-220 devices provide heat transfer capability of 13 C/W. The Series 297 also features an ultrasonic tin-dip process that allows the snap-on coolers to be wave-soldered directly to PC boards. Fin lengths range from 0.8 to 1.3 in., and black, gold or plain finishes are available.

CIRCLE NO. 357

PC board damaged? Replate on the spot

Pace Inc., 9329 Fraser St., Silver Spring, MD 20910. Rhoda Deblinger (301) 587-1696. $386.

Model PEP-230 bench-top SwaPlating system permits controlled replating of damaged or worn connectors, circuit tracks, contacts, plated-thru holes or other circuit surfaces. The system includes several plating solutions and other required materials. Gold and other noble solutions are optionally available. The power source provides pre-set dc voltages for each plating solution. A smaller system with carrying case (Model PEP-220) is also available ($371).

CIRCLE NO. 358

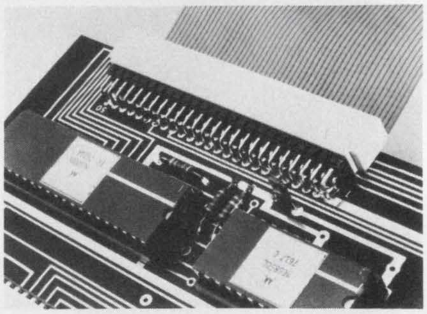
Nutty screw spares thin-walled bosses

Central Screw, 999 Touhy, Suite 165, Des Plaines, IL 60018. J. Richert (312) 296-1174.

Plastite is a tri-lobular screw, developed specifically for use in ductile plastics and soft metals such as aluminum and zinc die castings. It requires less driving torque and helps eliminate bursting of thin-walled bosses. Deep-root threads create a greater sheer area, increasing resistance to pull-out and vibration.

CIRCLE NO. 359

PC board headers mate boards connectors, cable



AP Products, Box 110, 72 Corwin Dr., Painesville, OH 44077. (800) 321-9668. Stock.

PC board headers come in both male and female configurations. The male headers are 0.025-in., square contact pins in a black polyester strip, spaced 0.1 in. The female headers have tuning-fork contacts, set in a black glass-filled nylon strip. Standard headers come in three configurations: 0.1 in. single-row, 0.1 × 0.1 and 0.1 × 0.2 in. Each variety comes in rows of 36 contacts, which can easily be cut to length.

CIRCLE NO. 360

Cable-tying tool fits southpaws as well

Thomas & Betts Corp., 36 Butler St., Elizabeth, NJ 07207. (201) 354-4321.

A lightweight, hand operated cable-tying tool (Cat. No. WT-1) for installing ties up to 0.19 in. wide and 0.05 in. thick is made of high impact plastic and steel, and is symmetrical to suit both left and right-handed operators. The shirt-pocket sized tool cinches up the tie when squeezed, and cuts away the excess tail with a 180° twist. A specially designed pawl prevents over-tightening which could damage the cable insulation.

CIRCLE NO. 361

Fast laser system scribes —also cuts, drills and welds

Prototype of Coherent Radiation's Everlase 150S shows the system elements: Laser (in cabinet, top left) delivers beam through the black tube to the numerically controlled work table. Controller is at right.

Coherent Radiation, 3210 Porter Dr., Palo Alto, CA 94304. Don Bennett (415) 493-2111. $68,910, plus $3000 for loading trays; 4 mo.

The Everlase 150S ceramic laser system can scribe four times faster than its own Coherent Radiation predecessor, the 50-W 610S, and approximately twice as fast as its closest competitor, the 100-W Photon Sources 1044. Scribing speed depends on hole depth and, for the 150S, ranges from 1 in./s for 16 mil to 13 in./s for a 10 mil.

The numerically controlled, 150-W Everlase also does things neither of the other models can do—it cuts holes of any desired size, saws and contours at 20 in./min., and even welds dissimilar metals.

Lasers are taking over scribing because conventional diamond tools for working fired ceramics are expensive and slow. Instead, microelectronic circuits can be produced on big substrates—typically 2 × 2 in., scribed (perforated) by laser, then broken apart. Little material is wasted, and sizes are tightly controlled.

Ceramic substrates are used for ICs, thick-film components, hybrid circuits, rf assemblies, and other microelectronic devices.

The 150S is set up for fast production, with quick-loading trays to handle 16 typical ceramic substrates at a time. A numerically controlled Aerotech X-Y positioning table permits the work tray to travel 10 in. on each axis at speeds up to 13 in./s. The table is closed-loop controlled with dc torque motors by a controller that accepts either paper tape or PROMs as a source of the numerical-control data.

The laser itself, three-year-old Model 150, is an electronically pulsed CO_2 gas laser that can produce 1000-W peak power. Its fast scribing rate comes from a high ratio of peak to average power (6.6:1), which also eliminates excess melting around vaporized holes. The 610S, with mechanical shutters, has a 3:1 ratio.

In a typical scribing job, a row of holes 3 mil in diameter and 10 mil center-to-center is vaporized in alumina. But many scribing modes are possible, and many materials are absorptive enough at the 150S's 10.6-μm wavelength to work as well—plastics, rubber, glass, beryllia, sapphire and barium titanate.

Clean pulse-mode welding of diverse metals is also possible. The 150S can weld thin (5-mil) stainless steel—even bi-metallic strips.

For a workload that doesn't require purchasing a scribing system, CR has a job-shop scribing/machining service.

Coherent Radiation **Circle No. 307**
Photon Sources **Circle No. 308**

Tiny coax switch boasts big specs, remote action

RLC Electronics, 83 Radio Circle, Mount Kisco, NY 10549. (914) 241-1334. $99 (1-9 units).

The Model Sr-2 remote miniature SDT coax switch boasts impressive specs: a dc-to-18-GHz frequency range with 60-dB min isolation, gradually rising to 80 dB at 4 GHz; a VSWR of 1.5 max, improving to 1.2 at 4 GHz; an insertion loss of 0.3 dB max, declining to 0.1 dB at 4 GHz. By using high-density packaging techniques, the over-all volume of the 2-oz package was kept under 0.75 in^3. High reliability, long life, and fail-safe operation are standard features. Latching, indicator circuitry, and make-before-break switching under power are optional.

CIRCLE NUMBER 362

Versatile rf transistors are moderately priced

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94394. (415) 493-1501. $18 & $40 (1-9).

Two general-purpose transistors have been added to HP's line: Model HXTR-2101 provides a tuned gain of 9 dB min at 4 GHz, with a 1-dB power compression of 70 mW. The more expensive HXTR 6105 offers a 4.2-dB max noise figure with an 8-dB min associated gain at 4 GHz (15 dB at 1.5 GHz). Its 1-dB compression power is 25 mW, and the typical noise figure is 2.2 dB.

CIRCLE NUMBER 363

now there is one... in signal processing

IF and Microwave Components From One Source.

At Merrimac we have over 750 standard catalog items from DC to 18GHz with lumped elements, stripline or ferrites. If these standard units don't meet your requirements we pride ourselves in designing and producing custom or special components... in fact specials are over 50% of our business. Additionally, we can design and manufacture Sub-Systems and Integrated Packages of active and passive IF, RF and Microwave components within an IF Processing Chain, Microwave sub-system or the combination of both. NOW THERE IS ONE IN SIGNAL PROCESSING... MERRIMAC with over 750 standard units, Custom components and Sub-system capability.

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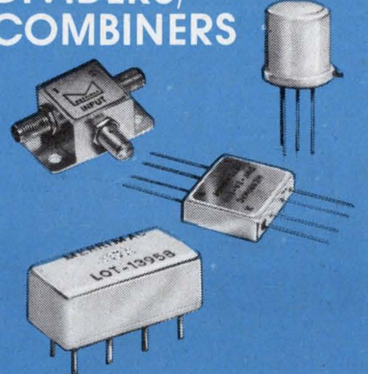
Circle the Reader Service Number **171**

AUDIO, VHF AND UHF IN-PHASE, REACTIVE LUMPED ELEMENT POWER DIVIDERS/ COMBINERS



50 kHz to 2 GHz

The winning combination is 83 different standard catalog 2, 3, 4, 6, 8, 12 and 16 way Power Dividers in TO-5, FLAT PACK, RELAY HEADER, LOW PROFILE PC PLUG-IN, SMA, BNC, TNC AND "N" CONNECTOR PACKAGES. Newest models feature ultra-broadband, multi-decade frequency ranges within the range of 50 kHz to over 1 GHz, at low costs.

Following are 4 standard low cost, ultra broadband, 2-way Dividers which demonstrate Merrimac's variety of different packages available off the shelf.
Frequency range (all models) 5 (or 10) to 500 MHz

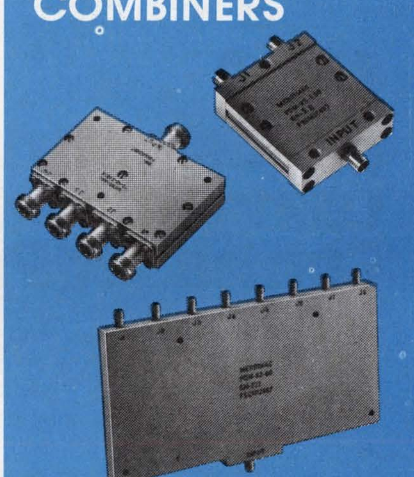
PACKAGE	MODEL NO.	PRICE	ISOLATION dB	PHASE BALANCE
TO-5 (0.3" high)	P-110	$12.00	25 TYP. 20 MIN.	2°
RELAY HEADER	113-C	$ 9.00	30TYP. 25 MIN.	1° TYP. 2° MAX.
FLAT PACK	PDF-2A-250	$17.00	30TYP. 25 MIN.	1°
WITH SMA CONNECTORS	PDM-20-250	$35.00	30 MIN.	1°

For complete detailed specifications on the above 4 models as well as our other 79 standard IF power dividers:

Send for our
NEW '77 CATALOG OF IF SIGNAL PROCESSING COMPONENTS.

Circle the Reader Service Number **172**

MICROWAVE IN-PHASE, STRIPLINE BINARY POWER DIVIDERS/ COMBINERS



.5 to 18.0 GHz

The winning combination is 58 different standard catalog 2, 4, and 8 way Power Dividers with SMA and TYPE N, in octave, multi-octave and straddle bands from 500 MHz to 18 GHz with in-line and angled output configurations.

Following are 4 standard models which are typical of the other 54 standard items: prices from $85.00 for 2-ways to $265.00 for 8-ways.

MODEL No.	POWER DIVISION	FREQUENCY RANGE (GHz)	ISOLATION dB(MIN)	INSERTION LOSS dB(MAX)
PDM-22-.75G	2:1	.50-1.0	20	.30
PDM-42-3.95GA	4:1	3.7-4.2	18	.50
PDM-82-6GA	8:1	4.0-8.0	17	1.0
PDM-22-15G	2:1	12.4-18	14	1.0

For complete detailed specifications on the above 4 models as well as our other 54 Standard Microwave Power Dividers:

Send for our
NEW '77 MICROWAVE CATALOG

Circle the Reader Service Number **173**

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Merrimac
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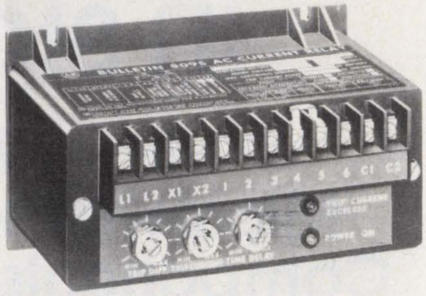
Toggle switches lock for safely

Alco Electronic Products Inc., 1551 Osgood St., North Andover, MA 01845. (617) 685-4371. $1.68 (500 up); stock.

Miniature locking lever switches, the MTL Series, feature a positive pull-to-unlock. The toggle locks in position to safeguard against accidental actuation, especially useful where critical or dangerous switching operations are prevalent. Terminals have a molded-in heat-sink construction that prevents solder flux or other contaminants from entering the switching mechanism. All models mount in a 1/4-in. hole and contacts are solid silver rated 6 A at 125 V ac or 3 A at 250 V ac. A gold-flash finish on the terminals and contacts promotes greater soldering ease, inhibits oxidation and extends shelf life.

CIRCLE NO. 365

SS ac-current relay trips at preset current

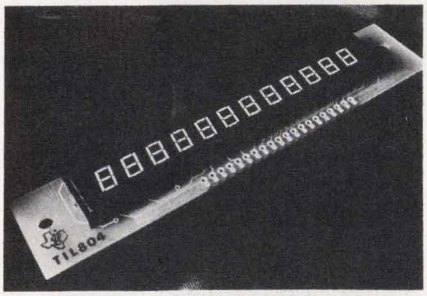


Allen-Bradley, 1201 2nd St., Milwaukee, WI 53204. (414) 671-2000.

The Bulletin 809S solid-state relay senses ac current and operates a sealed contact when the monitored current exceeds a preset trip point. The sealed contact is rated at 600 V maximum. Three time-delay modes—start, inhibit and trip—are included in the design. In addition to adjustable trip currents, the relay also incorporates adjustable differential settings with automatic reset. Though available in two continuous current ratings—5 and 12 A—high current applications should use the 5-A relay with a current transformer. LEDs provide visual indications when the supply voltage is applied and when the load current exceeds the trip setting.

CIRCLE NO. 366

Display stick contains 12 seven-segment digits

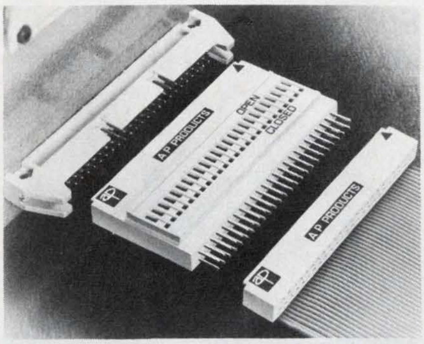


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, TX 75222. B. Alexander (214) 238-3940. $14.65 (1-99).

Multidigit visual LED display sticks with 12 digits, Model TIL804, have the largest number of digits on a single board, according to TI. Characters are seven-segment red units, 0.27-in. high with a typical brightness of 500 μcd at 20 mA. Some features of the display stick include right-hand decimals at each digit, uniform brightness of the segments, a wide viewing angle for distances to 15 ft and a common-cathode configuration for ease in multiplex operation.

CIRCLE NO. 367

Slide-switch assembly aids ribbon-system tests

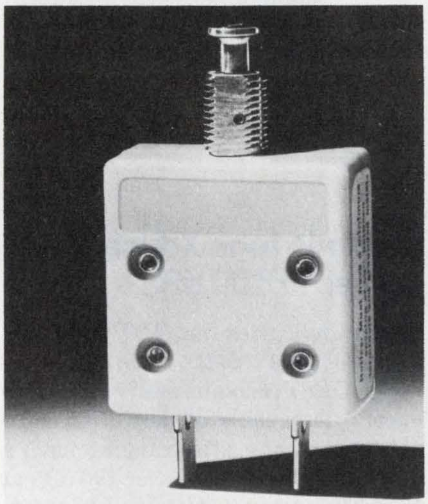


AP Products Inc., Box 110, 72 Corwin Dr., Painesville, OH 44077. (216) 354-2101.

Intra-Switch—up to 50 discrete slide switches—for interfacing between double-row flat-ribbon connectors is a testing aid. In the five widths popularly used in ribbon systems—20, 26, 34, 40 and 50 contacts—the unit has a female connector at one end, a male at the other and line-by-line discrete switching in between. A probe or pen point can set each switch open or closed for diagnostic testing, programming and selective inhibiting.

CIRCLE NO. 368

Panel-mounted breakers handle high currents



Aiken Industries, Inc., 1824 River St., Jackson, MI 49204. (517) 782-0391.

Small, thermal-trip circuit breakers feature push-pull actuation, "low unit cost" and high interruption capacity (to 5000 A). Dimensioned 1-3/8 × 1-7/16 × 11/16 in. deep, the units are trip-free with single-pole capacity. On-off marking is available on a separate metal plate. The 752 series is rated from 10 to 30 A; the 762 series, from 5 to 20 A.

CIRCLE NO. 369

COMPONENTS

Metric rotary switches mount on PC boards

Oak Industries Inc., Switch Div., Crystal Lake, IL 60014. (815) 459-5000. For the 684: $1.89 (1000-up); 6 to 8 wks.

Miniature metric rotary switches with 12 and 24 positions are designed for PC-board insertion. The Models 684 and 685, respectively, are each available with a bushing mount to the chassis or tab of the pin mount to the PC board. The switch sections are enclosed to prevent dust contamination. Adjustable stops on the Model 685 switch increase design flexibility. Because of its low profile, the Model 684 switch is particularly applicable where compactness is important. Contact material is phosphor bronze and brass with silver plating.

CIRCLE NO. 370

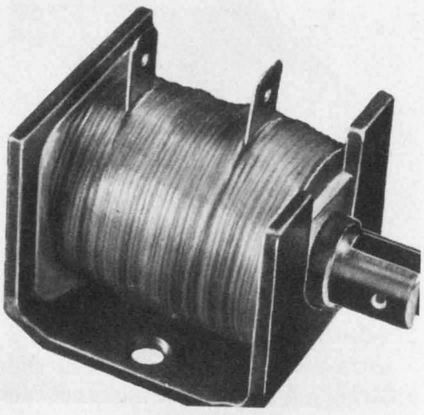
Contact protector gives EM relay SS advantages

Timeco, Inc., 1035 26th St., Huntington, WV 25705. (304) 523-5149. $6.85: 10 A at 115 V ac (unit qty).

With the use of Timeco's Model 757 contact protector, the advantages of both solid-state and electromagnetic relay switching are obtained, and the disadvantages of both are eliminated. When the electromagnetic relay coil is switched on, the voltage developed across the relay coil switches on a triac that is connected in parallel with the relay contacts. The triac closes the circuit before the relay contacts; energizes the load through the triac; and eliminates contact bounce and EM interference. Subsequent closure of the relay contacts then carries the load for the duration of the energization, eliminating heating of the triac. When the relay is switched off, the triac is held in the on condition by means of a delay circuit, until after the relay contacts open. Both EM interference and deterioration of the contacts from arcing is eliminated. Power is removed from the load and the triac opens when the ac line voltage goes through zero.

CIRCLE NO. 371

Solenoid delivers short, powerful strokes



AMP Inc., Potter & Brumfield Div., 200 Richland Creek Dr., Princeton, IN 47671. (812) 386-1000. $2.23 (1000 up); 6 to 8 wks.

A small, powerful solenoid for linear mechanical actuation, Model S9, delivers a pull-in operate force to 32 oz and holding force to 85 oz in a C-frame style of only 1.4 in^3. Maximum stroke is 0.5 in. and standard voltages are 6, 12, and 24 V dc or 24 and 120 V ac, 60 Hz. Other voltages are available to 110 V dc and 240 V ac, 60 Hz. Power consumption at continuous duty is 6 W or 10 VA; and at 25% duty cycle, 10 W or 20 VA. Life expectancy at optimum conditions is over 10-million cycles.

CIRCLE NO. 372

Ceramic tone Xducers deliver to 100 dBa

Gulton Industries Inc., P.O. Box 4300, Fullerton, CA 92634. (714) 871-2150.

The CATT (ceramic audio-tone tranducers) is capable of delivering variable sound intensities ranging from a quiet audible signal to over 100 dBa at 10 ft. The units are suited for electronic games, alarm clocks, intrusion alarms, keyboard signalers, industrial controls and smoke detectors. The thin construction, efficiency and rugged design of the CATT also makes it suited for solid-state alarm wristwatches and portable battery-operated equipment. Typically less than 0.03-in. thick, it has no moving coils, paper cones or electromechanical contacts and uses very low current—from 20 mA to as low as 750 μA.

CIRCLE NO. 373

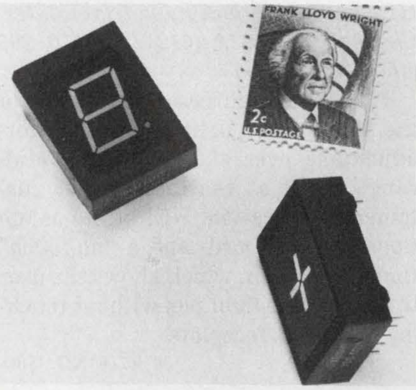
DIP reed relays handle 0.5 A and 100 V

Electronic Instrument Specialty Corp., 42 Pleasant St., Stoneham, MA 02180. (617) 438-5300. $3.12 (100 up); 2 to 4 wks.

Form 2A DIP reed relays only 0.22 in. high provide a contact rating of 0.5 A and 100 V with a 10-W power limitation. Relays are capable of running directly from TTL and DTL logic. Terminals are designed for automatic insertion and feature specially constructed internal locking to eliminate damage or loosening. They are offered in 5, 6, 12, and 24-V versions, and an optional internal clamping diode is available. Specifications include: operating time, less than 0.35 ms; release time, 0.1 ms; bounce time, 0.15 ms; insulation resistance, 10^{11} Ω min; operating temperature, 0 to 65 C.

CIRCLE NO. 374

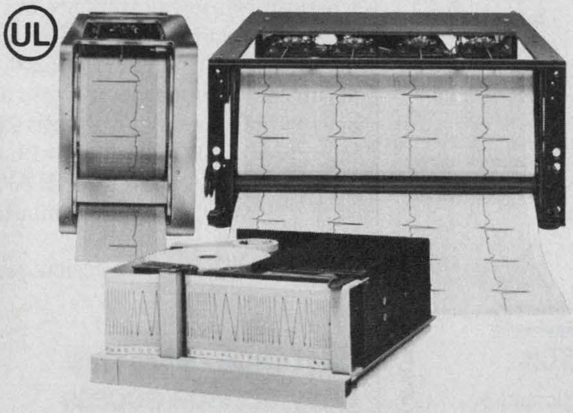
LED readouts readable from 40 ft



Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. $2.55: 6001, $3.10: 6005/6006 (1000 up); stock.

High-brightness Diode-Lite 730 Series LED modules with 0.6-in.-high numerals are readable from 35 to 40 ft and low in cost. Made with GaP, the series includes a module with decimal point (730-6001); a plus/minus module (730-6005); and a polarity/overflow module that incorporates a plus/minus symbol, the numeral one, and a decimal point (730-6006). The series features a typical 10-mA per segment current and common-anode construction, with common-cathode an available option.

CIRCLE NO. 375



Electrostatic printers plot metric conversion

Gould Inc., 3631 Perkins Ave., Cleveland, OH 44114. (216) 361-3315.

Two models of the 5000 Series electrostatic printer-plotters are available with metric print heads. The 5005 M has 40 stylii/cm, and the 5200 M 80 stylii/cm, with a writing width of 26.4 cm for both models. Respective printing speeds are 8.25 and 4.19 cm/s. Direct memory access for IBM 360/370, PDP-11, Nova, and HP computers is available.

CIRCLE NO. 376

Fast tape drive has easy service access

Wangco Inc., 5404 Jandy Pl., Los Angeles, CA 90066. (213) 390-8081. $4700 (OEM qty); Fall, 1977.

Model 14 is a 125-in/s tape drive with increased performance and reliability, but 50% reduced power consumption. Extra-length vacuum columns permit the high speed, while maintaining 19-in. rack dimensions. For fast maintenance, all subassemblies are accessible from the front. The Model 14 is format-selectable. It reads and records 1600 char/in. (dual-density PE format) or 800 char/in. (NRZI). Both formats can be implemented in the same unit. Built-in daisy-chain capability accommodates up to four units.

CIRCLE NO. 377

Brainy MUXs enhance distributed processing

Honeywell, 1100 Virginia Dr., Fort Washington, PA 19034. (215) 643-1300.

Honeywell's Total Distributed Control (TDC) family of μP-based process controllers has new members. The TDC 7100 remote multiplexer units are interconnected by a data "highway," and perform such tasks as limit checking, sequence-of-events timekeeping, and automatic reporting of changes and alarms. The TDC 4500 processor unit is more powerful then previous Series-4000 computers, providing 256-k words of MOS memory and a cycle time of 600 ns. Its Genie I/O bus boasts a transfer rate of 1 million words/s.

CIRCLE NO. 378

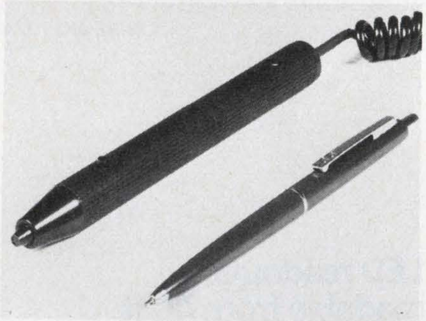
Interface helps IBM 360 print bar-code mix

Information Products Systems, Inc., 6565 Rookin, Houston, TX 77074. (713) 776-0071. $7500; 6 wks.

A hardware/software package allows IBM 360/370 computers to drive low-cost label printers. The printer controller mimics a standard IBM printer MO3/2821. The software package generates a graphics mode by converting the IBM's EBCDIC character records to coded graphics for bar-code printers (UPC, Plessey and Monarch Code-A-Bar). Lease and third-party maintenance are available.

CIRCLE NO. 379

Light pen adjusts to brightness level



HEI, Inc., Jonathan Industrial Center, Chaska, MN 55318. (612) 448-3510. $98 (1000 up); stock.

The spot-brightness sensitivity of the Model 120-2 light pen is operator-adjustable over a 3 to 1 ratio. Midrange is set at the factory, per customer specification. HEI offers as options a coiled cord, and a "no-touch" fingertip switch, which allows the user to activate the light pen without touching the CRT faceplate.

CIRCLE NO. 380

A farewell to the keypunch operator?

Hendrix, 645 Harvey Rd., Manchester, NH 03103. Stephen Silver (603) 669-9050. $14,900 (unit qty).

The Typereader is designed to read data prepared on an ordinary office typewriter and transfer it to a computer. It eliminates the need to retype data for computer input, and the errors that go with it. The new peripheral reads either OCR A (IBM Element 1167170) or OCR B (IBM Element 1167210), with an accuracy of 1 error in 20,000 characters.

CIRCLE NO. 381

Application notes

Flush circuits

Designers interested in incorporating flush-circuit technology into their equipment will find specific hints in a four-page reprint, "Design Considerations for Flush Circuits." The Sibley Co., Haddam, CT

CIRCLE NO. 382

Component testing

The gathering of component test data and its reduction for product analysis by quality-control, incoming-inspection and manufacturing departments are described in an application note. GenRad, Concord, MA

CIRCLE NO. 383

A/d converters

"Using the 4130 ADC Series, 4855 Sample-Hold, and 4550 Multiplexer in High-Speed Data-Acquisition Systems" analyzes possible system configurations, and discusses design consideration. Teledyne Philbrick, Dedham, MA

CIRCLE NO. 384

Ferrite material

A four-page brochure contains equations for calculating ferrite core sizes for the most common type of inverter. Graphs illustrate Ceramag 24B's low core-loss/high-permeability characteristic. Stackpole Carbon, St. Marys, PA

CIRCLE NO. 385

Hot melt adhesives

"How to Use Hot Melts for Efficient Fastening" describes how hot melts work, applications and equipment required for their use. Du Pont, Wilmington, DE

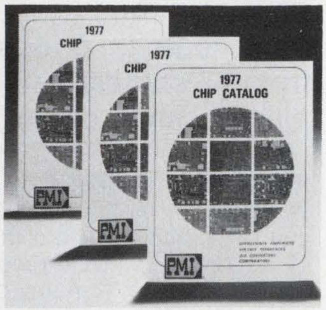
CIRCLE NO. 386

D/a converters

"Differential and Multiplying Digital to Analog Converter Applications" contains a tutorial section on multiplying d/a converter basics. Precision Monolithics, Santa Clara, CA

CIRCLE NO. 387

New literature



IC chips

The "1977 Chip Catalog" lists complete 25-C specifications—guaranteed min/max wafer-probe limits—for all PMI products in chip form. Precision Monolithics, Santa Clara, CA

CIRCLE NO. 388

Spectrum analyzers

Both the high-resolution 2048-line Model 4513 and the high-speed 512-line Model 4512 FFT spectrum analyzers are detailed in an eight-page catalog. Princeton Applied Research, Princeton, NJ

CIRCLE NO. 389

Limit switches

Six different types of limit switches are described in a 12-page booklet. It lists contact ratings, temperature ratings, types of actuators and enclosure classifications. Allen-Bradley, Milwaukee, WI

CIRCLE NO. 390

TTL data book

Detailed specifications on over 900 TI device types, including standard TTL and high-technology Schottky-clamped TTL are contained in a data book. It has pin-assignment drawings of all TTL types, including bipolar memories and microprocessors. The book sells for $4.95. Texas Instruments, Inquiry Answering Service, P.O. Box 5012, M/S 84, Dallas, TX 75222.

INQUIRE DIRECT

Packaging hardware

"Electronic Packaging Round-Up," 20 pages, offers an overview of hardware—wrapped-wire boards, cards, files, drawers, frames, panels and large assemblies—as well as optional wiring and documentation services. EECO, Santa Ana, CA

CIRCLE NO. 391

UPS

An uninterruptible power system for protecting computer systems against power fluctuations, brownouts and failures is featured in an updated catalog. General Electric, Stamford, CT

CIRCLE NO. 392

Synchro converters

A 30-page catalog describes synchro converters, displays and encoders. Computer Conversions, East Northport, NY

CIRCLE NO. 393

Linear motion products

A 52-page catalog describes ball bushings, ball-bushing pillow blocks and other components for friction-free linear motion. Thomson Industries, Manhasset, NY

CIRCLE NO. 394

Switches

Engineering drawings, specifications and ordering information on miniature rotary switches are contained in an eight-page catalog. McGraw-Edison, Edison Electronics Div., Manchester, NH

CIRCLE NO. 395

Active-filter modules

A new series of active-filter modules for low-speed modem applications is featured in an eight-page bulletin. Sprague Electric, North Adams, MA

CIRCLE NO. 396

SCR dc power supplies

Specifications, features and applications of high-power SCR dc power supplies are provided in a four-page bulletin. Electronic Measurements, Neptune, NJ

CIRCLE NO. 397

Rf signal processing

A 232-page catalog features specifications and performance data on the company's rf signal processing components. An extensive applications section is included. Watkins-Johnson, Palo Alto, CA

CIRCLE NO. 398

Semiconductors

"Semiconductor Circuit Elements" is a compact survey of these devices and contains a simple classification into groups. For more information circle the reader service number. Hayden Book, Rochelle Park, NJ

CIRCLE NO. 399

Precision components

A 208-page catalog describes metric-system standardized precison-mechanical components and assemblies. Also included are working prints, technical reference-data tables, gear data, metric terms and formulas. PIC Design Div., Benrus Corp., Ridgefield, CT

CIRCLE NO. 400

A/d converters

Construction, performance, operation, PC-board layout, power-supply bypassing and external offset and gain adjustments of Series 873-78 and 873-88 a/d converters are detailed in two 6-page bulletins. Tables and diagrams provide helpful information. Beckman Instruments, Helipot Div., Fullerton, CA

CIRCLE NO. 401

Vacuum equipment

A 200-page vacuum-equipment catalog features up-to-date prices, applications data, dimensional drawings and performance specifications. Perkin-Elmer Ultek, Palo Alto, CA

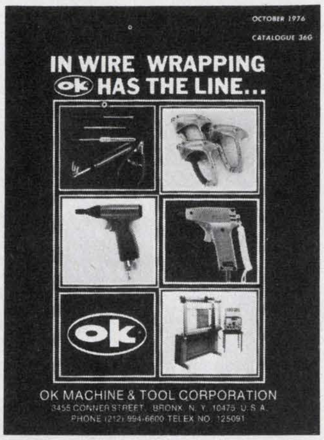
CIRCLE NO. 402

RTV sealers

Properties, uses, and recommended application techniques for General Electric's 11 grades of RTV sealers have been assembled in one comprehensive data package. Commercial Plastics & Supply, Cornwells Heights, PA

CIRCLE NO. 403

NEW LITERATURE



Wire-wrapping tools

Many new additions to the company's line of wire-wrapping tools, machines and associated products are included in a 58-page catalog. O.K. Machine and Tool, Bronx, NY

CIRCLE NO. 404

A/d, d/a signal converters

A/d and d/a signal converters and instrumentation amplifiers are featured in a four-page catalog. CPS, Converter Products, Sunnyvale, CA

CIRCLE NO. 405

Thin-film resistors

Performance and environmental specifications, stock resistance values, and prices for thin-film resistors are tabulated in a bulletin. Included are interior wiring and power-dissipation rating diagrams plus a package outline drawing. Beckman Instruments, Helipot Div., Fullerton, CA

CIRCLE NO. 406

Linear quad/dual ICs

Detailed specifications and application information on all Raytheon Semiconductor quad and dual op amps and quad comparators are given in a 42-page guide. Distronic Ltd., Harlow, Essex, England

CIRCLE NO. 407

Thermocouples

The 1977 Omega Temperature Measurement Handbook, over 176 pages, contains thermocouple, thermistor and RTD data. Omega Engineering, Stamford, CT

CIRCLE NO. 408

Bulletin board

Signetics is second-sourcing Motorola's MC1399 color processing IC and Motorola is second-sourcing the Signetics TCA440 five-stage AM radio IC.

CIRCLE NO. 409

Intersil has reduced prices up to 65% on its on its **12-bit CMOS μP.**

CIRCLE NO. 410

Raytheon has introduced its first **programmable ROMS:** the industry standard 256 × 4 (1-k) and the 256 × 8 (2-k). Both bipolar products are designed with nichrome fuses and come in either open-collector or three-state versions.

CIRCLE NO. 411

Synertek has introduced a **1-k × 4 static RAM, the SY2114.** It is a pin-compatible replacement for the Intel device of the same number. The SY2114 comes in ceramic packages and is priced at $20 (100s).

CIRCLE NO. 412

Advanced Micro Devices' series of **three high-speed, monolithic d/a converters—DAC-08, Am1508 and SSS1508A**—are designed as plug-in replacements for like-numbered devices from other manufacturers. AMD's first linear-circuit entries into the data-acquisition and telecommunications markets offer nonlinearity specs to 0.1%.

CIRCLE NO. 413

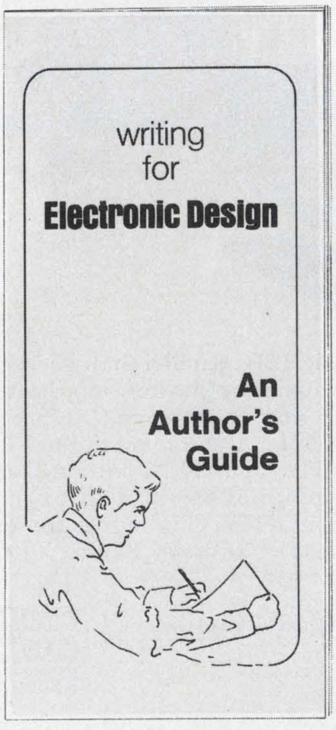
Precision Monolithics' MAT-01 ultra-matched npn transistor pair second-sources National's LM114, 114A, 115, 115A; Analog Devices' AD810, 811, 812, 813 and 818, and at least 17 standard 2N numbers.

CIRCLE NO. 414

Intersil is **second-sourcing National Semiconductor's LM148 quad 741 op-amp family.**

CIRCLE NO. 415

AUTHOR'S GUIDE



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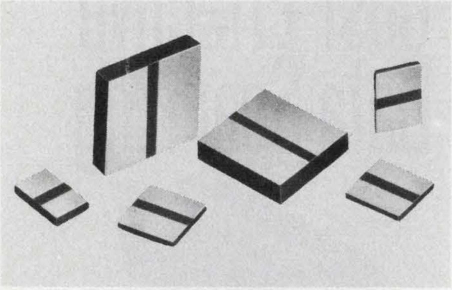

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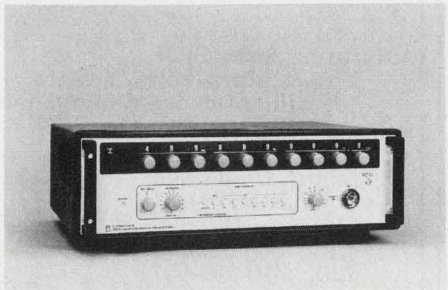

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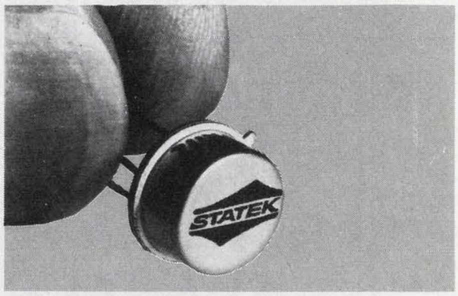

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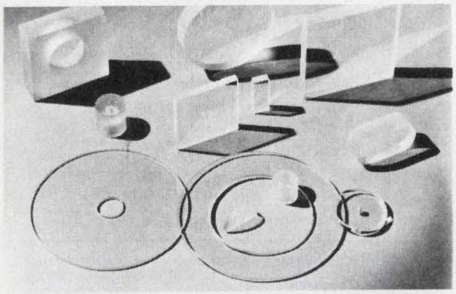

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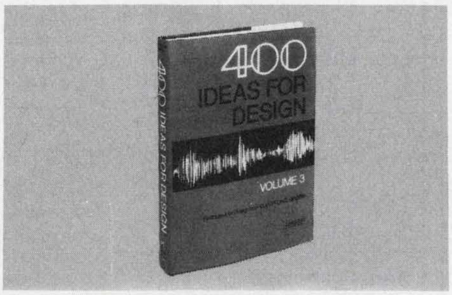

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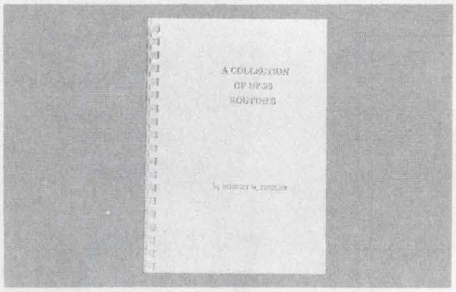

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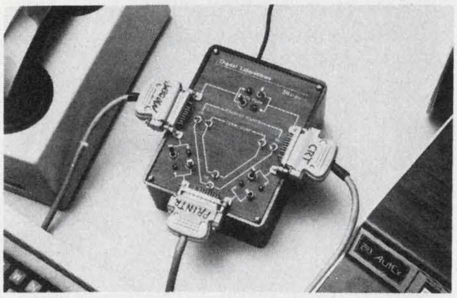

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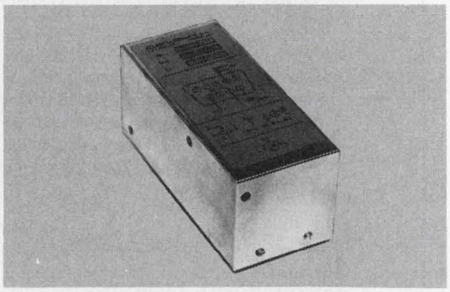

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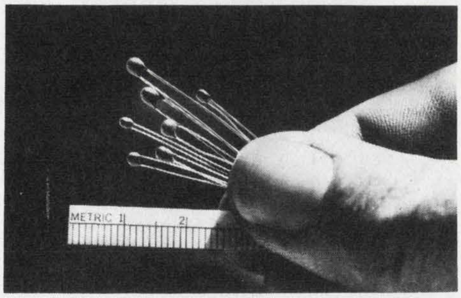

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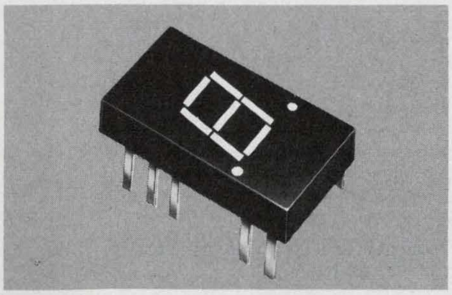

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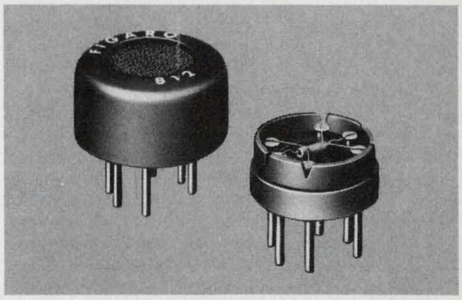

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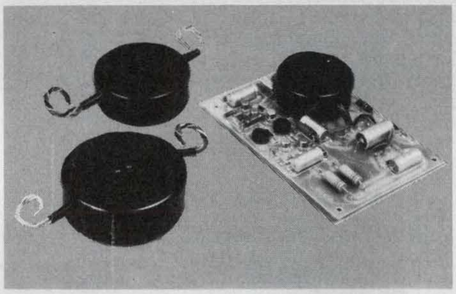

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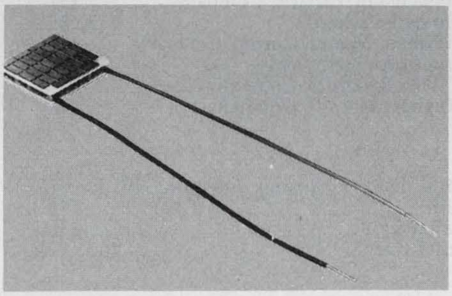

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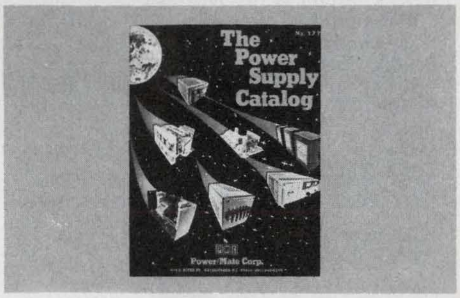

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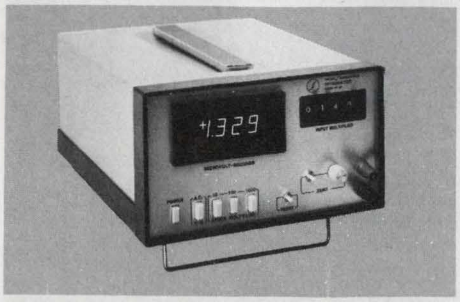

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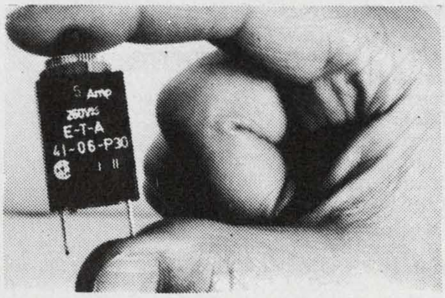

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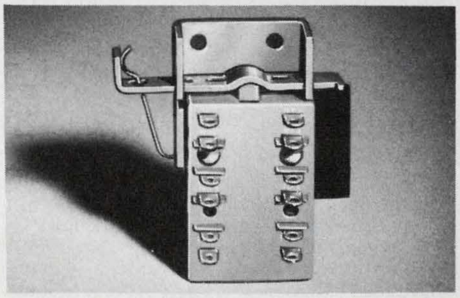

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application notes

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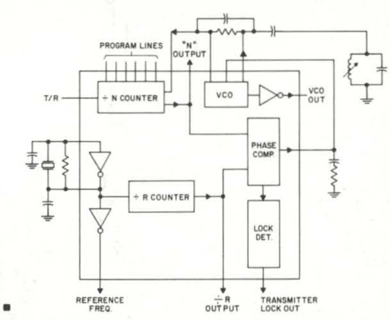
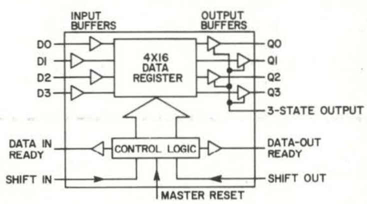
On a single chip you get 4 independent FIFO registers that can be used in parallel. CD40105B is 4 bits by 16 bits long, is expandable, and features independent asynchronous inputs/outputs (outputs are 3-state). It really shines in microprocessor applications requiring input/output peripheral buffering.

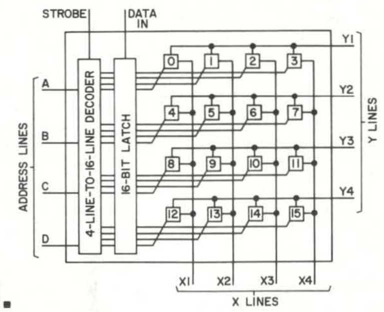
Circle 242



1.



2.



3.

3 4 x 4 Crosspoint Switch: lower the cost per crosspoint.

The CD22100 is 16 switches on a single chip, replacing 16 relays (at about 1/3 the cost) or 3 standard ICs. This can mean major space savings in in-house telephone and data communications systems, for example. And of course fewer connections means higher reliability. Coming soon: a 4x4x2 crosspoint switch.

Circle 243

For more information on these COS/MOS integrated circuits, contact your local RCA Solid State distributor.

Or write: RCA Solid State. Box 3200, Somerville, NJ 08876; Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste.-Anne-de-Bellevue, Quebec, Canada; Fuji Bldg., Tokyo, Japan.

RCA COS/MOS experience is working for you.

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