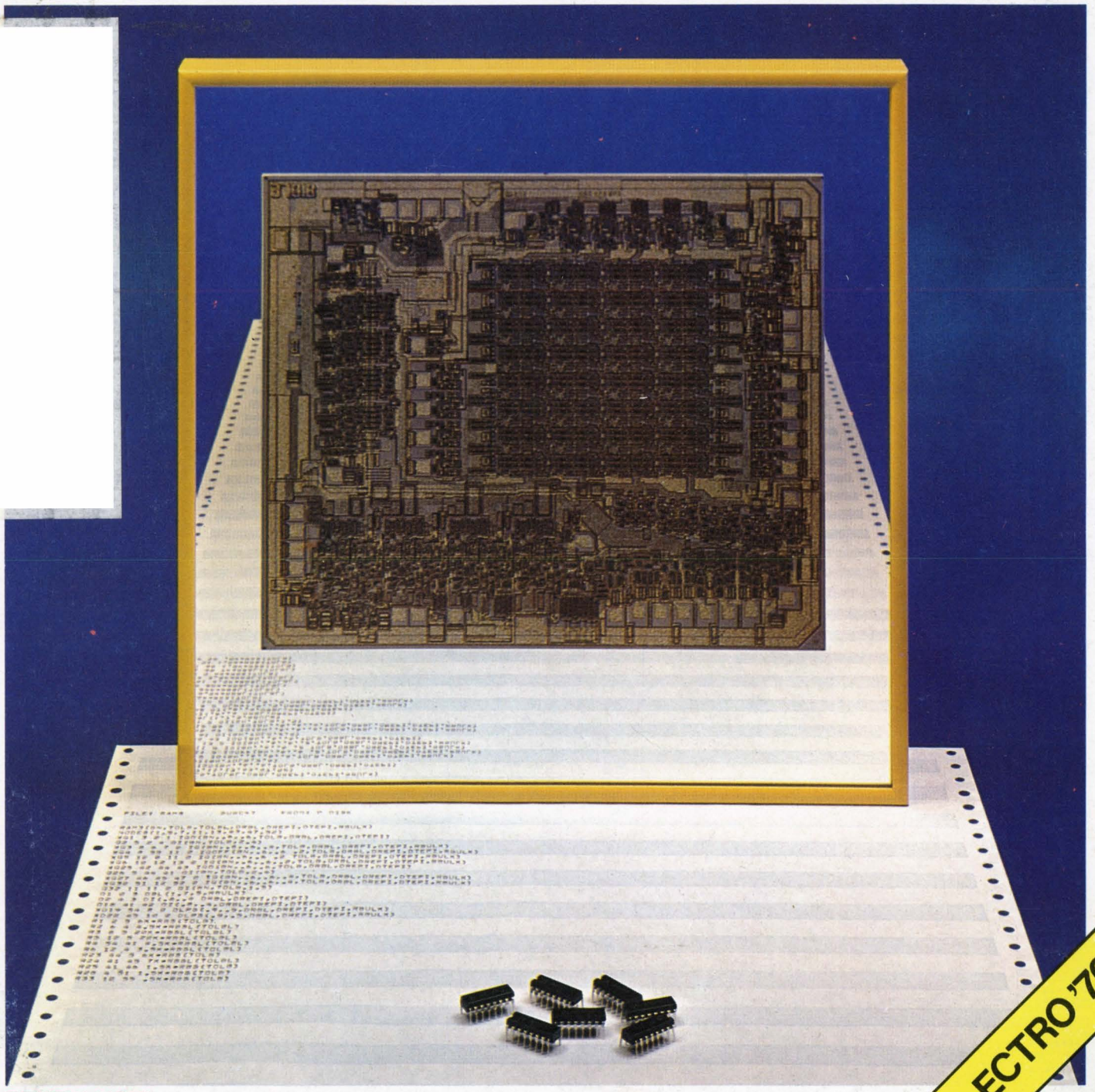
VOL. 24 NO.

Electronic Design 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1976

Bipolar bit-slice microprocessors replace scores of conventional logic circuits at reduced power. Through microprogramming, you can achieve a precise emulation of existing equipment without the need to change system software. The result: minis and high-speed controllers can be made smaller and more versatile. See p. 34.



ELECTRO'76

RENEW NOW
YOUR SUBSCRIPTION WILL EXPIRE. See card inside cover.

Swage-Bond™ ... a revolution in trimmer reliability!

... here today at no extra cost in every Trimpot® Potentiometer

Historically, pin-to-element termination problems have been one of the primary causes of trimmer failure . . . especially during handling and PC board process operations. Bourns exclusive Swage-Bond™ process virtually eliminates pin termination failure . . . truly a revolution in trimmer reliability. Furthermore, Swage-Bonding results in a marked improvement in temperature coefficient consistency.

Other trimmer manufacturers utilize a simple clip-on termination. Some solder this connection, some rely on tension pressure alone. In the Swage-Bond process, the P.C. pins are secured **through** the substrate, with a high-pressure compression swage on both top and bottom sides. The pressure of the swage locks the pin solidly into the element, and thoroughly bonds it to the thick-film termination material.

Swage-Bond™ eliminates pin termination failure, provides more reliable tempco. Microphotograph shows trimmer element magnified 20X.

The seal that seals . . . without springback

Bourns trimmers stay sealed when others fail. We know. We've tested them all. Bourns uses a chevron-type sealing technique, that seals without O-rings . . . eliminating the windup and springback that frequently occurs with such seals. The result is faster and more precise adjustability . . . with a seal that really works.

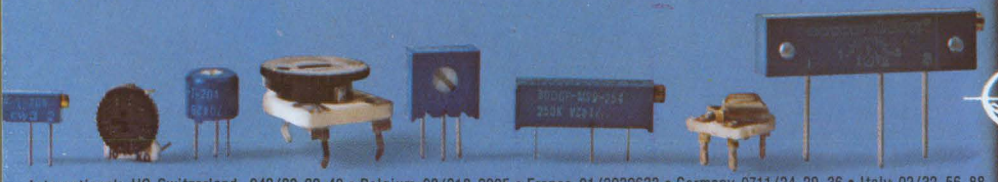
Wrap-around wiper for better setting stability

Bourns multi-fingered, wrap-around wiper delivers more consistent, more reliable performance. The unique design significantly reduces CRV fluctuations and open circuit problems due to thermal and mechanical shock . . . by maintaining a constant wiper pressure on the element. Compare the ruggedness of Bourns design with the common "heat-staked" wiper designs. Compare performance. Specify Bourns.

HERE'S PROOF:

Send for a copy of our new engineering report on TRIMMER PERFORMANCE. Tell us about your application, and we'll provide qualification samples that best suit your needs.

Bourns reliability is available at ordinary prices . . . off-the-shelf from nearly 100 local distributor inventories . . . plus our largest-ever factory stock. TRIMMER PRODUCTS, **TRIMPOT PRODUCTS DIVISION,** BOURNS, INC., 1200 Columbia Avenue, Riverside, California 92507. Telephone 714 781-5320 — TWX 910 332-1252.



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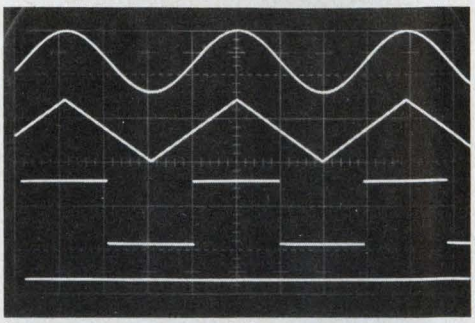
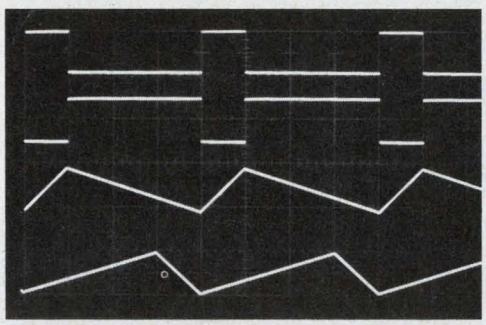
CIRCLE NUMBER 282

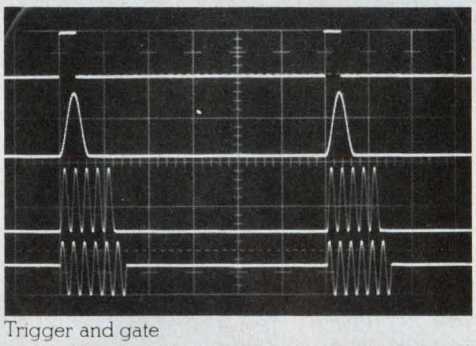
The Model 186 art gallery.



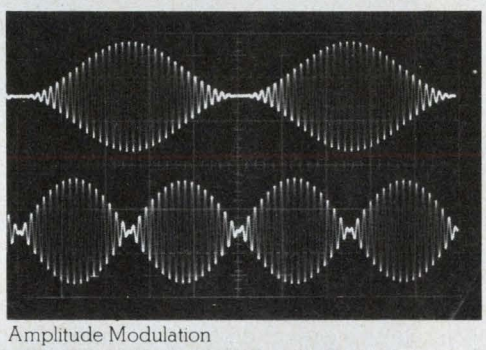
Sine, square, triangle and dc.



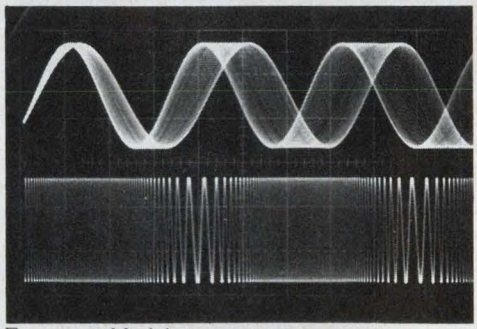
Pulse and ramp.



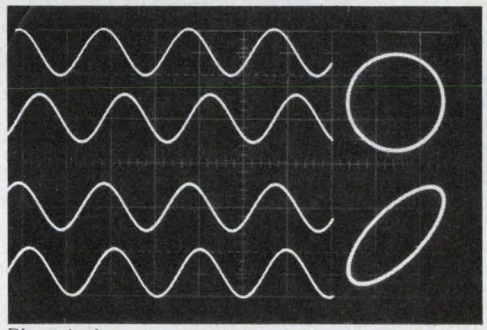
Trigger and gate.



Amplitude Modulation.

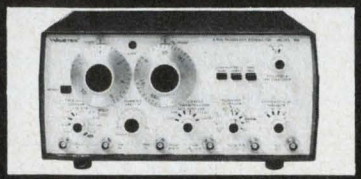


Frequency Modulation.



Phase lock.

There's a whole lot more to the Model 186 than just pretty pictures. Like its calibrated phase lock and built-in oscillator for 1 kHz AM/FM capabilities. It also has 30 v p-p output plus continuous, triggered and gated modes. And it's the only generator that gives you the combination of AM and phase lock.



The Model 186 has a frequency range of 0.0001 Hz to 5 MHz and sells for just $795. Just circle our bingo number and we'll send you the complete picture.

WAVETEK®

P.O. BOX 651, SAN DIEGO, CALIFORNIA 92112
TELEPHONE (714) 279-2200, TWX 910-335-2007

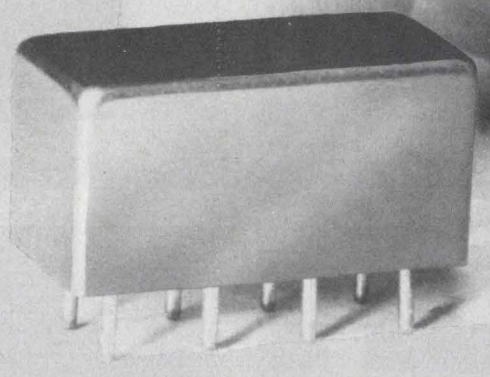
CIRCLE NUMBER 2

The only Double-Balanced Mixers with a 2-YEAR GUARANTEE*

featuring Hi-Rel tested diodes-

still only

$7.95 (500 pieces)
$9.95 (1-49)



***including diodes!**

Yes, a two-year guarantee for DBM's is now a reality . . . made possible by an accelerated-life diode screening program adopted at Mini-Circuits.

Each Schottky diode used in Mini-Circuits' SRA-1 mixers is now preconditioned by the HTRB (High Temperature Reverse Bias) technique, previously reserved almost exclusively for semiconductors assigned to space applications. With HTRB testing, each diode is operated for 168 hours at 150°C with one volt reverse bias applied.

To screen out "infant mortality", the diodes are deliberately stressed to accelerate aging and to force time-related failure modes to take their toll. In conventional testing or "baking", the diode does not experience anywhere near the stress encountered with the HTRB program. Hence, the ability at Mini-Circuits' to locate the potentially-unreliable diodes before they are assembled into SRA-1 units And, with double-balanced mixers, the overall reliability hinges almost entirely on the diodes used.

Yes, the HTRB procedure costs us more and screens out more devices. But our goal is to improve reliability to a level unmatched for off-the-shelf DBM's at no increase in cost to our customers. You — our customers by your overwhelming confidence in our product line have made us the number one supplier of DBM's in the world.

To earn your continuing support, we are now employing HTRB Hi-Rel testing for every diode used in the SRA-1, at no increase in cost to you. So, for the same low price of $7.95, you can purchase our SRA-1, with a two-year guarantee, including diodes.

To ensure highest system reliability demand highest quality diodes on your source-control drawings and purchase orders. Specify SRA-1 mixers, with HTRB tested diodes from Mini- Circuits... where low price now goes hand-in-hand with unmatched quality.

MODEL SRA-1

Freq. range (MHz) **LO** - 0.5-500, **RF** 0.5-500, **IF** dc-500

Conversion loss (dB)		**Typ.**	**Max.**
One octave from band edge		5.5	7.5
Total range		6.5	8.5
Isolation (dB)		**Typ.**	**Min.**
Lower band edge to	**LO-RF**	50	35
one decade higher	**LO-RF**	45	30
Mid range	**LO-RF**	45	30
	LO-IF	40	25
Upper band edge to	**LO-RF**	35	25
one octave lower	**LO-IF**	30	20

Min. Electronic attenuation (20 mA) 3 dB

Signal, 1 dB compression level + 1 dBm

Impedance all ports 50 ohms

HTRB Tested (High Temperature Reverse Bias)

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US DISTRIBUTORS: NORTHERN CALIFORNIA Cain-White & Co., Foothill Office Center, 105 Fremont Avenue, Los Altos, CA 94022 (415) 948-6533; **SOUTHERN CALIFORNIA, ARIZONA** Crown Electronics, 11440 Collins Street, No. Hollywood, CA 91601 (213) 877-3550

For complete product specifications and U.S. Rep. listing see MicroWaves "Product Data Directory," Electronic Designs' "Gold Book" or Electronic Engineers Master "EEM"

CIRCLE NUMBER 3

VOL. 24 NO.

Electronic Design 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1976

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94 **Log data under μP control** and enjoy the benefits of software flexibility. Among the advantages: reformattable interfaces and less hardware.

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CMOS analog switches can precisely control an op-amp's gain.
Control a VCO's start and stop phases with a squelch input signal.
Efficient switching controller drives low-power dc servo motor.

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Cover: Photo by Hal Smith, courtesy of Advanced Micro Devices.

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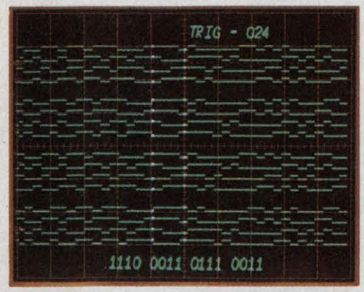
TEKTRONIX logic analyzers

for the digital domain



Timing and binary information together with intensified trigger marker and cursor displayed by the 7D01 Logic Analyzer. The number of sample intervals from the trigger point to the cursor appears at the top of the display; data stored at the cursor position is displayed in binary across the bottom of the crt.

New Plug-ins with Expanded Capabilities

For digital design and testing applications, you'll find that Tektronix Logic Analyzers and Oscilloscopes are literally made for each other. To expand your digital analysis capabilities, choose either the 7D01 Logic Analyzer (a new plug-in for our 7000-Series laboratory oscilloscope family) or the LA 501 Logic Analyzer and its new companion plug-in, the WR501 Word Recognizer (these two are packaged as modular TM 500-Series instruments to work with almost any oscilloscope).

Features these analyzers have in common include:

- **16 Channel Operation**
- **15-ns Asynchronous Timing Resolution**
- **4k Memory to Store Pretrigger Data**
- **Word Recognition**
- **High Z Probes**

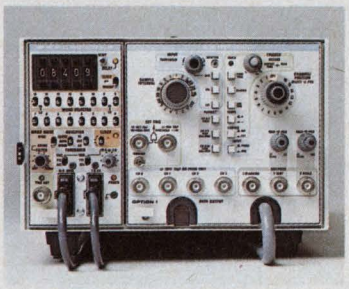
For versatile data acquisition, these logic analyzers let you select the number of channels and the resolution best suited to specific applications:

16 Channels, 20 MHz, 256 Memory Bits

8 Channels, 50 MHz, 512 Memory Bits

4 Channels, 100 MHz, 1024 Memory Bits

You'll like what we've done to **reduce circuit loading problems** associated with testing high-speed and high-impedance logic families. With our new P6451 active probes, which have an input impedance of **1 MΩ paralleled by 5 pF at the probe head,** you'll be able to test virtually any logic family.



LA501/WR501, Members of the TM 500 Series

Take your logic analyzer right to the problem with the LA 501 Logic Analyzer and its new companion word recognizer, the WR 501. Packaged as modular TM 500 test instruments, this pair works with any oscilloscope or X-Y monitor. Now you've got versatile logic analysis capabilities to complement the oscilloscope you probably already own.

Word recognition with digital delay gives you fast access to almost any location in the data stream.

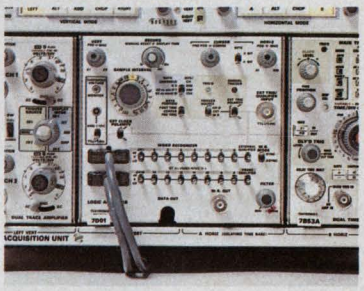
For **channel-to-channel timing comparisons,** you can select any trace and position it next to any other. And **timing tic marks** on each channel enhance visual analysis.

No matter what your application—design, production testing, or service we've got a TM 500 logic analysis configuration for you.

On the bench, power the LA 501 and WR 501 with the TM 503 mainframe or the TM 504 mainframe (now you've got room for another TM 500 module like the DMM 502 Digital Multimeter).

In a rack, use the RTM 506—there's room enough for the LA 501, the WR 501, the SC 502 Oscilloscope, and one more module. Or you can mount the LA 501 and WR 501 in a TM 503 side by side with a 604 Monitor. The 6½-in. display is easy to read.

For **field portability,** try the TM 515 Traveler Mainframe. It's rugged and durable, yet as attractive as carry-on luggage. You can pack the LA 501, the WR 501, and the SC 502 and have a complete logic analysis system in a suitcase.



7D01, A Member of the 7000 Series

Turn any 7000-Series laboratory oscilloscope into a versatile 16-channel logic analyzer with the new 7D01 dual-wide plug-in. Now, gaining logic analysis capability is as simple as adding a plug-in.

With a four-compartment 7000-Series mainframe and plug-ins, you get a truly powerful logic design tool: **a logic analyzer and a real-time oscilloscope in one unit.** Use the 7D01 Logic Analyzer to locate a digital domain problem, then zero in for detailed analysis by using the 7D01's word recognizer to trigger the analog portion of your oscilloscope. Now you can do it with one instrument and display your digital and analog information on the same crt.

With the 7D01 you also get **timing and binary information displayed simultaneously** on the crt. You do it with a cursor. And because the cursor can be moved in single clock intervals, **timing comparisons are faster, easier and more error-free than visual estimates.** When the cursor is moved to a given clock position, the binary word at that point is read out across the bottom of the display.

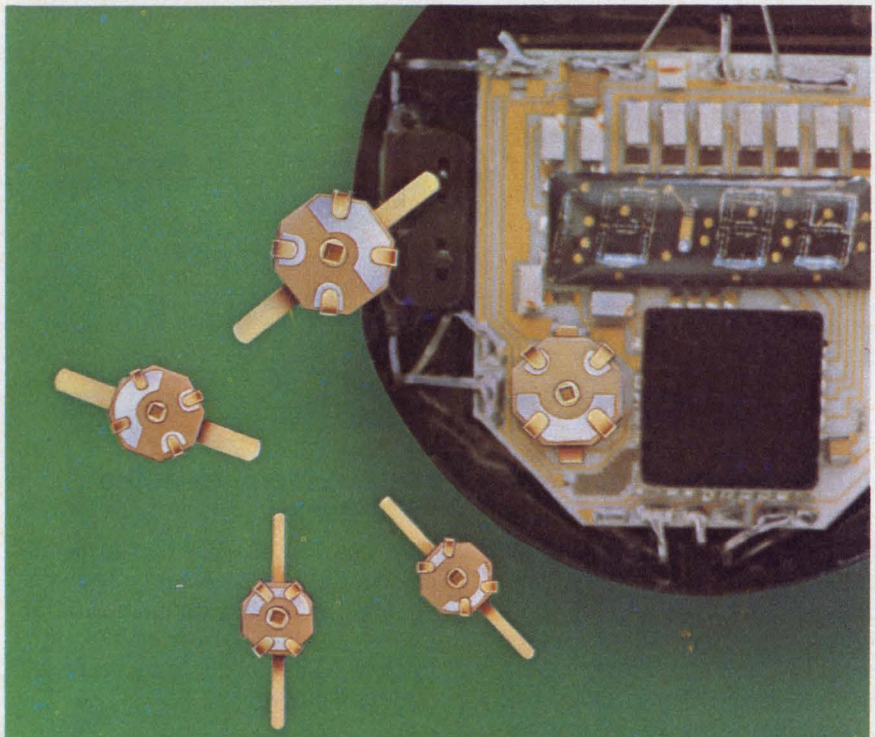
The LA 501/WR 501 and the 7D01 Logic Analyzers will be on display at ELECTRO76. Stop by our booth for all the details and a hands-on demonstration. If you can't make it to the show, call your nearby Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton OR 97077.

New at ELECTRO76

TEKTRONIX®

committed to technical excellence

FOR TECHNICAL DATA CIRCLE #275
FOR DEMONSTRATION CIRCLE #276



Thin-Trim® capacitors

Tucked in the corner of this Pulsar Watch is a miniature capacitor which is used to trim the crystal. This Thin-Trim capacitor is one of our 9410 series, has an adjustable range of 7 to 45 pf, and is .200" x .200" x .050" thick.

The Thin-Trim concept provides a variable device to replace fixed tuning techniques and cut-and-try methods of adjustment. Thin-Trim capacitors are available in a variety of lead configurations making them easy to mount.

A smaller version of the 9410 is the 9402 series with a maximum capacitance value of 25 pf. These are perfect for applications in sub-miniature circuits such as ladies' electronic wrist watches and phased array MIC's.

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CIRCLE NUMBER 4

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Across the Desk

Bicentennial issue praised

Look ahead

Congratulations on your "200 Years of Progress" issue (ED No. 4, Feb. 16, 1976) and the letter from President Ford. The Bicentennial makes me a little worried, unfortunately, that we may become so lost in retrospection that we may overlook what needs to be done in the future.

William N. Bushey
5002 N. 78th Street
Scottsdale, AZ 85253

Required reading

Last night I couldn't put down the ED Bicentennial Issue! Reads better than fiction—absolutely fascinating! My copy is already circulating around San Antonio to selected friends who would appreciate your efforts.

I can remember lamenting the meager (or nonexistent) historical data grudgingly given by EE profs during school. Your special issue should be required reading material for students of the industry.

Leroy H. Becker
Union Instrument Corp.
12108 Radium
San Antonio, TX 78216

'Absolutely great'

ELECTRONIC DESIGN has done it again! Your special Bicentennial issue was absolutely great! Dr. Dibner was especially pleased with your article.

Please extend our congratulations to all who participated.

Therese Michalic
Burndy Corp.
Norwalk, CT 06856

An early phonograph

Your account of "200 Years of Progress" was great—really great! It was all succinctly stated and the manner in which concurrent events from other fields were woven in put your account of electrical history into refreshing perspective.

One addendum may be of interest: you mentioned (p. 102) Bell's licensing the Orthophonic phonograph system to Victor. As I recall, this system was a high-fidelity acoustic phonograph of remarkable tonal quality. According to information I recently stumbled across, the design of the acoustic pick-up head for that system was among the first applications of network theory to mechanical problems.

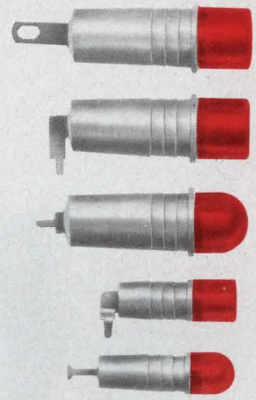
By manipulating the values of electrical analogs of the mechanical parts of the system, including a specially contoured aluminum diaphragm that functioned as the sound transducer, Bell engineers arrived at a design that had flat, broadband response—and it really delivered clean sound. Unfortunately, it didn't compete in the marketplace against the then-emerging, more powerful vacuum-tube systems.

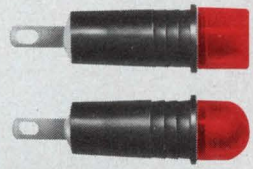
Howard Roberts
Hewlett-Packard Co.
1501 Page Mill Rd.
Palo Alto, CA 94304

(continued on page 10)

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, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

The smallest* re-lampable indicators are





Illuminated Products' QT Series incandescent, neon, and LED indicators

- ☐ Long-life reliability
- ☐ Simplified press-in panel mounting
- ☐ All popular lens colors and styles
- ☐ Distributor on-shelf availability now

*Actual size shown

Lighten your decisions
contact . . .

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Santa Ana, California 92711
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OAK
COMPONENTS GROUP

CIRCLE NUMBER 5

The AMI 6800 Micro

We started by redesigning a CRT. And ended with the fastest, easiest way to build microcomputer systems.

The AMI 6800 MDC architecture is so far ahead of the competition they'll have to change their whole development philosophy to catch up.

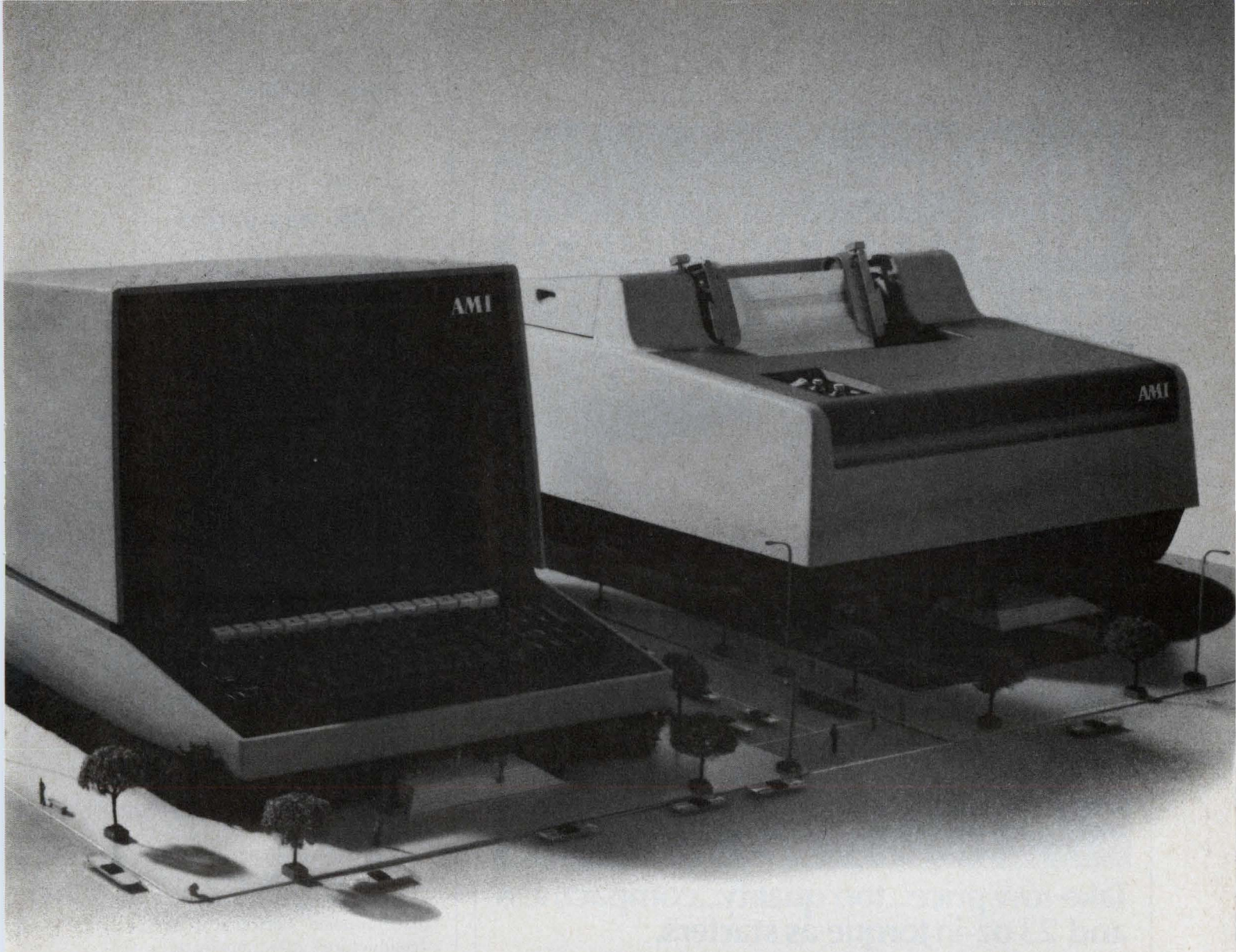
Unlike their multiple box approach, with lights and switches, our grand plan is centered around a very smart CRT, with full debug software.

There's a 6800 system in the terminal, so the processor you're working with is the same one you're developing. That cuts your learning time in half.

And you can forget about those long hassles with paper tape, front panels, teletype or cassettes. Put your hands on our keyboard and you never have to let go. You modify information instantaneously. Interrupt a program after every instruction, and get a complete snapshot of the state of the machine. Look at all the registers and change their values, simply by pressing a key. And you never have to translate addresses into binary to get information.

Our 6800 MDC not only cuts programming time in some cases from hours to minutes, it can also be configured as a test center for incoming 6800 parts. And it adapts easily to a powerful, one megabyte microcomputer for a variety of uses, such as inventory control.

The standard AMI Microcomputer Development Center consists of the 80 char. x 25 line CRT, the dual floppy disk with disk operating system, S6834 EPROM programmer,



computer Development Center.

RS232 interface and 16K words of RAM memory. The many options will include a character printer, an in-circuit emulator so you can use the CRT like a front panel, EPROM and RAM memory modules.

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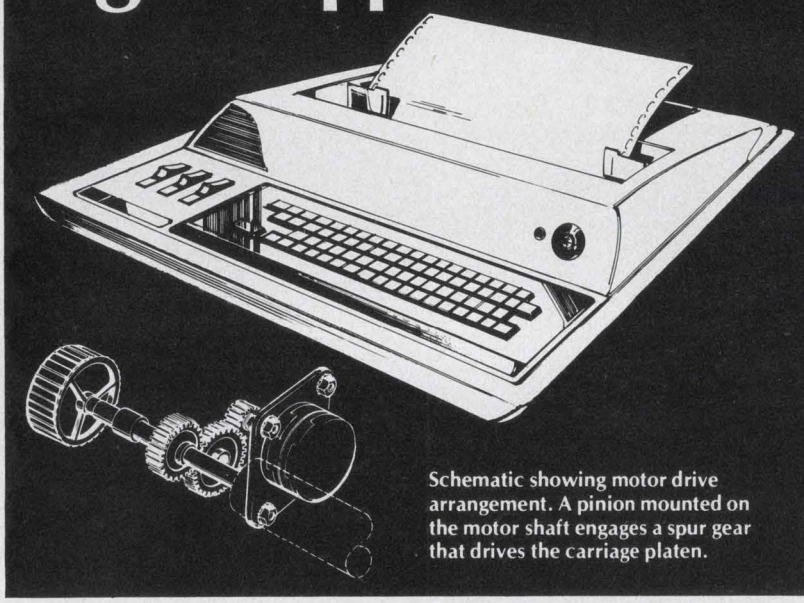
CIRCLE NUMBER 12

You'll like what printer designers like about the 82900 logic stepper motor.



Schematic showing motor drive arrangement. A pinion mounted on the motor shaft engages a spur gear that drives the carriage platen.

Take low price...top quality...compactness and 23 oz-in torque as starters.

The new 82900 stepper motor is built to do yeoman's service not only in impact and non-impact printers, but in small X-Y plotters, chart drives and computer peripherals. Yes, even medical instrumentation, where its reliability really pays off. Compact size, efficiency, low cost and 23 oz-in torque @ 200 PPS all combine to offer design advantages unobtainable in larger, bulkier and more expensive steppers.

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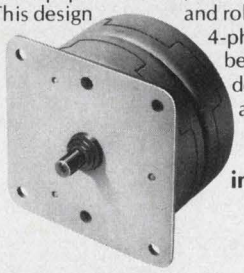

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CIRCLE NUMBER 7

(continued from page 7)

OSCAR was earlier

Your Bicentennial edition was well done. I would like to add that on Dec. 12, 1961, the OSCAR I satellite was orbited (Orbiting Satellite Carrying Amateur Radio), built entirely by radio amateurs. Is it then not the first privately owned satellite—contrary to a statement on p. 120 accompanying the picture of the Telstar satellite?

Thomas E. Wulling
1723 Terrace Dr.
St. Paul, MN 55113

Early terminology

On page 62 introducing your Bicentennial issue it is stated that Franklin ". . . was first to propose the theory that there are two kinds of electricity—positive and negative." Actually, this is incorrect, and Franklin's contribution of the one-electricity theory is duly noted later (p. 68) in Stanley Runyon's article.

However, earlier (p. 67), Runyon makes another small error. He writes, "It was Gilbert . . . who distinguished between electrics (conductors) and nonelectrics (insulators) . . ." The pre-19th century electricians referred to substances which could easily acquire a static charge by friction as "electrics" and those which could not (unless insulated) as "nonelectrics." Electrics today would be generally referred to as insulators and nonelectrics as conductors.

The polarity of electricity produced by rubbing electrics depended on their position in an empirical triboelectric series, ranging from glassy substances or "vitreous" (acquiring positive charge) to "resinous" like amber (acquiring negative charge), leading many of the ancients to adopt those terms for supposedly two types of electricity. Many of the phenomena associated with frictional electricity are still under investigation to this day.

David Ecklein
P.O. Box 203
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(continued on page 18)

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(851-D shown actual size.)

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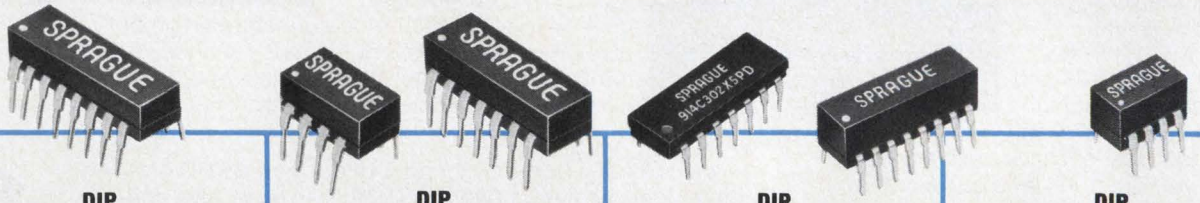
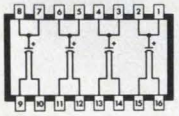
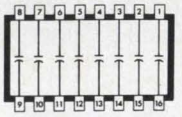


DIP MULTIPLE TANTALUM CAPACITORS



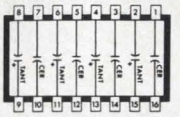
Solid-electrolyte tantalum capacitors with 2 or 4 sections per package. 8- or 16-pin configurations. Standard ratings are 6.8 μF @ 35V, 15 μF @ 20V, 22 μF @ 15V, 33 μF @ 10V. Capacitance tolerance, ±20%. Operating temperature range, −55 C to +85 C. Write for Bulletin 3542 or circle 151 on reader service card.

DIP MULTIPLE CERAMIC CAPACITORS



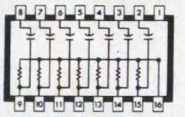
Monolythic® construction . . . alternate layers of ceramic dielectric material and metallic electrodes are fired into a solid homogenous block. 2, 4, 7, or 8 capacitor sections per package. Standard ratings, 18 pF to 0.1 μF @ 100V. Capacitance tolerance, ±20%. Write for Bulletin 6242 or circle 152 on reader service card.

DIP TANTALUM/CERAMIC CAPACITOR ASSEMBLIES



Solid tantalum and Monolythic® ceramic alternating isolated sections. Choice of 4 or 8 sections per package. Standard tantalum ratings, 6.8 μF @ 35V, 15 μF @ 20V, 22 μF @ 15V, 33 μF @ 10V. Ceramic ratings .01, .047, .1 μF @ 100V. Cap. tol., ±20%. Write for Engineering Bulletin 6642 or circle 153 on reader service card.

DIP RESISTOR/CAPACITOR NETWORKS



(1 of 3 designs)

Metanet® metal-film resistors and Monolythic® ceramic capacitors in bypassed pull-up, R-C coupling, speed-up, and active terminator networks. Resistor ratings, 100 to 6800 Ω with 125 mW power dissipation. Capacitor ratings, 100 pF to .01 μF @ 100V. Write for Engineering Bulletin 6612 or circle 154 on reader service card.

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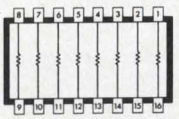
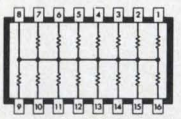


Noble metal film resistors encased in protective glass. Choice of 7 or 8 resistors per 14- or 16-pin package. Resistance values, 50Ω to 100,000Ω. Power dissipation, 125 mW. Standard resistance tolerance, ±5%. Operating temperature range, −55 C to +70 C. Write for Bulletin 7042 or circle 155 on reader service card.

DIP PRECISION RESISTOR NETWORKS



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Noble metal film resistors in pull-up, pull-down, interfacing, and terminating configurations, for applications requiring repetitive resistance patterns. 14- or 16-pins. Up to 28 resistors per package. Individual resistors from 50 to 100,000Ω. Dissipation, 125 mW. Write for Bulletin 7042 or circle 156 on reader service card.

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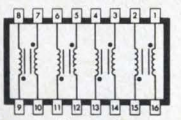

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Four transformers in 16-pin package. All cores have exclusive protective coating. Inductance values from 10 to 1000μH. ET product values of 5 volt-μsec. Choice of four turns ratios . . . 1:1, 2:1, 3:1, 4:1. Operating temperature range, 0 C to +70 C. Write for Engineering Bulletin 40400 or circle 157 on reader service card.

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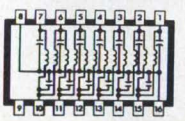

Lumped constant delay lines . . . ideal for timing and pulse synchronization circuits. 14- or 16-pin packages with delays of 50, 100, or 150 nanoseconds at a characteristic impedance of 100Ω. Working voltage, 50 VDC. Operating temp. range, 0 C to +70 C. Write for Bulletin 45004 or circle 158 on reader service card.

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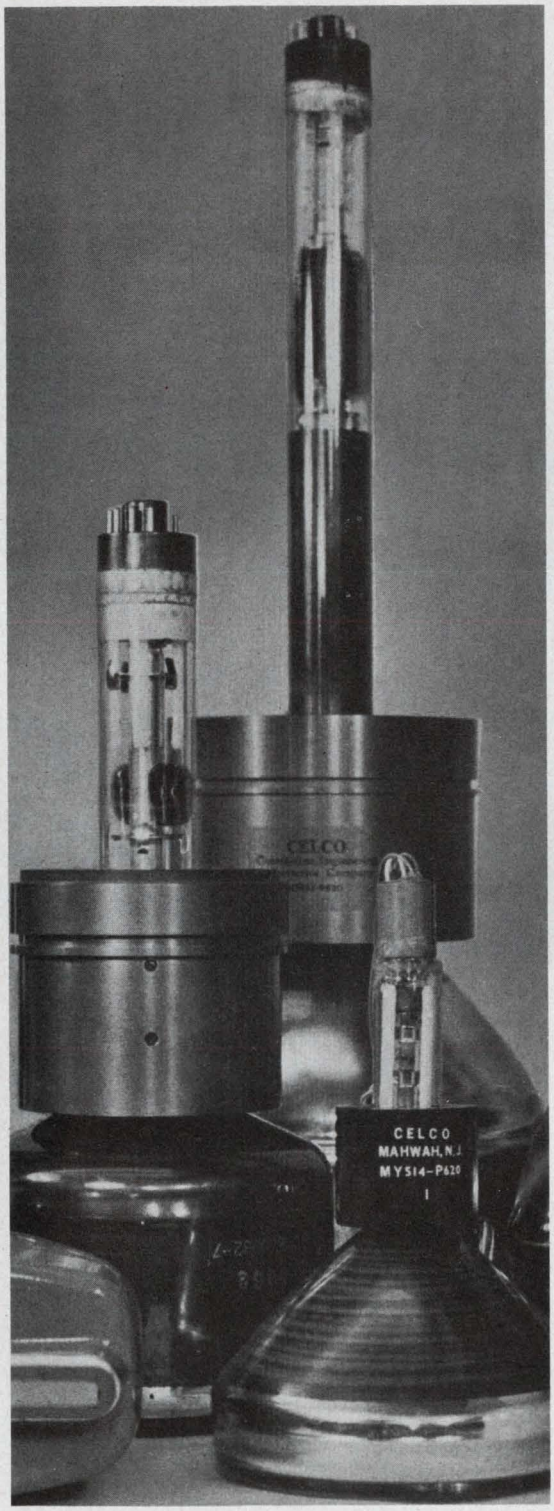

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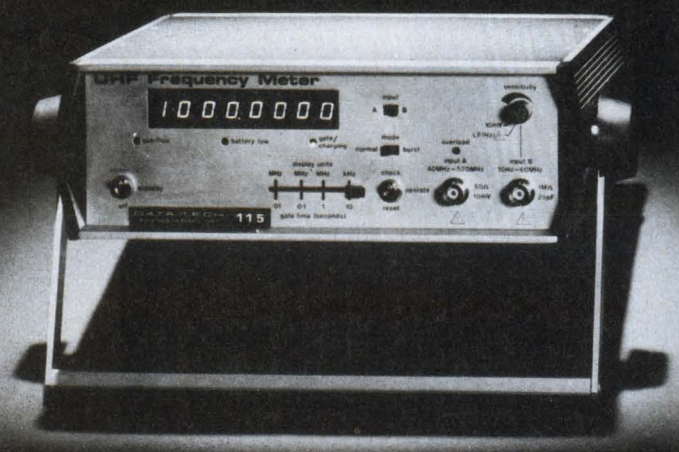

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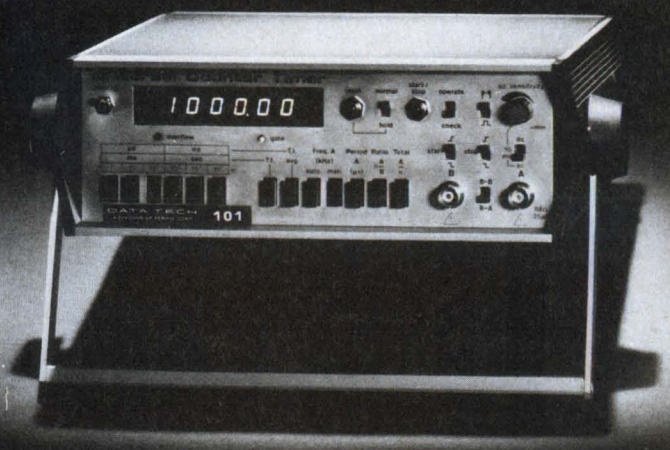

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CIRCLE NUMBER 31

(continued from page 10)

Filter article 'ideal'

Congratulations on your Feb. 16 issue! Not only did you give an exhilarating dissertation on two hundred years of progress, but the technical articles rated among the best I have ever seen.

The one article I found to be most interesting was Dr. Delagrange's "ideal" translating filter. The technique is something I was until now unfamiliar with (and I am sure this is true of many others). Although I am not usually called upon to create such a filter, the realization of the possibility of such a filter has added a new dimension to my knowledge. This is what a technical journal is supposed to do!!

And you did it!—Keep it up.

Rudy Schneider
Design Engineer
Carco Electronics
195 Constitution Dr.
Menlo Park, CA 94025

Misplaced Caption Dept.

There's something about the service in our company cafeteria.

Sorry. That's Pieter Brueghel the Elder's "A Country Wedding," which hangs in the Kunsthistorisches Museum in Vienna.

A LED lament

The News Scope item, "Color LEDs Gain in Brightness, Reliability," (ED No. 9, Apr. 26, 1976, p. 15) mistakenly said that the reliability of Monsanto's nitrogen-doped multi-colored LEDs has more than doubled in the last year. In reality, the reliability has been improved from 10 to 100 times.

Analog Devices introduces less of a DPM.

When we designed our new line of second generation digital panel meters, we had a clear objective in mind.

Give our customers less of everything. Less of everything they don't want in DPMs, and more of what they need.

Less confusion.

Like less confusion finding the exact DPM they require. With six different second generation DPMs (three +5VDC logic-powered and three AC line-powered) we have the biggest selection available. And each of them benefits from advanced MOS/LSI circuitry, 3½, 4½ or 4¾ digit large LED displays, a full week of failure-free, power cycled burn-in, lower power consumption and lower cost.

Less components.

But let's not talk in generalities. Let's talk specific Analog Devices DPMs where less is a plus. Take our 3½ digit 5VDC Model AD2021 for example. Through the use of MOS/LSI circuitry, we've been able to cut the number of components in it by 42%. And in doing so, chopped power consumption by 42%. Decreased the number of interconnections adding to reliability. Reduced its size to 3"W x 1.8"H x 1.25"D. And dropped its weight to 4 ounces. That's why logic power is your logical choice for compact instrumentation. Our line-powered version, AD2016, offers similar advantages, in its industry-accepted AC-powered package.

Less difficult to read.

Digital panel meters should be easy to read. Get a glimpse of our logic-powered 4¾ digit AD2028 and line-powered AD-2025. Like our other second generation Analog Devices DPMs, they have displays featuring big, high-intensity "light-pipe" LEDs almost twice the size of earlier ones.

Less cost.

With so much that's improved, you'd expect to pay more for our latest DPMs. Surprisingly, that's not the case. Our logic-powered 4½ digit Model AD2027 and line-powered Model AD2024, for instance, are priced 40% lower than their first generation predecessors.

Less is more.

When is less more? When you specify Analog Devices new line of second generation digital panel meters. The real company for precision measurement and control. For complete facts, get the Designers Guide to DPMs. Analog Devices, P.O. Box 280, Norwood, Mass. 02062.

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East Coast: (617) 329-4700, Midwest: (312) 894-3300, West Coast: (213) 595-1783, Texas: (214) 231-5094. Belgium: 03 38 27 07, Denmark: 97 95 99, England: 01/94 10 46 6, France: 686-77 60, Germany: 089/53 03 19, Japan: 03/26 36 82 6, Netherlands: 076-122555 and representatives around the world.

CIRCLE NUMBER 14

You can turn to AMP for thumbwheel switches that'll snap, plug or wire in place.

Or you can go on soldering.

Maybe you're used to connecting or terminating your thumbwheel switches the traditional way—with solder.

Fine.

You can solder an AMP switch, if you want to.

But if you're more inclined to break tradition in the interest of saving time and money, then innovate with AMP: take your choice of wrap-type, snap-in, posted or plug-in interconnections plus a variety of thumbwheel switches (including .500″ and .350″ wide), message wheel, enclosed and sealed configurations, and BCD and BCO codes.

When you turn to AMP for thumbwheels—or any other type of switch—you can expect the type of backup for which AMP is famous.

With professionally concerned sales engineers who want to know about your switching problems. And help you solve them.

And twelve district sales offices across the country—to help them help you.

After all, if you're going to innovate, it pays to have a stable company backing your design.

Why not take time out from soldering. Ask for our thumbwheel switch catalog. Today.

Call Customer Service at (717) 564-0100, or write: AMP Incorporated, Harrisburg, Pa. 17105.

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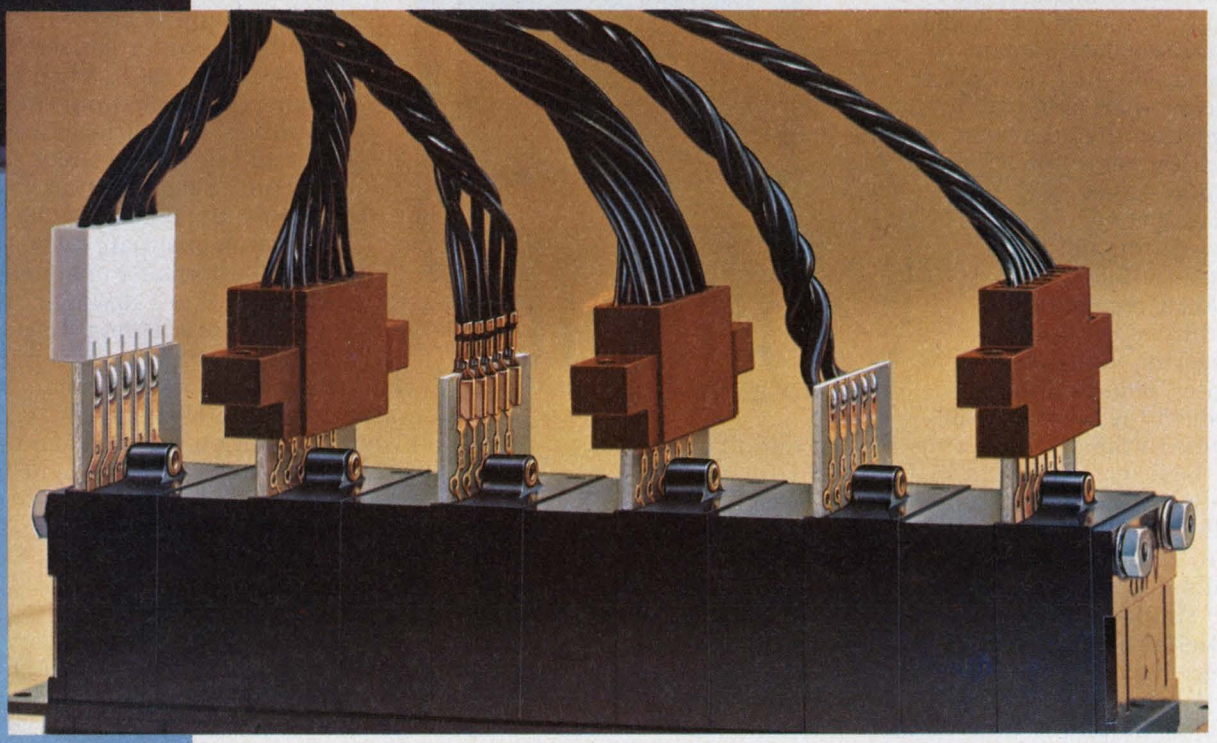
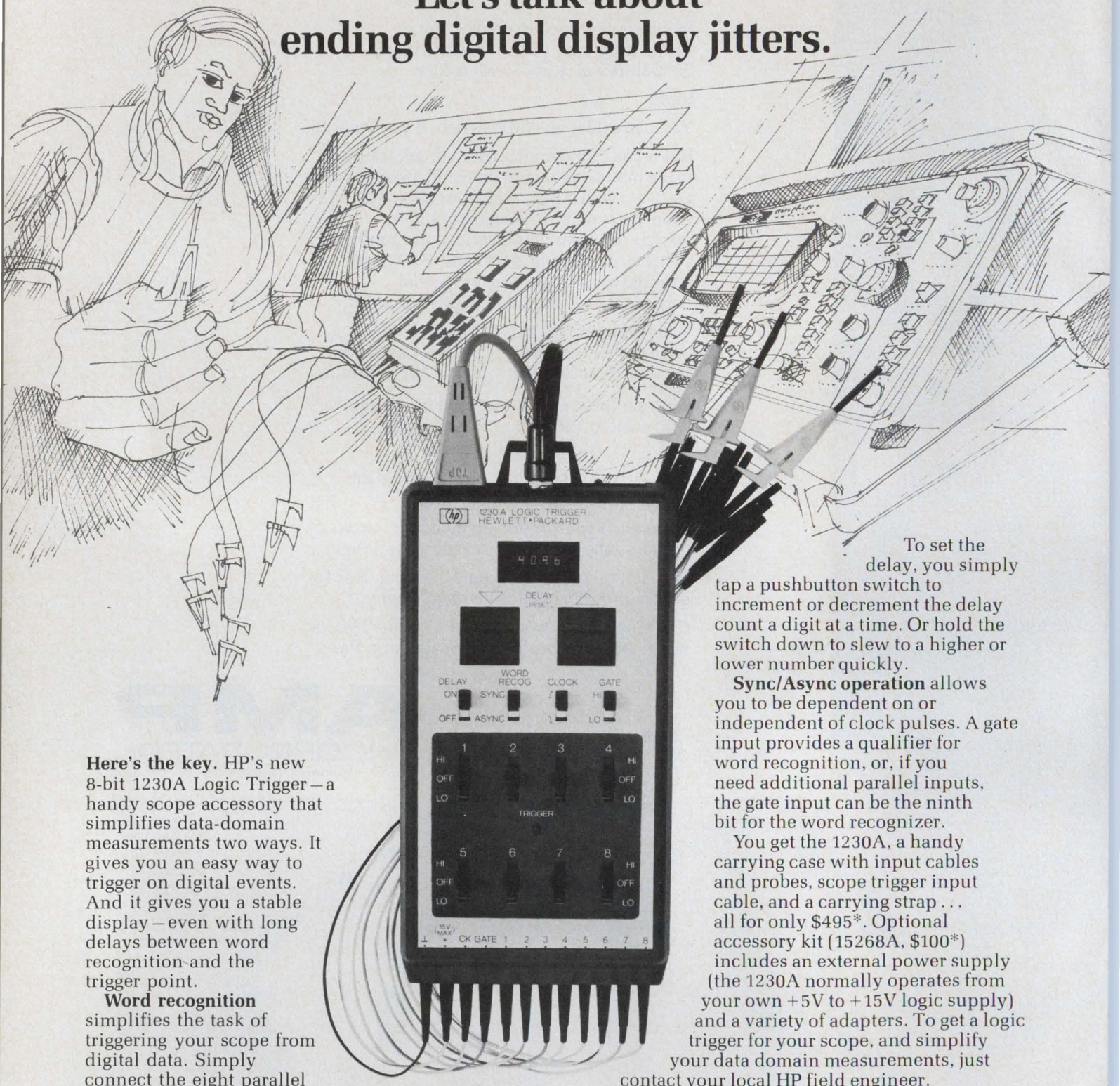
CIRCLE NUMBER 15



AMP is a trademark of AMP Incorporated.

Let's talk about ending digital display jitters.



Here's the key. HP's new 8-bit 1230A Logic Trigger—a handy scope accessory that simplifies data-domain measurements two ways. It gives you an easy way to trigger on digital events. And it gives you a stable display—even with long delays between word recognition and the trigger point.

Word recognition simplifies the task of triggering your scope from digital data. Simply connect the eight parallel inputs to the desired points in your circuit and set the level switches to HI, LO, or OFF (don't care). When the operating logic states agree with the selected input levels, the unit indicates word recognition. And, after the preset delay, sends the trigger signal to your scope. It's just that simple.

Digital delay is the key to stable traces. Trigger delay is based on clock pulses—not time. So you can window on an event occurring up to 9999 clock pulses from the point of word recognition and obtain a jitter-free trace every time.

To set the delay, you simply tap a pushbutton switch to increment or decrement the delay count a digit at a time. Or hold the switch down to slew to a higher or lower number quickly.

Sync/Async operation allows you to be dependent on or independent of clock pulses. A gate input provides a qualifier for word recognition, or, if you need additional parallel inputs, the gate input can be the ninth bit for the word recognizer.

You get the 1230A, a handy carrying case with input cables and probes, scope trigger input cable, and a carrying strap . . . all for only $495*. Optional accessory kit (15268A, $100*) includes an external power supply (the 1230A normally operates from your own +5V to +15V logic supply) and a variety of adapters. To get a logic trigger for your scope, and simplify your data domain measurements, just contact your local HP field engineer.

For 4-bit word recognition, ask him about the models 10250A (TTL), 10251A (MOS), and 10252A (ECL) priced at $95* each. If you need 16-bit serial or parallel word recognition, he'll tell you about the 1620A priced at $1,750*.

*Domestic U.S.A. prices only.

085/14

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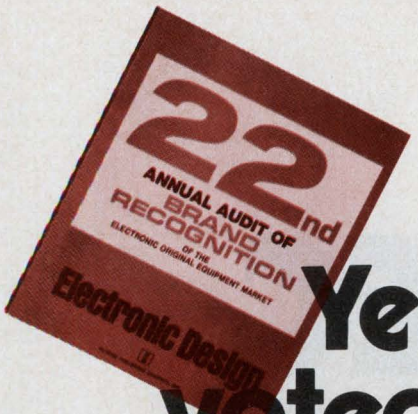
CIRCLE NUMBER 16

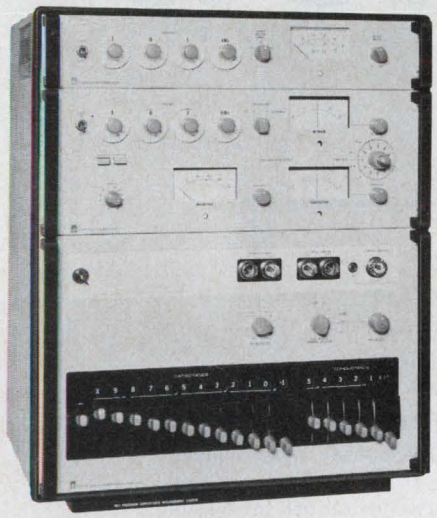


Year after year GR is voted #1 in RLC Bridges

Whenever a product-preference study is conducted, GR is always voted #1 for RLC bridges. And by a wide margin. Perhaps it is because we've been in the business for so long (over 50 years at making bridges). Or maybe our reputation for building in high quality is a factor. Or our engineering savvy. Or whatever. We think it is all these things plus a lot more that keep us in the top spot as a supplier of bridges and RLC standards.

Today, you'll find GR bridges and/or standards in laboratories, at QC and incoming-inspection stations, and in production environments throughout the world wherever R, L, or C measurements are made.

For complete information on GR's broad line of manual, automatic, and precision bridges, as well as RLC standards, request copies of our 40-page *Impedance Measuring Instruments* brochure plus the 36-page brochure on *Impedance Standards and Precision Bridges.*

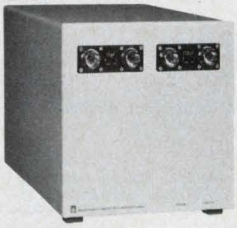


Precision Bridges

This line of products typically find their greatest use in standards labs, where scientists and engineers push the state-of-the-art in measuring electrical parameters. The 1621 Precision Capacitance-Measurement System shown here is capable of measuring capacitance in increments as small as 0.1 attofarads (10^{-1} pF).

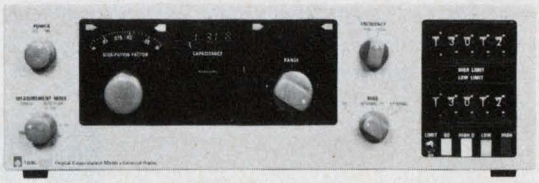
Manual Bridges

Shown here is the 1650-B Impedance Bridge, probably the most popular bridge in use today.



RLC Standards

No bridge is complete without a standard and the GR 1408 Reference Standard Capacitor shown here is just one of dozens available from GR.



Automatic Bridges

GR introduced its first automatic bridge at the WESCON show in 1964. Several other models have followed since, with the 1686 Digital Capacitance Meter shown here being the latest addition to the product line.

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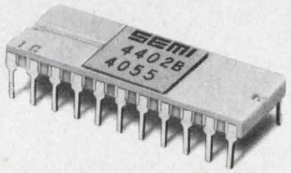
CIRCLE NUMBER 17

The 100 NSEC fully static 4K RAM is here now



100 nsec, access time. The SEMI 4402B is the fastest 4K RAM available today. Now you can build a 150 nsec. access memory system with 4K chip density, and minimum worry about soft bit errors.

Fully static. You can design systems without losing valuable time for refresh, or wasting board space with costly refresh circuitry. The simpler timing requirements mean an easy interface design.

Data protection. Brownout protection or battery backup features can be added to your memory, since the 4402B retains data at low voltage and power levels.

The SEMI 4402B, at 100 nsec. access and 300 nsec. cycle time is available now for immediate delivery. Contact your local EMM SEMI sales office, representative or distributor today.

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CIRCLE NUMBER 18

A new and better way to get crisp, clear facsimile-type records of sonar, radar, or IR thermography.

Honeywell's new 1856A linescan recorder.

The Model 1856A from Honeywell reflects a real advancement in fiber-optic CRT technology. Offers high resolution recordings (greater than 100 line pairs/inch), a broad gray scale capability, intensity modulation to 8 MHz, variable sweep range of 2μsec to 1 sec/cm and 1 cm pk-pk vertical recordings from dc to 75 kHz, with a choice of recording media.

In addition to print-out papers, the 1856A offers even greater flexibility through your choice of two accessory magazine assemblies. The Model 1218A, light-tight and self-contained, permits the use of recording papers and films for wet chemical photoprocessing to obtain an even greater resolution, and optimum reproducibility. When high writing and record speeds are not required, the Model 1219 Processor provides dry-processed high contrast or gray scale recordings on paper or film.

For complete technical specifications, call or write Bob Shipman, Honeywell Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217. (303) 771-4700.

Honeywell

FOR LITERATURE CIRCLE #19

ARE YOU GOING TO THE HARRIS FAMILY PROM?

Every day, more and more companies are making plans to.

Because since the introduction of the new Harris GENERIC PROM family, stand alone PROM designs are steadily losing their popularity.

Now the diverse requirements for density, modularity, and performance within a system can be totally satisfied by this one generic family.

Once you're at the Harris PROM, you'll enjoy many of the advantages of this GENERIC concept.

For instance, each device within a series features compatible DC electrical specifications plus common programming requirements, permitting easy use of other family elements.

The Harris GENERIC PROMs also feature fast programming speeds (guaranteed 1 ms per bit, max.). Equivalent I/O characteristics for easy upgrading. Fast access time, guaranteed to meet worst case N^2 sequencing over temperature and voltage. And improved testability.

Right now, our entire family of GENERIC PROMs is in volume production. With 100 up pricing below ½ cent per bit on the popular 1K, 2K, and 4K configurations.

So make a date to come to the Harris family GENERIC PROM.

Just about everyone will be there.

For details, see your Harris distributor or representative.

Device #	No. of Bits	Organi-zation	No. of Pins	Max. Access Time*		Price 100 up	
				Com	Mil	Com	Mil
HM-7602 (open coll)	256	32x8	16	40ns	50ns	$2.95	$5.95
HM-7603 (three state)	256	32x8	16	40ns	50ns	$2.95	$5.95
HM-7610 (open coll)	1024	256x4	16	60ns	75ns	$4.95	$9.95
HM-7611 (three state)	1024	256x4	16	60ns	75ns	$4.95	$9.95
HM-7620 (open coll)	2048	512x4	16	70ns	85ns	$9.95	$19.95
HM-7621 (three state)	2048	512x4	16	70ns	85ns	$9.95	$19.95
HM-7640 (open coll)	4096	512x8	24	70ns	85ns	$19.95	$39.95
HM-7641 (three state)	4096	512x8	24	70ns	85ns	$19.95	$39.95
HM-7642 (open coll)	4096	1024x4	18	70ns	85ns	$19.95	$39.95
HM-7643 (three state)	4096	1024x4	18	70ns	85ns	$19.95	$39.95
HM-7644 (active pullup)	4096	1024x4	16	70ns	85ns	$19.95	$39.95

* Access time guaranteed over full temperature and voltage range
Industrial (T_A = 0°C to 70° C. $V_{CC} \pm 5\%$)
Military (T_A = 55° C to 125° C. $V_{CC} \pm 10\%$)

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CIRCLE NUMBER 20

News Scope

MAY 10, 1976

Graphic display to compete with costly refresh systems

For the first time, an interactive graphics system combines the two leading techniques of computer-controlled displays—storage tube and refresh.

Designed by Tektronix, the industry leader in computer-graphics sales, the 4081 uses two computers to offer the memory and detailed pictures possible with a direct-view storage tube (DVST) and, simultaneously, the animation and selective updating capabilities of a refreshed system.

The Tektronix system costs $27,000 and includes a 19-in. display, a tape-cartridge drive, an ASCII keyboard, 12 function keys, a joyswitch and an RS0323-C communications interface.

In the past, a user of graphics bought an expensive (up to $200,000) refreshed system if he needed selective erase or picture dynamics: motion, three-dimensional perspective, complex rotations and translations. Other features, such as zoom and scaling, also require a refreshed system.

If the price of refresh was too steep, or such elaborate performance, wasn't needed, the user could select a graphics systems based on a DVST display. Since the tube itself captures and holds the display, no refresh is necessary, and expensive internal memories and other circuitry can be eliminated.

Although the price of storage-tube systems is accordingly slashed —to $10,000, or less—so is the performance. Thus a user must give up the important capability of selective erase. If one character in a line has to be changed—to enter new information or because of a mistake in data entry—the entire picture must be updated.

Updating takes up both the user's and the computer's valuable time. If the graphics system is remotely operated, then fast operation is also essential to keeping down communication charges. And because the tube stores the picture, animation isn't possible.

The 4081 overcomes these limitations by use of two internal computers: a general-purpose processor from Interdata and a special display processor or controller.

With two "brains" teaming up to control the picture, refresh graphics can be written at a rate of 54,000 vector-cm/s, and storage graphics at 13,500 vector-cm/s.

However, there are some limitations to the 4081's refresh characteristics. Dynamics are limited to a band, or portion, of the display. The band can appear anywhere on the screen, at the user's discretion. In terms of the number of display vectors, or the number of points, the picture is flicker free for up to 1600 vector-cm or 800 vectors, whichever limit comes first.

A number of standard and optional software packages allow stand-alone operation or connection to a host computer.

CIRCLE NO. 319

Thin films raise solar collector efficiency

Two thin films developed to improve solar-energy-collector efficiency may also be useful in the temperature control of electronic components or packages. The films were produced by vapor deposition at MIT's Lincoln Laboratory, Lexington, MA.

One type, a black-gold film about 0.15-μm thick, is deposited on flat-plate collectors to act as a heat trap. It is a combination of 75% magnesium oxide and 25% gold, by volume. When the film is applied to a metal surface it allows radiant energy such as sunlight to pass through, but prevents infrared energy from being emitted.

The second type of thermal film produced by the Lincoln researchers is a transparent, tri-layer structure that acts as a transparent "heat mirror," or radiation insulator. The film is composed of a transparent silver coating that is a sub-micrometer thick, sandwiched between thin films of titanium-dioxide. The layers are deposited sequentially on one side of a glass plate or panel that is used as a cover for energy-absorbing cells.

In experiments, 85% of the visible energy has been demonstrated to pass through the panel, while radiant heat generated internally has been reflected and contained within the cell with an efficiency greater than 90%.

Dr. John Fan, a member of the development team for the films, says the heat mirror can be reversed to maintain cool temperature inside a cell or cavity by preventing external heat from entering.

HP adopts TI's 4-k, 18-pin RAM

The use of newer, high-density, 18-pin 4-k RAMs was given a boost with Hewlett-Packard's recent multi-million-dollar order for Texas Instruments' 4-k dynamic devices. These 18-pin RAMs will be incorporated into memory modules for new 21MX HP minicomputers, according to an HP spokesman.

More than a quarter million of the earlier—and twice as large—4-k, 22-pin RAMs were used in the 21MX machines, beginning in 1974.

HP's adoption of the 18-pin version of the 4-k RAM tilts the scales in favor of industry-wide use of the device. There are presently five U.S.-made versions of the 4-k unit. Two have 22 pins, one has 16 pins and two have 18 pins. Japanese suppliers provide two other pin-outs.

Because of the small size of TI's 18-pin unit, the HP memory modules will have 16-k words instead of the 8-k words of the 22-pin-version modules.

Memory with the new product is priced 30% less than with the earlier modules. The 21MX systems with the new memory typically

cost 12 to 24% less than those using the earlier 8-k modules.

"HP's decision to design the TI 18-pin configuration into its 21MX minicomputer is an important boost for us," said Charles Clough, of TI. "The market for high-density RAMs is a young and growing one."

"The new 18-pin RAMs, while improving compactness and reducing costs are demonstrating a reliability equal to that achieved by the 22-pin RAMs as well as a greater reliability than that of magnetic-core memory systems of equivalent capacity," says HP's William Senske.

"Selection of the TI part was preceded by extensive qualification tests involving over 10,000 parts, through several million hours of accumulated reliability and life testing.

"In addition to our agreement with TI, we are evaluating 18-pin parts from RCA and Advanced Micro Devices for second-source purposes," Senske says.

"Building minicomputers that deliver the reliability promised by 4-k RAMs has turned out to be tougher than anyone expected," reports Richard Anderson, general manager of the HP Data Systems Division in Cupertino, CA, where the 21MX computers are produced.

"In a rush to get 4-k RAMs to the marketplace, many of the semiconductor vendors experienced process problems and included serious design flaws in their parts.

"Some of the major problems solved includes improved temperature-sensitive refresh requirements, oxide-layer breakdown under elevated temperature and voltage stress, and crosstalk internal to the chip that led to pattern sensitivities when the chips were imbedded in memory systems."

High voltage encapsulant triples voltage ratings

The voltage rating of several transformers has been more than tripled compared with materials previously thought of as best, by use of a long-polymer modified-polyurethane encapsulant.

"The voltage rating primarily increases because the encapsulant flows readily into all voids. The polymer cures into a flexible material, without air gaps, that is highly resistant to corona breakdown," says Lynn Whitaker of Hughes Aircraft, Culver City, CA.

"With the new material, we can go to 300 to 500 V/mm with no problem. It also allows transformer size to be reduced by 3 to 6 times that of earlier epoxy-filled designs," he continues.

The material is stable from −65 to +95 C and has a dielectric constant of about 3.0. The dissipation factor is 0.02. Hughes sometimes fills the material with aluminum oxide, or with glass bubbles, to tailor its characteristics. The nominal specific gravity of the material when filled with aluminum oxide is 1.5; when filled with glass bubbles it is 0.8.

It has been used in space applications with little or no outgassing.

The material, still in a developmental stage, has already been used for spaceborne transformers on the MARISAT program. It is also being proposed for use on the Atlas II Radar high-voltage power transformer. Whitaker says that the material is also being used to pot high voltage power supplies.

LSI family reduces size of high-speed systems

Designers of minicomputers and high-speed controllers can now build systems with far fewer components than has been possible, thank to an upcoming LSI family from Signetics.

Called System Logic, the 10-MHz family will use both low-power Schottky TTL and I^2L to replace bipolar MSI in μP support, communications and peripheral I/O applications.

Initial offerings of the series will be the 8X01 Cyclic Redundancy Character Generator/Checker, 8X02 Control Store Sequencer, 8X03 and 8X04 16 × 2 FIFOs, 8X06 and 8X07 64 × 8/64 × 9 FIFOs, and the 8X300 eight-bit microcontroller —originally introduced by Scientific Micro Systems.

Signetics, of Sunnyvale, CA, is developing the System Logic family to supplement its existing 3000 series bipolar bit-slice microprogrammed μP. (see "Bipolar Bit-slice μPs Shrink the Size and Cost of Minis and Controllers," ED No. 10, May 10, 1976, p. 34).

Air Force forms library of software abstracts

The Air Force has compiled more than 8000 abstracts of computer programs for design and analysis into a software library that enables users to avoid reinventing the wheel. The system allows rapid checking to determine whether or not software has already been generated for a similar problem.

During the past two years information from more than 40 government agencies has been supplied to the library, which is located at Hanscom Air Force Base, MA. M/Sgt. Patrick O'Brien, who is responsible for development of the library, says he expects the number of program abstracts in the library to reach 90,000 within the next few years.

The main data base containing the resident programs is located at the IBM 370/155 installation at Wright Patterson Air Force Base, Dayton, OH. At present the central computer-software repository is open only to government agencies.

NASA tests solar cell for home and industry

A program to test solar cells and solar-cell systems for commercial and residential use has begun at NASA's Lewis Research Center, Cleveland, OH. Individuals and organizations can submit their photovoltaic-energy-conversion designs for testing and evaluation under controlled conditions.

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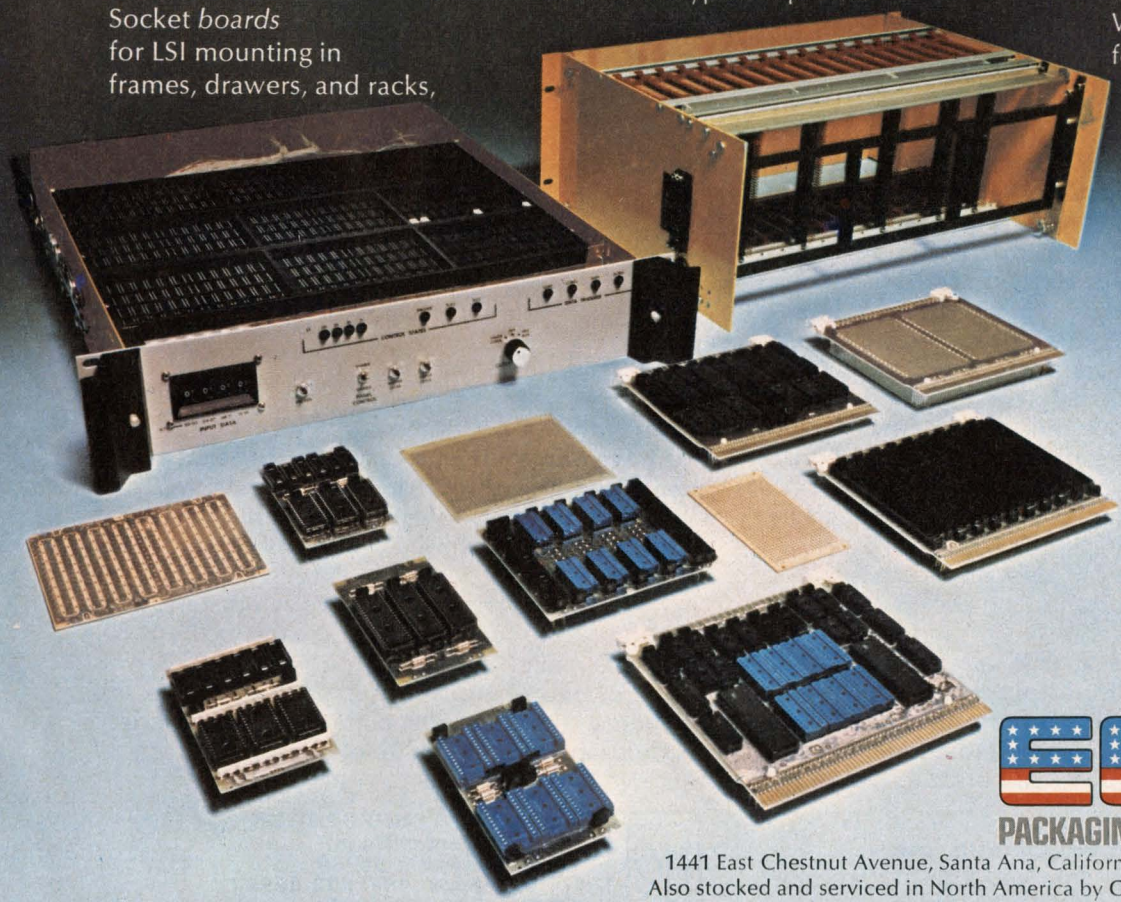

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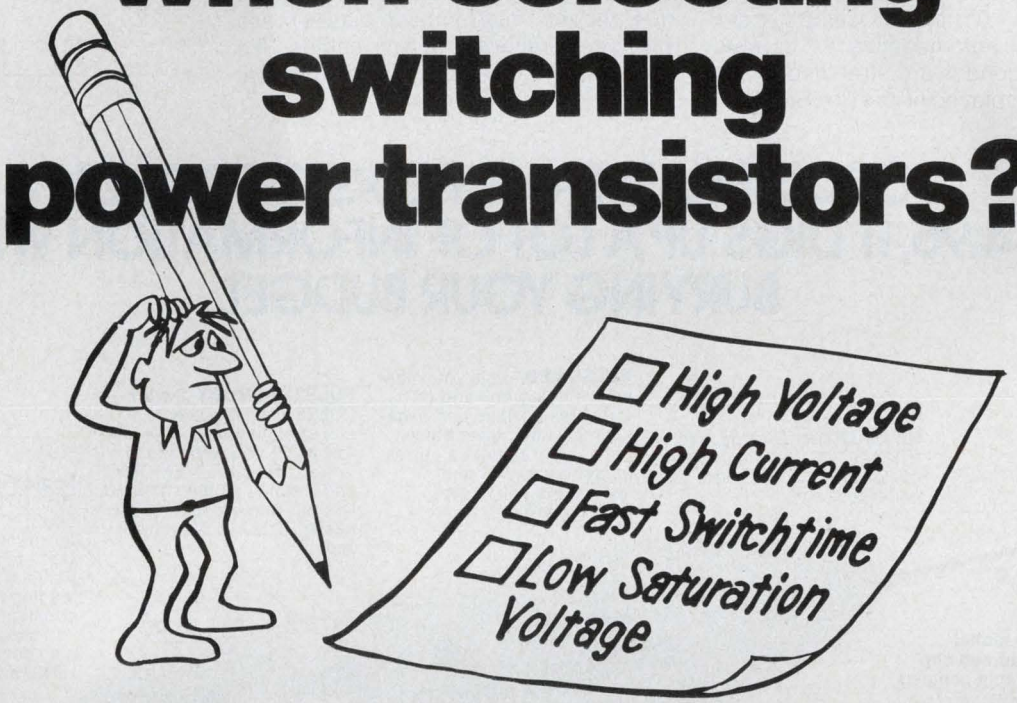

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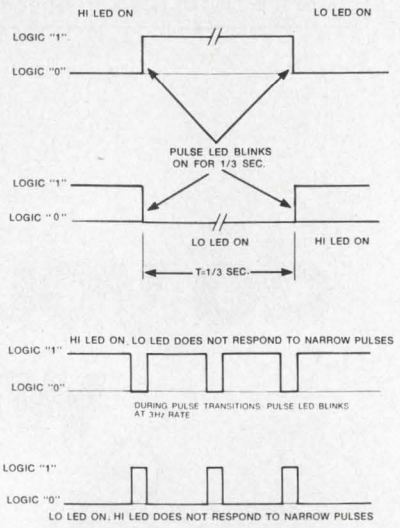

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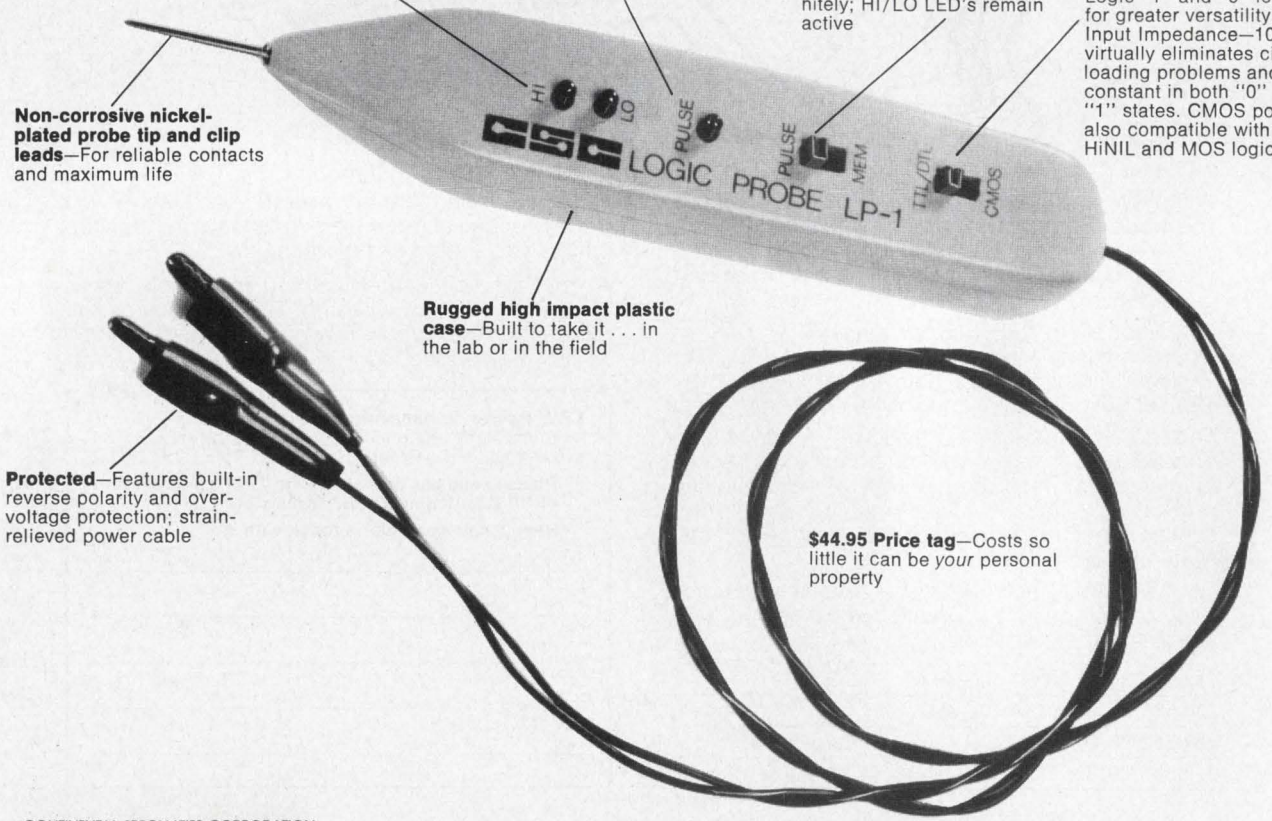

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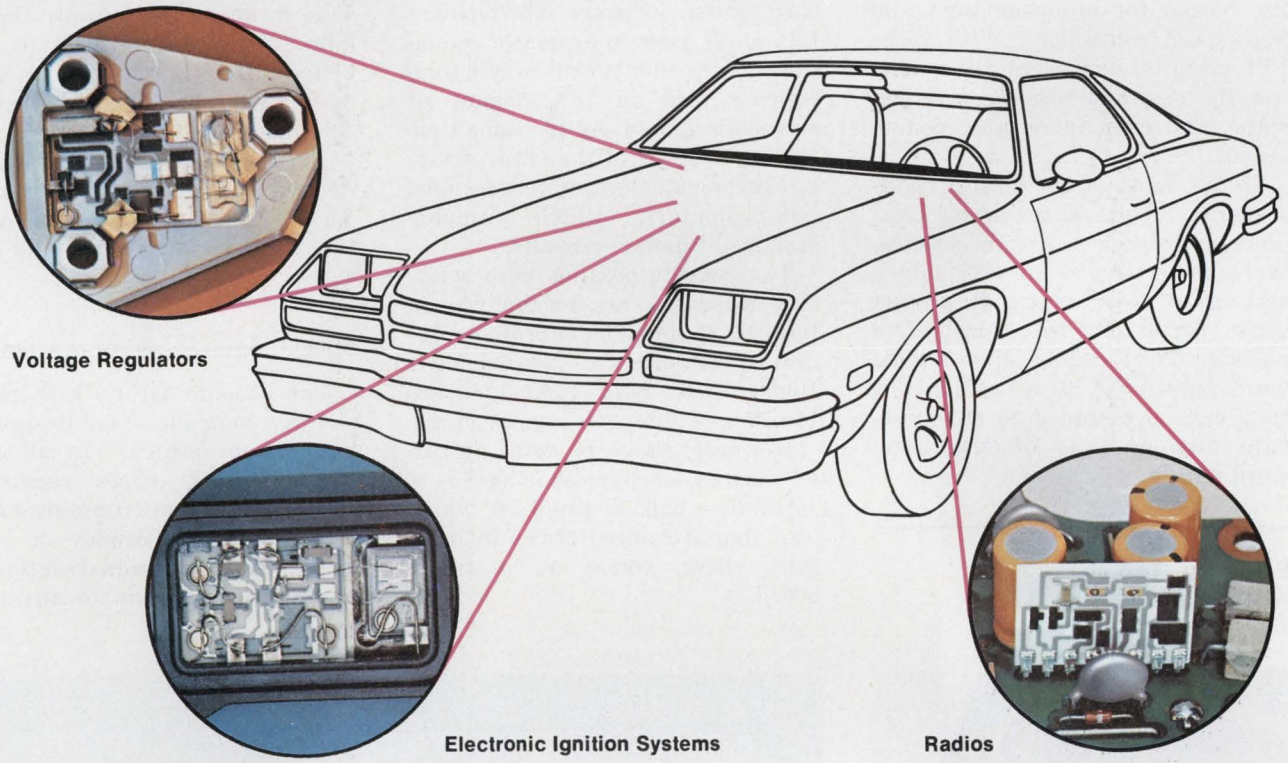

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News

Bipolar bit-slice μPs shrink the size and cost of minis and controllers

Bipolar microprocessor "slices" have become the hottest new building blocks for minicomputers and high-speed controllers. With these LSI circuits, engineers are reducing the size and cost of their designs, and even increasing system speed.

Unlike most of their MOS counterparts, bipolar slices aren't complete microprocessors. In essence, the bipolar circuits contain only a section of a conventional processor's arithmetic-logic unit and register file. Existing slices handle word lengths of 2 or 4 bits, but they can be cascaded to accommodate any multiple of the basic word length.

Edward A. Torrero
Associate Editor

Existing minis can be upgraded or replaced without having to discard system software. The bipolar/LSI chips permit dramatic reductions in the number of circuit components, and in the amount of power dissipated. At the same time the high speeds of the slices assure a precise emulation of conventional minicomputers, which employ standard-bipolar circuits.

The benefits possible with a bit-slice approach are exemplified in Interdata's new Model 6/16, an upgraded emulation of the company's Model 7/16. Both computers are 16-bit, medium-performance minis.

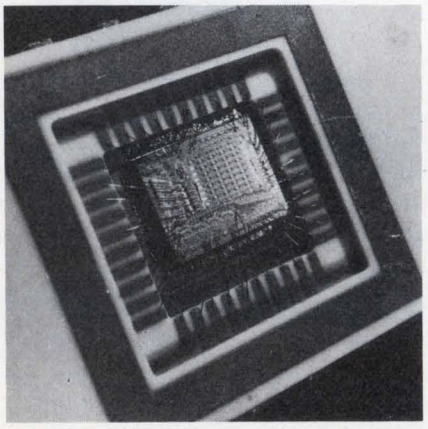
However, the 7/16 takes up two PC boards, each measuring 15 × 15 in. The bulk of the 6/16, which uses four Advanced Micro Devices' 2901 slices, comes on a single board.

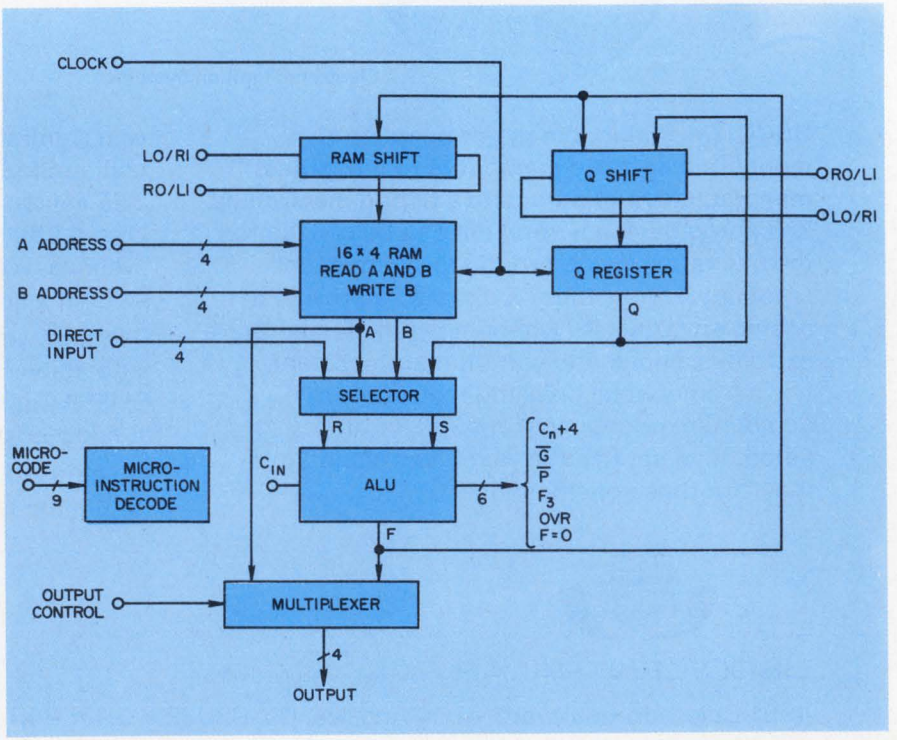
The total number of circuits drops from about 300 ICs for the 7/16 to about 180 ICs for the new mini. As a result, the 6/16, complete with 8-k bytes of memory, costs $2900, or $300 less than the original mini.

Further, system speed was increased by about 25% from the 1.5 μs specified for mini operations like register-to-register additions.

Slices require microprogramming

The benefits are no less impressive for controllers and designs begun "from scratch." In all cases, the key to the slices' remarkable capabilities is microprogramming, the ability to employ a unit's fundamental microinstruction set to tailor the system to any appli-

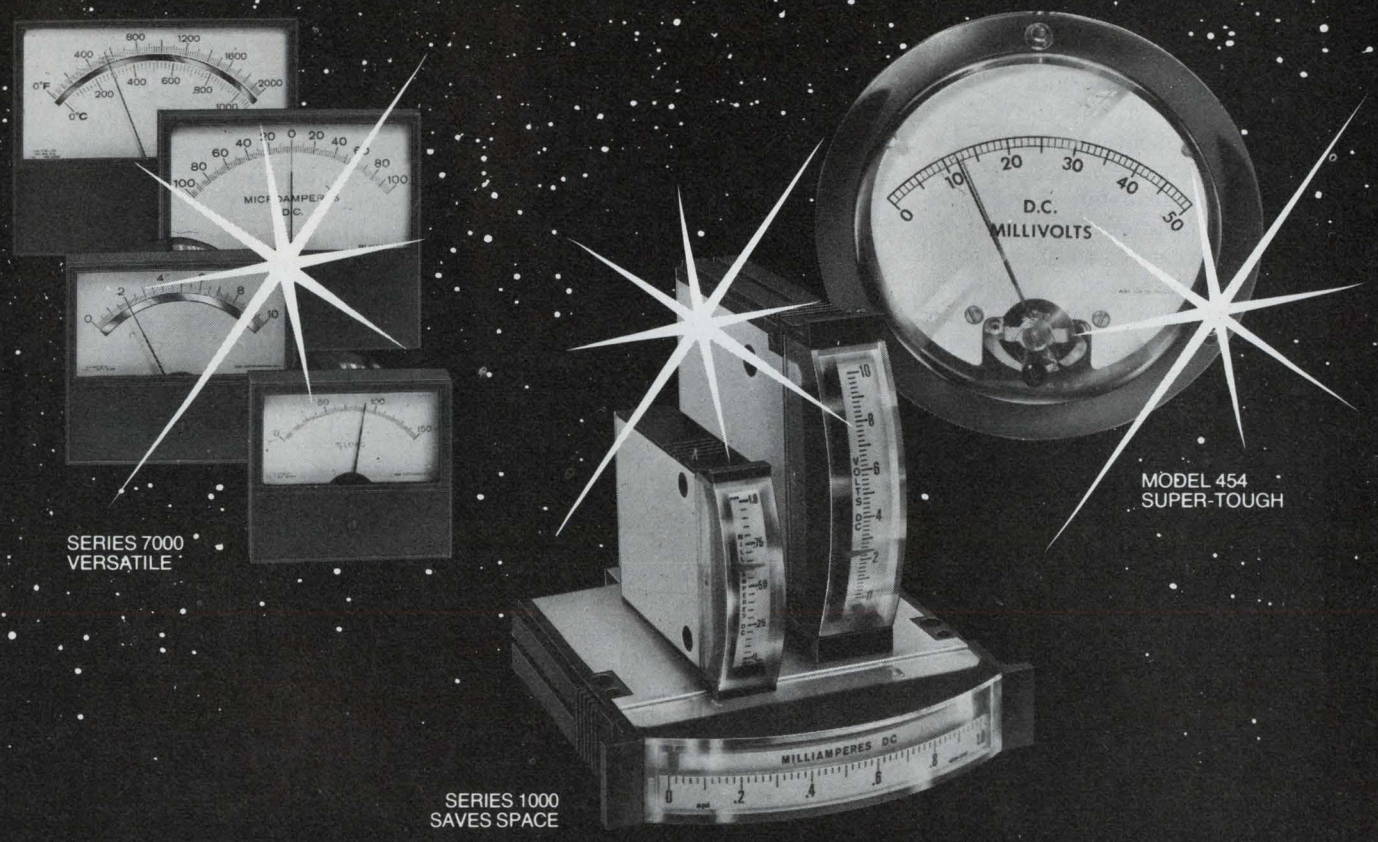




The fastest TTL microprocessor slice —Advanced Micro Devices' Am2901 (above)—specifies 100-ns microinstruction cycle over supply and operating temperature ranges. The 4-bit slice contains an eight-function arithmetic logic unit, a two-port scratch-pad memory with 16-word capacity and an additional accumulator register (right).

CIRCLE NUMBER 26 ►

STAR PERFORMERS



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cation.

When applied to minis, a microprogram stored in a control memory defines the computer's fixed-instruction set. For a controller, however, the microprogram can define the system's entire operation.

However, microprogramming can also be a designer's bane. It requires a designer to deal with the specific timing relationships of the chip's internal architecture. And since each application uses a separate microprogram, each has one that can't be transferred easily to another application. Nor can design aids, geared toward one slice model, be transferred to another.

Not that many aids are available. At the very least, a designer generally needs a microassembler: a program that lets him microcode without dealing with a processor's inherent and unwieldy machine language of ONEs and ZEROs. He'll also want to use a ROM simulator to check out the microprogram. However, few manufacturers offer these essential design aids, or suitable equivalents.

The growing acceptance of bit-slice microprocessors has spurred semiconductor manufacturers to develop improved circuits. Efforts are now under way to build enhanced sequencers for presently available slices. Sequencers—companion circuits to the slices—provide the logic needed to operate the microprogram control memory. They also generate next-address instructions, thereby simplifying the microcode.

Also in the wings are other sophisticated support circuits, such as field-programmable logic arrays, 4-k bit RAMs and 16-k ROMs. Employing advanced forms of ECL, Schottky-TTL or I²L (integrated-injection logic), upcoming products may even include complete bipolar microprocessors on a single chip, and increase slice word lengths (presently a maximum of 4 bits) to 8 bits.

I²L slices move up in speed

The first bipolar slice to use I²L technology—Texas Instruments' 4-bit SBP0400—never caught on. There were several reasons.

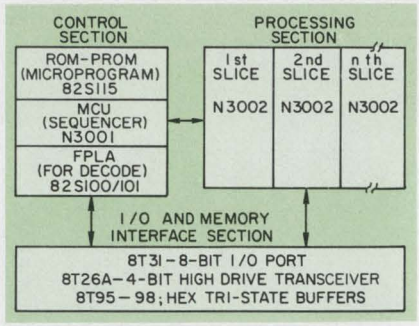
Operating at speeds comparable to complete, single-chip MOS microprocessors, the I²L slice required many more circuits to form a working system without offering any real speed advantage.

Moreover, the circuit's need for microprogramming made it more difficult to design with than MOS μPs.

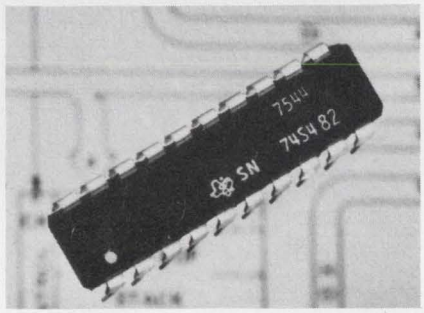
Still, the SBP0400 did establish TI as the only I²L slice maker. And now the company plans to strengthen that position when it offers, in the third quarter, an upgraded 0400—designated with a suffix A—that uses an advanced I²L technology to achieve Schottky-TTL speeds.

The 0400A's longest microcycle path takes 150 ns, when it is used in a 4-bit configuration. A comparison based solely on the same speed spec for other 4-bit slices puts the new slice about midway between Advanced Micro Devices' faster 2901 and Monolithic Memories' slower 6701.

Another version of the 0400—the 0401—offers speeds and capabilities similar to that of the 0400A. A key difference, though, is that the 401 can work readily with members of a forthcoming family of Schottky-TTL circiuts that TI calls, simply enough, the Schottky Microcomputer Chip Set.



This central-processing unit, based on the 3000 slice offered by Intel and Signetics, employs the latter's field-programmable logic arrays.



Packaged in a 20-pin DIP, a 4-bit Schottky-TTL sequencer from TI can be cascaded to handle various sizes of microprogram memory.

"The chips were a computer before they became a chip set," observes Dick Horton, TI's manager of bipolar product development, commenting on the use of the Schottky-TTL circuits in his company's 990 computer family (see "Processor Family Debuts," ED No. 22, Oct. 25, 1975, p. 137). "They started as the upper end of the family."

The chip set will mark TI's long-awaited entry into the TTL-slice sweepstakes. At the heart of the family is the 74S481, a 4-bit circuit that TI plans to introduce in the fall and that is described as the next-generation slice. Its claim is not likely to be refuted.

Inside the S481 is a programmable logic array with "hard-wired" control algorithms that yield a whopping 24,780 set of different microinstructions. No other slice responds to more than about 500.

The algorithms are actually those of the 990 computer, and directly provide for multiply and divide without having to microprogram for those operations. When applied to a 16 $\times$ 16-bit multiplication, a series of S481s can produce a 32-bit result in 2-1/2 μs.

For such operations, the S481 employs a kind of trinary logic. Depending on whether one of the input pins is connected to ground, supply or left floating, the circuit becomes the least-significant, most-significant or intermediate-bit slice, respectively. On receiving a multiplication or divide command, the most-significant bit slice takes charge of the other slices and executes the command.

Another distinctive feature is the S481's so-called memory-to-memory architecture. The chip doesn't have a dedicated register file. Instead, internal memory-control logic allows the use of all of program memory. A work-space pointer keeps track of the external register space, and a program pointer locates instructions.

As impressive as the new Schottky family promises to be, it might well be dwarfed in comparison with an I²L family that TI only hints at now. Advances in the technology have reportedly reached the point at TI where a single-chip I²L mi-

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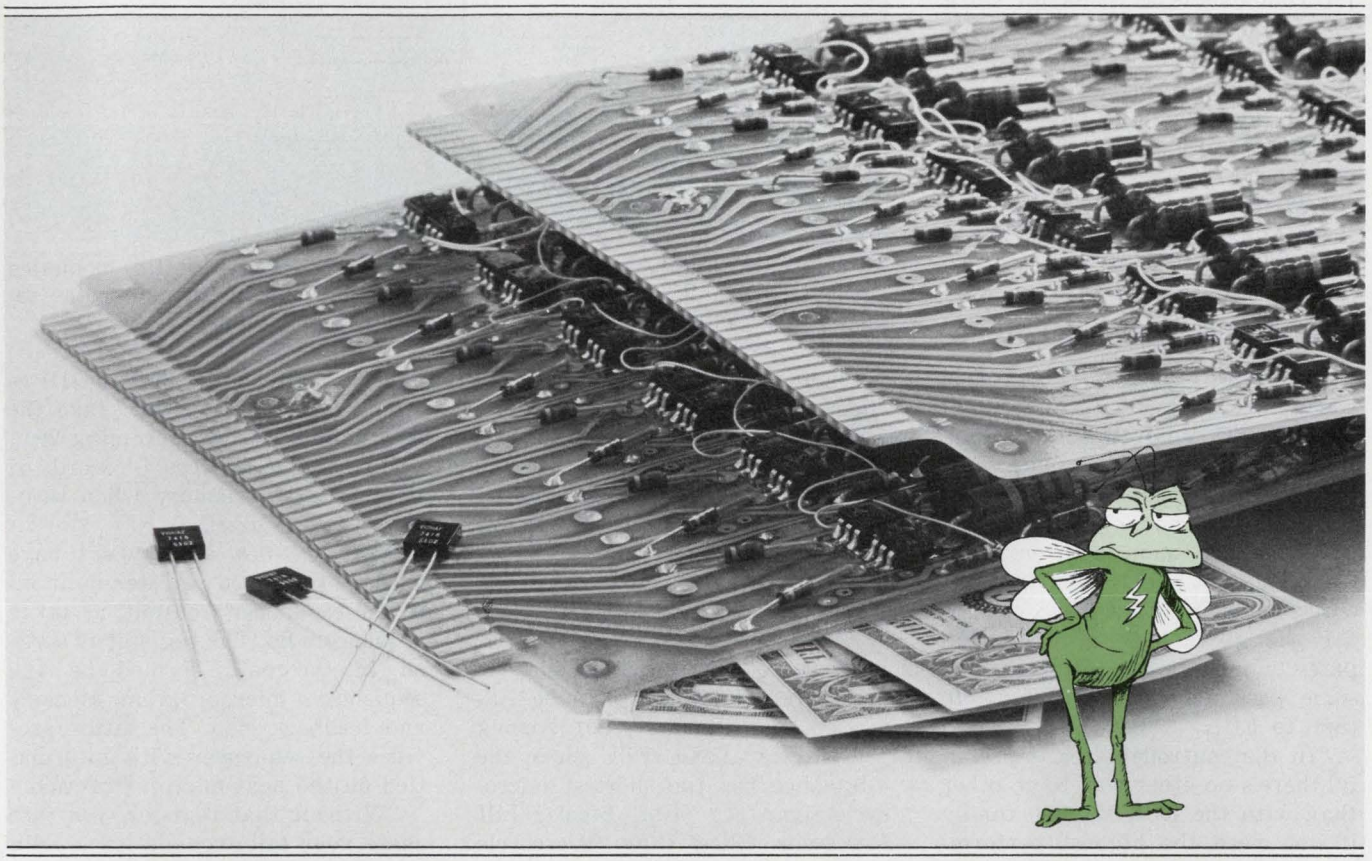

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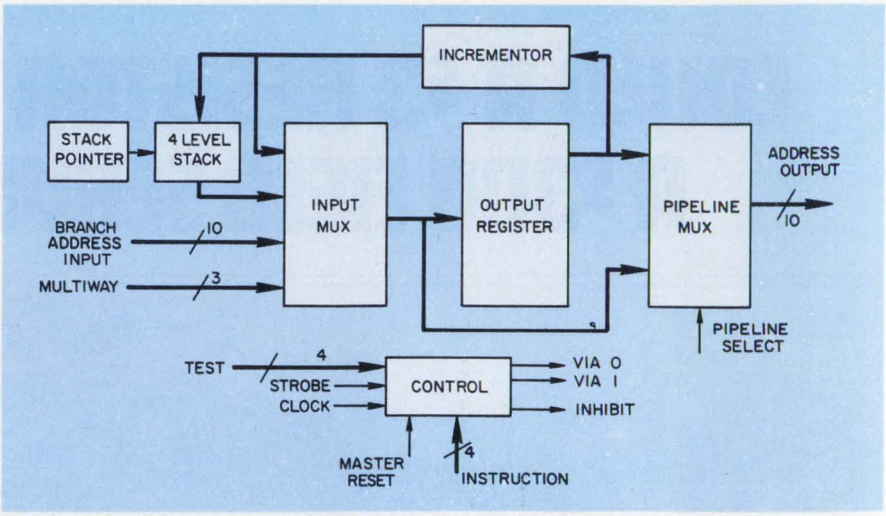
CIRCLE NUMBER 27

croprocessor—with speeds possibly overtaking Schottky-TTL—is now feasible. The μP could even have a word length as high as 16 bits.

Already, the company has indicated its plans to introduce such I²L components as a 4-k bit static RAM and a 16-k ROM. Along with other I²L circuits, the upcoming offerings could well mushroom into an I²L microcomputer chip set.

But as for an I²L CPU chip, Horton only says, "We're going to surprise a lot of people. They don't think you can do it in NMOS, but we'll have it in I²L."



An Isoplanar I²L sequencer from Fairchild directly addresses control memories up to 1024 words in size. A bipolar CPU can be built by combining the sequencer with other circuits in the company's Macrologic line.

ECL: still the speed king

For now, though, the fastest speeds are offered by an ECL bit slice from Motorola (see "ECL Bit-Slice Processor Arrives, Setting Top Speeds for Bipolar μPs," this issue, p. 53).

Like other manufacturers, Motorola doesn't see the bipolar circuits displacing their MOS cousins for the great bulk of microcomputer applications, although for some uses designers will have to turn to ECL.

"In the controller area, especially, there's no other way to go other than with the ECL M10800 family if you need the highest performance," asserts Jim Loro, Motorola's marketing manager for bipolar memories and LSI. He expects controllers to embrace his product more quickly than any other application area.

Still, the speed benefits of ECL show up dramatically when the bipolar circuits are compared with MOS ones. For the same algorithm (or system program) designers can expect an increase in speed by a factor of 10 because the ECL system's clock rate is that much faster.

And when the slice-based system is tailored to a high-speed application, the speed increase could soar to much more. The tailoring comes about primarily through microprogramming and the use of high-speed bipolar memories.

These facts aren't lost on the many designers who employ popular MOS μPs like the 6800.

"I have had several customers calling to ask how one does a 10800 version of a 6800 system," says Bill Blood, manager of bipolar LSI system development. Blood, though, agrees that the use of slices to emulate MOS μPs will amount to only a small part of their possible applications.

4-bit slices set the standard

Currently the leading slice is generally acknowledged to be Advanced Micro Devices' 2901. Among presently available TTL slices, the 4-bit slice has the shortest microcycle time (see "4-bit Bipolar/LSI Processor Slice Cuts Microcycle Time to 100 ns," ED No. 15, July 19, 1975, p. 77). It has been alternate-sourced by Raytheon and Motorola, and AMD boasts a customer list numbering over 200.

Among designers, one reason for the 2901's popularity is the flexible structure of the slice's microinstruction. The 9-bit word consists of three 3-bit segments that either control or determine the internal arithmetic-logic unit's source operand, function and destination register. The breakup reduces delays; it permits parallel decoding of different segments of the same microinstruction.

In addition, the three-way breakup leads to 512 possible microinstructions. However, not all 512 represent useful instructions.

Another factor in the 2901's success was the early availability of supporting circuits like the 2909 microprogram sequencer. AMD plans to offer a version of the sequencer housed in a smaller package—a board-saving 20-pin DIP vs 28-pin DIP for the 2909. Like the original circuit, the upcoming 2911 will be able to address 4-k words of microprogram memory when three are cascaded together.

Also, the new 2911 won't have an edge-triggered register built into the sequencer's output, as other sequencers do. The register is needed in the path formed by the sequencer, microprogram memory and feedback loop. The latter provides the sequencer with information on the next microinstruction.

"Without that register, you just chase your tail around," says John Springer, AMD's marketing manager for bipolar μPs. "But if it comes at the output of the sequencer, the unit isn't really intended for a pipelined system, implying a longer system cycle." A better spot would be at the output of the microprogram memory.

The internal architecture of Advanced Micro Devices' 2901 so closely resembles Monolithic Memories' earlier 6701 that a system designed for one could be adapted readily for the other.

"If I were a designer out there, I would be frustrated because the two circuits are so similar," observes Clive Ghest, applications systems manager at Monolithic Memories. The two 40-pin parts aren't pin-compatible.

"But if a designer started from scratch, he could more than likely develop an instruction set usable with either circuit. He would need a different PC card and different control memory. However the basic

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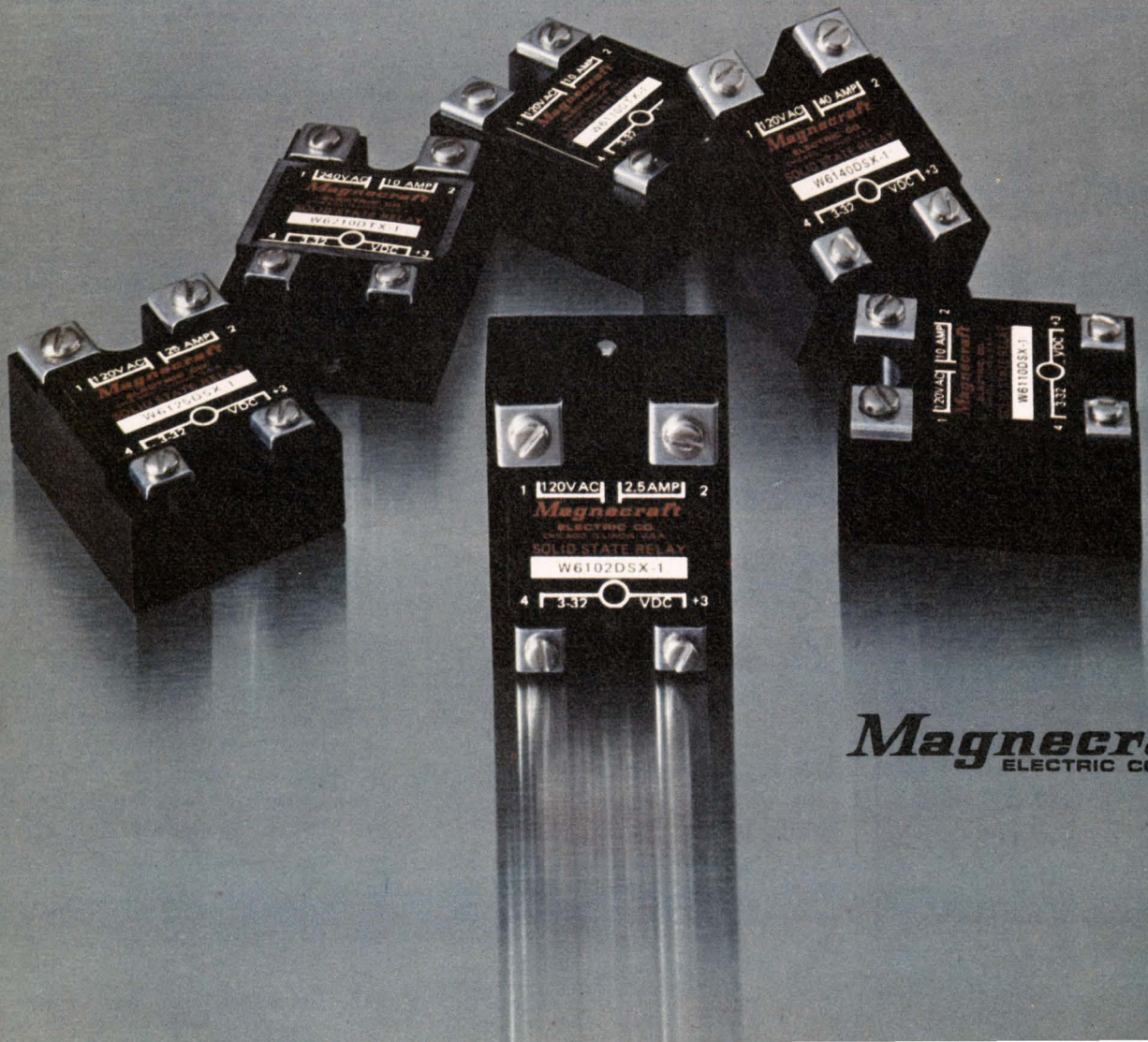

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CIRCLE NUMBER 29

operations of the two systems—operations like add, shift and compare—could be identical."

More importantly, the highly vaunted speed advantage of AMD's 2901 over MMI's 6701—as high as 2:1 for some operations—shrinks when the two are applied to a 16-bit system, like that common for minicomputers.

Though the 2901 is still the front runner, the winning margin is less. According to Ghest, the AMD circuit has a worst-case delay of 145 ns; that of his product is only 30 ns longer.

Monolithic Memories expects to close the gap and take the lead in speed with a dash-1 version to be offered later in the year. It will have worst-case cycle times of 100 ns in the commercial temperature range and 125 ns over the MIL range, making it, by Ghest's figuring, 40% faster.

2-bit slices available, too

Compared with 4-bit slices, which designers have embraced readily, 2-bit slices have yet to make their mark. These circuits are available in the 3000 series introduced by Intel and alternate-sourced by Signetics. Designers typically cite difficulty in using the circuits as the main reason for keeping their distance from the series.

Without minimizing the problems, Intel's Ron Yara, product manager for the 3000, points to the advantages.

The 3002 2-bit slice, for example, requires only seven bits to specify a function's source, destination and operation. That number is less than half the bits typically needed by 4-bit slices.

Also the 3002's multibus structure eliminates the need for external multiplexers. The slice has separate address and data outputs and two independent data inputs. A special "K" bus even permits the masking of unwanted bits, during logic testing, and the generation of constants.

A single 3001 sequencer can address 512 words of microprogram memory—a sufficient amount for many 16-bit minis. And the circuit's unusual row/column addressing scheme can actually be an advantage, according to Yara, since clusters of microcode can be located rather easily.

As for design aids, no manufacturer can match Intel's. The company offers a cross-microassembler (called Cromis) and a prototyping system (MDS) that allows in-circuit emulation, permitting simultaneous hardware and software development.

The 3000 series offered by Signetics provides the same functions and pinouts of Intel's. However, its slice features a 30% faster cycle time. And the company will soon have a version of the 3001 sequencer that will come in a reduced-size package but have twice the addressing range. The new sequencer will also incorporate a four-level stack.

Signetics plans to employ its bit-slice family in upcoming kits that emulate MOS microcomputers. The initial offering, planned for a June introduction, will be a bipolar version of the 8080A system. The kit will have about 60 ICs and include programmed PROMs.

Although two 2-bit slices are needed to obtain most features available from a single 4-bit slice, systems based on either circuits may actually use about the same number of IC packages.

"In the real world, you need additional circuits besides the slices to do the job," comments Steve Lau, a member of Signetics' technical staff.

"You may need additional registers for, say, memory addressing, or multiplexers to overcome bus limitations. For an 8 or 16-bit machine, you can't really say that either slice automatically leads to fewer packages."

However, there is one bipolar/LSI circuit that can lead to fewer packages than are needed for any slice. Scientific Micro Systems' SMS 300, the only bipolar single-chip CPU, isn't a general-purpose microprocessor, but it can simplify control systems.

Equipped with eight 8-bit working registers and a set of eight control-oriented instructions, the SMS 300 has an instruction-execution time of only 250 ns, which includes 85 ns for memory access. The chip will soon be alternate-sourced by Signetics. ■■

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Transient testing is spreading to systems designers

Transient testing is spreading from the power companies to such fields as computers, instruments and even home entertainment. As a result, the IEEE Surge Withstand Capability (SWC) test is now finding a wide application throughout the electronics industry.

An IEEE group currently is defining SWC specs applicable to the computer industry. The original specs were developed in 1974 for the power distribution industry.

In some cases power-line transients can mean very little, other times they can have disastrous results. A color-TV set need not maintain a flicker-free image, but a hospital X-ray scanner must.

Withstanding the surge

And yet, coping with transients is important in television too.

"You can have a 3000-V surge on the wall outlet for your color-TV set," warns Franz Martzloff, of General Electric's R & D facility in Schenectady, NY.

"If you could limit the transient from several thousand volts down to a sure 500-V max, then the TV-set designer could specify the component's voltage ratings with a reasonable assurance that the components would survive."

Amdahl Corporation of Sunnyvale, CA, uses a motor-generator system to ensure that line surges do not interfere with its Model 470V/6 supercomputer, but most designers cannot afford the motor-generator approach.

For digital controls, the simplest and most common method of isolating transients is to use relays or opto-isolators. For analog signals, gas discharge arc suppressors with RC or LC filtering are used.

But since relays tend to be slow and unreliable, and logic circuits with relatively low noise immunity are being used, designers are turning to solid-state suppressors. For example, metal-oxide varistors, such as the GE MOV made by General Electric in Syracuse, NY under license from Matsushita of Osaka, Japan, can limit surges to two or three times normal operating voltages. They are used to clamp both ac line inputs and signal lines.

Repeatable surge testing is now as easy as pushing a button, thanks to new IEEE specs and commercial surge generators, such as this Velonex Model 510.

Surge-rated avalanche diodes, such as the TransZorb from General Semiconductor of Tempe, AZ, rated from 5 V to 1 kV, are particularly suited to protecting open-collector TTL outputs because they present no dc-leakage path until they conduct a surge. Bidirectional TransZorbs are notably good for surge-protecting analog inputs and outputs.

Another successful approach to surge protection uses 4 kV capacitors of Mylar or polycarbonate film to absorb the transient energy. This approach would also include a special cable layout and lead dress to prevent low-level signal lines from coupling transients from power lines.

Separate cable harnesses for power and signals are used, with lines running at right angles whenever possible. Doubly shielded coaxial signal lines often are employed too.

Until recently the way to test for transients in electronic systems was to randomly connect inductive loads into the power line in an effort to simulate surges. The simulation might involve turning on electric drills, plugging large power supplies into the same wall outlet as the system being tested, or using more sophisticated impulse tests.

Impulse tests provide a unidirectional pulse input to the system under test, simulating high voltage arcing or other instantaneous phenomena. Typical of the inpulse testers on the market is the Model 424 Surge Generator/Monitor by KeyTek Instrument Corporation, Waltham, MA. But most power-line surges are not impulses and there is no absolute standard for impulse testing.

All that is changing since the IEEE adopted surge-testing standard 472-1974. The test surge described in the standard is representative of typical power transients, and is a compromise between two requirements. The 2.5-kV, 1.25-MHz damped-sinewave burst applied to power and signal lines is a voltage high enough that power companies can limit surges to it. And the voltage is also low enough that system designers can build systems to withstand it.

The Velonex Division of Varian Associates, Santa Clara, CA, recently introduced a surge transient generator that meets all of the requirements of IEEE standard 472-1974 and the identical ANSI standard C37.90a-1974. The unit also allows the operator to vary the burst duration, amplitude, source impedance, and phase with respect to the power line. ■■

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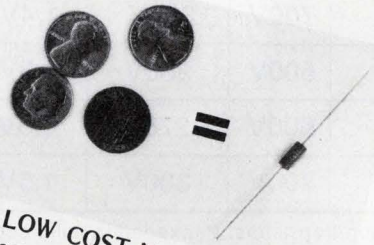

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DTS 517	5	500V	250V	1.6V	0.25 μsec
DTS 518	5	600V	275V	1.4V	0.25 μsec
DTS 519	5	700V	300V	1.4V	0.25 μsec
2N6573	5	500V	250V	1.5V	0.25 μsec
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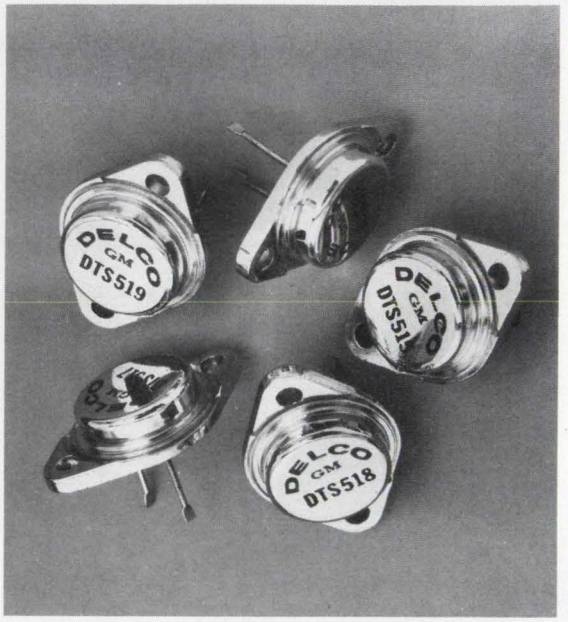

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And, of course, these high-energy silicon power transistors come in Delco's solid copper TO-3 packages to ensure low thermal resistance.

The accompanying curves, charts and circuits tell part of the story. Prices, applications literature and electrical data from your nearest Delco sales office or Delco distributor can supply another part.

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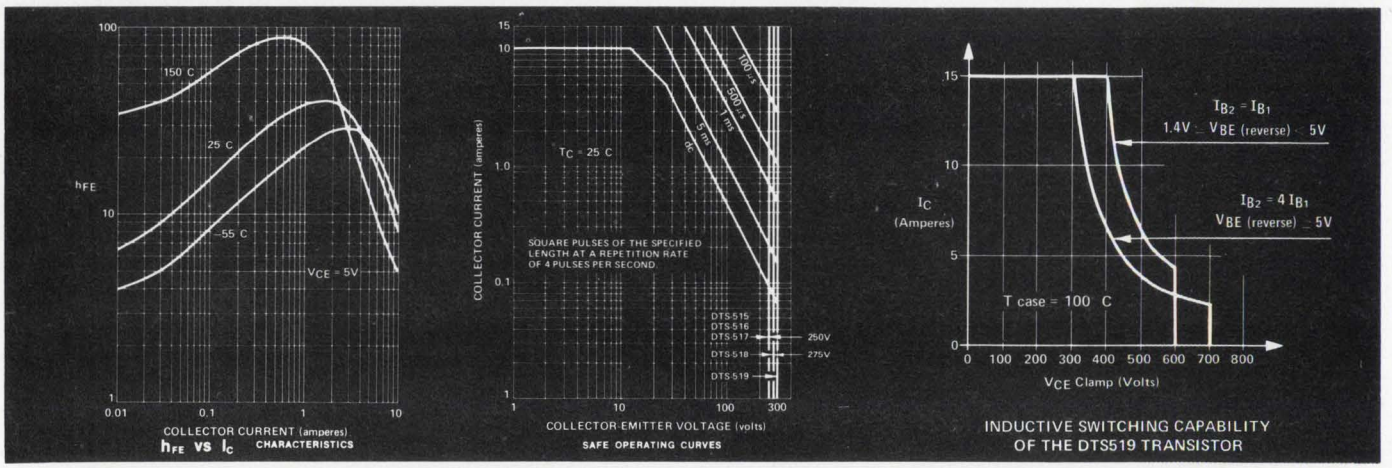

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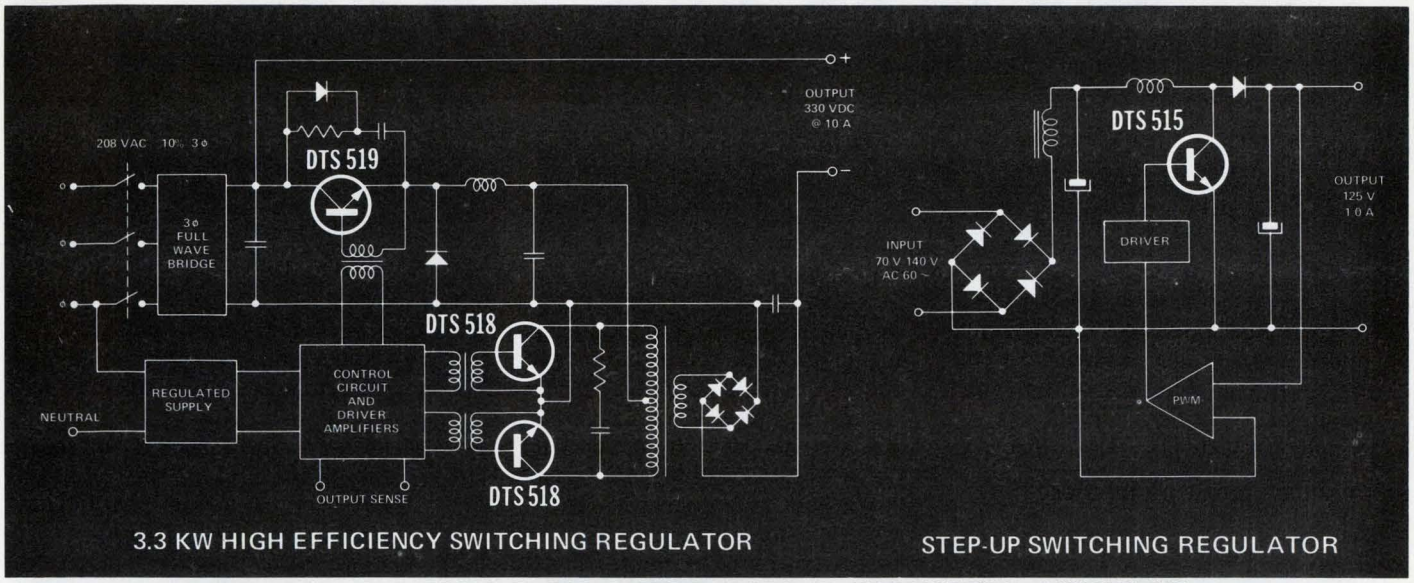

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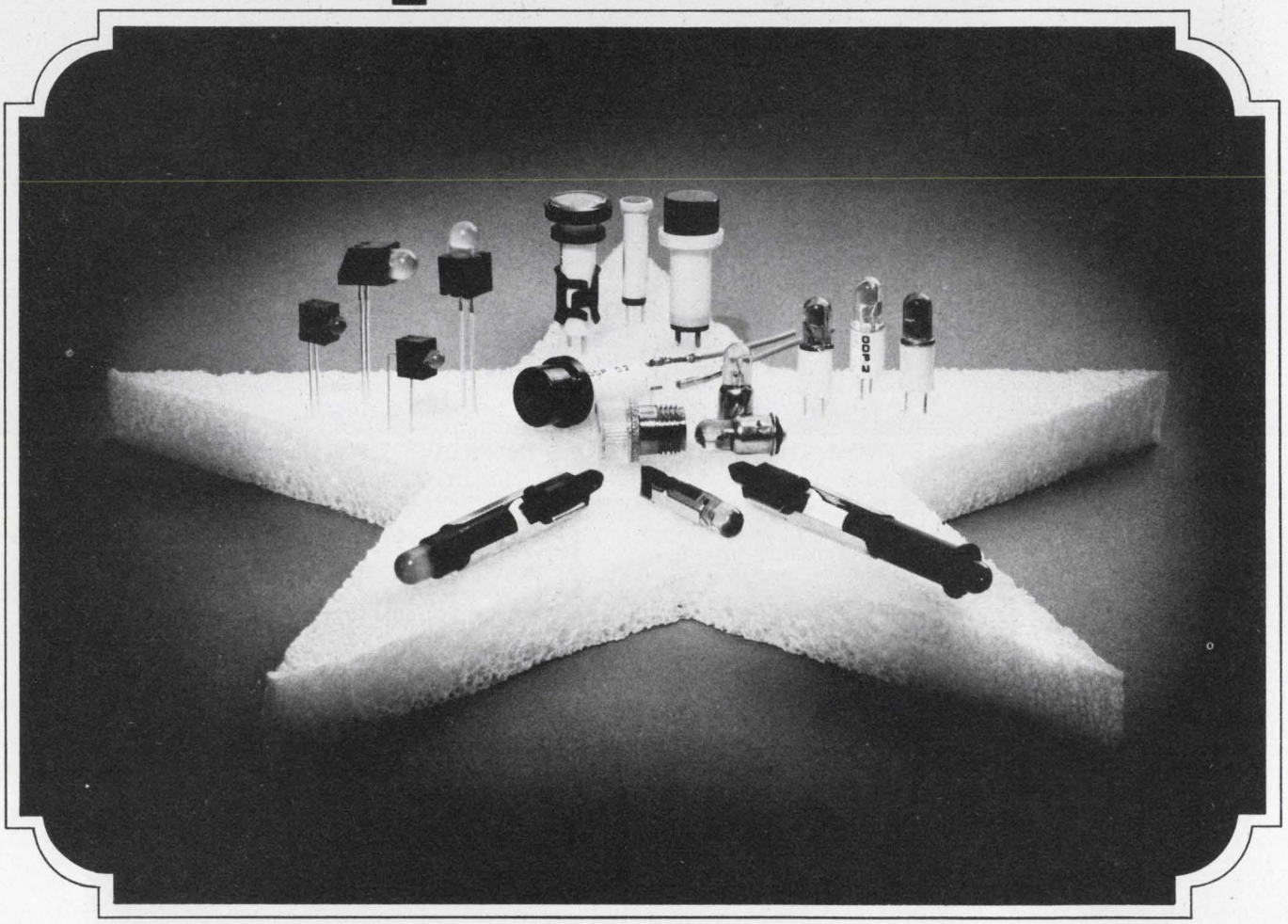
CIRCLE NUMBER 32

LED SUPERSTARS



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CIRCLE NUMBER 33

Washington Report

Coast Guard gets more sea to patrol

The Coast Guard, which nominally patrols the sea inside the 12-mile limit, is going to have a lot more ocean to cover now that the President has signed a bill to extend the nation's fishing boundaries out to the 200-mile mark.

The relatively tiny service will have to enforce fishing and—possibly—mining bans, so more ships and aircraft will be required. Accordingly, the House of Representatives recently passed a $304-million procurement authorization for Fiscal Year 1977 that included $109 million more than originally asked for by the Administration.

The House added funds for six long-range surveillance aircraft and five shorter-range patrol aircraft, four side-looking radars for the present C-130 patrol planes, and two additional cutters.

Test-before-buy procedures are questioned

The fly-before-buy concept now in favor at the Pentagon may be in for modification because of the growing length of time it takes to get a weapon from the drawing board into the hands of the troops.

Dr. Malcolm Currie, DOD director of defense research and engineering, says that in some cases the acquisition cycle "borders on the absurd" because there is too much emphasis on test and evaluation.

Some of our test programs do require a production run to support them, he says, but some testing goes on just to be able to construct statistical curves rather than because such testing is adequate and reasonable.

Obstacles to big defense budget fade

To the shock and chagrin of liberals in Congress, the Ford Administration's defense budget is sailing along in unexpectedly calm seas. A few months back there was the probability of a $5 to $7-billion cut, but Congress is now convinced there is a serious shift in America's military balance with the Soviets.

The first concrete evidence of the change in opinion came when the House added $700 million in spending authority to the Administration's procurement request, bringing it to a total of $33.4 billion. This was a $1.2-billion increase to the $21.8 billion requested for hardware procurement and a $498-million cut from the $10.8 billion wanted for research, development, test and evaluation. The major beneficiary is the Navy's shipbuilding program, which receives $1.08 billion more than the DOD requested for fiscal year 1977, which begins on Oct. 1.

Unsuccessful efforts were made to trim the B-1 production authoriza-

tion, delete funds for attack submarines, and to cancel a new carrier. Existing cuts were spread over some 1000 programs and few were fatal. The Army lost its aerial scout helicopter program for now, and the Navy its Shipboard Intermediate Range Combat System (SIRCS).

The House agreed to $474.7 million for the purchase of six E-3A airborne-warning-and-control-system (AWACS) aircraft, but the Air Force can't spend the funds until a favorable decision is made by NATO members to buy the system too.

Not only has the President clearly sounded a warning that he will veto any bill that reduces defense expenditures, but the Defense Dept. is reportedly planning a whopping supplemental bill. Some $475 million may be requested to build more Minuteman 3 missiles and upgrade older Minuteman missiles to counter the rising number of Soviet ICBMs.

FCC allows exhibit of nonapproved products

The Federal Communications Commission has retreated slightly from its tough rule banning the display or showing of nonapproved electronic products at trade shows.

Now the FCC will allow the display of noncertified devices at industry trade shows not open to the general public if the displays are clearly marked: "This device has not been approved by the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased."

The Electronic Industries Association, which led the fight for a relaxation of the rule for trade shows, told the FCC in a petition that in the government's zeal to protect the consumer, it is not only cutting industry profits, but is increasing the FCC staff workload and forcing up the price of products.

Prior to this rule change the FCC had cited six manufacturers of home video games for violations. In the future, these products can be shown at industry trade shows not open to the general public.

Capital Capsules:

Foreign military sales are likely to be in the $8-billion to $10-billion range annually for the next decade, predicts Deputy Secretary of Defense William Clements. . . . The Navy says that **New Mexico and Nevada are still in the running for the Seafarer ELF site, although Michigan apparently is considered for the first choice.** The system for communication with submarines is far from finding a home. The initial rebuff came from Wisconsin, where the Navy wanted to install Sanguine, the underground version. . . . The Electronic Industries Association has **a new two-level, 12-digit designation system for microelectronic devices.** The EIA says it is designed to be compatible with the Pro-Electron System that's been in use in Europe for several years. The new system also complements the existing program for registering discrete semiconductor devices that is in universal use today. . . . **The Renegotiation Board's plan to close down its two regional boards located in Los Angeles and Washington, DC, supposedly in the interest of economy, has been shelved.** An angry letter from Rep. Jack Brooks (D-TX), chairman of the House Government Operations Committee, insisted that any reorganization should await the outcome of legislation now pending that either passes and extends the life of the agency or allows the board to die. Industry, of course, is rooting for the latter. The House has passed a bill that would alter the board slightly, and make it permanent. The board's mandate is to make industry refund "excess" profits from Government contract work.

ANNOUNCING

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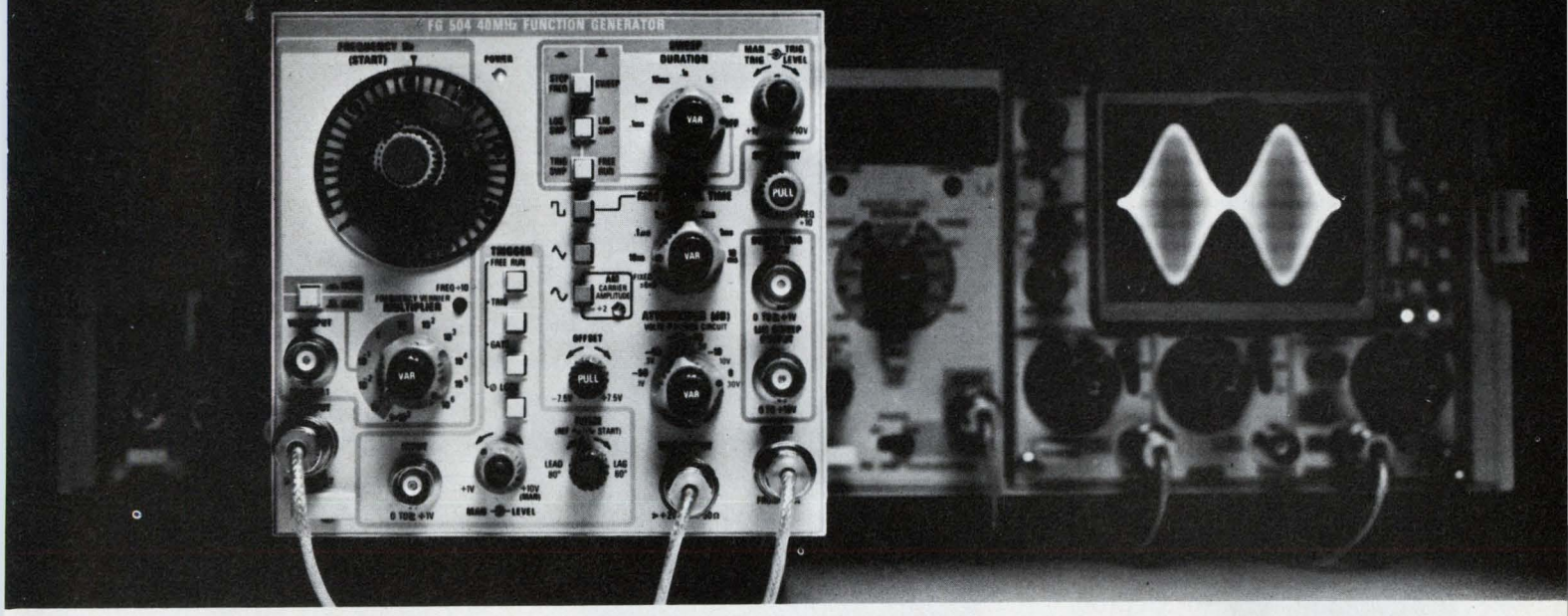

The TEKTRONIX FG 504

In its phase lock mode, the new FG 504 Function Generator will capture and track a periodic signal, such as a logic pulse or house standard frequency, letting you synchronize the generator's output or convert from one waveform to another. Its am input circuitry senses the presence of an applied modulating signal and reduces the output amplitude by one-half, allowing 100% upward modulation without adjusting the amplitude control. It can be frequency modulated, and it can be swept with its built-in logarithmic or linear sweep. Concentric knobs set the frequency start and stop points.

Frequency range: 0.001 Hz to 40 MHz • up to 6 ns rise/fall time • 3 basic waveforms • a wide range of pulse shaping with variable rise and fall and symmetry controls • up to 30 V p-p output • built-in attenuator • post-attenuator offset • external and manual trigger or gate.

In the phase lock, trigger, or gate modes, a phase control shifts the output of the FG 504, so that you can create setups such as a bi-phase clock. A capable instrument for driving logic circuits, the FG 504 is a "clean," 50 Ω source of pulses to less than 20 ns wide and up to 30 V p-p. Post-attenuator offset enables use of the full ±7.5 V offset range with small signals.

The FG 504 features independent push-button selection of many of its operating modes, so you are not limited to typical "either-or" decisions. Special modes of operation can be set up through independent or simultaneous use of such functions as AM, VCF (fm), SYMMETRY, VAR RISE and FALL, SWEEP, Waveform HOLD, and TRIGGER or GATE or PHASE LOCK.

Order FG 504T ($1350) for a stand-alone instrument operable from 100-240 Vac, 48-440 Hz.

For example, the FG 504 may be operated as a free-running burst generator by using the LIN SWEEP OUTPUT to gate the main generator. With the generator in the SWEEP mode but the START and STOP frequencies set the same, the actual sweep will be zero. Adjusting the trigger level controls the length of the burst. SWEEP DURATION controls the period between bursts.

A special range allows the audio engineer to sweep from 20 Hz to 20 kHz, or a single internal capacitor may be replaced to change the start and stop points.

And dynamic reaction of AGC, squelch, or amplitude-sensitive circuits such as Dolby systems are easy to test with the FG 504 in a square wave or pulse am mode that varies the output between two different levels.

Order FG 504 ($1200) for a plug-in instrument that operates in any multi-compartment TM 500 mainframe power module.

For further information or a demonstration of the FG 504 and TM 500 Instrumentation, write or phone: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077, (503) 644-0161 ext. 5542. In Europe: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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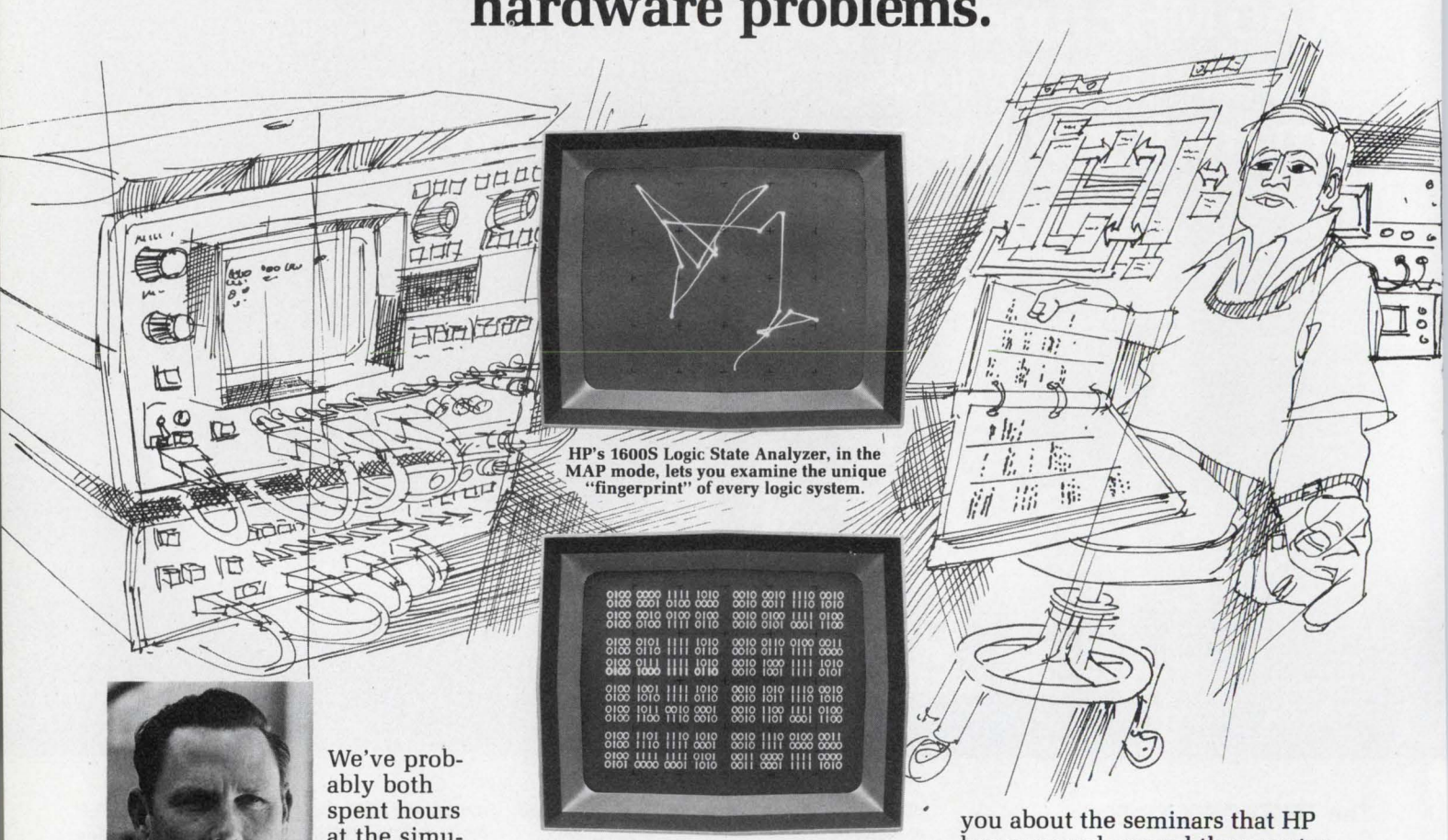
FOR TECHNICAL DATA CIRCLE #241
FOR DEMONSTRATION CIRCLE #242

Let's talk about the easy way for you to spot microprocessor hardware problems.



HP's 1600S Logic State Analyzer, in the MAP mode, lets you examine the unique "fingerprint" of every logic system.

In the TABLE mode, the 1600S displays up to 16 32-bit words. These words could be combinations of addresses, instructions or states of the control lines.

We've probably both spent hours at the simulator to prove we had good software and then discovered the hardware won't play—what do we do? You know the traditional answer. Dig out the scope, get out the program printout, and brace yourself for hours of grinding, point-by-point checks. But I can tell you that doesn't have to be the case. Especially now that HP has introduced some new tools that can really cut down your troubleshooting time.

HP's Logic State Analyzers can really take a lot of pain out of your troubleshooting procedures. You'll find wiring errors, defective components, and even solder splashes; and you'll find them a lot more quickly than ever before.

Let me give you an example. We had an eight-bit microprocessor system with start-up problems. The clocks were running and phased right, and the address lines toggled, but the machine didn't function. So, we set up an HP 1600S Logic State Analyzer to look at both the Address and Data buses. It was then we noticed that only "zeros" were being fetched from memory. Knowing the ROM was good, we then added several control lines to the display and the problem showed up immediately. The "Enable" line never went high. A quick look at the "Enable" driver showed the input was ok, but no output. Obviously, the gate was defective.

I don't know how long it would have taken to find that one without HP's Logic State Analyzers, but I *know* it would have taken us a lot longer.

Call your local HP field engineer. He'll give you all the details on the 1600S (priced at $6800*) including spec sheets and application notes detailing the use of mapping for troubleshooting minicomputer and microprocessor systems. He'll tell you about the seminars that HP has arranged around the country and tell you when one will be held in your area and how you can attend. You ought to go to one, because you'll discover an exciting new concept in digital troubleshooting.

*Domestic U.S.A. price only.

086/5

HEWLETT hp PACKARD

Sales and service from 172 offices in 65 countries.
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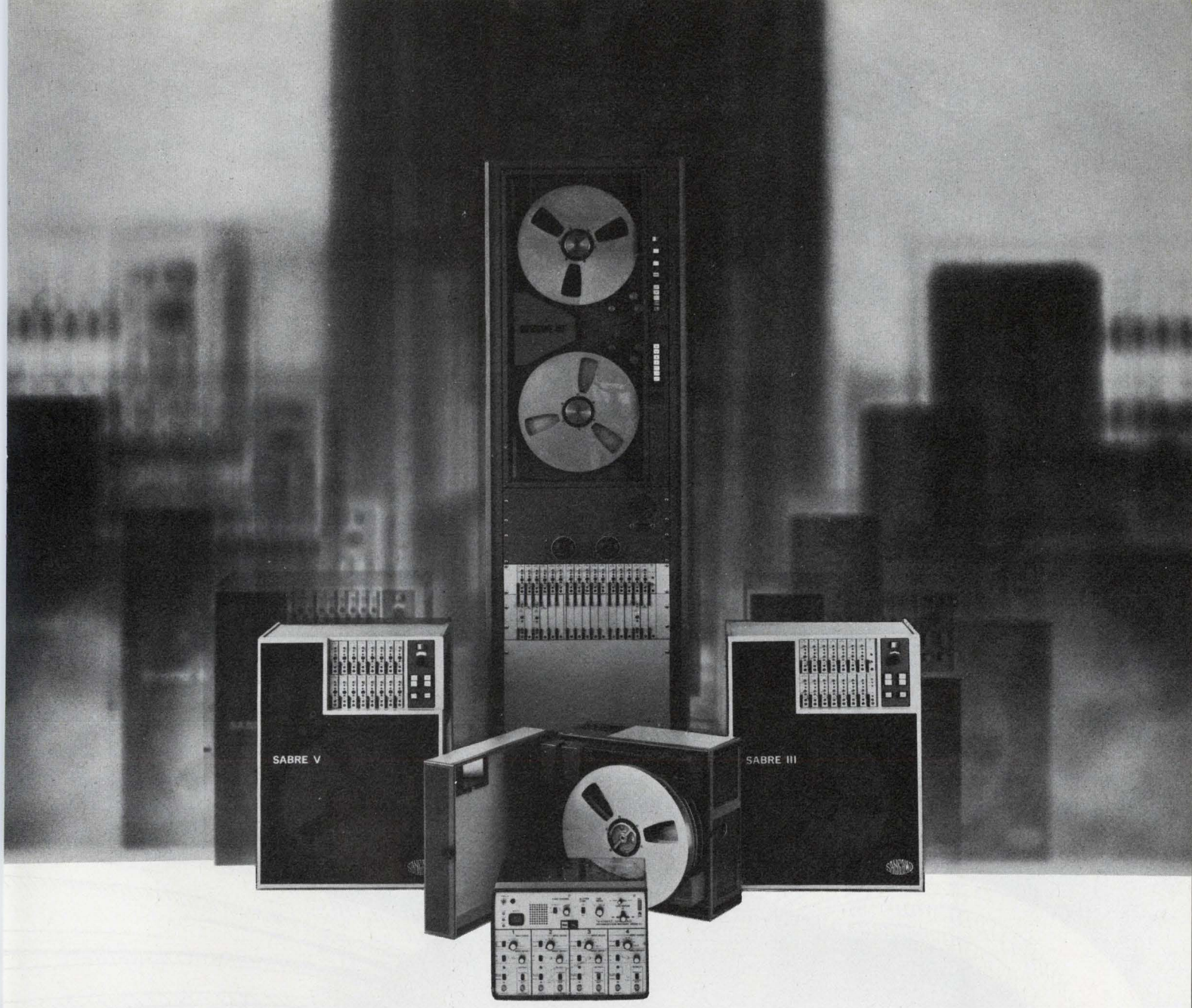
CIRCLE NUMBER 35



Now our expandable line offers DC to 4 million bits per second!

We offer PCM capability, in addition to Direct and FM electronics, in three of our recorder/reproducers. There's the 7 to 14 channel Sabre III and the 28/32 channel Sabre V, both IRIG all-band portable recorders; and the Sabre IV, a 7 to 48 channel laboratory recorder/reproducer.

In addition our line includes the new Sabre VI which offers superior performance plus ultra-portability, and the Tandberg TIR-115, a 4-channel, FM, 25-pound system.

Those basic five recorders are actually an almost unlimited line because each is designed and built to adapt to an amazing variety of functions. Just tell us what you want one to do!

For information write: Sangamo Electric Company, Data Systems Division, P.O. Box 3347, Springfield, Illinois 62714. Area Code 217, 544-6411. Telex 406-461. Sales and service representatives worldwide.

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CIRCLE NUMBER 36

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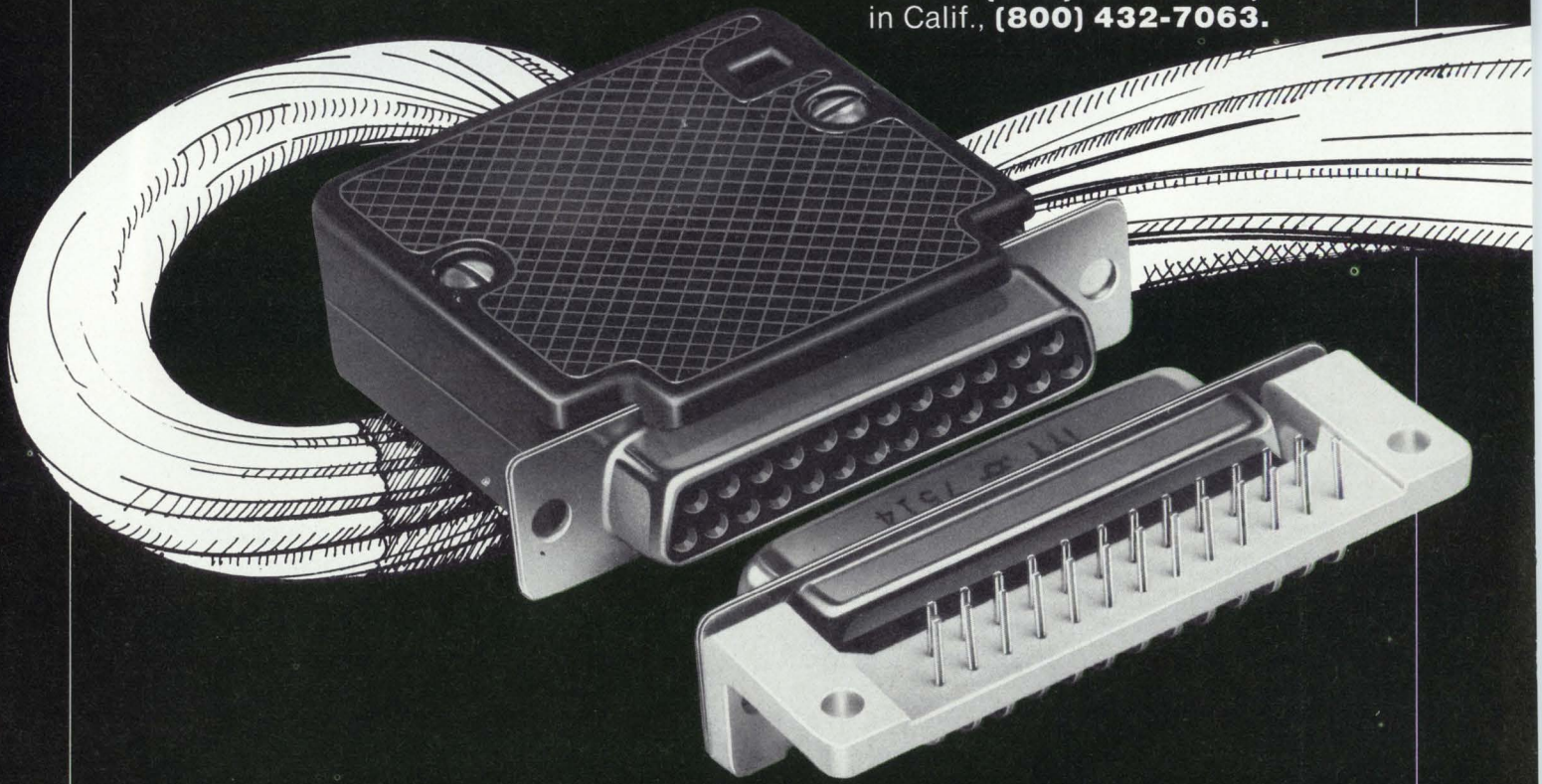
It lowers your total installed cost. Want to save on assembly time? Increase production? Buy in bulk? Reduce inventory? Simplify tooling? They're your system's real costs—your total installed cost—and we can cut them with our new flame-retardant-plastic, UL-recognized Burgun-D Mark IV D Subminiature Connection System. It's a whole, low-cost, reliable production system built around our universal Burgun-D.

Crimp, removable contacts • Printed-circuit contacts, straight or 90° • Screw machine or stamped contacts • Semi-automatic strip and crimp—crimp machine: 1500-2000 contacts per hour • 5 different connector sizes • 9, 15, 25, 37, 50 contact arrangements • #20-#30 wire sizes • Rugged metal shells • Complete accessories • Intermateable, interchangeable, intermountable, layout for layout with all D Subminiatures • Available at any authorized Cannon distribution center throughout the world. Applications: computer peripherals; data machines; telecommunications; machine tools; consumer electronics. Send for our "Cannon Cost Cutters" brochure today. ITT Cannon Electric, 666 East Dyer Road, Santa Ana, Calif. 92702. **Toll-free, 24-hr (800) 854-3573;** in Calif., **(800) 432-7063.**



Six decades on the leading edge of interconnect technology.

CANNON ITT

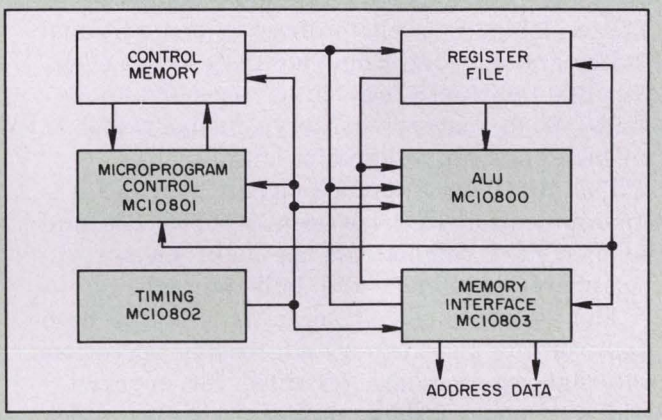
CIRCLE NUMBER 37

ECL bit-slice processor arrives, setting top speed for bipolar μPs

The fastest bit-slice microprocessor—Motorola's long-awaited M10800 ECL family—cuts instruction-execution time to as little as half that of other bipolar versions. In a 16-bit system, the MC10800 4-bit slice takes only 62 ns to execute a micro-instruction. Present processor slices employ TTL and require much longer times (see news story this issue, p. 34).

Besides the MC10800 arithmetic-logic unit (ALU), the family consists of the MC10801 microprogram-control function, the MC10802 timing circuit and the MC10803 memory interface. All members of the family are fully compatible with the company's high-speed MECL 10,000 logic line. Hence any circuit in the series—especially memory circuits—can be used in conjunction with the new circuits from Motorola (P.O. Box 20294, Phoenix, AZ 85036. 602-244-3465).

The ALU circuit requires an external register file, in contrast to TTL versions like Advanced Micro Devices' Am2901, which has an internal file. Although the requirement increases package count, the external memory can be built to any size and configuration. Also, unlike the



Am2901, the slice performs both BCD and binary arithmetic.

The MC10800 performs all logic operations and does both logic and arithmetic shifting. It contains an accumulator for temporary storage, and a special mask network that allows bit manipulation—an important feature for controller applications. Status bits are provided to allow branching in the main program or in the microprogram.

The MC10801 control circuit provides the addressing and sequencing logic needed to

(continued on page 54)

Next in kits: do-it-yourself PROM programmers

Not only do microcomputers come in kit form. Now PROM programmers can be put together from kits offered by Cramer Electronics (85 Wells Ave., Newton, MA 02159. 617-969-7700).

The 2708/2704 EPROM Programmer Cramerkit contains all the components, software and design documentation needed to build a self-contained programmer for the popular 2708 (1 k $\times$ 8) and 2704 (512 $\times$ 8) erasable EPROMs. All timing requirements of the EPROM are handled by the hardware, minimizing the required software and simplifying connection of the kit to virtually any system.

The kit is available for immediate delivery for only $99.95. With a special customized Augat board, the cost is $129.95. The kit was developed in conjunction with Microcomputer Techniques, Reston, VA.

Booth No. 1510-1530 *Circle No. 502*

MICROPROCESSOR DESIGN

(continued from page 53)

operate the microprogram memory. It also generates a series of next-address instructions, thereby easing the burden of writing the microprogram code. Like the ALU slice, it can be cascaded and as a result, can handle virtually any memory size. A single MC10801 can address 256 words; three of the circuits can handle 4-k words.

Contained within the MC10801 are various registers for status, instruction and address; a last-in first-out stack; and an incrementer. Built-in logic provides 16 instructions, any one of which can generate the next address. These instructions allow direct and conditional jumps and subroutining. One instruction even permits multipath-branching decisions to be made. Such features conserve memory and save on medium-scale-integration circuits.

The MC10803 interface circuit provides a communication link between M10800 ICs and such system components as main memory, peripheral terminals and bulk storage.

The interface circuit contains logic for both data routing and memory-addressing operations. Internal registers are provided for memory address, memory data, program counter, stack pointer and other memory-related functions. Seventeen data-transfer instructions can be used to route information between different registers and I/O ports. The interface circuit may be operated in parallel with the ALU slice to enhance system speed.

The MC10802 circuit handles various timing chores, such as starting and stopping the processor. It has a reset capability and generates up to four clock phases. A larger number can be obtained by cascading several circuits. Also offered in the MC10802 is a diagnostic capability for running through a program one step at a time. Thus the timing circuit offers a means to perform program debugging and even system checkout.

All M10800 circuits operate from MECL 10,000 supplies of −5.2 and −2 V and over the −30-to-85-C temperature range. Typical operating dissipation for the ALU circuit is 1.4 W. Other circuits in the family need about the same amount of power.

This high dissipation is handled by a special quad in-line (QUIL) package that has a maximum rating of 2 W. Developed especially for the M10800 family, the QUIL package takes up about the same board space as a standard 24-pin DIP, but the QUIL's 48 pins are arranged in four rows of 12 pins each. The package is compact and wire-wrappable.

Initial shipments of the M10800 family will come with sockets for the QUIL packages. The MC10800 slice is available now at a price of $75 in single-unit quantities and $50 in hundred-up quantities. Other members of the family are similarly priced. The MC10801 will be available in August, and the MC10802 and MC10803 in October.

Motorola plans to expand the family by introducing special circuits to interface with TTL systems, but the initial offering will be the nucleus of any future system.

CIRCLE NO. 501

$295 μC-on-board aims to satisfy most requirements

A single board measuring just 6.75 × 12-in. provides the computing power, memory storage and I/O facilities needed for the bulk of OEM-processing and equipment-control applications. Moreover, the new 8080-based SBC 80/10 from Intel (3065 Bowers Ave.. Santa Clara, CA 95051. 408-246-7501) costs only $295 in quantities of 100.

The SBC 80/10's versatility stems from its programmable parallel and serial I/O, which allows designers to use the same single-board μC in different equipment by simply changing six or less program instructions and plugging in appropriate line drivers and terminators.

The board's central processor subsystem includes an 8080A μP, interrupt control, crystal-stabilized system clock system bus control (intraconnection control logic) and high-current drivers for memory expansion.

Memory consists of 1 kbyte of static RAM and up to 4 kbytes of ROM. Sockets on the board can

(continued on page 56)

Point by point, line by line:

See why our lowest-cost Graphics package has no competition.

Our 1024 X by 780 Y viewable points separate Graphics from mere graphing. The price has never been lower. But Tektronix' new 4006-1 provides the same superior information capacity that has made us the company for all your graphics needs.

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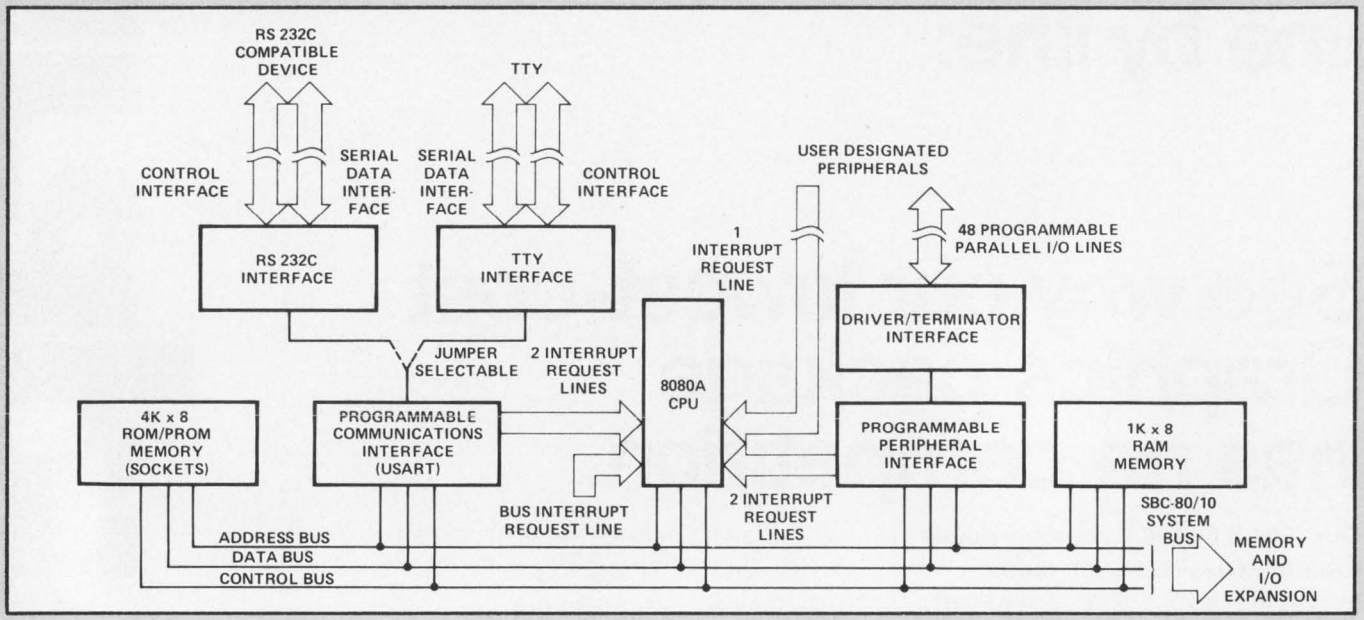
CIRCLE NUMBER 38

Graphics $2995

(continued from page 54)



be used to plug in up to four optional 1-kbyte EPROMs, or interchangeable 1-kbyte masked ROMs.

The parallel I/O features 48 lines organized as six programmable, eight-line I/O ports. Sockets for line drivers and terminators provide a means to establish the desired electrical characteristics.

The serial I/O features a programmable USART (universal synchronous/asynchronous receiver/transmitter), standard data-communication interfaces (RS232C and teletypewriter) with built-in drivers and receivers, and a variable baud-rate generator.

CIRCLE NO. 503

Custom board simplifies assembly of 8080A kit

With a wire-wrappable socket board, assembly time for the Intel 8080A Cramerkit can be reduced to a matter of minutes. Offered by Cramer Electronics (85 Wells Ave., Newton, MA 02159. 617-969-7700), the board sells for $275 to $325. The custom board is manufactured exclusively for Cramer by Augat, Attleboro, MA.

Booth No. 1516-1530 *Circle No. 504*

Component tester speeds checkout of 6800 family

Users of Motorola's Exorciser development system can now employ an external component tester to speed incoming inspection of 6800 circuits.

The MEX68CT tester from Motorola (P.O. Box 20294, Phoenix, AZ 85036. 602-244-3465) consists of a "mother" board and a series of special "personality" boards and test programs that evaluate the following circuits: 6800 μP, 6820 peripheral-interface adapter, 6850 asynchronous communications-interface adapter, and the family's 6810 RAM and 6830 ROM. Moreover, Motorola says that forthcoming boards and programs will be able to test popular microcomputer components now offered by other manufacturers.

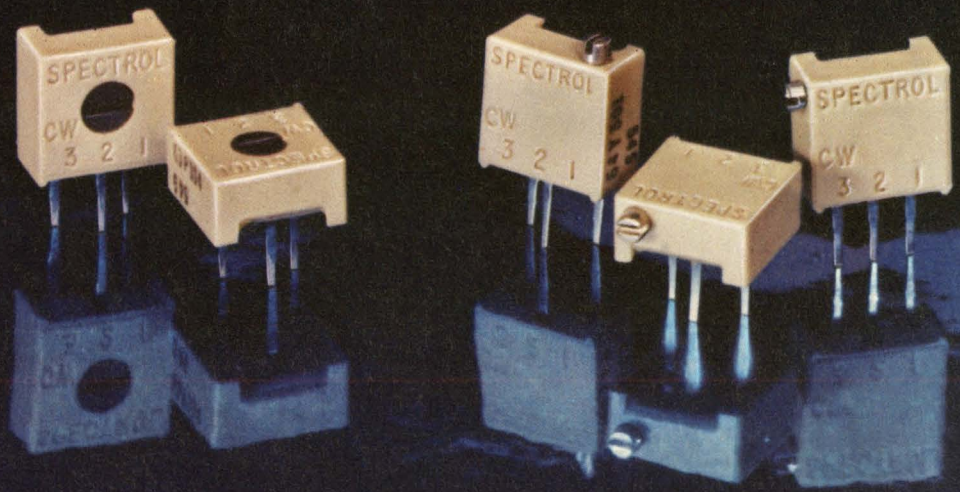
To test a circuit, a user first connects the circuit's personality board to the mother board, which is then hooked up to the Exorciser. The circuit's test program is entered in the Exorciser. Next the user simply installs the device to be evaluated in the tester, presses a Test switch and obtains a good/fail indication.

One Exorciser system controls up to eight testers, and power for the testers may be obtained from the development system or from an external source. Optional features include footswitch control and extender cable for environmental testing in special chambers.

The mother board plus Exorciser-interface card cost $1500. Individual personality boards range in price from $175 to $260. Delivery is from stock.

CIRCLE NO. 505

Six great features these two popular trimmers have in common:



The Model 63
3/8″ Singleturn Cermet

The Model 64
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1. Soldered terminations for reliability.
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CIRCLE NUMBER 39

Our incred

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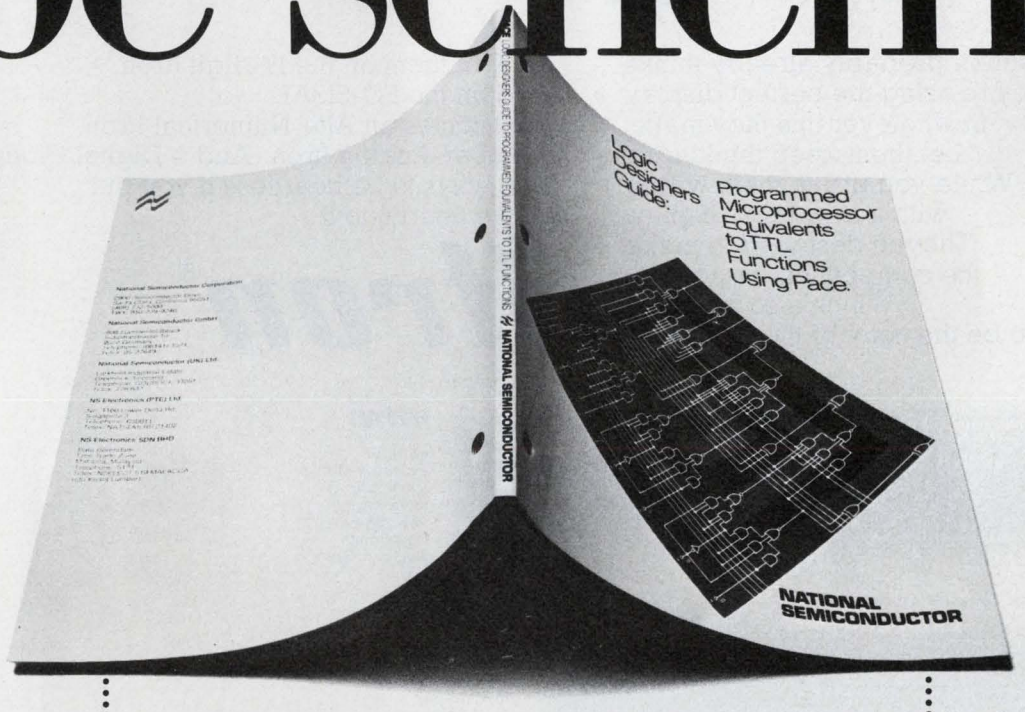

National Semiconductor Corporation
2900 Semiconductor Drive, Santa Clara, California 95051

ED510

You clever devils:
I think this whole thing is a scheme to get *you* rich. But here's my $5.00, anyway.
If the Logic Designer's Guide is as good as you say, I probably won't regret it.

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Company_____ Address_____

City_____ State_____ Zip_____

It's the "Logic Designer's Guide to Programmed Microprocessor Equivalents to TTL Functions Using Pace." And it's intended to help system designers make the transition from design in hardware to design in software. Thus saving your company a lot of money, which they will probably turn over to you. Or will they?

National Semiconductor

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Your competition probably already thinks they're using the perfect display in whatever it is they make. Let them keep thinking it. While you prove them wrong with a new Itron display. They're designed to make the competition turn green. Which also happens to be the color of the segments.

All 17 of them on the 17-digit Itron.
All 5 on the FG-512A1.
Next comes an Alfa-Numerical Itron.
A Linear-Analog Itron. And a Digital Clock Itron.
Five ways to be heartless if you put a little heart into it.

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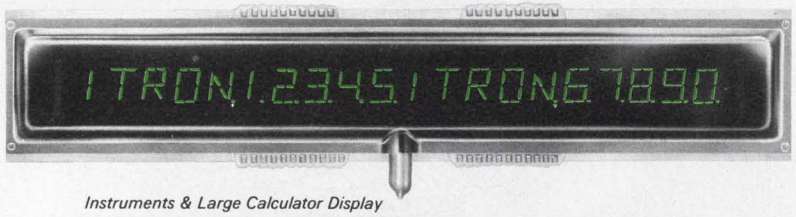
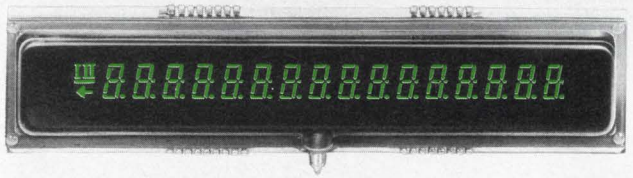
Alfa-Numerical Display



FG209M2

ef=10V
ec=eb=40Vp-p
ic=10mAp-p
ib=8mAp-p
Wd. 205mm
Lg. 40mm
Segment 9mm

Instruments & Large Calculator Display



FG179F2

ef=7V
ec=eb=35Vp-p
ic=7mAp-p
ib=5.5mAp-p
Wd. 170mm
Lg. 40mm
Segment 9.5mm

Digital Clock Display

FG425A1

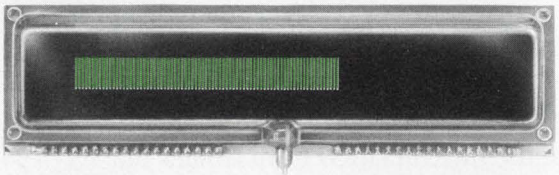
ef=5.5V
ec=eb=35Vp-p
ic=8mAp-p
ib=6.5mAp-p
Wd. 140mm
Lg. 59mm
Segment 25mm

Instruments & Terminal Units Display

FG512A1

ef=3.5V
ec=eb=24Vp-p
ic=4mAp-p
ib=3mAp-p
Wd. 100mm
Lg. 40mm
Segment 12mm

Linear Analog Display



FG120S1

ef=5.5V
ec=eb=35Vp-p
ic=4mAp-p
ib=0.2mAp-p
Wd. 140mm
Lg. 40mm
Segment 8mm

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CIRCLE NUMBER 41

Someday Issaquah will be famous.

Someday, people will say: "Issaquah, Washington, that's the home of Data I/O!"

But that's "someday." Today, more people remember us for our PROM programmers than for our name. We understand. After all, the 1500 companies who use our machines need programmers—not a name. So here's what's behind "Data I/O."

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Our new Programmer VIII is a completely portable, microprocessor based unit. You can take it anywhere and easily update it year after year.

Our Programmer X is for Programmable Logic Arrays (PLA's). It features CRT display, multiple inputs and outputs, and error detection through both logical and array verification. It's also microprocessor based.

Our Romulator lets you emulate any PROM configuration on the market today, develop a complete program and debug it before you ever have to commit it to a PROM.

Data I/O offers a unique calibration standard which lets you calibrate to each PROM manufacturer's specs—before you program—for maximum yields and long term I-C reliability.

Data I/O total three point service

1. Every Data I/O customer receives a quarterly update on currently available PROMs.
2. Through our direct (computerized) mailing program, Data I/O customers are kept constantly up-to-date on PROM specification changes and technological innovations.
3. Eight field offices in the U.S. and 22 distributors worldwide provide our customers with direct sales support, installation, and operator training.

Get the facts.....

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Title_____

Company_____

Address_____ M/S_____

City/State/Zip_____

Data I/O

CIRCLE NUMBER 42

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$795 never bought a system DMM like this...

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- **Fully programmable in function, range and even autorange**
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- **0.007% Basic accuracy for 6 months**

Until now, you'd pay $2000 to get what the Model 3400 gives you and even then, you might come up short.

The Data Precision Model 3400, at just $795, is the world's most accurate systems/lab 4½-digit multimeter. It is the only DMM in this price range designed with digital data interface as a true system multimeter as well as a highly versatile stand-alone unit. It is completely and independently programmable from its rear terminal digital interface for both range, function and even autorange.

The Model 3400 features include TRI-PHASIC®, the Data Precision exclusive conversion cycle for drift-free overall system performance; up to 12 complete full-scale conversions per second providing printer-compatible data throughput rates; overload protection to 1000 Volts peak on all Volt and Ratio ranges, plus 270V on all resistance ranges; and optimum utilization of 4½ digit resolution through 100% overrange.

And there is still more. The Model 3400 implements "overlap mode" for interlacing MUX advance and sampling, so that system throughput rate equals instrument conversion rate, without MUX settling errors; BCD output is fully printer-compatible; accurate, stable, repeatable 10 μV resolution DC and AC; and it provides full function versatility: DC Volts; AC Volts; Ohms; DC/DC and AC/DC Ratio. IEEE Standard 488 BUS optional.

In the Model 3400, Data Precision has put complete system-implementing control within reach of many new customers. It's just part of our on-going commitment to provide the most accurate and reliable instrumentation at the lowest possible price.

For complete information or a demonstration, contact your local Data Precision representative or Data Precision Corporation, Audubon Road, Wakefield, MA. 01880, (617) 246-1600. TELEX (0650) 949341.

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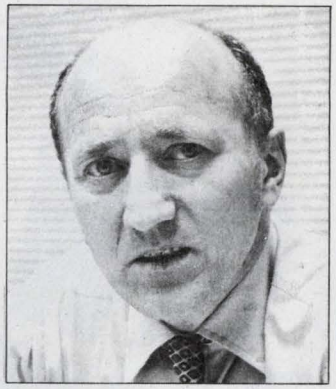
FOR DEMONSTRATION CIRCLE #273
FOR ADDITIONAL INFORMATION CIRCLE #274

Editorial

The importance of Jack



Jack was an important executive and everybody knew it. You could tell it right away because Jack was extremely difficult to get to. Even his secretary was difficult. It was clear that her mission was to protect Jack from his subordinates. Following Jack's instructions, she spent most of her time making certain that callers didn't waste her boss' precious working hours.

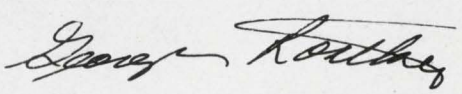
Jack was always available—instantly—when his boss called. His "Hi, Sally. Can I speak to Jack?" always met a super-prompt, super-enthusiastic, "Certainly, Mr. Jones, right away." But if one of Jack's engineers called, Sally bristled. "He's very busy. Can it wait until some other time? Can somebody else take care of it? Can you tell me about it so I can discuss it with him when he's free? Can't you take care of it yourself?" And often, Sally would so grind down an engineer that he would give up. He would make a decision that should have been Jack's and risk Jack's wrath—for which there was always time—if Jack's decision would have been different.

But most of the time Jack never knew decisions were being made. He would assemble his engineers occasionally to criticize or give them instructions. But he had little else to do with them or, for that matter, with customers or vendors. Sally warded them off, too. So customers and vendors learned to call Joe, one of Jack's subordinates. With his secretary, he made everybody feel welcome and made everybody's problems important enough to merit attention.

The sequel to this tale is predictable. In the next economy wave, Jack and Sally were let go. It was apparent that their principal activities were pleasing their bosses.

Jack and Sally probably got what they deserved. But there are probably hundreds of other Jacks and Sallies who, alone or together, render frequent disservice to their co-workers, customers, suppliers, employers and, in fact, themselves.

A secretary who derives status from sheltering her boss from the outside world injures him and everybody else. And the boss who, through design or innocence, allows himself to become too "important" to stay in touch with others soon loses touch with everything.



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Editor-in-Chief

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	12.0	EC2N12	80.00	65.50	62.00
	17.0	EC2N17	101.00	82.00	78.00
	25.0	EC2N25	137.00	112.00	106.00
5 V.	3.0	EC5N3	31.00	24.95	22.95
	6.0	EC5N6	51.00	41.50	39.00
	9.5	EC5N9.5	63.00	51.00	48.50
	12.0	EC5N12	80.00	65.50	62.00
	17.0	EC5N17	101.00	82.00	78.00
	25.0	EC5N25	137.00	112.00	106.00
6 V.	2.6	EC6N2.6	31.00	24.95	22.95
	5.4	EC6N5.4	51.00	41.50	39.00
	8.5	EC6N8.5	63.00	51.00	48.50
	11.0	EC6N11	80.00	65.50	62.00
	15.0	EC6N15	101.00	82.00	78.00
	23.0	EC6N23	137.00	112.00	106.00
12 V.	2.2	EC12N2.2	31.00	24.95	22.95
	3.5	EC12N3.5	51.00	41.50	39.00
	6.0	EC12N6	63.00	51.00	48.50
	7.5	EC12N7.5	80.00	65.50	62.00
	10.0	EC12N10	101.00	82.00	78.00
	16.0	EC12N16	137.00	112.00	106.00
15 V.	1.8	EC15N1.8	31.00	24.95	22.95
	3.0	EC15N3	51.00	41.50	39.00
	5.0	EC15N5	63.00	51.00	48.50
	6.5	EC15N6.5	80.00	65.50	62.00
	9.5	EC15N9.5	101.00	82.00	78.00
	14.0	EC15N14	137.00	112.00	106.00
20 V.	1.5	EC20N1.5	31.00	24.95	22.95
	2.5	EC20N2.5	51.00	41.50	39.00
	4.2	EC20N4.2	63.00	51.00	48.50
	5.3	EC20N5.3	80.00	65.50	62.00
	8.0	EC20N8	101.00	82.00	78.00
	11.0	EC20N11	137.00	112.00	106.00
24 V.	1.3	EC24N1.3	31.00	24.95	22.95
	2.4	EC24N2.4	51.00	41.50	39.00
	4.0	EC24N4	63.00	51.00	48.50
	5.0	EC24N5	80.00	65.50	62.00
	7.5	EC24N7.5	101.00	82.00	78.00
	10.0	EC24N10	137.00	112.00	106.00

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±12	3.0	EC12D3	89.00	72.00	67.00
±15	3.0	EC15D3	89.00	72.00	67.00
±12	5.0	EC12D5	122.00	99.00	92.00
±15	5.0	EC15D5	122.00	99.00	92.00

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±15	3				

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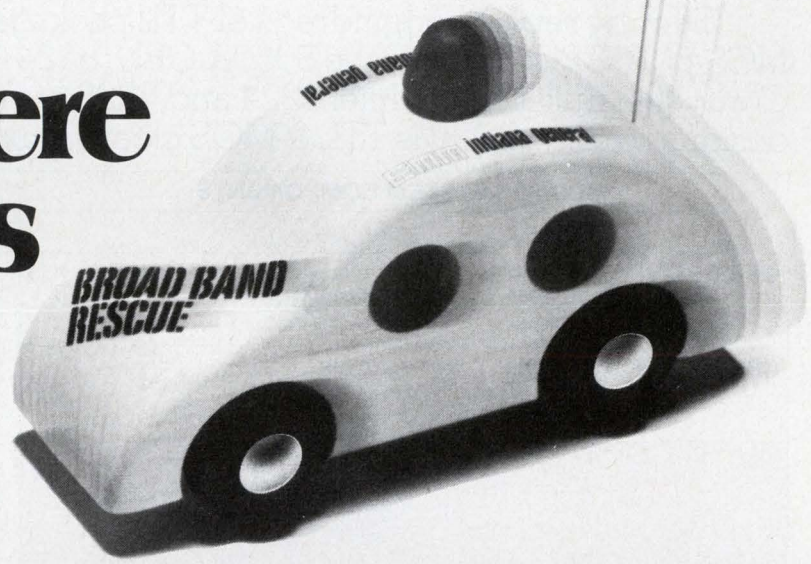

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	Part No.	Description
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	8224	Clock Generator
	8228	System Controller
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	8080A-2	1.5μs cycle
	M8080A	2 μsec cycle (−55 to +125°C)
I/O	8212	8-bit I/O Port (15 mA drive)
	8251	Programmable Communication Interface
	8255	Programmable Peripheral Interface
PERIPHERALS	8205	1 out of 8 Binary Decoder
	8210	Dynamic RAM Driver (8107B)
	8214	Priority Interrupt Control Unit
	8216	Bidirectional Bus Driver, Non-Inverting (50 mA)
	8226	Bidirectional Bus Driver, Inverting (50 mA)
	8222	Dynamic RAM Refresh Controller (8107B)
	8253*	Programmable Interval Timer
	8257*	Programmable DMA Controller
	8259*	Programmable Interrupt Controller
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	8704	512 x 8 Erasable, 450 ns
	8708	1K x 8 Erasable, 450 ns
ROMs	8302	256 x 8, 1μs
	8308	1K x 8, 450 ns
	8316A	2K x 8, 850 ns
RAMs	5101	256 x 4 Static CMOS, 650 ns
	8101A-4	256 x 4 Static, 450 ns
	8102A-6	1K x 1 Static, 650 ns
	8102A-4	1K x 1 Static, 450 ns
	8107B	4K x 1 Dynamic, 420 ns
	8111A-4	256 x 4 Static Common I/O, 450 ns

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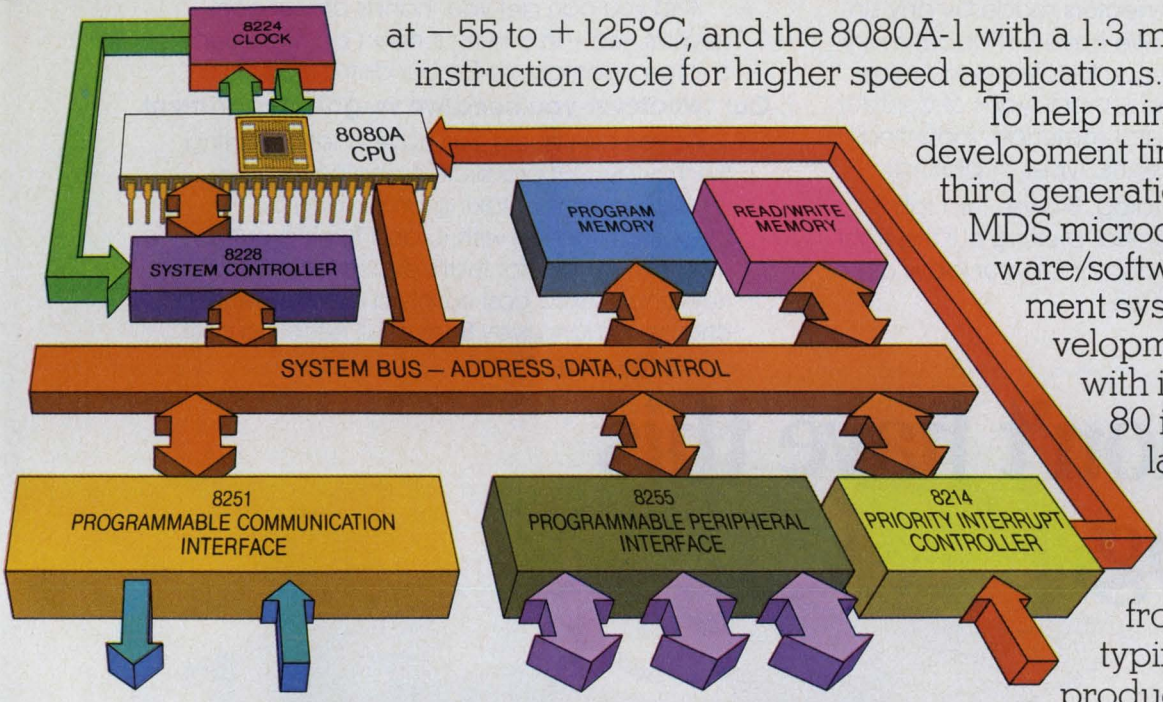

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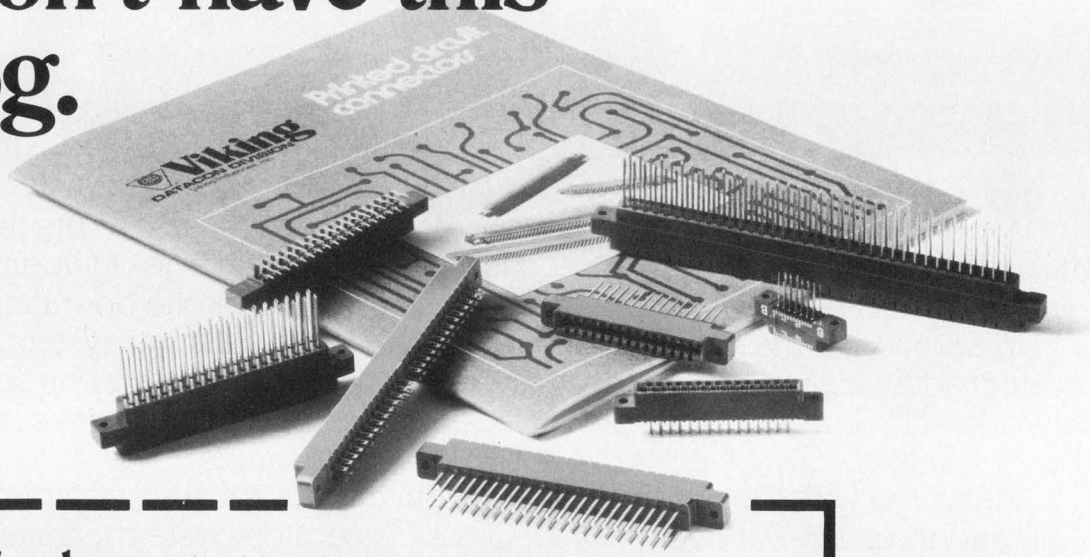

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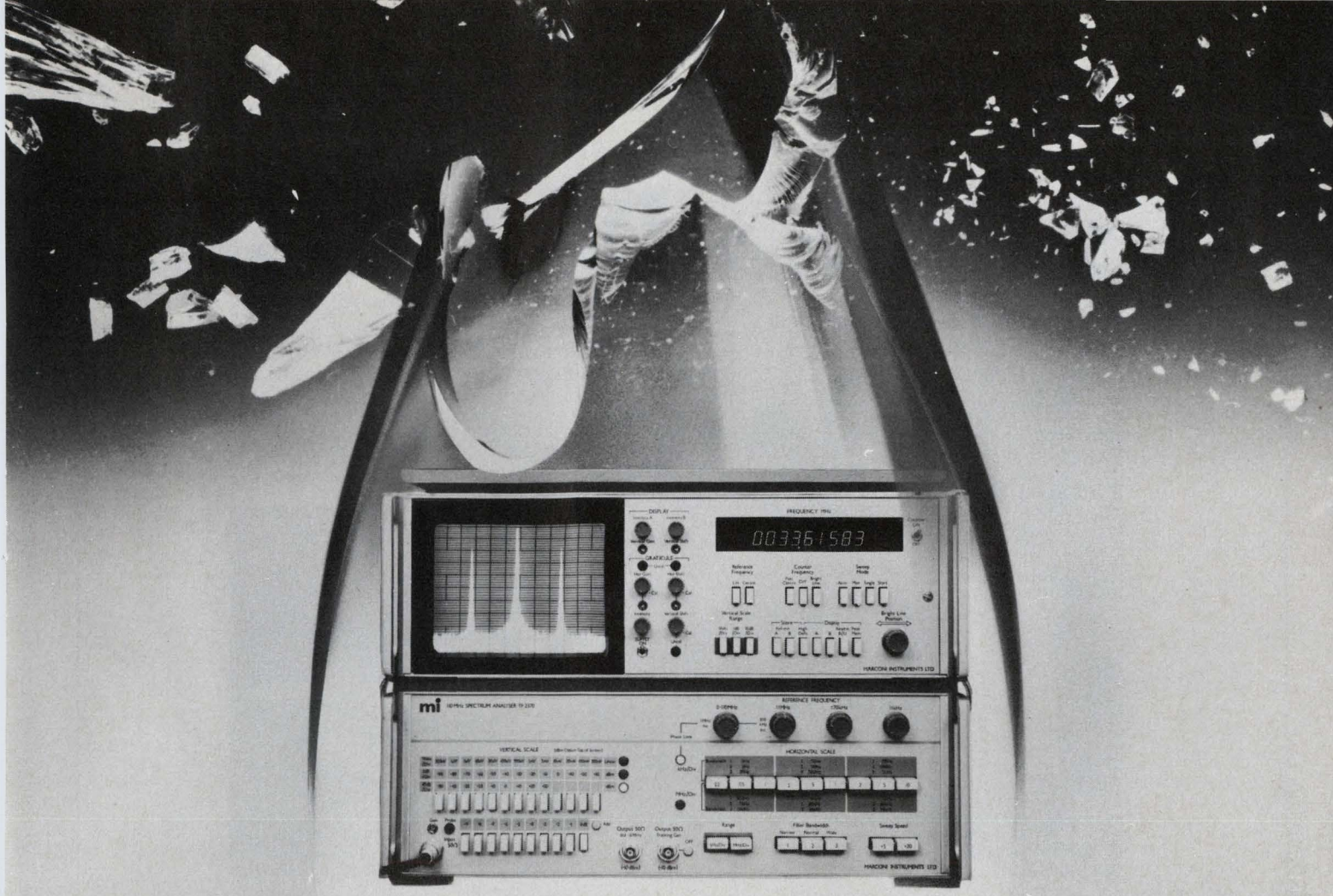

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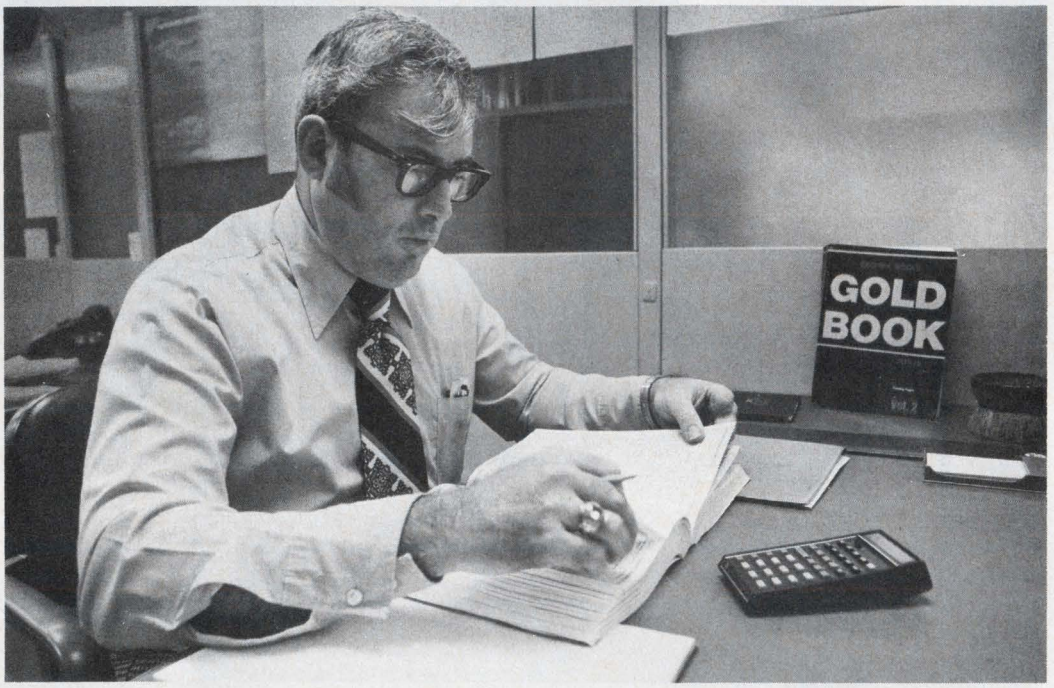

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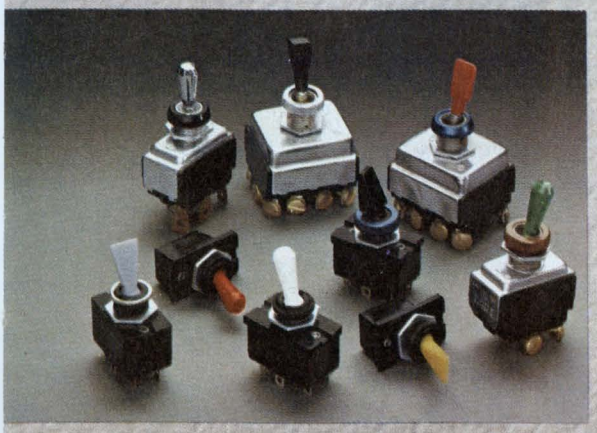

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CIRCLE NUMBER 45

Switch to No. 1

Electro 76

It's an all new show--

A number of significant firsts mark this year's international IEEE convention and product exposition.

The show is being held in Boston, the first time the annual electronics extravaganza has been held outside of New York City. It's got a new name—Electro 76. And it's being held later than ever—May 11-14 instead of March or April.

The exhibition will take place in Hynes Memorial Auditorium, and according to an IEEE spokesman, has been sold out since early January. American and overseas exhibitors—including major representations from the USSR, Israel, the United Kingdom, West Germany and Japan—will occupy 250 booths. The four-day exhibition is expected to attract some 25,000 visitors.

The technical program will be held in the Sheraton-Boston and will consist of 34 morning and afternoon sessions.

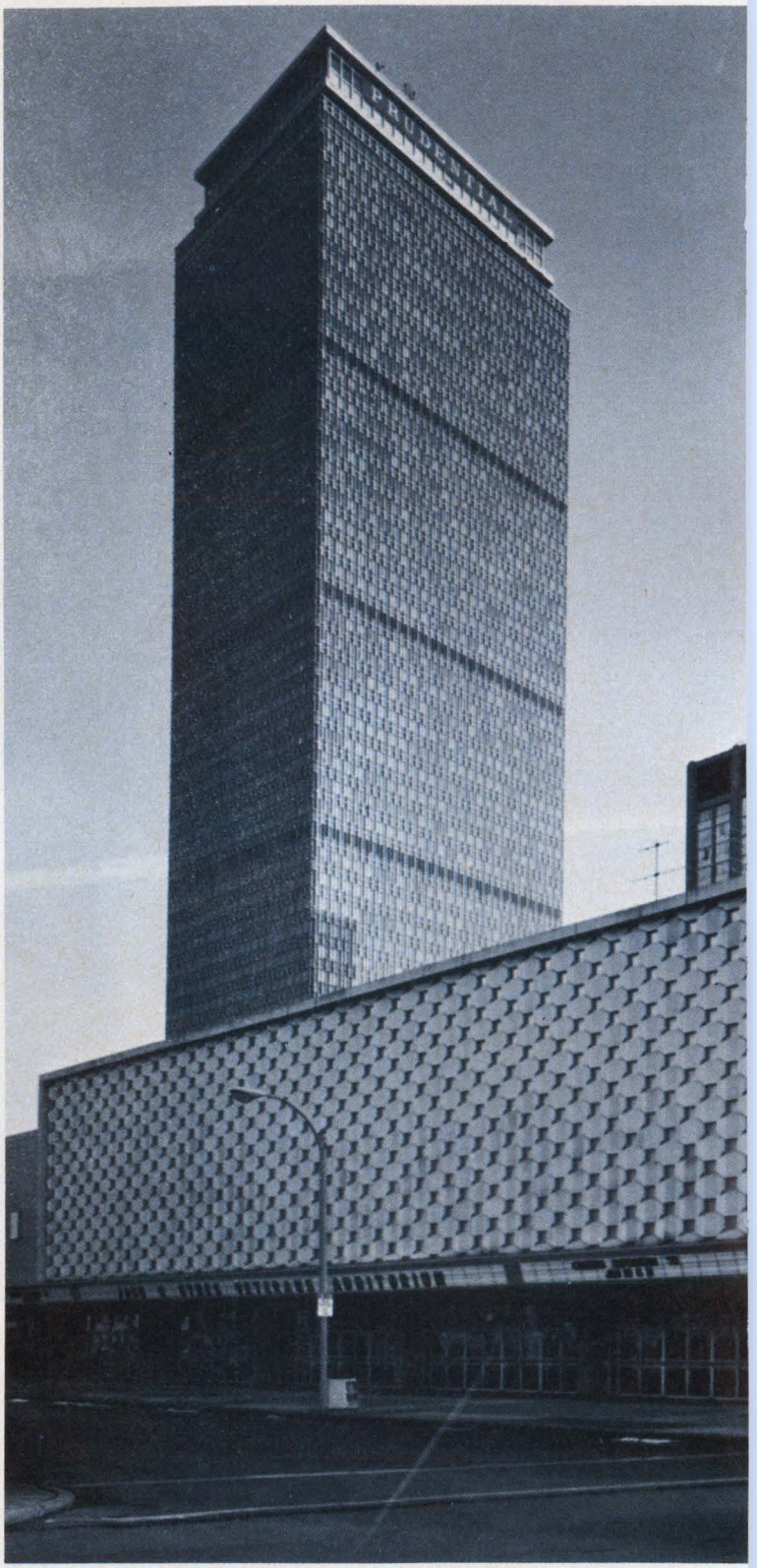
Dr. C. Lester Hogan, vice chairman of Fairchild Camera and Instrument Corp., will give the keynote address during a special session on opening day.

The emphasis in the technical program is on microprocessors, microcomputers and LSI; six sessions are dedicated to applications, testing, languages, and design aids, and the impact of μPs is seen in many other papers.

"Smart" instrumentation, power semiconductors, trends in communications equipment and modern radar techniques are also strongly represented in the program.

Some of the more important technical papers on microprocessors are offered in Session 8, "Design Aids for μPs," and Session 23, "High-Level Languages for μPs."

The papers in Session 8 survey the hardware



Boston's Hynes Auditorium and the Sheraton are expected to attract nearly 25,000 visitors.

And it opens in Boston

and software tools available for μC system development, including "low-end" inexpensive kits and evaluation boards and "high-end" complete development systems, including high-level languages usable both for MOS processors and bipolar bit-slice micros.

Session 23 papers examine the higher-level vs assembly language controversy and offer guidelines to help users decide which language would be more cost-effective in their applications.

In the test and measurement area, Session 6 covers new uses of signal processing to improve measurements. Papers discuss the use of mini and microcomputers to improve measurements by mathematically processing instrument-output data.

The practical side of designing with power semiconductors is covered in Sessions 5 and 16. Among the topics discussed are trends in Darlingtons, SCRs and power Schottky diodes, and the application of high-voltage power transistors to efficient switching-power supplies.

Present and future trends in communications equipment design are the theme of Session 20. Papers concentrate on improved receiver dynamic range, low-noise reception and measurement techniques.

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U.S. engineers take a second look at European radar and ECCM designs 78

Systems designers face bewildering array of hardware-software tools

The microcomputer systems designer is today faced with a confusing array of hardware and software tools for microprocessor-systems-development. They range from small kits and evaluation boards for under a hundred dollars, up to fully developed systems, with sophisticated software and peripherals, costing in the thousands.

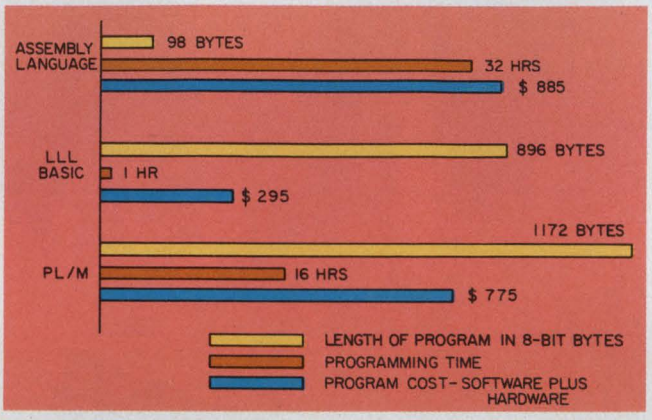
Just which type of hardware and software is most cost effective for a given range of applications will be discussed in Session 8, "Microprocessor Design Aids," organized and chaired by Edward Torrero, an associate editor of ELECTRONIC DESIGN.

Because most system logic is implemented in software rather than hardware, creating and testing the first prototype of a microcomputer system requires tools and techniques that have no parallel in hardwired logic, reports A. Scott McPhillips in his paper: "Hardware-Software Breadboards."

For microcomputer prototyping the designer must have, as a minimum, a machine that executes the software, shows him what is happening and allows him to make modifications, says McPhillips, vice president of Microcomputer Technique, Inc., Reston, VA.

This prototyping machine can be a simple system assembled from chips or small boards and provided with such bare debugging essentials as a teletypewriter and a ROM to operate it. But the lack of displays, controls and interfaces makes working with this primitive system arduous and time-consuming. At the other prototyping extreme are costly development systems, the expense of which often cannot be justified.

For testing small-volume and medium-volume production designs McPhillips recommends a middle-of-the-road approach that is based on a "standardized breadboard" Microcomputer Technique developed for several of the popular microprocessors. These breadboards, which have a variety of simple debugging controls, as well as displays, peripheral interfaces and supporting software, were developed for Cramer Electronics, a Boston distributor that markets them.



A new LLL Basic language from Lawrence Livermore Laboratory shows substantial savings when used in an 8080 benchmark program for a scientific instrument.

Effective low-cost techniques have been devised in the development of these breadboards. For example, a simple tool to get the hardware working is a plug-in 16-word memory comprised of switches. To use this, all memories are removed from the system and the switch ROM is connected so that it ignores all but the four least-significant address bits. It thus responds to any address the processor may generate.

In most microcomputer systems, the 16-word switch memory and an oscilloscope are all that are needed to test every aspect of hardware behavior, McPhillips says.

Also included, for program entry and display are a "poor man's terminal" (consisting of 16 additional switches) and a pair of seven-segment LED displays. The supporting software controls each segment of the display so that hexadecimal characters and even a question mark can be shown.

One bank of eight program switches is used to enter addresses and the program. The second bank is used to control and sequence the system software without using a teletypewriter.

"In our breadboard designs," McPhillips says, "we include LEDs on all system busses and often on inputs and outputs, too. The amount of time required to check the state of 8 or 16 points with conventional instruments is astounding compared

with the time needed for looking at an array of lights."

Bipolars need special design aids

Design aids useful for bit-slice bipolar microprocessors are different from those used for the single-chip MOS devices because of two factors, according to David C. Wyland, author of another Session 8 paper, "Design Aids for Bipolar Microprocessors." One factor is architectural flexibility and the other is the existence of a second level of programming called "microprogramming."

"The microprogram design phase can benefit greatly from a general purpose microassembler," reports Wyland, manager of LSI applications and systems design, Raytheon Semiconductor Div., Mountain View, CA. He calls the microassembler "probably the single most important design aid for microprogram-controlled bipolar μPs.

"Unit checkout can benefit from inclusion of checkout features that will interact with a microprogram display panel that allows the designer to step the microprogrammed unit through its various sequences and observe the corresponding activity."

Microprogram design consists of devising a flow chart that specifies the desired sequences. These sequences are then converted into bit patterns for ROMs containing the microprogram control. At this point in design a microcode assembler can greatly reduce the effort and error of translating the flow-chart sequences into ROM code.

Microprograms can be created by hand for a control ROM of up to 2048 bits, consisting of 256 8-bit bytes, Wyland points out. But above this size a number of problems appear that make hand-creation undesirable and the use of the general purpose microassembler almost mandatory.

The general-purpose microassembler is useful for both horizontal and vertical microprogram architectures. The horizontal microcode is characterized by wide microinstruction words of 40 to 80 bits, with many independent functions controlled directly by bits in the microinstruction. The vertical microcode is characterized by 12 to 32-bit words that are decoded to perform one or a few functions per microinstruction.

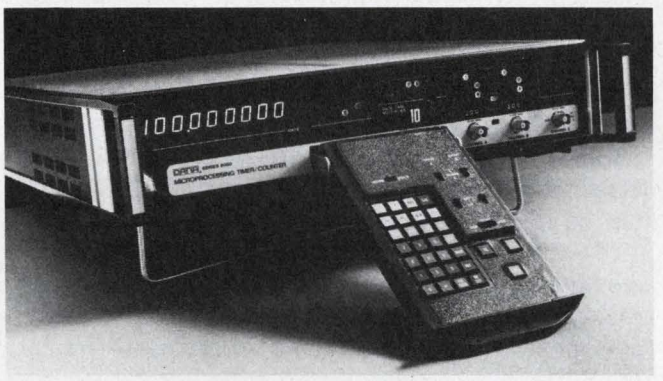
Horizontal system design results in simple, fast systems, Wyland says, because the system functions are driven directly by the ROM bits. But he cautions that horizontal design is expensive because many microprogram bits require numerous ROMs to drive each of them.

Small, high-speed systems of less than 256 words tend to be horizontal in design because relatively few chips are involved in the control-ROM section. For example, 40 lines can be controlled by five 256 $\times$ 8-byte PROM chips.

There is a tendency to add bits to the control ROM rather than to the microprogram, says Wyland, because horizontally organized systems often have up to ten 10-step microroutines. An added microprogram step here may increase operating time by 10 to 50%.

Vertical design is used to minimize the cost of the control ROM. That is, rather than use a large number of control-ROM bits for function control, a few ROM bits are decoded and the decoder outputs are used to control the system's functions.

Reducing the number of bits in the microinstruction reduces the number of chips required for the control ROM. But this reduction is obtained at the expense of speed and complexity.



Massive application of microcomputers by 1980 is predicted for consumer and for electronic applications like this Dana 9000 microprocessor-based timer-counter.

Large microprogram systems of 1024 words or more tend to be vertically organized, Wyland points out. These systems usually have long microcode sequences. As a result, microprogram steps are added, rather than a change in hardware, to solve design problems.

Several microassemblers have been developed for internal use by a number of companies, Wyland says.

The Rapid assembler developed by Scientific Micro Systems, Mountain View, CA, is available on the National CSS time-sharing network. It is probably the most widely used microassembler at this time. While it is well suited for vertical microprograms, Wyland cautions that it is difficult to use for horizontal microcoding.

Which high-level language is best?

The controversy over which high-level language is best to use for microprocessors continues unabated, with several late entries into the field.

"Based on realistic cost and production levels as well as the productivity of programmers, we find that Intel's PL/M is especially good for low volumes and inexperienced programmers," reports Terry Dollhoff, director of engineering at

Microcomputer Technique and author of a Session 23 paper, "Measuring the Cost Effectiveness of Microprocessor Languages."

When production volumes of 20 units or less are expected, there is little in favor of using assembly language, Dollhoff says. But there is considerable argument for assembly language use with a production volume of over 200 units.

"If future programming costs remain constant, reduced memory costs could drive that 200-unit break point upwards. However, since both of these costs are likely to rise in the future, we feel there is an absolute upper limit of about 250 units below which PL/M is favored.

"If the PL/M compilers become more efficient, the production boundary will shift in favor of that language," Dollhoff notes. "However, because of the way PL/M compilers are constructed, significant gains in efficiency are not in the offing.

"Perhaps five years from now there will be a better suite of compilers, but there will also probably be a better choice of languages."

To study the feasibility of high-level, interactive languages for use with their microcomputers, researchers at Lawrence Livermore Laboratory, Livermore, CA, selected two languages—PL/M and Basic.

"In general, PL/M is a subset of PL-1 written by Intel for its 8-bit microprocessors," says Eugene Fisher, programming supervisor at Livermore, in his Session 23 paper, "High Level Languages in Microcomputer Automation."

"PL/M's major deficiencies for the Livermore Laboratory included the fact that it is not interpretive and therefore there is time lost during debug," Fisher notes. "Also, there is no floating point capability.

"As a result, a subset of Basic called 'LLL Basic,' which could be used in both the interpretive and compile modes, was written for Livermore under contract to Idaho University.

"Both PL/M and Livermore Basic showed significant reductions in programming time and manpower cost," Fisher points out. The benchmark program, which was an actual calculation required for a scientific instrument, showed that the LLL Basic was 16 to 32 times faster to program than either assembly language or PL/M.

"This speed was the direct result of an immediately interactive language," Fisher says. "The benchmark also indicated that compared with assembly language the high-level languages were not particularly efficient in memory use. However," he notes, "with memory costs going down and manpower costs skyrocketing, this may be a very efficient tradeoff."

Newer, high-level languages adapted to microprocessors are appearing. One of these, called FORTH, is discussed by Geoffrey Leach, Sycor, Inc., Ann Arbor, MI, in his Session 3 paper "The

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State of the Art in Microprocessor Software."

"The FORTH language defies categorization," he reports. "However, its advertised use in the development of application language appears to place it in the system-implementation category.

"These system-implementation languages," he explains, "provide the designer with an algorithmic language that is close enough to the architecture of the target machine to permit the generation of reasonably efficient code while still being sufficiently close to the application to permit rapid coding. PL/M is such a language.

"The FORTH system appears to be a highly efficient and economical package that is relatively simple to develop and highly tailored to the needs of the end user."

FORTH was originally developed six years ago for minicomputers, and has now been tailored for RCA's COSMAC and Digital Equipment Corporation's LSI-11. FORTH programming is described in detail in a Session 23 paper entitled: "FORTH High-Level Programming Technique on Microprocessors," by Elizabeth D. Rather and Charles H. Moore of Forth, Inc., Manhattan Beach, CA. ■■

TEST & MEASUREMENT

Microprocessors continue to improve instruments and testing concepts

Microprocessors, microprocessors, and more microprocessors.

That's the pervasive theme at Electro this year, and the one dominating the sessions on instrumentation, testing and measurements. Papers to be presented at Electro run the gamut from design of equipment with μPs, to use of equipment to test μPs.

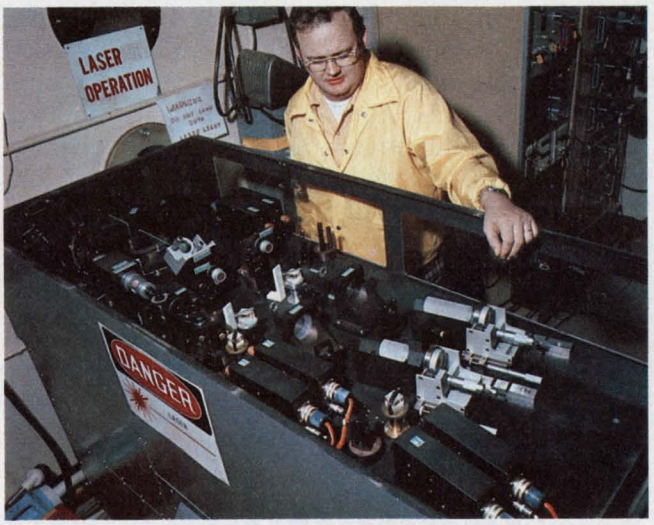
Improved measurements are, of course, a standing goal in test equipment and the obvious target of internal intelligence. By mathematically processing data, minicomputers—and μPs—boost instrument power, and also let users make entirely new measurements.

In a Session 6 paper entitled "Microprocessor Controlled Calibration and Diagnostics in a DMM," Zoltan Tarczy-Hornoch of Systron-Donner, Concord, CA, describes how a μP contributes to a DMM's accuracy and long-term stability:

"Among its other advantages, the μP permits a self-calibration feature that corrects automatically and periodically for gain and zero-offset errors in all modes and all ranges. Self-calibration can be based on internal references or, for more accuracy, on external sources."

Faster than a speeding bullet

A more exotic application of measurement enhancement through signal processing is outlined



Monochromatic light detects motion of a specimen in an interferometry technique, and a digitizer/computer processes the data to produce the specimen's velocity.

in another Session 6 paper by Robert Lederer of Sandia Laboratories, Albuquerque, NM. The problem: to measure with high accuracy the velocity of objects moving at super-high speeds—bullets leaving a gun barrel, for instance, or particles from explosive blasts.

Sandia's solution: Use laser interferometry to obtain a doppler-shift analog signal, digitize the signal with a fast waveform converter, then process the data with a PDP-11/40 minicomputer

to get velocity readings. The technique provides 1% accuracy with particles moving at speeds from 0.1 to 10 mm/μs.

"The analysis process involves quite a bit of software" Lederer says, "but the key is the measurement of velocity with two complex waveforms that are analyzed independently and then compared to dig out the required velocity."

He continues: "Applications of the technique include seismometers, displacement measuring devices, and the like. Or you can monitor any moving target and get continuous information on its motion."

Ironically, although the μP allows designers to create instruments that make better tests, how to test the μP itself is a sticky problem yet to be solved. New techniques and new equipment are necessary, whether the aim is production testing, engineering evaluation or field service.

With the proliferation of μPs, testing is of topical and urgent importance. This is reflected by two sessions—18 and 28—at Electro dealing with the problems and solutions of testing μPs and μP/μC-based systems.

The headaches of μP testing, from the semiconductor vendor's point of view, are outlined by Y. Feng of Intel in his paper "Testing Microprocessors in the Semiconductor Manufacturing Environment."

You don't have to be a vendor, however, to benefit from Feng's information. For example, Feng derives the total number of possible CPU states in the 8080 μP as 2^{117}, an absurdly high number. To this number, Feng adds another stratospheric quantity—the possible number of memory-address switchings in a program-counter-generated Galpat test. Putting two and two together, Feng concludes: "There's no such thing as truly exhaustive testing."

The problem thus becomes one of developing tests and equipment that will provide economical testing with a desired confidence level. Feng goes on to review the three different techniques available in commercial testers which, he says, represent today's μP test technology.

Laboratory testing of μP-based systems—the subject and title of a paper by Stephen Swerling of Arthur D. Little Inc., Cambridge, MA—is another area in which available equipment is found wanting.

In Swerling's opinion, both logic analyzers and development systems fall short in testing and debugging, and what is really needed is an interactive test system—one that "talks" to both the system and the engineer.

Requirements for an ideal system

Swerling goes on to list 15 general requirements for an ideal test system. Included in the list are such items as hexadecimal or octal display format, rather than binary; efficient means of operator input; ability to take a "snapshot" of a prototype's dynamic behavior without interfering with the prototype; and sufficient memory, computing ability and peripheral options to execute utility programs.

One person who might take exception to some of Swerling's conclusions is Hewlett-Packard's Bruce Farly, another Electro speaker. Farly's "Troubleshooting Processor Based Designs" details the contributions of logic-state analyzers to μP measurements.

Farly states in summary that the analyzer offers designers "a clear window into the data domain, the ability to record data transactions on either side of the I/O, and the sync signal needed to bridge the two domains of time and data." ■■

COMMUNICATIONS

Innovations abound in amateur radio equipment and techniques

New hardware and design concepts for both the amateur radio experimenter and the data-systems designer are the focus of the communications papers at Electro '76.

Three of the four papers of Session 20, "Present and Future Trends in Communications Equipment Design," describe modern communications techniques as applied to amateur radio.

Radio "hams" are not all amateurs according to design engineer Wes Hayward of Tektronix Inc., Beaverton, OR. Since many are employed in industry, and are in the forefront of communi-

Timetable to the technical sessions at Electro/76

Tuesday May 11	10 am	**1** Trends in Communications Components	**2** Developments in Optical Fiber Transmission	**3** Microprocessors: The Future Is Now	**4** Computer Communication Networks	**5** Trends in Power Devices
	2 pm	**6** New Uses of Signal Processing in Measurement	**7** Advances In Display Devices	**8** Design Aids For Microprocessors	**9** ATE Role in Field Service for PCBs	**10** Production Research and Technology
Wednesday May 12	10 am	**11** Engineering Management Techniques. Today and Tomorrow	**12** Effects of Noise on Man	**13** Microprocessor Applications	**14** Automatic Testing of Printed Wiring Boards	**15** Computer Technology Assessment
	2 pm	**16** Power Semiconductors in Off-Line Switching Supplies	**17** Electronic Problems in Medical Monitoring	**18** Microprocessor/ Microcomputer Testing	**19** The Synthesizer: Component, Signal Source, Complete Instrument	**20** Trends in Communications Equipment
Thursday May 13	10 am	**21** CAD I: Modeling Analysis, Problems	**22** Crime and Computers	**23** High-Level Microprocessor Languages	**24** Instrumentation: How Smart Should It Be?	**25** Trends in Radar Systems
	2 pm	**26** CAD II: Digital Circuit Development	**27** The Engineer After 40	**28** Designing and Debugging Micro-Processor-Based System	**29** IEEE Standards 488 and 583 As Engineering Tools	**30** Radar Electronic Counter-Countermeasures
Friday May 14	10 am	**31** What's New in Air Traffic Control?		**32** Advanced Pocket Calculators	**33** New Memory Techniques	**34** A/D and D/A-To-Processor Interfaces

cations design, there often exists a two-way traffic in ideas, Hayward says, with industry benefiting from innovations first thought of for "ham" equipment.

In the opening paper, "Modern Trends in Communications Receiver Design—an Overview," Hayward describes current techniques being applied in the HF and low-VHF radio spectrum to design receivers of wide dynamic range. Dynamic range is a measure of how well the receiver responds to two input signals closely spaced in frequency. The larger the amplitude of these signals —before distortion harmonics set in—the better the dynamic range.

Hayward emphasizes narrow-tuning-range receivers, such as CB and "ham" radios, but says his ideas needn't be restricted to those types. His ideas apply, for example, to the design of spectrum analyzers. There is a continuing trend of sophisticated gear being built by individual experimenters for comparatively low cost, Hayward says.

"I can build a good home-made receiver for much less than I can buy one. Average noise figure in the HF range would be 5 to 6 dB, with a typical two-tone dynamic range of 95 to 100 dB, as compared with 75 to 80 dB for a typical commercial receiver."

Amateur radio enters a new phase

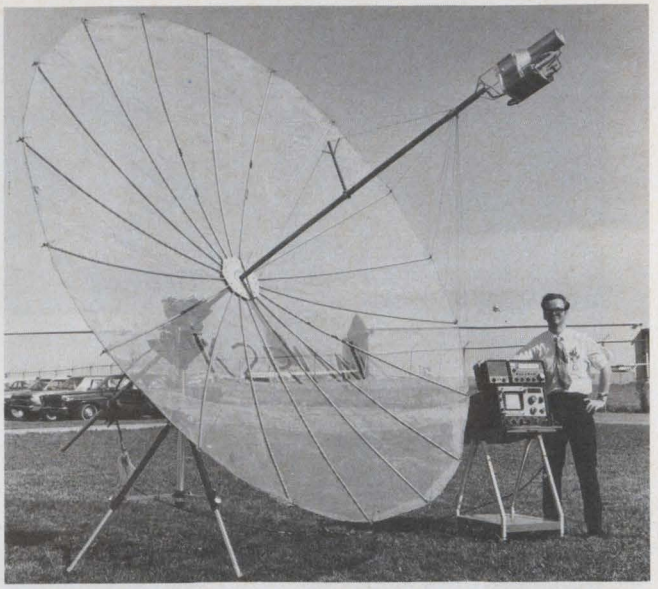
Joseph Reisert Jr., in the fourth paper at Session 20, "Low Noise VHF/UHF Receiver Design," describes how radio "hams" have now begun implementing earth-moon-earth communications at frequencies of 144, 432, 1296 and 2304 MHz.

This type of transmission uses the moon as a passive reflector to bounce signals back to distant points on earth, in much the same manner as was done by passive man-made satellites like ECHO-1, in the early days of the space program.

Using a transmitter output of less than the maximum FCC-allowed 1 kW, amateurs can now hear their own reflected signal. Reisert describes a dramatic system test in which he transmits for two seconds, stops, and then listens for his own signal, returned from its half-million-mile journey.

The breakthrough in this process came with the availability of low-cost, low-noise receivers. Although they may not be as sophisticated as those employed in long-range radar or radio astronomy, the receivers are practical and use hardware that is low in cost and easily available. That is their big advantage, Reisert says.

Reisert also describes considerations for designing receivers of minimum noise figure. He examines such basic elements of a receiver as the preamplifier, mixer, and postamplifier, and describes what steps must be taken to achieve low-noise operation of each.



Voice signals from Apollo 15 and 16 astronauts on the moon, were received by radio amateur Richard Knadle using his home-made $42 parabolic antenna. Transmitter power on the moon was only 13 W.

Lowest noise figures in the frequencies of interest are achieved with bipolar transistors and gallium arsenide field-effect transistors, with the FETs outperforming bipolars at frequencies above 500 MHz, Reisert reports. However, because of the high cost (over a hundred dollars each) of GaAs FETs, most high-frequency amateur equipment today uses bipolar transistors. Future cost reductions should spur increased use of GaAs devices.

Below 300 MHz, silicon junction FETs perform very well. For example, a low-cost device such as the U-310 yields noise figures of 1.25 to 1.5 dB at 144 MHz. The U-310 is a silicon JFET costing under a dollar for the epoxy version. It is currently manufactured by Siliconix and National Semiconductor.

Improved techniques for receiver design, in the form of broadband, high-power matching networks, are discussed in the paper "Broadband Transmission Line Matching Networks," by Dr. Jerry Sevick of Bell Laboratories, Murray Hill, NJ.

These networks provide the following characteristics, previously unavailable in a single component:

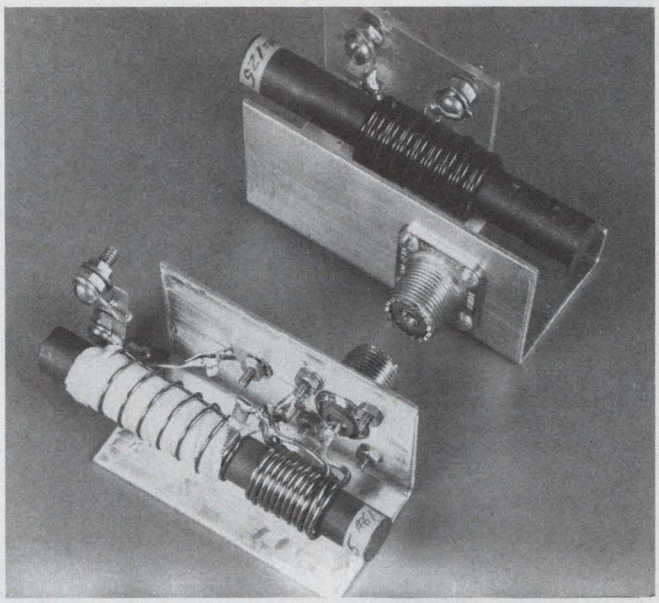
- Broadband impedance matching over a wide range of frequencies.
- High power-handling capability.
- High efficiency.
- Fractional transformer ratios.

These features result in more flexibility for the design engineer in such situations as matching output stages to an antenna, or matching the interstages of solid-state rf power amplifiers, Sevick says.

Suppose it is necessary to match an output signal from a 50-Ω coaxial cable to a short vertical antenna whose impedance can be somewhere in the 3-to-20-Ω range. Previously, only integral-ratio transformers (4:1 is a typical ratio) were available. Such transformers would restrict the designer to antennas in the 10-to-15-Ω range.

Using a design based on a concept of short, coiled transmission lines, Sevick shows that both integer and noninteger transformers can now be fabricated. These devices also provide the very important advantages of covering a broad bandwidth (for example, 2 to 30 MHz), and of operating at high power levels (up to 1 kW).

The new transformers have efficiencies in excess of 98%. Older designs were only 93% efficient, typically, with "good" units measuring as high as 95%.



High efficiency matching transformers, designed by Jerry Sevick of Bell Labs are intended for the mf and hf bands. They can handle power up to 1 kW.

A proliferation of data networks

Communications networks that link data-processing systems are the subject of Session 4.

A network that can connect many computers, terminals, and users—all distributed over a wide geographical area—is the subject of a paper by Stuart Wecker, a technical consultant at Digital Equipment Corp., Maynard, MA.

The network, consisting of a set of software tools known as Decnet, permits sharing of computer resources as follows:

(1.) It allows the terminals of one system access to terminals and peripherals of other systems.

(2.) It enables remote accessing of data files anywhere in the net. For example, this permits data files to be transferred between systems.

(3.) It provides program sharing capability. Loadable programs can be sent from one system to another for execution, thus permitting the creation of a central program storage that is accessible by any member of the network.

(4.) It enables the opening of a data path between programs so that processing can be done on a distributed basis. Different segments of a computing job can then be processed by different network components.

A number of potential markets for such a system are described by Wecker. These include users in industry, business, and research laboratories.

The possibility of using cable-television lines for local data distribution (within a city) is discussed in a paper by a group from Network Analysis Corp., Glen Cove, NY.

Using a data terminal in place of the usual TV set, a system can handle about 100,000 subscribers, each of whom can interact with a computer network, the authors report.

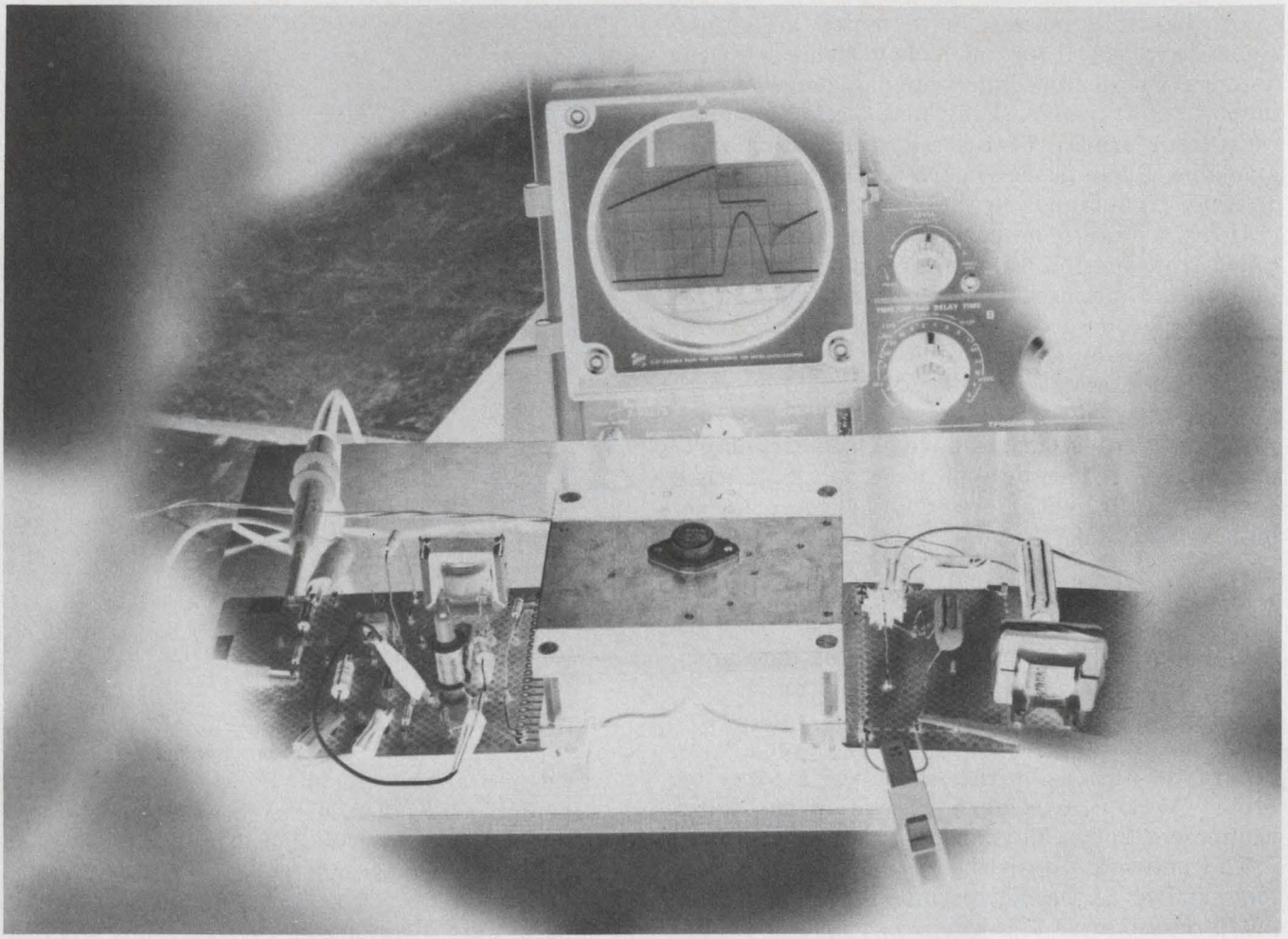
Another topic analyzed in the paper is "packet switching." This procedure, in effect, chops up a long data message into relatively small segments of from 1000 to 8000 bits in length. The packet-switching process permits transmitting each segment, or packet, separately over the most advantageous route. ■■

SEMICONDUCTORS

Across-the-board improvements made in a variety of power devices

The practical side of designing with power semiconductors, including power Darlingtons, SCRs, gate-turn-off SCRs and power Schottky diodes is emphasized in Sessions 5 and 16.

Power Darlingtons, for example, appear destined for automobile ignitions. "However, they will have to have high transient tolerance," says Gerald Owens of Prestolite, Decatur, IL, in his



The tradeoffs between SCRs and transistors in the design of television horizontal-deflection circuits are evaluated in this test setup at the RCA Solid-State Div., Somerville, NJ.

Session 5 paper entitled "High-Voltage Darlington Power Transistors in Automotive Applications." They will have to stand 400-V transients for 0.1 ms, 150 V for 1.0 ms and −75 V for 38 ms. They will also have to take 8 A of collector current, he continues. For ignition use, the collector-emitter breakdown voltage of a Darlington will have to be at least 400 V. These specs are now possible, Owens notes.

"Selecting Your High Voltage Power Transistor," a Session 5 paper by Bill Mickelopoulos from International Rectifier, El Segundo, CA, offers some guidelines on choosing these power devices.

"Selection," he says, "is complicated by the fact that although a device may be offered under the same basic family number as another device, its characteristics may differ from manufacturer to manufacturer, depending on the particular process used, size of the semiconductor chip, diffusion and passivation techniques, device geometry and other factors."

He concentrates his discussion on proper specification of the breakdown sustaining voltage; dc-current gain and saturation voltage; reverse-biased second-breakdown energy; and unclamped, clamped and forward-biased second-breakdown energy.

"Gate-turn-off SCRs have really come of age," reports Mel Kravitz of Trio Laboratories, Plainview, NY. He describes switching-power-supply designs using GTO/SCRs that switch at 20 kHz and deliver 150 and 300 W. He also shows how to handle up to 800 V at 5 A and switch in less than 1 μs. Kravitz feels that the GTO/SCR is unsurpassed for fast switching 400 V and higher. He notes that push-pull supplies can now be built with an input dynamic range of better than 2:1 and a regulation of at least 0.1%.

How to make circuits radiation tolerant

"The best way to design a linear-power-transistor circuit that is radiation-hardened, is to select high f_T transistors operating on the I_C vs β curve just beyond where β peaks. A high derating factor for I_C should not be used for linear circuits. Conversely, for digital circuits the lower the I_C the harder the circuit," note C. E. O'Neil and A. J. Chesavage in their Session 5 paper,

Diodes and SCRs in Hockey-Puk packages have current ratings into the thousands of amps. Mounting considerations for this type of device are covered in a Session 16 paper.

"Characteristics of Power Transistors in Neutron and Ionizing Radiation and Environments."

"To minimize the probability of damage from high levels of photocurrent generation, external current limiting is effective. The penalties paid for current limiting are usually minor," they point out. Neutrons are the dominant factor of permanent degradation in power transistors. From specified electrical characteristics, the best indicator of neutron tolerance has been shown to be gain-bandwidth product (f_T).

Frequently, hardness and the safe-operating region of a power transistor conflict, particularly for inductive loads. One paradox is that neutron hardness requires a thin base, even though a thick base is harder for ionizing radiation.

Fortunately, such other geometry alterations as decreasing the base-sheet; resistivity or the emitter's strip-width can be used, say the authors, to decrease photocurrent generation without sacrificing neutron hardness. Two examples of moderately priced neutron and ionizing radiation hard transistors are the 2N5262 and the 2N5038 families.

Making efficient switching supplies

"Probably the most significant factor in the development of efficient switching-power supplies that are competitively priced, has been the availability of high voltage, fast-switching power transistors such as the 2N6342-45 family," contends Derek Chambers of the Sorensen Co., Manchester, NH, in his Session 16 paper, "Measurement and Efficient Analysis of Losses in Switching Regulators."

The use of these and similar devices has enabled the cost of switching regulators to approach that of series-pass regulators at moderate and high-output power levels (200 W to 1 kW), Chambers says.

He lists the power-transistor characteristics that allow the design of an efficient (better than 75%) switching-power supply:

- fast switching speed (20 kHz or above),
- high collector-voltage ratings,
- large, safe operating area,
- good secondary-breakdown capability,
- low saturation voltage.

To obtain maximum switching speed and efficiency, the collectors of the switching transistors should be kept just out of saturation when conducting, according to Chambers. This mode of operation reduces storage time and minimizes its variation under different load conditions and from one device to another.

The trade-offs between SCRs and transistors in the design of horizontal-deflection circuits is the subject treated by Wally Deitz and Thomas McNulty of the RCA Solid State Div., Somerville, NJ, in their Session 16 paper, "Trade-Offs Between SCRs and Transistors in Horizontal Deflection Circuits." They note that the main difficulty in the design of transistor deflection circuits is the base-drive circuit. In SCR designs, it is the need for commutation circuitry to turn off the SCR. Gate-turn-off SCRs can't handle the required voltages yet for this type of circuit.

Each design has certain advantages, says Deitz. Transistor circuits are easier to design, need less magnetics and take 4 to 5 W less input power. SCR circuits yield better high-voltage regulation, have more current safety margin and have better line isolation. The authors do not recommend one technique over another. They merely detail the trade-offs and leave the decision to the circuit designer.

"Power Schottky diodes are relative newcomers to the power scene," remarks Bryan Bixby of International Rectifier, El Segundo, CA. He discusses reliability problems with these devices in his Session 16 paper.

"Although Schottky diodes are starting to find wide use they still suffer from an unexplained failure mechanism. Occasional collapses in the reverse-voltage characteristic of the devices are yet to be understood."

Because of this phenomenon, Bixby recommends that a 24-hour burn-in be performed to eliminate at least some of the potential failures. If a device doesn't fail in the first 24 hours, there is a good chance that it never will.

If reliability is the key concern, says Bixby, conventional p-n diodes are still better.

"Mounting Considerations for High Current

Hockey-Puk SCRs and Diodes," the final paper in Session 16, is written by International Rectifier's Arthur Connolly and Sam Pollack. The paper notes that mounting Hockey-Puk packages has always been troublesome.

"The Hockey-Puk is a pressure-mounted power semiconductor in which an external force is applied to achieve the proper internal and external electrical and thermal contacts," the authors state. "Superior heat transfer occurs because double-sided cooling results in a very low thermal impedance.

"In addition, elimination of solder joints considerably improves the ability to withstand thermal cycling." They describe a method of carefully adjusting the pressure applied as the device is mounted between a pair of heat-exchangers. ■■

MICROWAVES

U.S. engineers take a second look at European radar and ECCM designs

You can't design military radar without providing it with a built-in capability to defend itself from enemy electronic countermeasures. Two sessions will be held to bring you up to date on both radar design and the design of electronic counter-countermeasures: Session 25, "Trends in Modern Radar System Design," and Session 30, "Radar Electronic Counter-Countermeasures (ECCM)."

Trends in European radar technology are becoming more and more interesting to United States designers, according to Robert Hill, Naval Sea Systems Command, Washington, DC, who leads off Session 25.

"We see a firm base in automation with good 2D, and more recently 3D radar in England and Italy," he says. "There is a thorough array-technology base in the Netherlands, the recent emergence of whole-system work in West Germany, and an attempt to acquire a working phased-array radar system soon in France. A forecast of similar trends for air traffic systems, including complex adaptive systems with multi-static configurations, was made by Plessey of England."

There's been significant work in Great Britain on moving-target indication and low sidelobe antennas, Hill says. Except for Plessey, which has steadily pursued its well-automated AR-3D system, there's been less emphasis on 3D until recently. High-quality 2D systems, have been more consistent in the U.K., as have back-to-back systems and line feeds for precise control of azimuth sidelobes and stabilization at sea.

The U.S. fleet's air defense system, Aegis, developed by RCA, includes a phased-array radar, AN/SPY-1, that automatically detects and tracks multiple targets while maintaining surveillance coverage of the air.

Hill points out a number of design approaches that seem more popular in Europe than in the United States: line feeds and singly-curved reflectors (Marconi); Nyquist rate-scanning (RRE, Marconi); stainless-steel construction to prevent corrosion problems at sea (HSA); emphasis on polarization control and circular polarization as desirable features (Plessey, HSA, Telefunken, Selenia); use of hydraulic drive (Telefunken, Philips); multiple antennas on common mounts (Marconi, HSA); and an apparent pride in mechanical work.

Another European trend cited by Hill is the use of surface acoustic-wave devices in signal processing.

Europeans are more inclined to incorporate technical advances into established company product lines; in the United States, advances are allowed to accumulate until a new generation radar is built.

As for air traffic control, Hill says there seems to be a closer liaison in Europe than in the United States between what's being done for civil aviation and what's under way for the military.

Converting solar energy to microwaves

Larger power aperture is very likely to continue as an important trend in phased-array radar, predicts Peter Kahrilas, consulting scientist at Raytheon's Missile Systems Div., Bedford, MA, in his paper, "Phased-array Radar Trends."

Phased-array technology is particularly applicable to systems requiring very large power aperture with steerable beams—for example. to convert solar energy in space to microwave energy, and then beam it to earth. The high efficiency provided by a phased array is required to make the project economically feasible.

Another trend is multifunction radar applications requiring hemispherical coverage for ground, shipborne and airborne applications, Kahrilas says.

Existing phased-array technology provides hemispherical coverage by using a pencil-beam that is electronically scanned in elevation and mechanically rotated in azimuth. For more demanding applications, by using four-planar arrays, a spherical geodesic lens, or dome-lens technology can be used.

The demand for equipment that can handle steadily increasing target densities, however, is straining the capability of most present-day radars, especially those providing hemispherical coverage.

A technical innovation is required, Kahrilas says, to create a simple and inexpensive electronic-scanning technique for multibeam hemispherical coverage.

The trend toward using solid-state components in transmitter modules has been slow because of the resulting low-power output, the high duty-cycle continuous-wave nature of operation and the poor performance at higher-frequency bands. These undesirable characteristics limit the possible power aperture, peak power, waveform and operation-frequency selection. Technological improvement in these areas is needed, Kahrilas says.

There is a trend toward cutting the cost of all components used in phased-array radar, particularly the cost of phase shifters and their drivers, since they are a large portion of the array cost. Improvements are likely to continue in the material, design and manufacturing processes of phase shifters. One effort is to reduce costs by reducing drive power, insertion loss and size, and by increasing microwave power capacity and reliability.

Microprocessors are making inroads

Integrated circuits are becoming widely used in phased-array radars, Kahrilas says. And as denser chips become cheaper, more sophisticated microcomputer architecture can be expected. Larger read/write memories, for example, will be available on microprocessor chips.

In phased-array radar designs, microprocessors are already replacing conventional circuits for control of system self test diagnostics, beam steering units and signal processors. High speed ICs are used to perform the FET function in signal processors.

The increasing use of ICs is shifting a phased-array radar from control by a single computer to a more economical system that contains a main computer and several microprocessors.

Over the past few years inexpensive solid-state components have been introduced to make possible the design and construction of digital signal processors only dreamed of in the past, says Charles E. Muehe, MIT, Lincoln Laboratory, Lexington, MA.

Changes have come especially fast in radar, Muehe says, where doppler filtering was usually limited to analog or digital delay-line cancellers. Now inexpensive components allow the construction in each range-azimuth resolution cell of digital filters that markedly improve the signal-to-ground clutter ratio for each target velocity.

Muehe describes a digital signal processor called the Moving Target Detector (MTD), which is designed to improve the FAA's airport surveillance radars.

In using the MTD the signal to be processed is taken from the output of the intermediate frequency preamplifier and fed through a special linear, wide-dynamic-range amplifier to the quadrature video detectors. The two quadrature video-detector outputs are converted to 10-bit digital

numbers by a-to-d converters and hence into the digital processor. The MTD contains an 8000-word input memory and about 900 ICs. A disc memory is used as a fine-grained ground-clutter map. The parts cost total is approximately $25,000.

The MTD achieves its superior performance principally through fine-resolution linear-filtering and adaptive-thresholding techniques.

The filters have been tailored to reject ground clutter by using wide-dynamic, linear, range processing. The result is much better moving-target indication than achieved by present-day airport surveillance radars.

Phased-array for the range?

Range-instrumentation radars of the future will have to track multiple targets simultaneously and cost less, says Josh T. Nessmith, Systems Manager, RCA Government and Commercial Systems, Missile and Surface Radar Div., Moorestown, NJ.

Phased-array radar, either with a limited scan or a full scan, offers a potential for meeting some of the future requirements of the range, Nessmith says. The phased-array presents an opportunity for direct integration of multiple tracks and the metric data associated with each track.

The question, Nessmith says, is whether a single phased-array radar would be more cost effective than an integrated group of single-target or limited-scan-array radars.

At the very outset of the design phase, the designer faces the fact that the life of the system design is at least 25 years, while the gestation period of a countermeasure is a year or two in peace time and a few weeks during war.

How to live with these conditions is discussed by Matthew F. Radford, Marconi Research Laboratories, Great Baddow, Essex, England, in "Radar ECCM—A European Approach."

The designer can't possibly know in advance the precise nature of the threats his system will be called upon to face, Radford emphasizes. He does know, however, that any fundamental weakness in his design is likely to be discovered very quickly and exploited.

The first task then, is to build a system with optimum resistance to ECM and to avoid built-in limitations that could restrict the choice of operational routines or provide openings for future ECM.

Radford cites four other problems the designer faces:

- ECM may affect his own side's defensive radars;
- Airborne ECM may reduce the sensitivity of homing and warning receivers;
- Responsive jammers may respond to each other; and
- Airborne ECM may interface with terrain-avoidance radar.

The pros and cons of adaptive control

When confronted by jamming or chaff, Radford says, search performance can be improved by adaptive electronic control of the antenna beam. But practical methods of electronic scanning will penalize ECM resistance in other ways. For one thing, the maximum available antenna bandwidth is significantly reduced.

Transmission losses are inevitably increased by electronic scanning. A frequency-scanned antenna uses a dispersive line in which an appreciable amount of energy is stored, and this storage results in a predictable heat loss. Waveguide delay lines are the least subject to loss, according to Radford, but they are bulky. With compact folded lines, it's unlikely that a minimum additional loss of about 1 dB will be introduced.

Phased arrays have phase-shifter losses that are likely to be around 1.5 dB in a typical antenna of simple design. Losses may be higher if the design incorporates dielectric loading or lossy microstrip dipole radiators.

Taking all of these factors together, a fully adaptive phased-array antenna may have a disadvantage of as much as 10 dB on basic ECCM parameter values. The disadvantage cancels out at least part of the potential advantage of adaptive dwell time.

Radford describes some of the achievements that have been made in European radar:

- Transmitters: To permit the use of advanced, coherent-ECCM processing techniques, transmitters have been designed with unusually clean spectra. A typical high-power transmitter has intra-spectral-line noise 120 dB below the peak pulse output.
- Low-sidelobe antennas: The objective of 35-dB sidelobe protection and 30% bandwidth has been reached. The antenna can handle high power and can be adapted to provide a difference channel for monopulse operation.
- Multiple-beam antennas: A number of ways have been found to generate multiple beams without undue loss of sidelobe protection. Multiple-beam antennas are particularly effective against deception jamming, since they always observe the true jammer position.
- Data handling and control: There are families of modular digital processors that can be reprogrammed or extended during the service life of the radar, thus enabling additional ECCM to be added as required.

Radford concludes that unless the application requires adaptivity for some special task, a relatively simple radar may be as cost-effective in ECM as a more complex adaptive system. ■■

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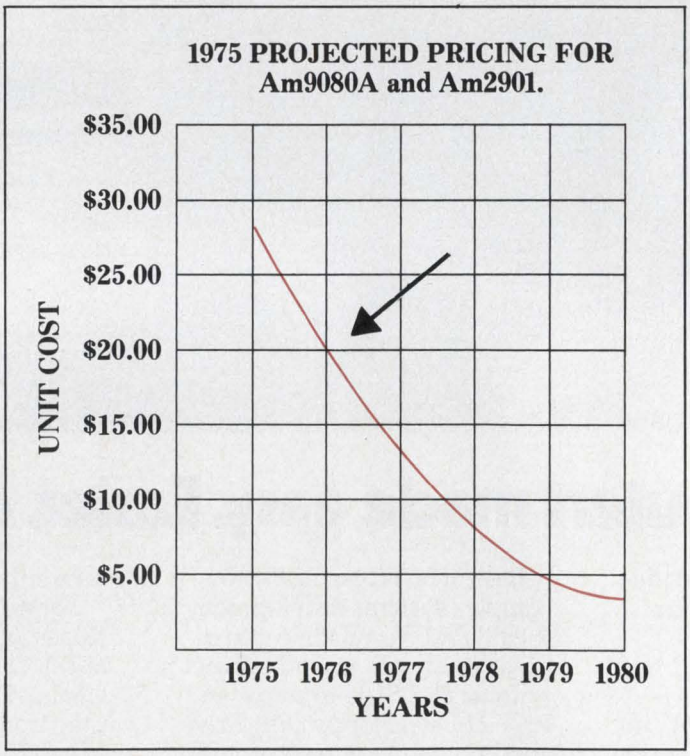

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Am9080A/−2	Speeds to 380 nsec −55 to +125°C	In Dist. Stock
	Static Read/Write Random Access Memories	
Am9101A/B/C/D	256x4 Speeds to 250 nsec	In Dist. Stock
Am91L01A/B/C	256x4 Speeds to 300 nsec	In Dist. Stock
Am9102A/B/C/D	1Kx1 Speeds to 250 nsec	In Dist. Stock
Am91L02A/B/C	1Kx1 Speeds to 300 nsec	In Dist. Stock
Am9111A/B/C/D	256x4 Speeds to 250 nsec	In Dist. Stock
Am91L11A/B/C	256x4 Speeds to 300 nsec	In Dist. Stock
Am9112A/B/C/D	256x4 Speeds to 250 nsec	In Dist. Stock
Am91L12A/B/C	256x4 Speeds to 300 nsec	In Dist. Stock
Am9130A/B/C/E	1024x4 Speeds to 200 nsec	In Dist. Stock
Am9140A/B/C/E	4096x1 Speeds to 200 nsec	In Dist. Stock
	Dynamic Read/Write Random Access Memories	
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Am9214	512x8 mask programmed Speeds to 500 nsec	Available Now
Am9216B/C	2Kx8 mask programmed Speeds to 300 nsec	Available Now
	Erasable Read-Only Memories	
Am9702	256x8 Speeds to 1.0 μsec	In Dist. Stock
Am1702A	256x8 Speeds to 1.0 μsec	In Dist. Stock
Am2708	1024x8 Speeds to 450 μsec	2nd Q. 1976

AMD Part Number	Description	Availability
	Processor System Support Circuits	
Am8212	8-bit I/O Port	In Dist. Stock
Am8224	Clock Generator	In Dist. Stock
Am8228	System Controller	2nd Q. 1976
Am8216/26	Bus Transceiver	2nd Q. 1976
Am25LS138	1 of 8 Decoder	In Dist. Stock
Am9555	Programmable Peripheral Interface	2nd Q. 1976
Am9551	Serial Communications Interface	2nd Q. 1976

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

Am2900 System Circuits

AMD Part Number	Description	Availability
Am2901	4-Bit Microprocessor Slice	In Dist. Stock
Am2902	Carry Lookahead Chip	In Dist. Stock
Am2905	4-Bit Transceiver For Open Collector Bus	In Dist. Stock
Am2906	4-Bit Transceiver For Open Collector Bus With Parity Generator/Checker	In Dist. Stock
Am2907	4-Bit Transceiver For Open Collector Bus With Single Data Input	In Dist. Stock
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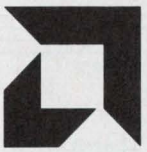

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CIRCLE NUMBER 47

Build a compact microcomputer by starting with a μP like the 8080 and surrounding it with peripheral LSI interfaces that can be programmed for specific jobs.

Systems based on the single-chip 8080 μP can be built with far fewer components than has been possible until now. What makes the parts reduction possible is the availability of programmable LSI interface circuits.

These programmable I/O and peripheral devices provide the means to standardize hardware designs for system interfaces. They can be used to upgrade or replace specialized logic assemblies involving scores of conventional digital circuits.

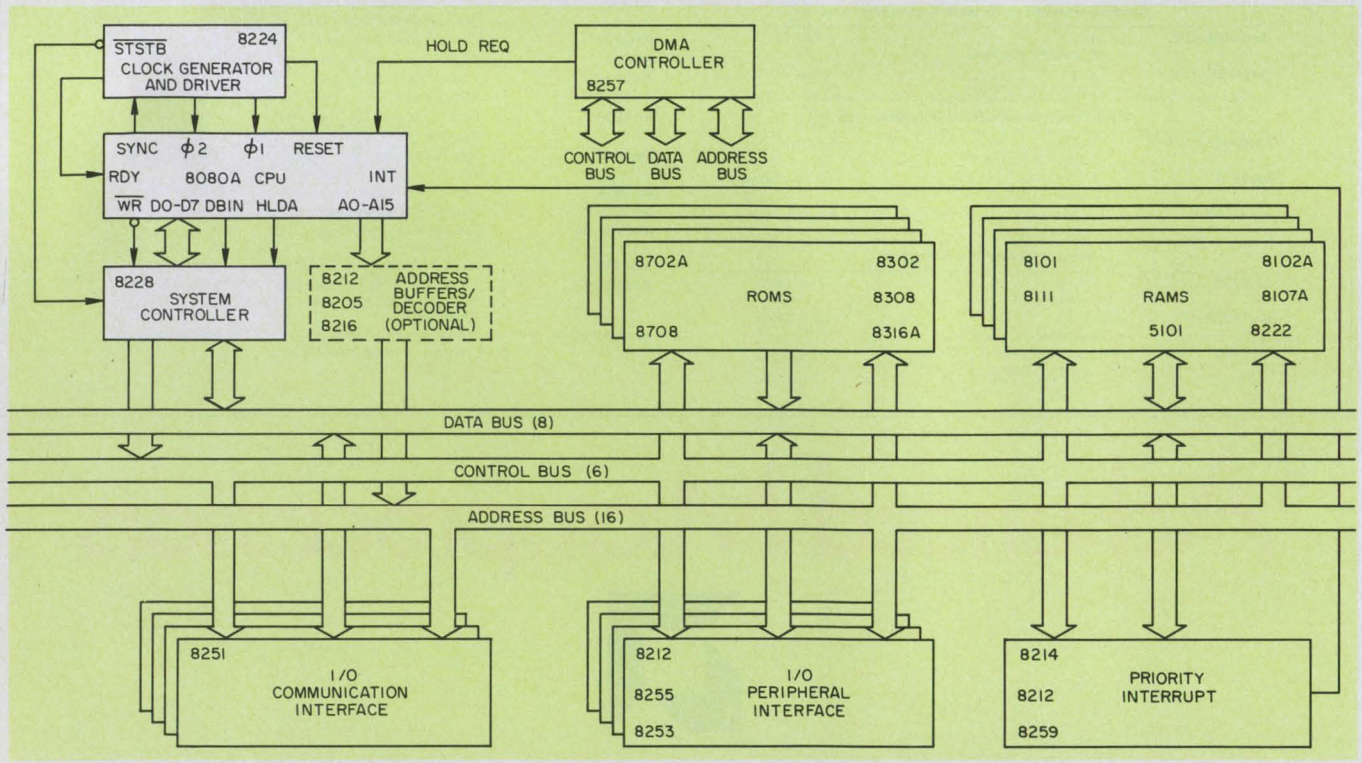
An additional benefit of these peripheral LSI circuits: they simplify microcomputer design. Since the bus standardizes the internal interface structure, a system designer's main task reduces to that of organizing external interface and interrupt structures. The complete 8080 system can be used as an interrupt-driven system in on-line computation and control applications.

A. J. Nichols, Manager, Microcomputer Applications, **Kenneth McKenzie,** Manager, MCS-80 Microcomputer System, Intel, 3065 Bowers Ave., Santa Clara, CA 95051.

Basic system components

The 8080 microcomputer system (MCS-80) consists of a family of n-channel MOS and Schottky-bipolar devices, and development support products (Tables 1 and 2). It is based on the 8080A CPU group, which consists of an 8080A 8-bit central processing unit, an 8224 clock generator and an 8228 system controller. The CPU can directly address up to 65,536 bytes of memory and 512 I/O ports (256 input, 256 output ports).

Bipolar timing, bus control and drive functions normally required to support the CPU are integrated into the 8224 and 8228. Major I/O



1. **The 8080 microcomputer system** features a modular organization, based on a bus standardized by the 8080 CPU group—the 8224 clock generator and driver, 8228 system controller and 8080A.

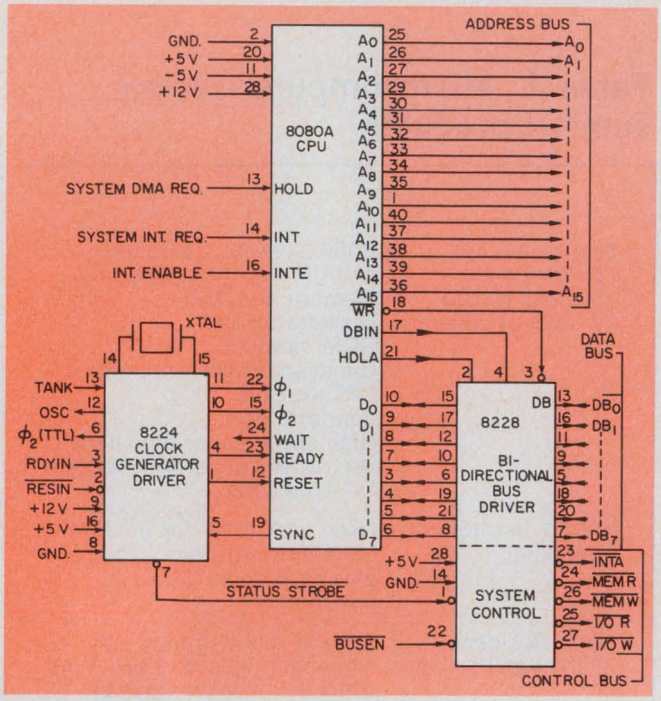
Table 1. MCS-80 system components

Function	Type	Pins	Name/specification
CPU Group	8080A	40	8-bit CPU, 2-μs cycle
	8224	16	Clock generator
	8228/38	28	System controller
CPU Options	8080A-1	40	1.3-μs instruction cycle
	8080A-2	40	1.5-μs instruction cycle
	M8080A	40	2 μs, −55 to 125 C
Input/ Output	8212	24	8-bit I/O port
	8251	28	Programmable communication interface
	8255	40	Programmable peripheral interface
Peripherals	8205	16	1-of-8 binary decoder
	8214	24	Priority interrupt-control unit
	8216	16	4-bit bidirectional bus driver (50 mA), noninverting
	8226	16	4-bit bidirectional bus driver (50 mA), inverting
	8222	22	Dynamic RAM refresh controller (for 8107B)
	8253	24	Programmable interval timer
	8257	40	Programmable DMA controller
	8259	28	Programmable interrupt controller
EPROMs	8702A	24	2 k (512×8), 1.3-μs access
	8708	24	8 k (1024×8), 450-ns access
ROMs	8302	24	2 k (512×8) 1-μs access
	8308	24	8 k (1024×8), 450-ns access
	8316A	24	16 k (2048×8), 850-ns access
CMOS static RAMs (all 650-ns access)	5101	22	256×4, 15 nA/bit standby
	5101-3	22	256×4, 200 nA/bit standby
	5101L	22	256×4, data retained at 2 V_{CC}, 15 nA/bit
	5101L-3	22	256×4, data retained at 2 V_{CC}, 200 nA/bit
NMOS Static RAMs	8101-2	22	256×4, 850-ns access
	8102A-4	16	1024×1, 450-ns access
	8102A-6	16	1024×1, 650-ns access
	8111-2	18	256×4, 850-ns access
Dynamic RAMs	8107B	22	4 k (4096×1), 420-ns access
	8107B-4	22	4 k (4096×1), 270-ns access

Note: All access times are maximum values

Table 2. Microcomputer-system support products

Microcomputer Development System (MDS) and peripherals	8080 system with interrupt and DMA control, expandable memory and I/O Diskette system ROM simulator Universal PROM programmer CRT console Line printer High-speed paper-tape punch High-speed paper-tape reader Teletypewriter
ICE-80 In-Circuit Emulator	Used with MDS for in-circuit hardware/software debugging in product's own environment
MDS Resident Software Packages	System monitor supports diagnostic aids and real-time checkout; controls system and drives peripherals Macro assembler translates symbolic assembly language to machine code, provides full macro and conditional assembly Text editor supports program entry and correction; includes string search, substitution, insertion and deletion commands DOS (Diskette Operating System) supports symbolic file management for development of programs and filing of data such as diagnostic information ICE-80 supports debugging with English-language type commands ROM-SIM supports the ROM simulator (a high-speed RAM memory)
Cross-product software packages	PL/M cross compiler MAC-80 cross compiler provides full macro and conditional assembly INTERP/80 simulator supports program-execution simulation and debugging
SDK-80 System Design Kit	Contains all components and software required to assemble and operate a basic 8080 system
SBC-80/10	Single-board computer
Manuals	80 Microcomputer Systems User's Manual Intellec MDS Hardware Reference Manual Intellec MDS Operator's Manual 8080 Assembly Language Programming Manual PL/M Programming Manual MAC-80 User's Manual INTERP/80 User's Manual



2. **The CPU group connects** to the address, data and control busses—the three elements of the system bus. The Interrupt Acknowledge output of the 8228 may be tied to 12 V through a 1-kΩ resistor and used as a vectored single-level interrupt control.

and peripheral units are programmable: they are both configured and controlled by software. The I/O units provide serial data and parallel I/O; the peripheral units augment the CPU group's control capability by managing multilevel interrupts, peripheral-service timings, and direct-memory access (DMA). Memory components have industry-standard configurations.

The CPU options provide typical instruction cycle times as low as 1.35 μs in the commercial temperature range and 2 μs in the military range (M8080A). Introduced in 1974 as the first NMOS CPU, the 8080 has become an industry standard. It now accounts for more than half of all microcomputer applications, and components are being widely second-sourced.

Microcomputer architecture

The 8080-based microcomputer features a modular architecture (Fig. 1). The CPU group represents the only dedicated components in the μC (Fig. 2). The remaining subsystems—memory, I/O and peripheral control—are modular. They are constructed by use of other components in building-block fashion on the bus.

The CPU group standardizes system-bus control logic and ac timing and dc electrical characteristics. Other components interface directly with the group via the bus. Thus, the over-all design is comparable to that of a computer with standardized "mainframe" logic and modular peripherals that plug into the bus.

The system bus consists of three groups of interconnections: A_0 to A_{15}, a three-state bus used by the CPU to address memory locations and to select ports; DB_0 to DB_7, a bidirectional, three-state bus driven by the 8228 and used for all information transfers; and the control bus. The latter includes control lines operated by the 8228, which gates selected devices on and off the data bus.

The bus is TTL compatible and is driven by the CPU group at or above TTL drive levels (1.9 mA on all 8080A outputs and typically 10 mA for the 8228). In general, bus buffers—or bidirectional driver and decoder units—are required only in large systems.

The CPU group performs the following:

- Makes all CPU inputs essentially asynchronous. Selected device operations align with CPU operations regardless of the device's operating times.
- Stabilizes the data bus to ensure the validity of transferred data.
- Sinks and sources the currents required to maintain direct component-to-bus interfacing as the system expands outward from the CPU group.

Programmable peripherals

The key I/O and peripheral devices are these:

- 8255 programmable peripheral interface, which provides three ports (24 lines) for parallel I/O and control.
- 8251 programmable communications interface, a universal synchronous/asynchronous receiver/transmitter (USART) for serial data I/O.
- 8259 programmable interrupt controller, which allows eight levels of priority-interrupt control, expandable to 64 levels.
- 8253 programmable interval timer, which consists of three 16-bit BCD/binary counters. The circuit may be used to set system-timing delays, replacing software-timing loops.
- 8257 programmable DMA controller, which offers four channels of direct-memory-access control for bulk-data transfers between peripheral equipment and RAM.

A designer seeking to use these devices chooses control words and algorithms from sets supplied for each device. He then adds them to the intialization or service routines of the system-application program. Initialization control words, for example, define communication and control configurations of the 8255's 24 I/O lines. Algorithms govern the priorities of the interrupt levels controlled by the 8259.

Of course, since software defines the devices' functions, it can also be used to change them. One method is to use control words as replace-

Microprocessor architecture

The nucleus of an 8080-based system is, of course, the CPU, a single-chip, 8-bit parallel processor.

In turn, an important part of the CPU is its register section, a static RAM array organized into six 16-bit registers. The array's six 8-bit general-purpose registers (they may be addressed individually or in pairs) provide single or double-precision (16-bit) operators.

Up to 64-kilobytes of memory may be directly addressed. The stack pointer allows any portion of RAM memory to be used as an external stack, so that subroutine nesting is bounded only by memory size. The stack can be used to store the contents of the program counter, flags, accumulator and all six general-purpose registers.

The arithmetic logic unit (ALU) performs arithmetic, logic and shift/rotate operations. Associated with it are an 8-bit accumulator, and 8-bit temporary accumulator, and a 5-bit flag register (zero, carry, sign, parity, auxiliary carry). Testing the auxiliary carry for decimal correction allows decimal arithmetic to be performed.

Accumulator-group instructions include arithmetic and logic operators with direct, register-indirect and immediate-addressing modes. Move, load and store-instruction groups can be used to move either 8 or 16-bits of data between memory, the six general-purpose working registers and the accumulator. In each of these cases, the same addressing mode can be used. Jump, jump conditional and computed jumps provide program branching.

Calls to and returns from subroutines can be made conditionally and unconditionally. RST (restart) provides a single-byte Call instruction for interrupt operation. This Call saves the contents of the program counter upon completion of the current instruction and points to any of eight memory locations usable as the start of an interrupt-service routine. RST is normally initiated by the peripheral logic, which can also generate additional Call instruction bytes for vectoring to more than eight interrupt levels.

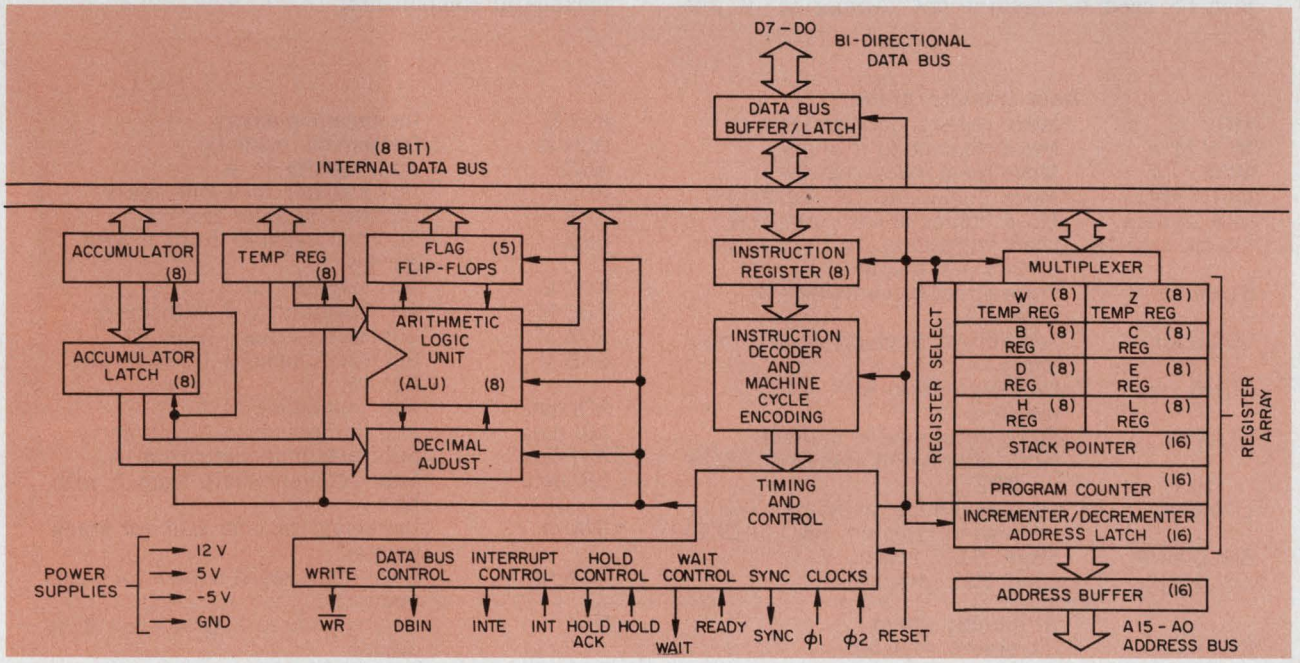
A basic instruction cycle is four states long (T_1 through T_4). For example, adding the contents of an 8-bit general-purpose register to the accumulator (ADD r) requires three states for the instruction fetch and one state for execution. Some instructions take two execution states.

A machine cycle is required for each fetch and for each memory or I/O access. Each instruction cycle must begin with a fetch, but other machine cycles may be used in succession, between the fetch and the execution state or states.

The first machine cycle of an interrupt operation resembles a fetch but does not increment the program counter. Thus, when the peripheral logic generates the Call, the program-counter contents are automatically saved. Other system-status information can also be saved in the RAM stack. The stack pointer automatically provides for retrieval of the interrupted program address upon completion of the interrupt.

A Hold input causes the CPU to complete an instruction's execution, then come to rest. Hold is generally used during DMA operations. In this case, the CPU doesn't use the bus during the last two states (T_4 and T_5), so DMA operations can overlap instruction cycles.

A Ready input inserts a Wait state (or states) after T_2. The Halt instruction stops the CPU in the next machine cycle after T_2. A Reset, Hold or Interrupt brings the CPU out of Halt.



(continued on page 88)

(continued from page 87)

Instruction set and programming methods

The basic instruction set of the 8080 can be divided, for convenience, into data-transfer, arithmetic, logic and branch groups. The final division is stack, I/O and machine control (see instruction table).

The first byte of an instruction is an operation code. The op code is supplemented in many cases by one or two address or data bytes. Data stored in memory or registers may be addressed in one of four modes:

- Direct—a memory address of the data is contained in bytes 2 and 3 of the instruction;
- Register—the register or register pair containing the data is specified by the instruction;
- Register indirect—a register pair containing the data's memory address is specified by the instruction;
- Immediate—the instruction contains the data, rather than the data address.

Branch instructions specify the next instruction by containing the next instruction address (direct) or by indicating a register pair containing the next instruction address (register indirect).

Two complete sets of software packages are available to the programmer: those resident in the Intellec MDS system, and cross products (available on both computer tape and time-shared computer networks) written in ANSI-standard Fortran IV.

The cross products and resident software generate completely compatible code. Routines written with either method can be linked, emulated and debugged in the microcomputer environment with the Intellec MDS system, which can also be used to combine the debugging of program and hardware design.

```
                        /*  BUBBLE SORT DECLARATION  */
SORT: PROCEDURE (N) ADDRESS;
      /*    N = LENGTH OF A
            COUNT = NR. OF SWITCHES PERFORMED TO-DATE
            SWITCHED = (BOOLEAN) HAVE WE DONE ANY SWITCHING YET ON THIS SCAN?  */
      DECLARE (N, I, SWITCHED) BYTE,
            (TEMP, COUNT) ADDRESS;
      SWITCHED = 1;              /*  SWITCHED = TRUE MEANS NOT DONE YET  */
      COUNT = 0;
      DO WHILE SWITCHED;
            SWITCHED = 0;        /*  BEGIN NEXT SCAN OF A  */
            DO I = 0 TO N-2;
                  IF A(I) > A(I+1) THEN
                        DO;                  /*  FOUND A PAIR OUT OF ORDER  */
                        COUNT = COUNT + 1;
                        SWITCHED = 1;        /*  SET SWITCHED = TRUE  */
                        TEMP = A(I);         /*  SWITCH THEM INTO ORDER  */
                        A(I) = A(I+1);
                        A(I+1) = TEMP;
                        END;
            END;
            /*  HAVE NOW COMPLETED A SCAN  */
      END  /*  WHILE  */;
      /*  HAVE NOW COMPLETED A SCAN WITH NO SWITCHING  */
      RETURN COUNT;
END SORT;
```

A. **"Bubble sort" routine written in PL/M** arranges data pertaining to events according to the frequency with which individual events occur. Events occurring most frequently move to the top.

Programs can be written with a macro assembler or PL/M compiler (PL/M is Intel's high-level programming language). The macro assemblers translate mnemonics into machine code. PL/M allows programs to be written in a natural algorithmic language and eliminates the need to allocate memory or manage register usage.

An example of a sorting routine written with PL/M appears in Fig. A. The free-form input shown is translated into 8080 object code by the compiler; the programmer can concentrate on the software design structure and system-logic requirements. Fig. B illustrates a macro-assembly approach to programming one of the peripheral components.

	Data transfer group
MOV r1, r2	Move register to register
MOV M, r	Move register to memory
MOV r, M	Move memory to register
MVI r, data	Move immediate (to register)
MVI M, data	Move immediate (to memory)
LXI rp, data 16	Load immediate (to register pair or to stack pointer)
STA addr	Store direct (accumulator to memory)
LDA addr	Load direct (memory to accumulator)
XCHG	Exchange H&L with D&E registers
STAX rp	Store accumulator indirect (with address in registers B&C or D&E)
LDAX rp	Load accumulator indirect (with address in registers B&C or D&E)
SHLD addr	Store H&L direct
LHLD addr	Load H&L direct
	Arithmetic group
INR r	Increment register
DCR r	Decrement register
INR M	Increment memory
DCR M	Decrement memory
ADD r	Add register to A
ADC r	Add register to A with carry
SUB r	Subtract register from A
SBB r	Subtract register from A with borrow
ADD M	Add memory to A
ADC M	Add memory to A with carry
SUB M	Subtract memory from A
SBB M	Subtract memory from A with borrow
ADI data	Add immediate to A
ACI data	Add immediate to A with carry
SUI data	Subtract immediate from A
SBI data	Subtract immediate from A with borrow
INX rp	Increment register pair (or stack pointer)
DCX rp	Decrement register pair (or stack pointer)
DAA	Decimal adjust A (gives two BCD digits)
DAD rp	Add B&C, D&E or H&L to H&L

```
                        ;       MODE INSTRUCTION
                        ;       ==== ===========
                        ;
                        ;       2 STOP BITS
                        ;       PARITY DISABLED
                        ;       8 BIT CHARACTERS
                        ;       BAUD RATE FACTOR OF 64
                        ;
                        ;       COMMAND INSTRUCTION
                        ;       ======= ===========
                        ;
                        ;       NO HUNT MODE
                        ;       NOT(RTS) FORCED TO 0
                        ;       RECEIVE ENABLED
                        ;       DATA TERMINAL READY
                        ;       TRANSMIT ENABLED
                        ;
0000    3ECF            MVI     A,MODE
0002    D3FB            OUT     CNCTL   ; OUTPUT MODE SET TO USART
0004    3E27            MVI     A,CMD
0006    D3FB            OUT     CNCTL   ; OUTPUT COMMAND WORD TO USART
```

(a)

```
                ; FUNCTION: CI
                ; INPUTS: NONE
                ; OUTPUTS: A - CHARACTER FROM CONSOLE
                ; CALLS: NOTHING
                ; DESTROYS: A,F/F'S
                ; DESCRIPTION: CI WAITS UNTIL A CHARACTER HAS BEEN ENTERED AT THE
                ;              CONSOLE AND THEN RETURNS THE CHARACTER, VIA THE A
                ;              REGISTER,  TO THE CALLING ROUTINE.  THIS ROUTINE
                ;              IS CALLED BY THE USER VIA A JUMP TABLE IN RAM.
                ;
01D0            CI:

01D0    DBFB            IN      CONST   ; GET STATUS OF CONSOLE
01D2    E602            ANI     RBR     ; CHECK FOR RECEIVER BUFFER READY
01D4    CAD001          JZ      CI      ; NOT YET - WAIT
01D7    DBFA            IN      CNIN    ; READY SO GET CHARACTER
01D9    C9              RET
```

(b)

B. **Typical routines for the 8251** programmable communications interface are written with the 8080's macro assembler. The first routine (a) initializes the circuit. The second (b) specifies the input character, C1. Another program, similar to (b), specifies the output character.

Logic group

ANA r	AND register with A
XRA r	EXCLUSIVE-OR register with A
ORA r	OR register with A
CMP r	Compare register with A
ANA M	AND memory with A
XRA M	EXCLUSIVE-OR memory with A
ORA M	OR memory with A
CMP M	Compare memory with A
ANI data	AND immediate with A
XRI data	EXCLUSIVE-OR immediate with A
ORI data	OR immediate with A
CPI data	Compare immediate with A
RLC	Rotate A left
RRC	Rotate A right
RAL	Rotate A left through carry
RAR	Rotate A right through carry
CMA	Complement A
STC	Set carry
CMC	Complement carry

Branch group

JMP addr	Jump unconditional
Jcond addr	Jump on condition specified (carry, no carry, zero, no zero, positive, minus, even or odd parity)
CALL addr	Call unconditional
Ccond addr	Call on condition specified (see above)
RET	Return
Rcond	Return on condition specified (see above)
RST	Restart
PCHL	H&L to program counter

Stack, I/O and machine control group

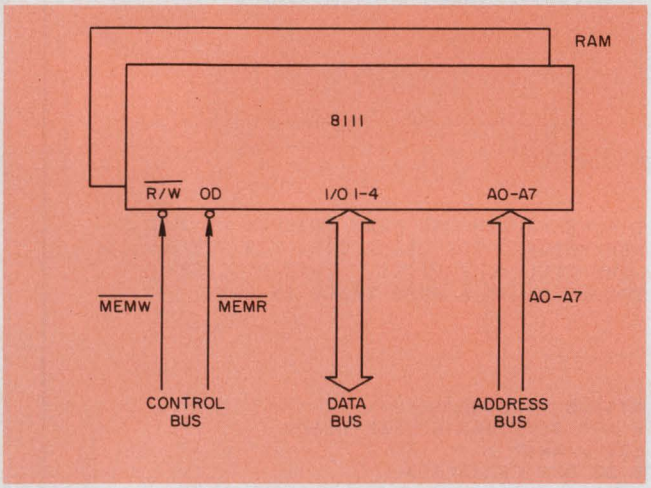
HLT	Halt
IN port	Input (from port to A)
OUT port	Output (from A to port)
PUSH rp	Push register pair on stack (in memory)
PUSH PSW	Push A and flags on stack
POP rp	Pop register pair off stack
POP PSW	Pop A and flags off stack
XTHL	Exchange top of stack with H&L
SPHL	Move H&L to stack pointer
EI	Enable interrupts
DI	Disable interrupts
NOP	No op

(continued on page 90)

able software modules. One set of basic hardware can then be used with various peripheral equipment in different end-products.

Furthermore, operating modes can be changed "on the fly" during system operation. This feature permits dynamic changes in priority levels, thereby enhancing a system's real-time response. When the CPU determines that particular types of services become more critical than others, it can rearrange the priorities.

All units contain internal control logic and "housekeeping" functions. These reduce CPU overhead software. They enable the CPU to manage the I/O structure with acknowledgements and operating commands after receiving requests



3. **In a typical memory interface** to the system bus, two 8111, 256 × 4-bit, static RAMs are operated in parallel to provide byte-wide data.

for service (interrupt and DMA). Thus they help the CPU perform an increased number of real-time tasks.

Two ways to handle interrupts

All I/O devices, including the 8253 timer, can generate interrupt requests. The 8080 handles interrupts in one of two ways: vectored interrupts and Call structures. In the first case, a vector instruction (RST) "points" the program counter to the specific memory locations to be used as the starting points of service routines. RST acts as a program Call. The vector instruction is generated by an interrupt-control device, and up to eight branches can occur.

In the second case, the CPU's regular Call structure may still be used. Thus, any location in memory can be the start of a service routine and the number of interrupt levels is bounded only by memory size. Again, the interrupt-control device generates the Call instruction.

Implementing the interrupt-handling techniques are these circuits:

- 8228 system controller, which generates one vector (RST 7). This provides a single-level interrupt control built into the CPU group.
- 8259 programmable interrupt controller, which generates eight Call vectors and can be cascaded for up to 64 service levels.
- 8214 priority-interrupt control unit, which is similar to the 8259, but has fixed priorities, and can be expanded from 8 to 40 levels.

The interface structure may be isolated from memory or may share the memory-address space. This gives the programmer the option of using either I/O or memory-reference instructions (that read, write or operate on data in memory) for I/O operations. Memory-reference instructions can significantly increase throughput in applications requiring frequent I/O data manipulations. Also, they allow more ports to be addressed without decoding, thereby reducing component count.

When a DMA Request is acknowledged, the 8257 takes control of the system bus. It uses the CPU Hold function to suspend CPU operation and transfer blocks of data. Hold Acknowledge tells the DMA controller to take control of the bus.

Operations of the system bus

During each machine cycle, the CPU first addresses the device to be used in the data transfer. Then it sends to the 8228 system controller a status word defining the operation to be performed, and uses the data bus to make the transfer.

The control lines operated by the 8228 handle device input and output gating. The 8228 controls data-bus flow through its bidirectional driver. The status words are translated into specific gating signals: "write" signals MEMW and I/OW, and "read" signals MEMR, I/OR and INTA (interrupt acknowledge).

Bus timing requires that a specific peripheral device should respond to or be prepared to receive valid data within a specific "window" in the CPU cycle. The window is obtained by giving the device time to settle between addressing and gating. Adjustments for devices that have a relatively long cycle time are made with a function called Wait Request (or Ready).

The function, a special feature of the 8080, allows timing signals to be extended without seriously sacrificing CPU speed. For example, a designer can choose an inexpensive memory, one that has an access time of twice the CPU state time. However, typical instruction-cycle time increases only 25 percent. The Ready function inserts a synchronized Wait state into the cycle between addressing and gating, and increases the

cycle from four states to five. Using other methods, the clock period would be doubled, resulting in a 100% increase in cycle time.

The Ready control can be used to insert one or more Wait states into every machine cycle, or it can be used selectively to accommodate different devices. Ready control also simplifies single-step operations.

During each cycle the CPU also sends to the 8228 various gating commands (Data Bus In, Write, and Hold Acknowledge). Other commands include Interrupt Enable, which is used to permit or inhibit interrupts, and Wait, which signifies that an idling state is in progress.

Memories needn't slow the system

Typical memory organizations and memory-to-bus connections are indicated in Fig. 3. In large memory arrays, drivers and 8205 one-of-eight decoders may be added as bus interfaces.

Access times have no effect on component-to-bus interfaces. The 8111 256 × 4-bit static RAM and 8316A 2048 × 8-bit ROM, for example, have maximum access times of 850 ns while the CPU can operate at a state time of 480 ns or less. A Wait state is simply inserted into the cycle time. If the designer decides to change to faster memory, the logic element used to activate the 8224's Ready Input is simply removed.

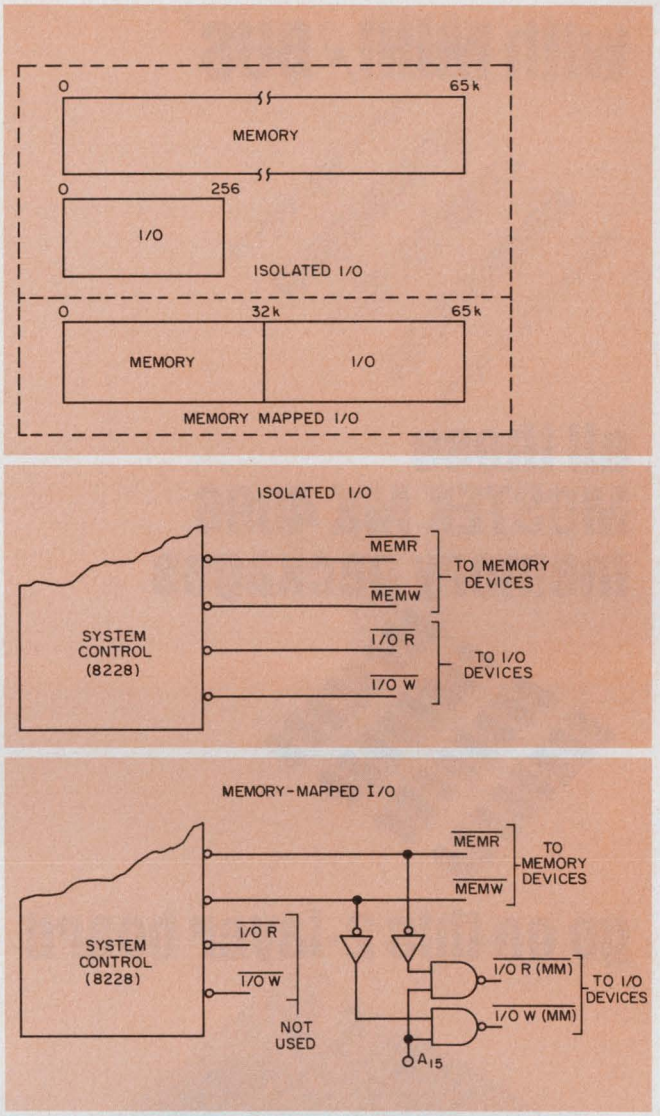
Available EPROMS (erasable and electrically reprogrammable PROMS) are interchangeable with the 8316A, mask-programmed ROMs. The EPROMS are 24-pin static devices with three-state, byte-wide outputs. The 8316A 16-kilobits ROM is generally used to double storage density after program development with an 8708 8-k EPROM.

The 8107B 4-k dynamic RAM may be used for large memories. An available 16-kilobyte dynamic-RAM board (Model in-481) matches CPU speed and synchronizes memory-to-CPU operations. Also, Schottky-bipolar PROMs and ROMs are available for very fast program storage.

Organizing the system interface

The organization of I/O and peripheral devices can proceed in one of three ways: isolated or memory-mapped, or a combinatian of each (Fig. 4). When memory and I/O are controlled separately, up to 65,536 memory bytes and 512 input and output ports can be directly addressed.

With memory mapping, the I/O is controlled by memory-control lines and operated with memory-reference instructions. I/O shares the memory-address space, and a memory-address bit is typically used as a flag to denote that an



4. **I/O can be organized** by either an isolated or a memory-mapped method. The latter allows the use of memory-reference instructions, and employs memory-read and write control lines for I/O devices. An address bit acts as an I/O flag.

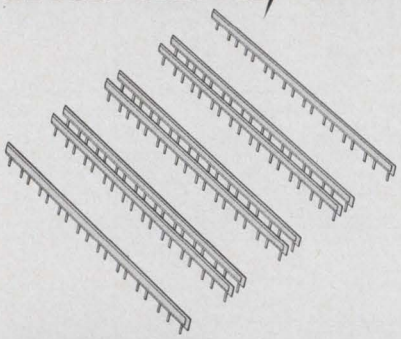
I/O operation is occurring. A combination of the two techniques is exemplified by a memory-mapped scheme for I/O devices, and isolated I/O for peripheral units.

The memory-mapped approach is often advantageous for complex structures, because memory-reference instructions offer numerous shortcuts in I/O data manipulation. Further, substantial I/O structures can be operated without address decoders.

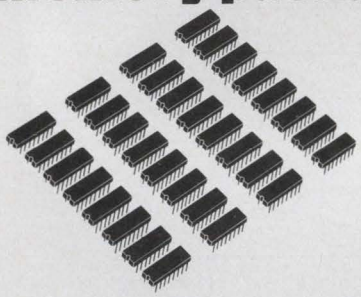
In either case, two port-selection (or port-addressing) methods apply—linear or decoded select. With linear select, a single address bit forms an exclusive enable for a specific device, and no decoders are used. In decoded select, the address bus is decoded into exclusive enables to maximize the number of directly accessible ports.

Memory-mapped I/O with linear select makes

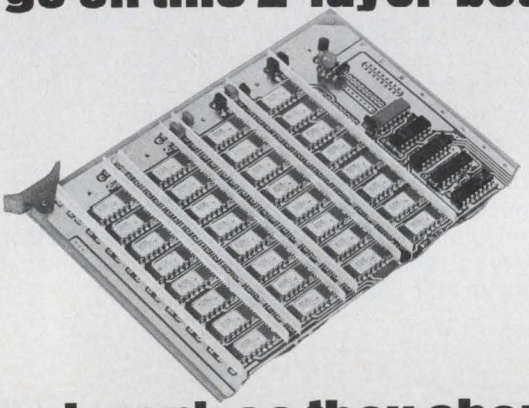
with MINI/BUS®



all these MOSTEK MK 4096 memory packages

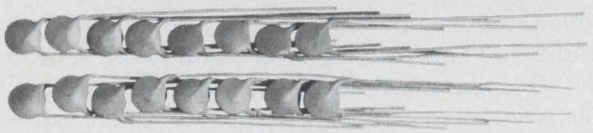


go on this 2-layer board



and work as they should!

. . . and these weren't needed!



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up to 39 ports (up to 312 I/O lines) available without decoders. If this technique is used for I/O devices, an isolated I/O and linear-select method can still be used for peripheral devices. With decoded select, either method provides a structure of practically unlimited size.

Design and development aids

For design prototyping, Intel supplies the SDK-80 system design kit, which contains the following:

- A basic 8080 system—8080A CPU group, two 8111 static RAMs, two 8708 EPROMs, plus the 8251 and 8255 peripheral circuits. One of the EPROMs is pre-programmed with a system monitor;
- PC board, discrete components, sockets and other hardware. The board is pre-drilled for expansion and has an area for adding wrapped-wire interconnections;
- Design and operating manuals.

Software and hardware development are supported by the Intellec MDS (microcomputer development system) and the ICE-80 in-circuit emulator subsystem. The basic MDS contains an 8080 system, with optional peripherals, and resident software.

The MDS can be used for program generation, assembly, emulation, and debugging. It can also be used as a system prototyping tool. Software includes a monitor and a disc-operating system as well as programming packages.

The ICE-80 module and its supporting software offer two unique development features:

(1) Debugging in the actual operating environment. Since ICE-80 plugs into the 8080A CPU socket on the microcomputer board, all operations of the system bus can be controlled and analyzed through the MDS console. An auxiliary connector can be used to observe the operations of external devices;

(2) Debugging can be done through the console, with readily understandable commands. Also, symbols can be used to refer to critical program labels and parameters, rather than to absolute memory locations.

An example of a system based on the 8080 is the SBC-80/10 Single Board Computer. It contains a general-purpose 8-bit microcomputer designed to be used as a plug-in component. (see "$295 μC-on-board Aims to Satisfy Most Requirements," this issue, p. 54). ■■

The first article in the series appeared in the April 26 issue. The next article will discuss the F8 μP.

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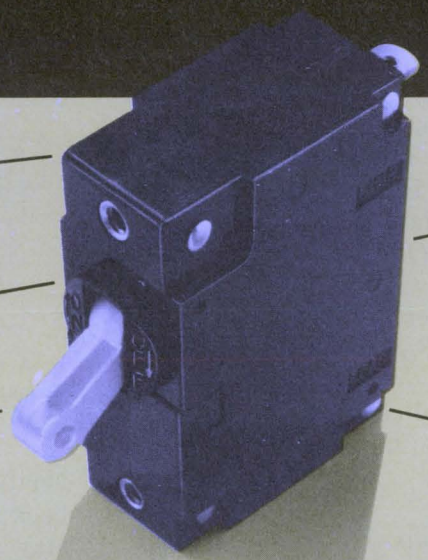

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CIRCLE NUMBER 49

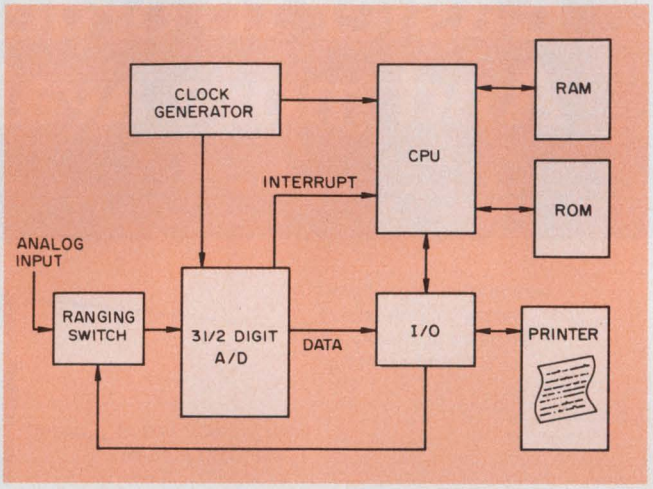
Log data under μP control and enjoy the benefits of software flexibility. Among the advantages: reformattable interfaces and less hardware.

Consider a microprocessor-based data logger before you settle on the usual methods. The μP unit offers far more flexibility and less bulk than conventional loggers. With it, you can reduce component count by transferring printer interface and synchronization problems from hardware to software. Such an interface can easily accommodate printer format/font changes or implement new ideas or market trends.

The arithmetic logic unit (ALU) of the processor provides arithmetic functions—a natural addition to an upgraded data logger that, with the addition of memory (RAM), provides the desired data handling.

One intelligent data logger mates a μP, an a/d converter and a printer (Fig. 1) to provide the following features:

- Autoranging of the a/d converter.
- Printout of days, hours, minutes and seconds along with the a/d reading.
- Direct printer drive.
- Programmable intervals of time between printings.
- Programmable changes of the analog variable between printings.
- Calculation and storage of maximum and time of occurrence.
- Calculation and storage of minimum and time of occurrence.
- Calculation of mean.
- Presettable time.



1. **A smart data logger** is designed around three major elements: a μP, an a/d converter and a printer.

Which μP is best?

Evaluation of μPs for an intelligent logger centers around two important points. First, man-machine interaction requires the ability to handle BCD easily. This points to decimally based μPs, often four-bit devices. Second, the time-keeping algorithm of the logger requires a μP with an interrupt system.

The BCD coding format is preferred for applications in which numbers are made available for human use at some point. Rather than converting from other coding systems to BCD then back again, it makes more programming sense to stay within a single format like BCD, and use devices that excel in handling this format.

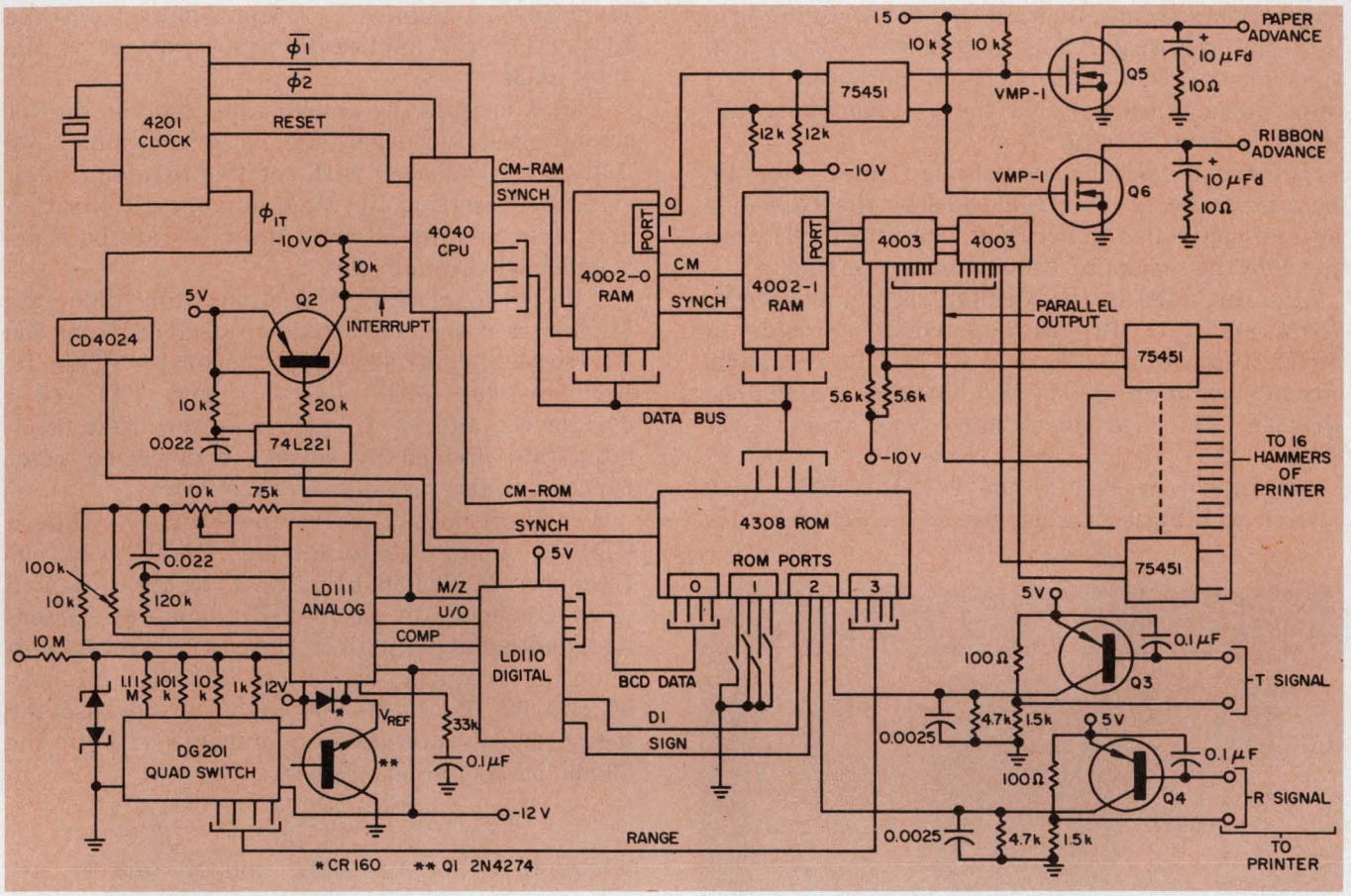
Typical numeric printers work with decimally based characters, a set that often uses the full four-bit capability of BCD to give 16 characters: 10 decimal digits and six other characters.

Several available μPs have a calculator architecture specifically designed to manipulate and store decimal digits. These μPs handle decimal arithmetic with special "decimal adjust" instructions that maintain the BCD format. The four-bit μP is a natural for all BCD data-handling applications in which low speed is not a problem. An added bonus: four-bit μPs are inexpensive.

It follows also that the a/d converter used in a μP-printer application should provide data in BCD—a multiplexed-output format of parallel bits/serial digits provides the easiest interface with the μP. This allows each four-bit BCD digit to be taken as one nibble (1/2 byte) at a four-bit input port. Digit-select outputs can mark the appropriate digits.

The fundamental blocks of the intelligent data logger are the Siliconix LD110/111 3-1/2-digit a/d converter, the Intel MCS-40 (4040 μP) system and the Seiko EP-101 printer.

Gary Grandbois, Applications Engineer, Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054.



2. **In the complete logger,** the input signal is attenuated to 200 mV full scale, then converted to a 3-1/2-digit word for the μP. Program instructions reside in the ROM, and processed data in the RAM.

The two-chip converter offers a number of outstanding features, including autozero and autopolarity, and incorporates all of the necessary precision linear circuitry, digital housekeeping and analog switching.

The output format of the LD110, a multiplexed BCD, is useful for both display and μP applications. Unlike other 3-1/2-digit converters, the MSB (1/2 digit) is not brought out as a static signal on an additional pin, but is multiplexed as though it were an additional digit. This minimizes the input requirements of the μP system by eliminating software and an additional port.

Ideal applications for the logger are those in which slowly varying analog quantities—temperature, pollution, lighting levels, noise—must be monitored. Since high-speed conversion isn't essential, an integrating a/d is the obvious choice and errors caused by extraneous noise are minimized. In addition, the outstanding stability of the integrating converter makes it especially useful for monitoring analog quantities under adverse environments.

No drift to worry about

The LD110/111 autozeroing system eliminates zero-offset drift over time and temperature, and the low gain tempco of the system (typically 25 ppm/°C) reduces full-scale drift over temperature. The very high input impedance (over 1000 MΩ) of the LD111 eliminates source-loading errors of high-impedance transducers.

Features of the 4040 that make this μP a logical choice for a data logger include: (1) a four-bit decimally based ALU; (2) interrupt capability; (3) 24 working registers; (4) subroutine nesting to 7 levels; and (5) extensive hardware and software backup.

The Seiko EP-101 is representative of the electromechanical "flying" class in which printing occurs when a mechanical hammer is actuated as a character drum rotates under the paper. A history of reliable operation, clean copy and low cost make this unit an attractive choice.

Interface for the hammer drive is readily achieved since the large drive current demanded by electrically driven hammers isn't needed here. Instead, low-power solenoids release a mechanical hammer driver (a rotating ratchet). Microprocessor interface to the hammer-release solenoids is achieved through standard dual peripheral drivers (75451).

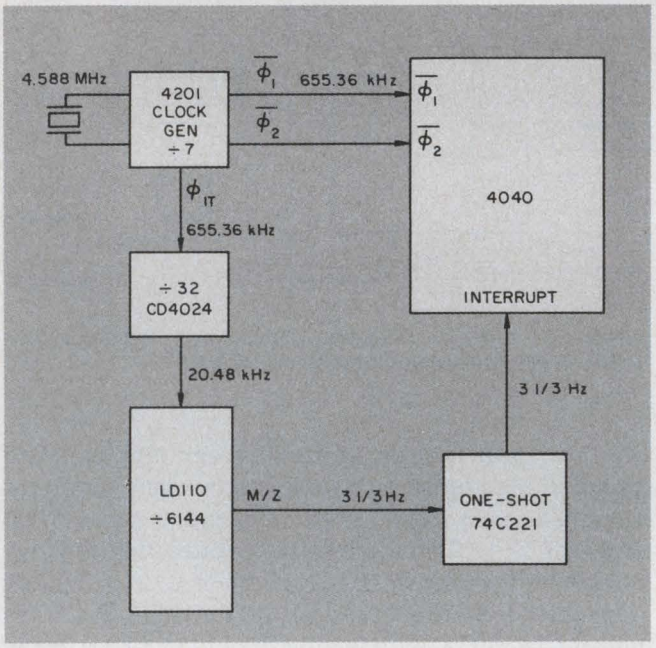
In the complete data logger, the ranging switch attenuates the monitored analog signal according to μP control (Fig. 2). This attenuated (properly

ranged) signal is converted to a 3-1/2-digit word, and the digitized value enters the μP system through the input/output (I/O) ports. An interrupt pulse originating in the a/d converter initiates pick-up of data.

Interrupts occur at precise time intervals because the converter is clocked by the MCS-40's crystal-controlled generator. The interrupts thus provide the means of keeping accurate time.

Also included in the MCS-40 system are RAM, ROM and I/O. Program instructions reside in ROM, and processed data in RAM. The I/O ports provide communication with both the a/d and the printer, which produces hard copy from RAM data.

As shown in Fig. 2, the DG201 CMOS quad switch and the associated resistor ladder comprise



3. **Timing for the μP and converter** is derived from a crystal clock. The interrupt signal synchronizes the two major elements.

the autoranging input circuitry. The autorange switch is driven by a four-bit output port (ROM port 3).

The DG201 switch connects the appropriate range resistor to ground, thereby giving the proper input attenuation—X 10, X 100, X 1000, X 10,000—for the 2, 20, 200 and 1000-V ranges, respectively. The LD111 analog processor is programmed for exactly 200 mV full-scale, and all inputs are attenuated to this level.

Tempco is kept down

Reference for the a/d is developed by the 2N-4274, configured as a temperature-compensated zener. The CR160 current-regulator diode properly biases this zener to give a very low tempco (typically 20 ppm/°C). Output data from the LD110/111 are applied to input port ϕ of the 4308 ROM.

Port 1 accepts the polarity bit and the digit-1 strobe, used for overrange determination. Note that port 1 is shared with the two printer timing signals. Presetting the time during initialization and programming of print intervals are both accomplished through port 2.

Two-phase clocking functions for both the MCS-40 and the converter are derived from the 4201 crystal-controlled clock generator. This IC provides both MOS (ϕ_1, ϕ_2) and TTL (ϕ_{1T}, ϕ_{2T}) levels, and its frequency is the basic oscillator rate divided by seven. A power-on reset function is also provided by the 4201.

The MOS outputs drive the MCS-40, while a CD4024 binary counter divides the TTL output frequency of 655.36 kHz by 2^5 to yield an a/d clock frequency of 20.48 kHz. This rate offers many advantages; with it, the a/d provides maximum line-frequency rejection (NMRR) for both 50 and 60 Hz. It is able to do so because the measurement interval is a multiple of both the 50 and 60-Hz periods. Thus:

$$T_{meas} = \frac{2048}{f_{clock}} = \frac{N_1}{60} = \frac{N_2}{50},$$

where $f_{clock} = 20.48$ kHz, and N_1 and N_2 are integers; $N_1 = 6$, $N_2 = 5$.

(Note that the sampling period is split into two intervals: zeroing and measurement; hence the M/Z line.)

Thus only the average value of the line noise contributes errors to the reading. A second significant reason for choosing the 20.48-kHz clock frequency is that it gives 10 conversions every 3 s:

Sampling rate =

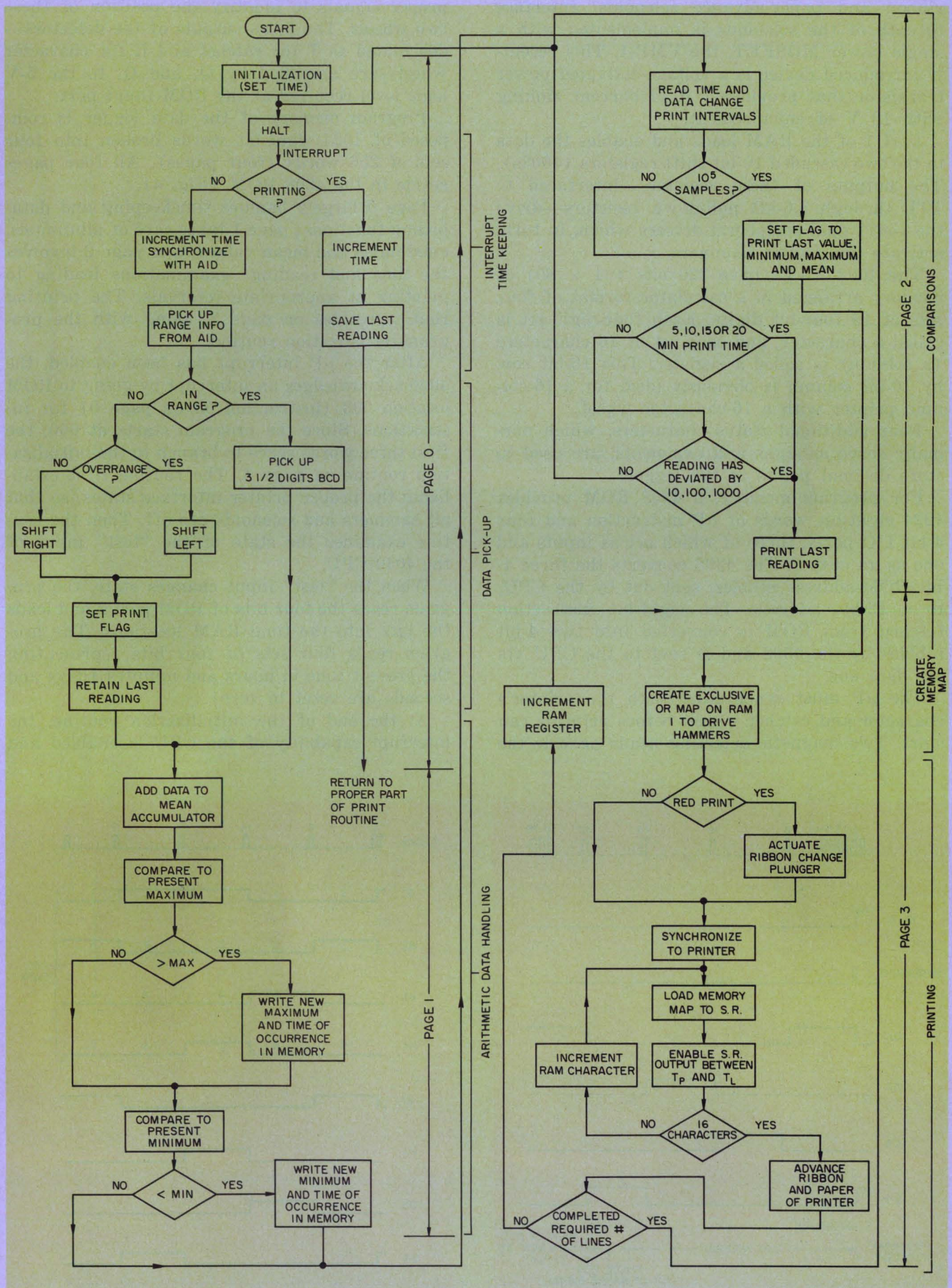
$$\frac{20.48 \text{ kHz}}{6144 \text{ cycles/sample}} = \frac{10}{3} \text{samples/s}.$$

With this sample rate—by interruption of the 4040 μP after every sample—a timekeeping system is readily implemented. The μP merely counts each interruption and adds 3 to a counter for every 10 interruptions. The 3-s increment lends itself to easy turnover at 60 s (200 samples).

To interrupt, the M/Z line of the a/d triggers a 74C221 one-shot. The resulting pulse is level shifted by transistor Q_2 and has a pulse width less than the minimum amount of time required to service the interrupt. The μP system also depends on this interrupt for proper synchronization with the a/d (Fig. 3).

With the ϕ_1 and ϕ_2 clock signals, the 4040 generates a signal every machine cycle (8 clock intervals) that synchronizes the RAMs and ROMs to the addresses that subsequently appear on the four-bit data bus (D_0, D_1, D_2, D_3). The two 320-bit RAMs each provide a four-bit output port.

Two bits of RAM port ϕ actuate the printer-



4. **The logger's program** resides in four ROM pages: page 0 stores housekeeping; 1 handles maximum, minimum and mean values; page 2 handles comparisons. Page 3 stores printing and start-up.

ribbon and paper-advance solenoids. Interface to each of the solenoids is implemented with a single power MOSFET, the VMP-1. This recently introduced device is a voltage-activated power transistor that provides 1 A of current sinking with 10 V of enhancement.

Port 1 of the RAM loads and enables the data to the two cascaded 10-bit shift registers (4003s). The outputs of these registers—interfaced to TTL through 5.6-kΩ pull-down resistors—drive the 75471 dual peripheral drivers which, in turn, activate the printer hammers.

The 4002 RAMs have 320 bits (4 × 80) of memory arranged in a calculator format of four sets of 16 four-bit digits. Each four-digit set is called a character, and each set of 16 characters (a column) is called a register. This 16-bit row by 16-bit column is obviously ideal for a 16-column printer with a 16-character wheel.

Four additional status characters, which normally serve as signs and exponents, are used to store decimal points in the logger.

For program memory, a 4308 ROM provides 1024 eight-bit words of μP instruction and four 4-bit I/O ports, three of which act as inputs and one as an output. The 4308 converts the three 4-bit ROM-address nibbles, sent out by the CPU, to a 12-bit address. The eight-bit instruction fetched from ROM is converted into two 4-bit nibbles by the 4308 and is sent to the CPU via the data bus.

The μP must synchronize with the printer's character and ratchet wheels before printing can start. Two magnetic detecting heads provide the proper signals to identify the position of these two wheels. The pulse outputs of the detectors—designated as T for ratchet and R for character wheel—are amplified by Q_3 and Q_4 to the 5-V logic level required at the ROM input port.

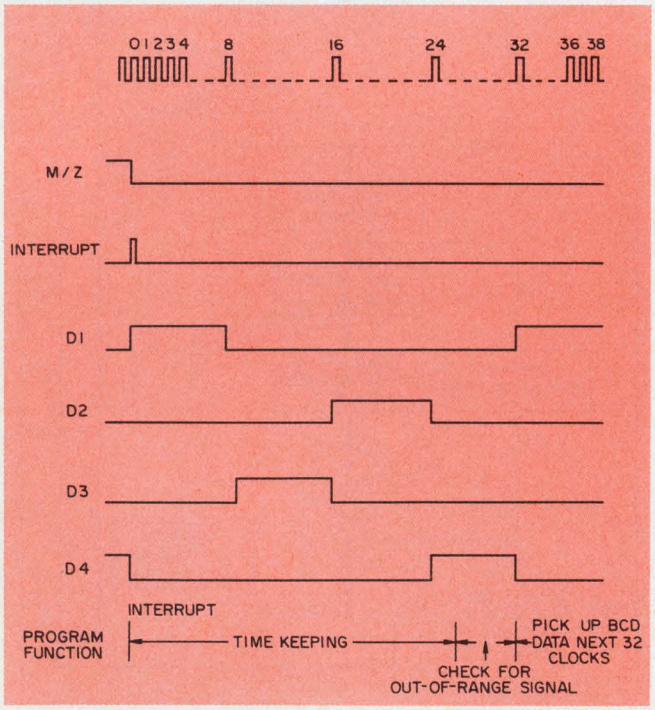
Program memory of the data logger is composed of 1024 eight-bit words broken into four sets of 256 words (four pages). All four pages reside in the 4308 ROM (Fig. 4).

Page 0 largely handles timekeeping and data-pickup functions; page 1 takes care of minimums, maximums and mean values; and page 2 involves the time and reading examinations leading to printing at appropriate intervals. The printing routine resides on page 3, along with the program-initialization routine.

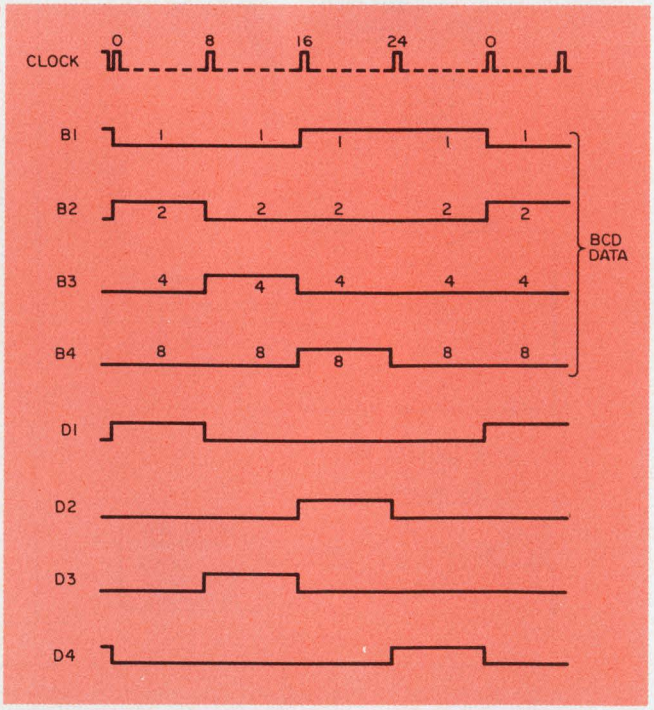
After the μP interrupt has been enabled, the 4040 acknowledges an interrupt by going to ROM location 003 (instruction 03 on page 0) for instructions. Since the program starts at 000, the first three words serve to branch to the initialization routine on page 3. The routine first establishes the proper printer-interface states, so that all hammers and solenoids are off. Then the routine examines the state of the "test" input of the 4040 CPU.

When the "test" input changes state, the program reads the four bits of ROM port 2 and loads the bits into the time RAM locations. The program reads four sets of four bits representing the present time in hours and minutes (days and seconds are reset to zero).

At the end of the initialization routine, the interrupt capability of the CPU is enabled and



5. **Interrupt timing signals** for the μP/converter: The BCD data are read-in at the digit-1 strobe.



6. **Output format of the LD110 a/d converter** consists of parallel BCD in an interlaced scan (digits 1, 3, 2, 4).

the program goes into a print-enable examination loop. If a print flag has been set, the program goes into the print mode; otherwise, the program waits for an interrupt.

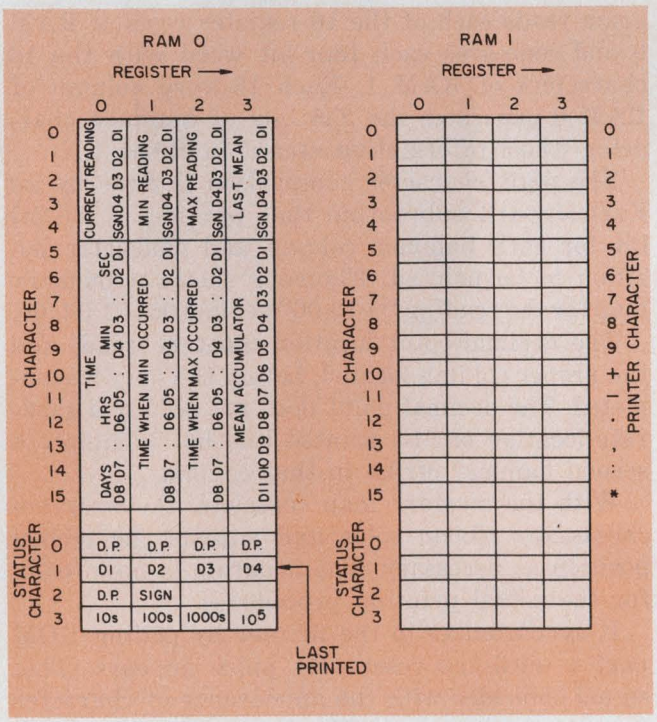
A complete a/d conversion is signalled by the interrupt pulse. The CPU program counter returns to location 003, where the conversion counter is incremented. If the interrupt doesn't occur during a printing cycle, the carry bits continue rippling through the seconds, tens of seconds, minutes, tens of minutes, hours, tens of hours, days and tens of days.

If a print cycle is interrupted, the program immediately returns to the next instruction in the printing operation.

With the completion of the time-keeping chores, the instructions lead into the pick-up of the BCD data from the a/d converter. Because of a short override interval, the output of the LD110's multiplexer may not be valid for the preceding conversion. Consequently, data pick-up is inhibited until the start of the second digit scan.

Since there are four μP machine cycles for every LD110 clock interval, and since the digit scan takes 32 intervals, the program takes 128 machine cycles before it looks for the data.

Prior to this sequence, however, the program examines bit four of the digit-four time slot (at ROM port 0). If this bit is a ONE—the underrange signal (count $<$ 100)—the program will down-range the DG201 switch to increase a/d sensitivity by a factor of 10. Reading of the BCD data at the input port starts during the LD110 digit-1 strobe (Fig. 5).



7. **Memory organization of the RAM:** 320 bits are arranged in four sets of 16 four-bit digits.

The overrange condition (count $>$ 2000) occurs on the digit-1 time slot and forces the digits low during the zeroing interval. In the program, the overrange signal causes the DG201 to uprange and decrease sensitivity by a factor of 10.

The absence of either out-of-range signal tells the program to process all four digits available at ROM port 0. The digits enter during the successive four digit times of the LD110 and are written into RAM 0, register 0, characters 0 through four.

The polarity bit, picked up during the overrange test, is converted into the proper printer character code (10 or 11 for + or −, respectively) and written into RAM.

Since the LD110 provides the digits in an interlaced scan of digits 1, 3, 2, and 4 (D_1 = LSB), digits 2 and 3 must be exchanged in memory. The memory locations of the stored a/d and time data are given in Fig. 7. Following the data pick-up are the handling processes that establish minimum, maximum and mean.

Calculation of data properties

The new data are first compared with the present minimum and maximum. If the absolute value is less than that of the present minimum, a new minimum and time of occurrence are written into register 1 of RAM 0. If the magnitude is greater than the present maximum, the data and time of occurrence are entered into register 2 of RAM 0.

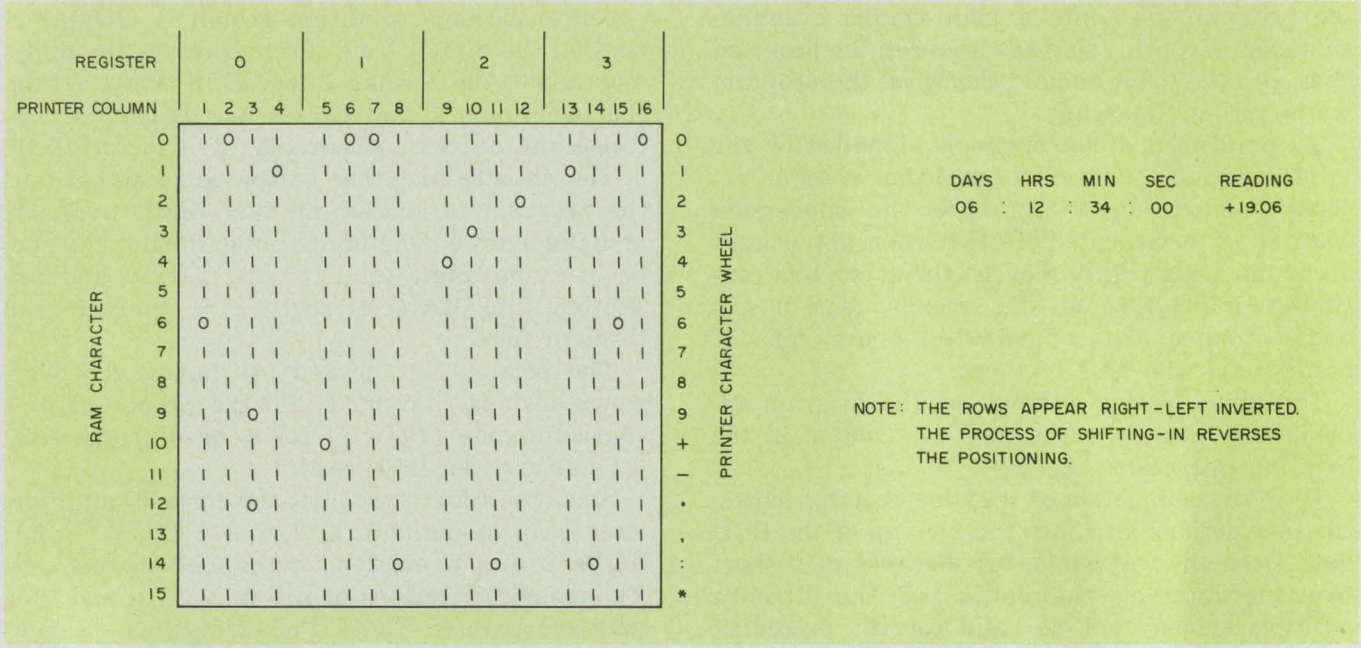
All of the comparisons take into account the floating decimal point provided by the autoranging a/d converter. Algebraic minimums and maximums can be kept if the sign bit is considered. Then, the minimum is either a minimum positive value or a maxmum negative value. The maximum is either a maximum positive value or a minimum negative value.

Mean determination follows the min/max tests. A conversion counter keeps a tabulation of conversions (interrupts). Every 100,000 conversions, or 8 h and 20 min, a new mean is determined. At this time a print flag is set (a nonzero number in index register 15) to print the mean and the minimum and maximum.

Progressing to the averaging process, the program provides the necessary left or right shifting of the new data to reflect the decimal point relationship of the two numbers.

A comparison of the mean-summations' polarity bit with that of the latest data, routes the program through either the addition or subtraction routine as necessary. A very small mean summation can give a subtraction result less than zero. This possibility is avoided by monitoring of the carry bit after each subtraction.

When 100,000 readings have been summed, the four MSDs of the mean summation are written



8. **RAM 1 memory map** designates the characters to be printed. Four 4-bit columns in the map represent the 16 printer columns, and the 16 map rows represent the 16 characters of the printer wheel.

into the mean memory location (ROM 0, register 3, characters 0 through 4) for subsequent printing. Calculation of the mean at power-of-10 intervals (10^5) eliminates floating-point-division routines and holds the program size down.

The decision to print is based on two criteria: the present time and the change in the reading since the last printed value. The state of the four switches connected to ROM input port 2 programs this evaluation; the two MSB switches determine the time intervals between printings. An input of 00 gives a time-reading printout every 5 min; 01 prints at 10-min intervals; and 10 or 11 programs 20-min print intervals.

The two LSBs control printing when the count from the a/d varies by a specific amount from the last printed count. The logger then records the profile of a period of rapid change in the measured analog quantity. When the analog variable stabilizes, the data logger returns to time-interval printing.

The two bits that program the profiling can provide four count intervals. A 00-bit input does not allow count-interval printing; a 01-bit input gives 10-count intervals; and 10 and 11 yield intervals of 100 and 1000 counts, respectively.

In addition to the special printouts, any change in range results in a printing. Each of these non-time-interval conditions is identified by a switch to red printing.

The interrupt routine terminates after the time and data processing are completed. The program then returns to the print-enable examination loop. If a print flag was set previously (nonzero number in index register 15), the program advances to the print routine on page 3.

The printing operation can be interrupted at any time, but the interrupt service can only increment a conversion counter; the program then returns to the printing cycle.

Before any printing can be initiated, however, the program first creates a map in RAM 1 to designate the characters that must be printed. The 16 printer columns are represented by the four columns (registers 0, 1, 2, and 3) of four bits each. The 16 rows represent each character of the 16-character wheel (Fig. 8).

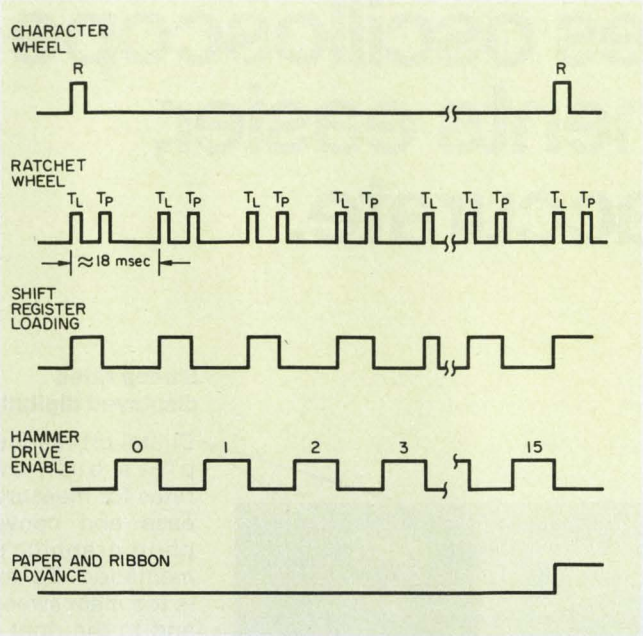
Creation of the map takes place when the program reads each of the 16 register rows of RAM 0 and compares each four-bit word with the 16 characters of RAM 1. Each 16-word column of RAM 0 generates the 256 bits of hammer/character wheel information stored in RAM 1.

The digit/character comparison is done by an Exclusive-OR subroutine that provides a ZERO bit for each hammer column and character position to be printed. Figure 8 shows a memory map for the reading "+19.06" at time 06:12:34:00.

The decimal-point location must be read, and the proper column located, before the map is completed. The decimal point does not occupy a separate location on the printed line but is simply a second hammer strike in that column.

With the memory map complete, the program checks for ribbon color and adjusts the ribbon position as necessary. The program is now ready for the actual printing procedure:

It synchronizes to the printer by polling ROM port 1 until the reset (R) pulse appears. This signal coincides with the appearance of character 0 under the hammers. The R pulse is also coincident with T_L, the pulse that signals that the ham-



9. **Timing signals for the μP/printer:** Pulse T_L starts shift-register loading; T_p enables register outputs.

mer must be disabled. For the next 16 characters (one line), the program ignores the R signal.

As shown in Fig. 9, the shift registers are loaded following T_L. Row (character) 0 of the memory map is shifted bit-by-bit through RAM 1 output port into the two cascaded 10-bit registers. One bit of the port provides the data line, the second provides the clocking function, and the third provides the shift-register enable, whereby the internal state of the bits appears at the parallel outputs.

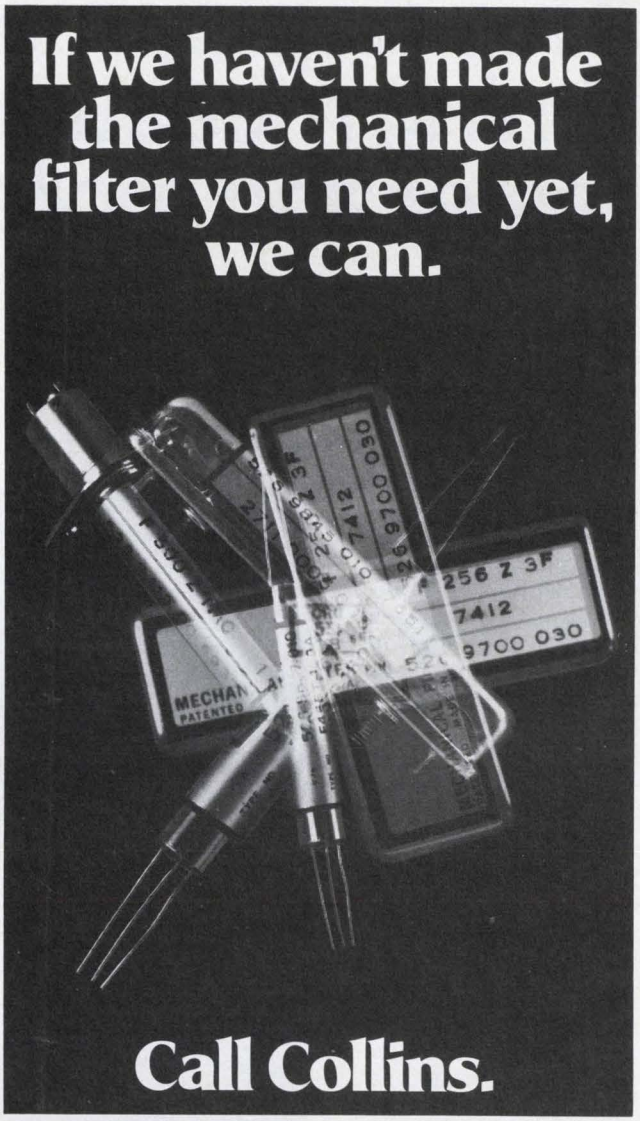
Hammer drives are enabled

After all the bits are shifted out, ROM port 1 is again polled for timing signal T_P. The 12.2-μs machine cycle time allows the μP to load this data in much less than the 5 ms time between pulses. The appearance of T_P enables the shift-register outputs which, in turn, activate the 75451 hammer drivers. (A ZERO at the register output enables the hammer drive.)

The program then awaits the return of the T_L pulse. When T_L appears, the hammers are disabled, and the next row (character) of the memory map loads into the shift registers. The printed line is completed after 16 iterations and the paper and ribbon are advanced.

If more than one line is to be printed (mean output), the cycle continues on to print the mean, the minimum and its time of occurrence, and the maximum and its time of occurrence.

After exiting from the print mode, the last a/d reading enters into memory. This last printed reading is used for difference comparisons with future data. ■■



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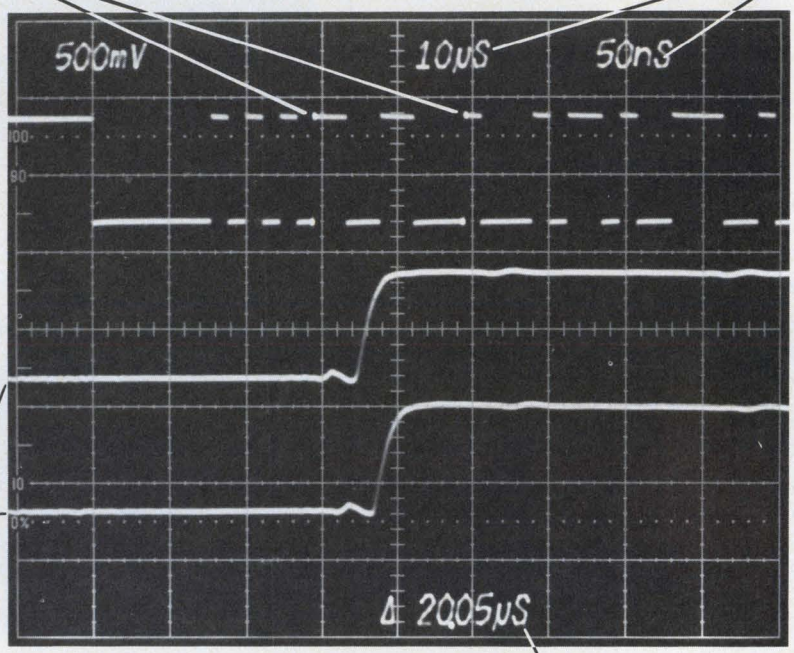

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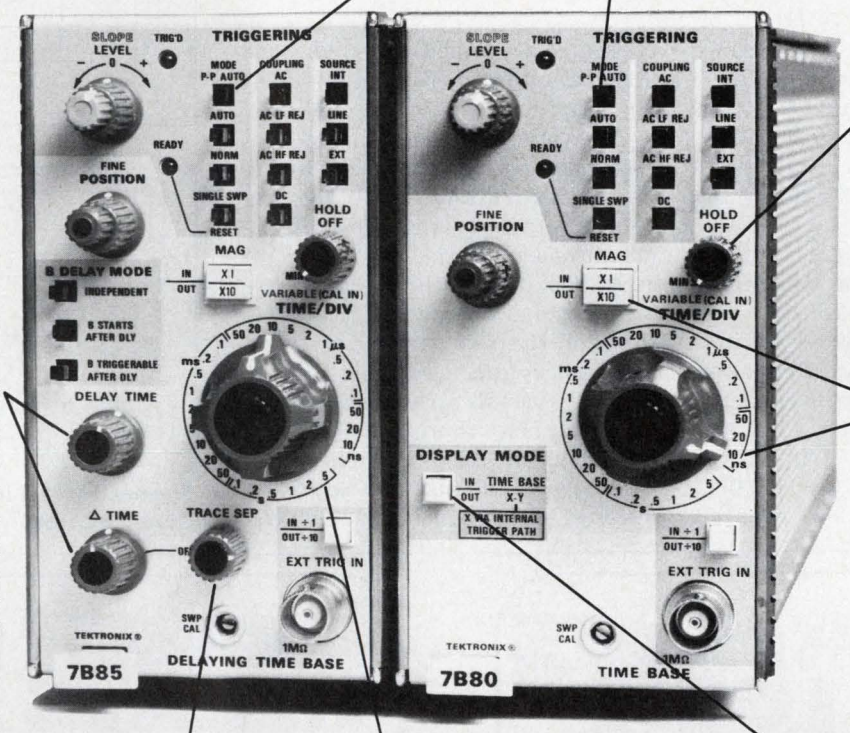

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DELAY TIME positions the first intensified zone. Δ TIME positions the second intensified zone relative to the first. The Δ delay time value — the time between the two intensified zones — is presented digitally on the crt.

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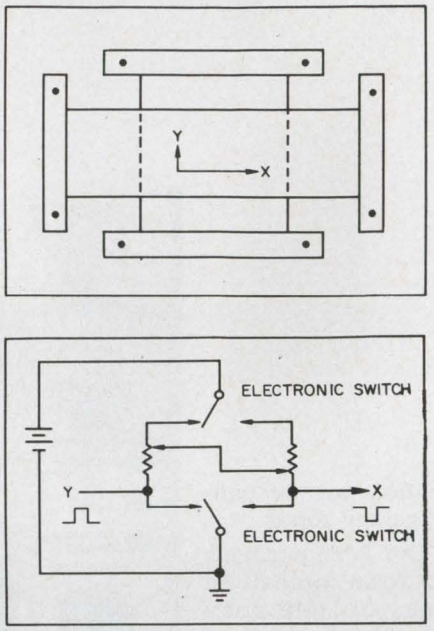
FOR DEMONSTRATION CIRCLE #272

Graphic-input terminal allows easy writing

A freehand-writing graphic-input terminal that has a simple, sensitive surface and that can be used with any type of stylus, has been developed. The writing surface can be covered with paper to produce hard copy.

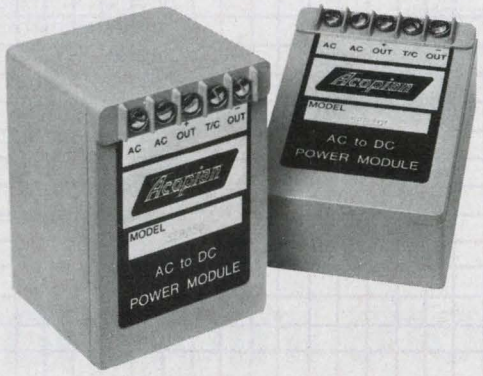
Designed at the National Physical Laboratory, London, England, the graphic terminal consists of two orthogonal resistive strips separated by an air gap. Pressure from writing on the upper strip, which is flexible, deforms it into contact with the lower strip. Electrodes are connected across the ends of the strips so that when a current is passed through one strip a uniform voltage gradient is produced.

The voltage at the point of contact is proportional to the position on the X-axis (see Fig.) The second strip acts as the wiper of the potentiometer formed by the first strip. To obtain the Y-coordinate of the point of contact, the functions of the two strips are interchanged by an electronic switch. If the reversals are repeated sufficiently fast, there is a continuous sampling of the X and Y coordinates of the path traced by the moving stylus. In computer sys-



Freehand graphic terminal (top) is shown with equivalent circuit.

POWER MINI'S FOR LOGIC OR OP AMPS



Terminal strip input/output connections on these miniature power modules eliminate the need for sockets or soldering. They mount in an area only 3.5″ x 2.5″. Ratings: 5 volt models to 2.5 amps, ±15 volts to .5 amps. Other models from 1 to 75 volts, all with 3-day shipment guaranteed.

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CIRCLE NUMBER 296

tems an a/d converter is used to produce a binary representation of the two coordinates.

The input terminal, called Chit, is low in cost and requires only four electrical connections to the writing tablet, which is tolerant of external fields. The surface can be sealed to prevent damage. Since the operation is independent of the absolute value of the strip resistance, a wide range of operating temperatures is allowed.

Solar cell panel adds efficiency and protection

Increased efficiency and protection for solar-cell batteries has been achieved with a new manufacturing technique developed by Mullard of London. These batteries are used for radio repeaters on mountain tops, equipment in desert regions and radio beacons at sea.

The technique consists of embedding the solar-cell array in a flat, molded panel of transparent plastic. Sunlight falling on the solar cells produces electrical energy. Sunlight passes through the transparent, structural areas of the panel with low heat absorption. This minimizes the panel's over-all temperature rise and the cell's operating temperature, thus increasing efficiency.

A typical solar battery contains 34 series-connected cells, each 40-mm in diameter, embedded in a panel measuring 468 × 365 × 15 mm. The array can produce 10.7 W in sunlight.

Improved glass may aid in IC manufacture

A new glass developed specifically for photomasking can overcome the undesirable thermal expansion of the hard glass normally used in photomasks for integrated circuits. This expansion causes a deviation in line width of 1 μm/°C rise for a 100 mm^2 mask.

For LSI with line widths of about six μm the expansion is tolerable, but it becomes a problem with very-large-scale integration, which requires line widths of 1 μm.

The Hoya Glass Works, Ltd. of Tokyo has produced an alumina-silicate glass that has an extremely low thermal-expansion coefficient that is not more than 0.3 microns per 100 mm^2.

The glass is also three times more resistant to water penetration than current glasses and has a greater resistance to acid corrosion. As a result, etching can be performed with much greater precision and yields of very high-density ICs should be improved.

Low-light underwater TV

A highly sensitive underwater television system that requires little if any artificial lighting has been introduced by EMI Electronics Ltd. of Middlesex, England. The silicon-intensified tube used in the camera is said to be some 2500 times more sensitive than a standard vidicon tube.

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CIRCLE NUMBER 298

CMOS analog switches can precisely control an op-amp's gain

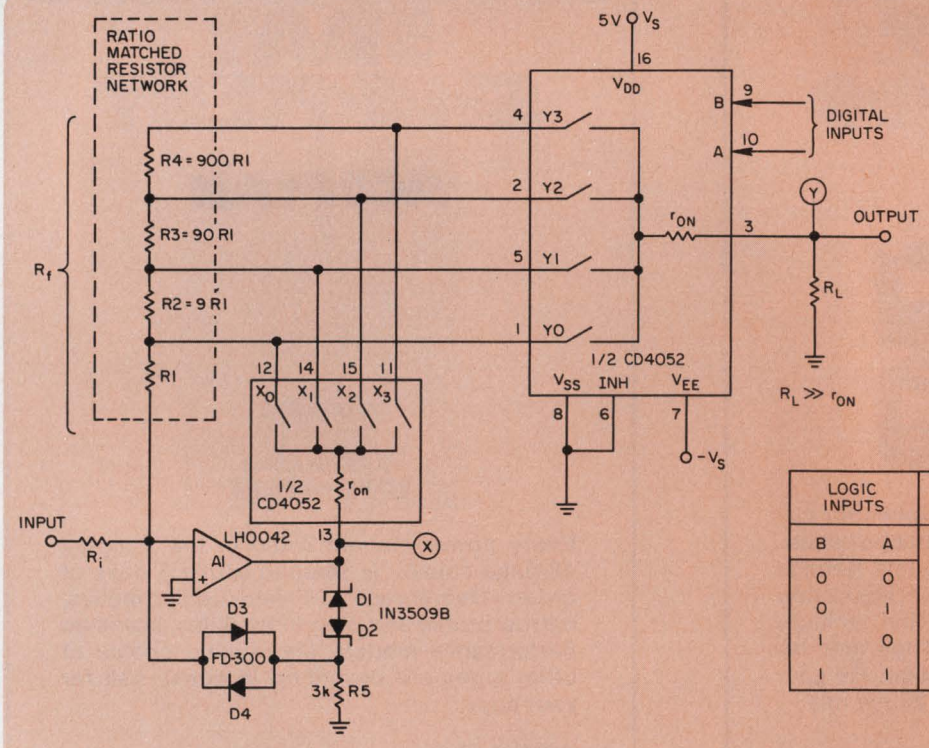
CMOS analog switches, when used in the proper circuit, can accurately control the gain of precision instrument amplifiers (Fig. 1). CMOS switches are inexpensive and consume very little power, but have fairly high ON resistances, r_{ON}, which typically range from 100 to 300 Ω. The proper use of a CD4052 as a dual-channel multiplexer can overcome this limitation.

Resistors R_1 to R_4 form a precision network that is ratio-matched to obtain the desired accuracy. Op-amp A_1 operates as an inverting amplifier whose gain to point X is $(R_f + r_{ON})/R_i$. However, at point Y the amplifier gain is accurately defined by R_f/R_i. Note that r_{ON} has no effect on the gain to point Y.

Since the CD4052 can handle input-voltage swings of $+V_s$ to $-V_s$, the clamp network, R_5 and D_1 to D_4, is designed to clamp node X to these limits.

The design provides four decades of gain or attenuation depending upon the value of R_i. For gain, set R_i equal to R_1; for attenuation, set R_i equal to R_T. (See the table in Fig. 1.)

Gordon L. Wong, Project Engineer, Data Tech, Div. of Penril Corp., 2700 S. Fairview Ave., Santa Ana, CA 92704. CIRCLE No. 311



LOGIC INPUTS		ON CHANNEL	GAIN $R_i = RI$	ATTENUATION $R_i = R_T$
B	A			
0	0	0	1	0.001
0	1	1	10	0.010
1	0	2	100	0.100
1	1	3	1000	1.000

1. **By use of a dual-channel CMOS multiplexer,** an amplifier's gain can be accurately defined as R_f/R_i, independently of the ON resistance, r_{on}, of the multiplexer.

Our modular dc supplies have always been UGLY™ because we're designers, not stylists.

But we may have outdone ourselves with our new SOLV-15.

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But even with all this, it still looked stark.

So we took a stab at making it more attractive by getting it UL-listed and adding sense protection (free), reverse diode protection (free) and a fixed OVP (free). We wrapped it all up in a new low-profile package that uses the same mounting holes as the supplies you're probably using now.

And then priced it all a couple of bucks under the nearest competition ($23.50, 100-pieces).

We just figured that since it was so UGLY, it was really going to have to deliver.

ELPAC

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CIRCLE NUMBER 53

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Control a VCO's start and stop phases with a squelch input signal

A voltage-controlled oscillator (VCO) can be built with a squelch feature that can start and stop the oscillations with a predetermined phase.

Built with five standard ECL gates and two discrete transistors, it was originally designed for phased-locked-loop operation at frequencies of about 10 to 15 MHz (Fig. 1). But with the proper timing capacitor, C, the control voltage, V_x, can cover a frequency range from audio to vhf. The upper limit is about 128 MHz with C = 5.1 pF and $R_1 = R_2 = 300\ \Omega$. Type MC10105 gates, which don't have internal output load resistors, are used; otherwise the VCO's frequency range is narrowed.

Two npn transistors form a constant-current source controlled by the input voltage, V_x, to charge and discharge the timing capacitor, C. Gates G_1 and G_2 form a bistable latch, and gates G_3 and G_4 "sense" the voltage across capacitor C. Gate G_5 can open the feedback loop by inhibiting G_3 and G_4.

To help in examining the circuit, assume that the squelch input is HIGH, that output $\overline{Q_1}$ is LOW and that $\overline{Q_2}$ is HIGH.

With Q_1 HIGH, the charge in capacitor C is gradually changed by the constant current, I_2, until the voltage at Q_2 becomes equal to the gate's ECL threshold level. Then the output of G_4 becomes HIGH and reverses the state of the latch, G_1/G_2. Note that one of the output emitter followers is always reverse biased.

Now $\overline{Q_1}$ is HIGH, $\overline{Q_2}$ is LOW and the voltage at Q_1 becomes

$$2\,V_H - V_{th} = -2 \times 0.9\ V + 1.3\ V = -0.5\ V.$$

Voltage V_H is the ECL HIGH output level and V_{th} is the ECL input threshold voltage. The next transition occurs after an interval,

$$t_1 = \frac{2}{I_1}\,C\,(V_H - V_{th}),$$

and the transition that follows occurs after an interval

$$t_2 = \frac{2}{I_2}\,C\,(V_H - V_{th}).$$

The oscillation frequency then is

$$f = \frac{1}{t_1 + t_2} = \frac{1}{2\left(\frac{1}{I_1} + \frac{1}{I_2}\right)(V_H - V_{th})\,C}.$$

The transfer function of the VCO therefore is

$$\frac{\Delta f}{\Delta V_x} = \frac{1}{2\,C\,(R_1 + R_2)\,(V_H - V_{th})} = \frac{1.25}{(R_1 + R_2)\,C}.$$

Of course to obtain symmetrical output waveforms, R_1 and R_2 must be equal.

If the squelch input is set LOW, G_3 and G_4 are inhibited as soon as $\overline{Q_1}$ also goes LOW. The oscillations stop, but in a known state—with $\overline{Q_1}$ LOW and $\overline{Q_2}$ HIGH. And when the squelch input is made HIGH again, the first oscillation transition occurs after the time interval

$$t = \frac{C}{I_1}\,(2\,V_H - V_L - V_{th}),$$

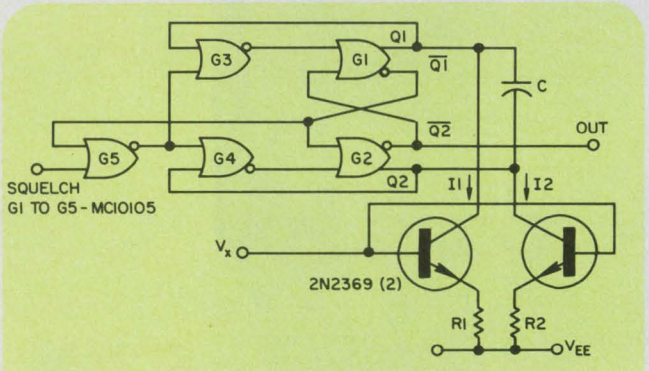
where V_L is the ECL LOW output level. In this manner, the oscillation start phase is defined by the rising edge of the squelch signal.

Plots of frequency vs input voltage are shown on Fig. 2 for C = 62 and 510 pF. For best linearity the control voltage, V_x, should be restricted between −1 and −3 V.

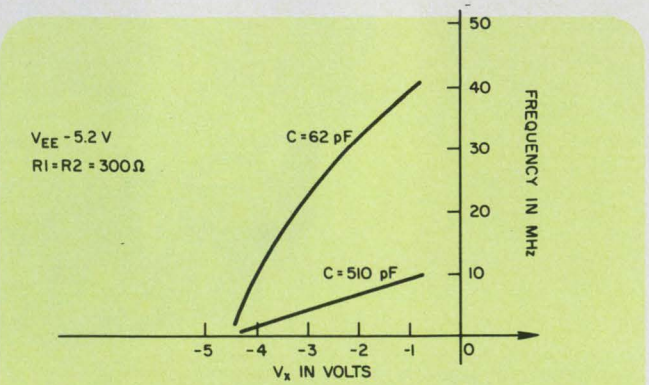
Tests on the circuit showed that for a temperature change from 0 to 80 C, the frequency change was 2.3% at nominal output of 12 MHz when the control voltage is −2 V. Spectrum analyzer measurements showed that output jitter at 12 MHz was 15 ps.

Todor Bodurov, Senior Engineer, Linear Circuit Development Dept., Memorex Corp., San Tomas at Central Expressway, Santa Clara, CA 95052.

CIRCLE No. 312



1. **The squelch input on this VCO can stop and start the oscillations** with a predetermined phase.



2. **Best linearity of frequency control** is obtained when V_x is kept between −1 and −3 V.

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CIRCLE NUMBER 54

Efficient switching controller drives low-power dc servo motor

A high-performance switching controller for a low-power dc servo motor can be built using a symmetrical complementary-transistor bridge (Fig. 1). The bridge acts as a reversing switch between the motor and a single-ended power supply.

Since the transistors operate either fully on or completely off—except during a very short transition period—much less heat is dissipated than in linear-amplifier circuits. Damping is provided by the circuit's inherent dynamic braking. Since either maximum or zero voltage is applied to the motor, dynamic response is faster than that of linear servo drives.

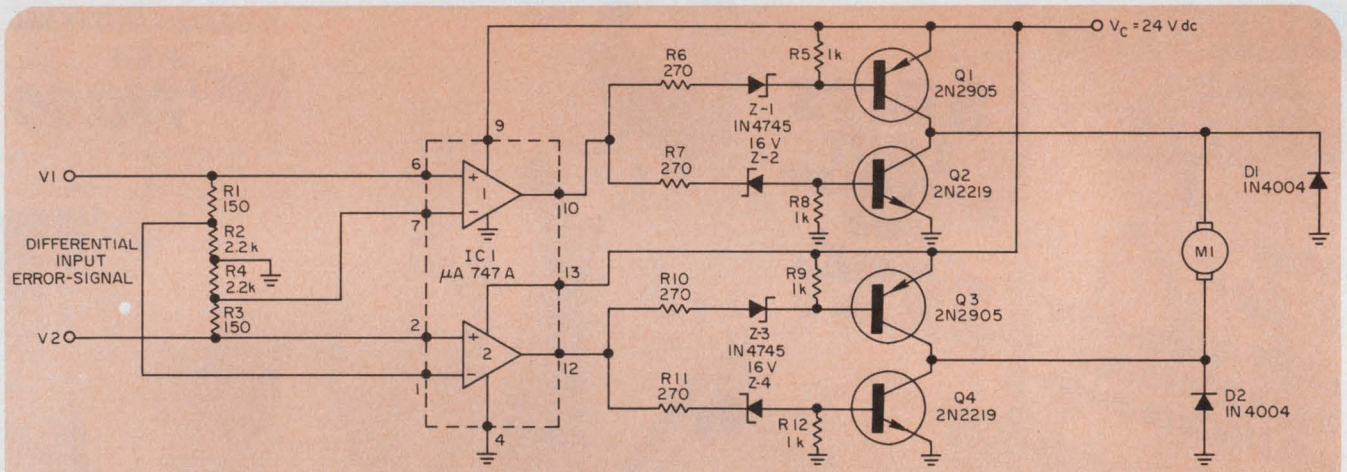
The circuit uses a dual input-amplifier IC in a nonlinear differential configuration and four output driver transistors. The error-signal input has a common-mode voltage, $(V_1 + V_2)/2$, approximately equal to $V_c/2$. Bias levels, $V_B \cong R_1V_c/2(R_1 + R_2)$, which appear across resistors R_1 and R_2, establish an amplifier dead zone. When the absolute value of the error signal $|V_1 - V_2|$ is less than V_B, a voltage slightly less than V_c appears across both the amplifier outputs; thus, no base current flows in transistors Q_1 and Q_3. However, sufficient base current flows via zeners Z_2 and Z_4 into the bases of transistors Q_1 and Q_2 to saturate them. The motor, with the help of diodes D_1 and D_2, is thereby clamped to ground for dynamic braking.

When $(V_1 - V_2) > V_B$, the output of IC_{1-1} is almost equal to V_c, while the output of IC_{1-2} is close to ground. Consequently, Q_1 and Q_4 are cut off, and Q_2 and Q_3 are saturated on.

Similarly, when $(V_2 - V_1) > V_B$, Q_2 and Q_3 are cut off, and Q_1 and Q_4 are on. Thus the transistors act as a reversing switch controlled by the voltage difference across the input terminals.

The breakdown values of zeners Z_1 through Z_4 are chosen somewhat larger than $V_c/2$ to ensure an all-off state between current reversals to the motor. Otherwise, catastrophic failure can occur if both transistors of either pair Q_1 and Q_2 or pair Q_3 and Q_4, conduct at the same time.

Max Fishman, Member of the Technical Staff, The Israel Electro-Optical Industry Ltd., P.O. Box 1165, Rehovot 76110, Israel. CIRCLE No. 313



A complementary-transistor bridge provides voltage reversal from a single-polarity supply to drive a servo motor. The circuit provides dynamic braking for error signals below a preset bias level.

IFD Winner of January 5, 1976

E. R. Fisher, Electronics Engineering Dept., Lawrence Livermore Laboratory, University of California, P.O. Box 808, Livermore, CA 94550. His idea "Expand a System's Memory Capacity without Mounting Hardware and Board Space" has been voted the Most Valuable of Issue Award.

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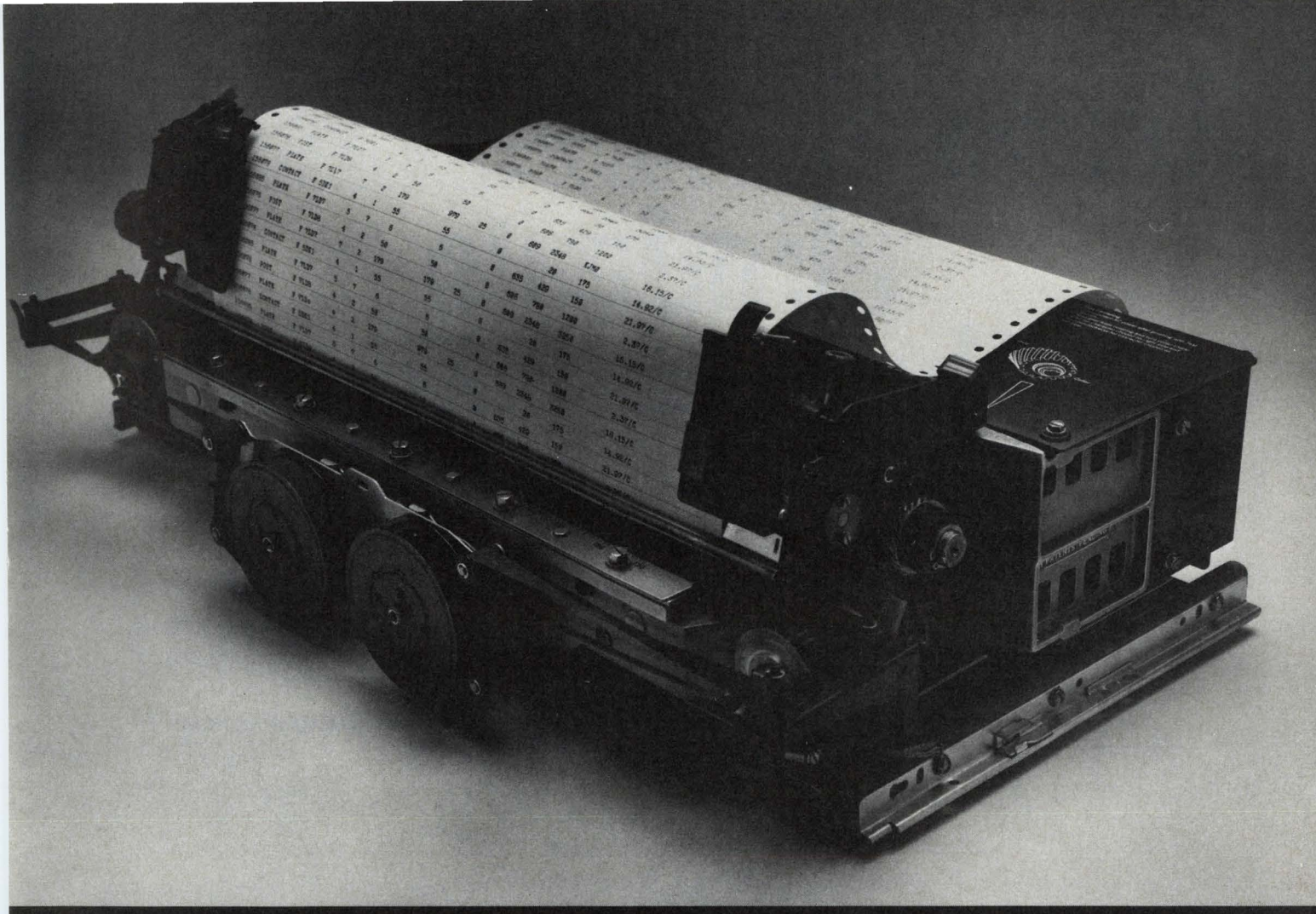

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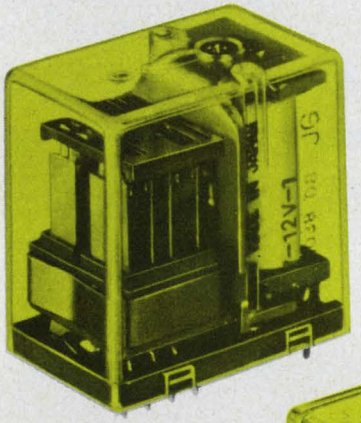
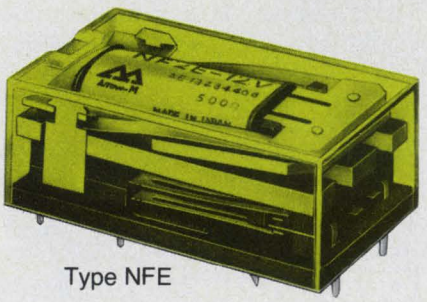
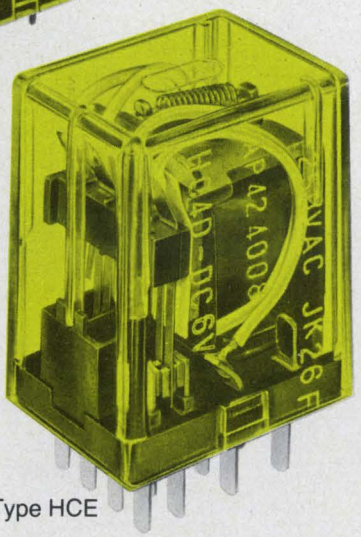


Type KE



Type NFE



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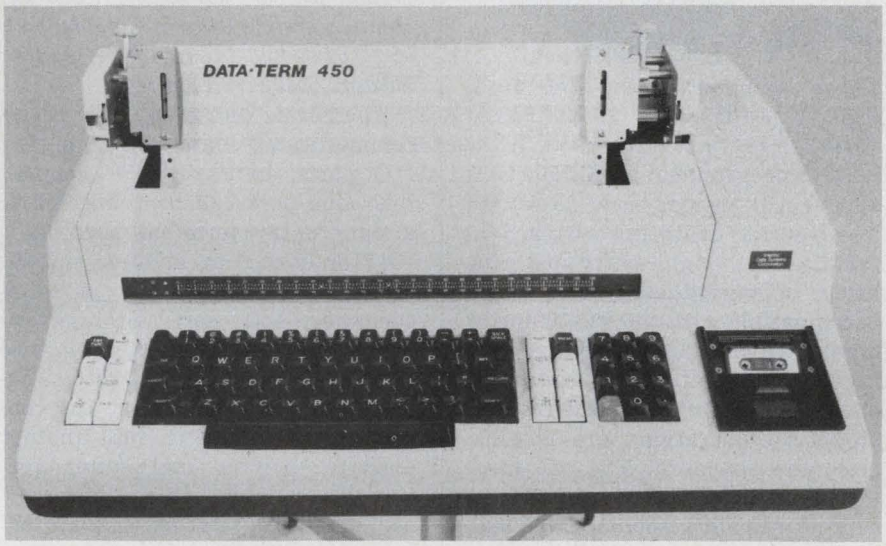
CIRCLE NUMBER 56

Data terminal features low-cost, programmable character set



Intertec Data Systems Corp., 1851 Interstate 85 S., Charlotte, NC 28208. (704) 377-0300. See text.

A low-cost data terminal, the Data-Term 450, can be programmed to print any character set desired. It boasts a cost of only $1300 in single units for the basic terminal.

The system as supplied prints the standard 96-character ASCII set. In addition, engineering symbols or foreign characters may be printed under keyboard or program control.

To program up to 16 additional special characters, the user punches a sequence of keys that define each point on the 7 × 7 dot matrix forming every character. This information is stored inside the terminal, and the character may then be called by a simpler sequence of keystrokes or through external control.

Unused ASCII codes may also be used to recall special, previously programmed characters. For instance, ASCII codes of lower-case alphanumeric characters can be interpreted by the terminal as preprogrammed special characters.

Programmed characters may be single or double width, which allows flexibility in font layout. One disadvantage of the user-programmed character set is that the user-defined characters cannot be stored in the terminal when power is shut off. They may, however, be transferred to cassette tape.

The terminal's printer uses an impact mechanism onto ordinary paper, so special thermal paper is not required. Print width is 132 columns, and speed is 45 chars/s. Options include higher speeds of 60, 120 and 180 chars/s.

The keyboard is similar to an IBM Selectric, has tactile feedback, and has an additional 30-key alphanumeric keypad with dual function keys.

Communication to the outside world is through a standard RS-232C interface, Bell 113A data set, or an acoustic coupler. When using the latter two methods there is a built-in 3-s delay before the unit will send or receive information. This delay eliminates initial hook-up noise. Transmission speed is switch-selectable from 75 to 1200 baud.

Intercette, a built-in tape microcassette, is also available on the Data-Term 450. A second Intercette tape unit may be added as an external peripheral for dual tape requirements. 25,000 characters may be stored on one tape cassette. The built-in drive adds $700 to terminal cost.

The terminal is internally controlled by an 8080 microprocessor. The internal RAM that does housekeeping functions and stores the programmed characters contains 16,000 bytes. Various high level software packages loaded from the Intercette tape system may be run if additional optional memory is added.

Other standard features: horizontal and vertical tabs, variable form control and terminal weight of 45 lb. The unit consumes 225 W when printing; otherwise it takes 75 W.

Booth No. 2807-2811

Circle No. 304

Word generator reacts to external inputs

Interface Technology, 852 N. Cummings Rd., Covina, CA 91724. (213) 966-1718. $5985; 10-12 wks.

The Model RS-432 data and timing generator can change its output depending upon external conditions. Under microprocessor control, the unit can generate data contingent on special inputs such as levels, pulses or sense switches. It generates data continuously or intermittently. The RS-432 also generates serial or parallel data of specified period or from selected blocks of memory. Simultaneously with the data, all control and timing signals required by the unit under test are available. The RS-432 is completely self-contained, requiring no external clocks or dc power. The basic unit allows the user to configure program memory and word memory to suit the specific application. Memory modules for the program memory are provided in 64 and 256-word blocks.

Booth No. 2417 *Circle No. 305*

Matrix printer produces little acoustic noise

Tally Corp., 8301 S. 180th St., Kent, WA 98031. (206) 251-5644. $2575; 90 days.

The Model 1200 dot matrix serial printer features a new low-noise cover for exceptionally quiet operation. The unit prints 132 columns at 120 char/s. The Model 1200 uses a stepper-motor print-head advancement and microprocessor controlled electronics. Other features include dual tractor engagement above and below the print line for positive paper advancement and positioning, and snap-in ribbon cartridge for easy ribbon replacement. Slew speed is 10 in./s. The Model 1200 prints an original plus four carbon copies and handles form widths from 4 to 15 in. Specifications include 6-lines/in., 10-char/in. and a 64 character ASCII set.

Booth No. 2217 *Circle No. 306*

Programmable unit offers 100 steps

Texas Instruments, P.O. Box 5012, MS 84, Dallas, TX 75222. (214) 238-2481. $179.95; stock.

Key programmable SR-56 is a 100-step, 10-memory calculator with an algebraic operating system featuring left-to-right entry and nine levels of parentheses. The SR-56 is compatible with the PC-100 print cradle, which allows complete tracing and printout of any calculator operation. Over 25 scientific and statistical operations are possible from the keyboard. The two looping capabilities and four levels of subroutines allow sophisticated programming.

CIRCLE NO. 307

Floppy disc transfers data via RS-232C

Dynalogic Corporation Ltd., 141 Bentley Ave., Ottawa, Canada K2E 6T7 (613) 226-1383. 7002A: $3950; Editor: $495; 30 days.

The Series 7002A DynaTermDisk communicates data through two I/O ports, both RS-232C compatible. One port can be connected to a data entry terminal such as a CRT or hard copy printer, and the other port connected to a minicomputer I/O port. Storage capacity is 630 kilo-bytes on two diskettes. The unit can also automatically copy and verify the contents of one diskette onto another diskette. An optional editor feature is available, which allows the user to edit data from the data entry terminal.

CIRCLE NO. 308

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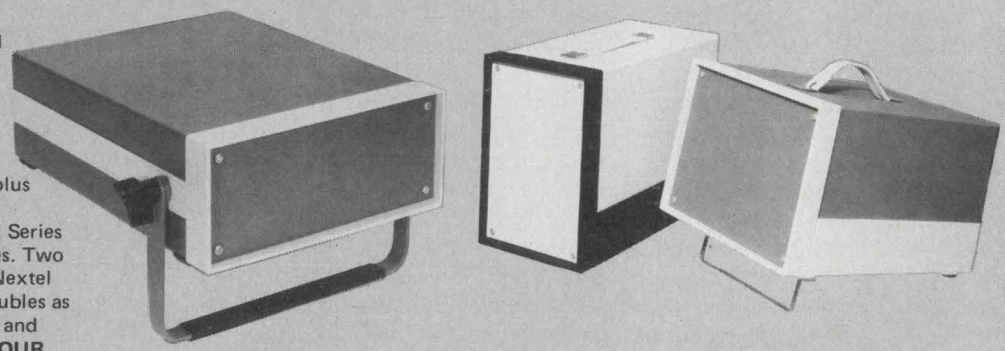

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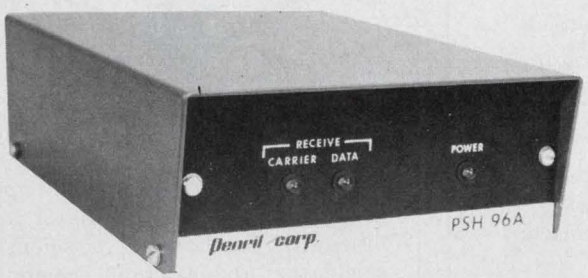

THE PSH 96A — an asynchronous modem for short haul transmission of digital data at rates up to 9600 bps half/full duplex over non-loaded cable pairs.

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THE 313B — an FSK full duplex modem providing asynchronous 0 to 300 bps operation over the dial network.

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CIRCLE NUMBER 57

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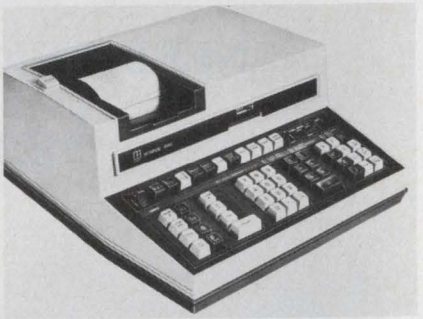
CIRCLE NUMBER 59

DATA PROCESSING

Calculator prints and is programmable

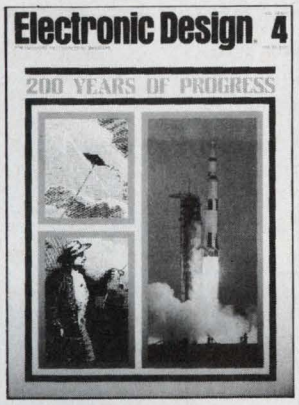


Monroe, The American Rd., Morris Plains, NJ 07950. (201) 540-7300. $3240; 30 days.

The Monroe Model 1880 programmable printing calculator combines the features of a scientific calculator and portable computer with I/O capability. The heart of this system is a user-microprogrammable microprocessor, plus 7 k bytes of ROM operating system for hi-level instructions and 1.5 k bytes of working storage. This microprocessor subsystem is complemented by a keyboard for input, a 21-column printer for output and a magnetic card reader/writer for offline program and data storage. All of this is packaged in a desktop unit the size of a typewriter. Weight is only 22-1/2 lb. Keyboard operation is simple and straightforward, following algebraic rules of equation solving and includes two-level nesting of arithmetic operations. By single keystroke operations, 27 mathematical functions are provided. The 1880 offers optional user-definable keys which allow the user to address up to three programs or subroutines with one key depression. The 1880 calculator also offers user access to more than 230 microprogramming instructions for implementing an operating system and I/O control. I/O communication is via a serial bus or via an 8-bit parallel input. The calculator also allows byte or word transfer, DMA and interrupts. The unit provides 1024 program steps with main memory expansion in 1024-byte increments to a total of 4096. The programming flexibility of the Model 1860 is further enhanced by symbolic and indirect addressing techniques.

Booth No. 2309, 11, 13
Circle No. 309

Bicentennial Issue



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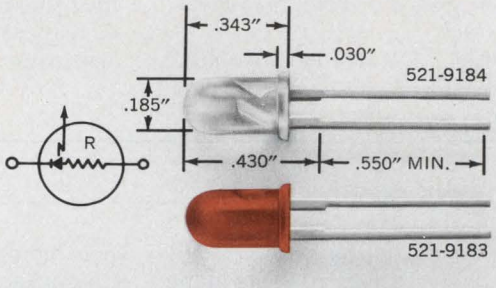
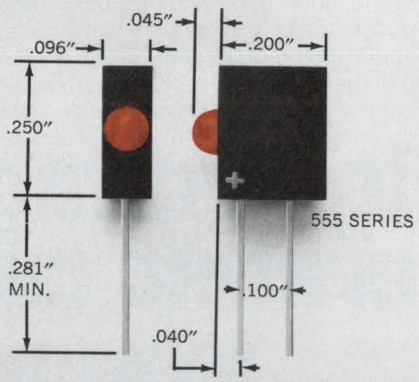


Available in red or clear LED packages with or without a built-in current limiting resistor. Red LED is also made without resistor. Suitable for circuit status indication, alpha-numeric displays and visual indicators. Features long wire-wrappable leads. IC compatible with solid state reliability. High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



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

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See Dialight.

CIRCLE NUMBER 60

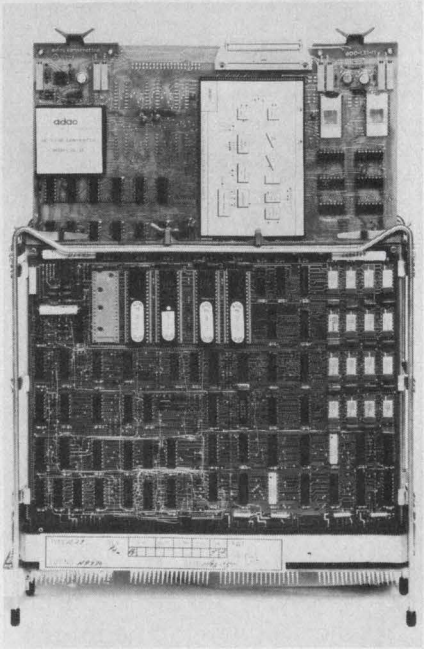
Disc unit mates with Data General computers

EMM Computer Products Div., Dept 1000, 1015 Timothy Dr., San Jose, CA 95133. (213) 644-9881. $4995; stock.

The Model EMM 1000 disc subsystem replaces or augments the floppy-disc units on Data General and equivalent computers. The subsystem has a 3-megabyte capacity and consists of one to four disc drives and one controller. The disc drive uses a moveable head with a fixed disc, and the controller consists of a single board that plugs into the computer. The EMM 1000 is transparent to Data General's operating systems.

CIRCLE NO. 310

A/d converter card connects to LSI-11



Adac Corp., 118 Cummings Park, Woburn, MA 01801. (617) 935-6668. $895 (16 ch); $1185 (64 ch).

The Model 600-LSI-11 is designed as a companion peripheral for the DEC LSI-11 series of low cost 16-bit microcomputers. The multiplexed 12-bit a/d converter system has 16 to 64 channels and is built on a quad size (8-1/2 × 10 in.) DEC-style PC board. The multiplexer of the Model 600-LSI-11 can be connected either single-ended or differentially, and can operate either in a sequential mode or for random access. Four jumper-selectable ranges of analog gain are provided. The system throughput rate is 50 kHz. The card plugs directly into the LSI-11 backplane and derives its power from the same +5 V that powers the computer. A dc/dc converter is included to provide noise-free power to the analog circuitry. A program interrupt interface is also included to allow efficient operation of this peripheral. An optional software programmable gain amplifier allows the computer to select one of four gain settings for any of the input channels over a 10 to 1 range. Included with this option is an automatic zeroing feature that prevents offset drifts even at the highest gain. Provision is also made for two 12-bit d/a converters to provide analog output capability.

Booth No. 1203 *Circle No. 320*

Experience can't be bought at any price and with over 30 years in the design and manufacture of high voltage ceramic capacitors, Murata has experience that's unsurpassed in the field. This experience has made Murata the world's largest producer of high voltage ceramic capacitors and generated a reputation for quality and performance second to none. What's more, our line covers virtually every high voltage application requirement. Check some of the brief features listed below and we're sure you'll want to know more. Our complete information package is yours for the asking. Write or call today.

DH, DHL, DHG Types. For Power Supplies and Power Distribution Systems: 10-30 KVDC WV. 40, 50 & 60 KVDC WV also in DH. 500-5,000 pF. Z5V, Y5P & N4700 Temp. Char. Epoxy Resin Encapsulation.

DHR Type. For Color TV Doublers and Triplers: 500-1,000 pF. 10, 12 and 15 KVDC WV. Z5P & N4700 Temp. Char. Extremely Low Noise Level. (Higher Capacities are also available.)

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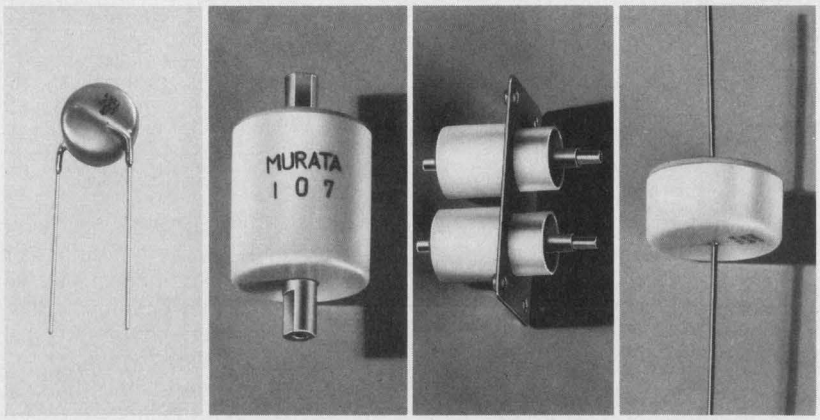

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CIRCLE NUMBER 62

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SELF-SCAN II
240-CHARACTER PANEL
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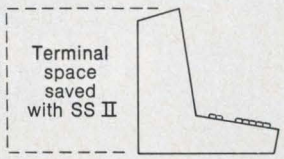
Burroughs' new, low-cost SELF-SCAN II 240-character displays offer many features compared with CRT terminal displays. Contrast and readability are better than ever under all conditions. Characters are jitter- and flicker-free bright neon-orange color, with no fuzziness or loss of linearity at the edges of the display. An all-new manufacturing process has significantly reduced cost, weight, size, and has improved reliability. And, the SELF-SCAN II panel's 40-character line is compatible with popular software. Graphics can also be displayed using additional drivers.

Other significant advantages include easy interface to micro-processors, thin cross-section, small overall size, and rugged construction for long service life under all operating conditions.

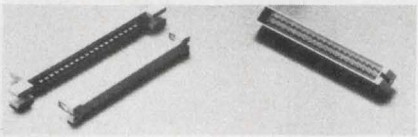


Give your data terminals a bright new outlook; call or write for complete information. Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Plainfield, New Jersey 07061. Telephone (201) 757-5000.

You can see the difference

Burroughs

Connector designed for mass termination

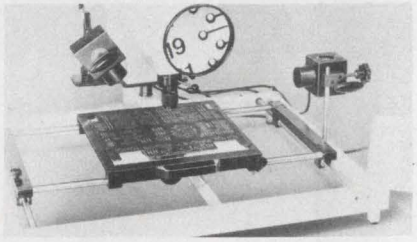


3M Co., P.O. Box 33600, St. Paul, MN 55133. (612) 733-1590.

Versatile new male connectors available in two configurations for mass termination applications feature 0.025-in. square pins, with mounting flanges for rack-and-panel applications, and without flanges for midspanning. Manufactured in a variety of sizes from 10 to 50 contacts, they are compatible with Scotchflex-brand socket connectors. Applications include use as a T-tap from a cable bus, a splice connector or an I/O interface. The plastic-connector housing is a glass-reinforced polyester material with a UL flammability rating of 94 V-O. Cables on 0.050-in. conductor centers are available for use with all connectors.

Booth No. 2424 *Circle No. 321*

Microscope projects for easy viewing

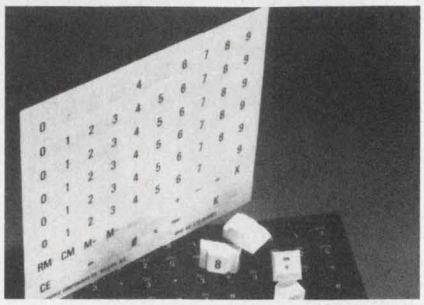


Aikenwood Co., 223 Forest Ave., Palo Alto, CA 94301. (415) 326-2151. From $3600.

The Visomet-300 projects a high-resolution image on a ground glass screen, enabling the operator to sit at a comfortable viewing distance and eliminating the fatigue associated with bending over a conventional microscope. The new instrument accommodates flat samples sized up to 20 by 25 in. on its large floating stage, which runs on ball bearings. The magnified image is presented without reversal. A shade eliminates the possibility of stray reflections on the fine-grain viewing screen. Standard magnifications from 5× to 30× are available.

Booth No. 2614 *Circle No. 322*

Mylar legends applied to keycaps



Stackpole Components Co., P.O. Box 14466, Raleigh, NC 27610. (919) 828-6201.

Engraving legends on keycaps is a serious economic problem for low-volume users. However, characters printed on sheets of pressure-sensitive Mylar can be applied to Stackpole caps. Because the Mylar characters are recessed into the caps, they can't be peeled off unintentionally. For reprogramming, the Mylar can be removed and new legends applied. Mylar keycaps may be specified for keyswitches LO PRO 5, LO PRO 20, their high-profile .equivalents or for custom keyswitches.

Booth No. 2424 *Circle No. 323*

DIP REED RELAYS
35 MODELS

Your choice of:

- SPST, DPST & SPDT dry reed contacts, 3 to 10 watts.
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- 5 to 24 VDC coils. 4, 8, or 14 terminals. TTL compatible.
- Optional clamping diodes and electrostatic shielding.

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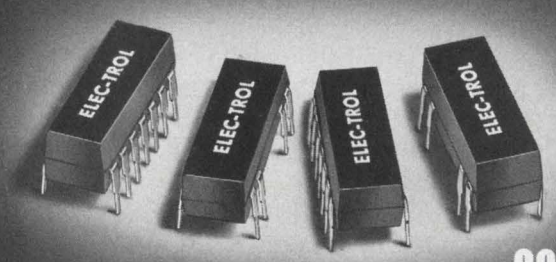
ELEC-TROL, INC.



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CIRCLE NUMBER 64

REED RELAYS TO FIT YOUR SPECS... AND BUDGET

Our Open-Line reed relays will give you high performance at remarkably low cost if you have no critical environmental factors to worry about.

Our Encased-Line is epoxy sealed to meet extreme environmental and handling conditions.

Both offer top performance; choice of Form A, B, or C dry reed contacts; Form A mercury wetted reed contacts; up to 6 poles; coil voltages 5 to 48 Vdc; either .1" or .15" terminal spacing; optional electrostatic or magnetic shielding.

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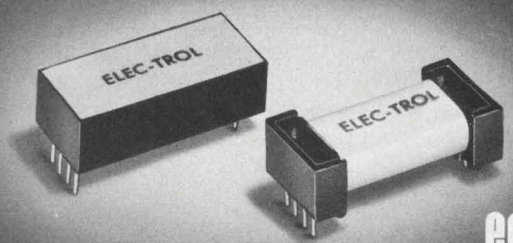
ELEC-TROL, INC.



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CIRCLE NUMBER 65

5-Volt, 10-AMP Power Supply

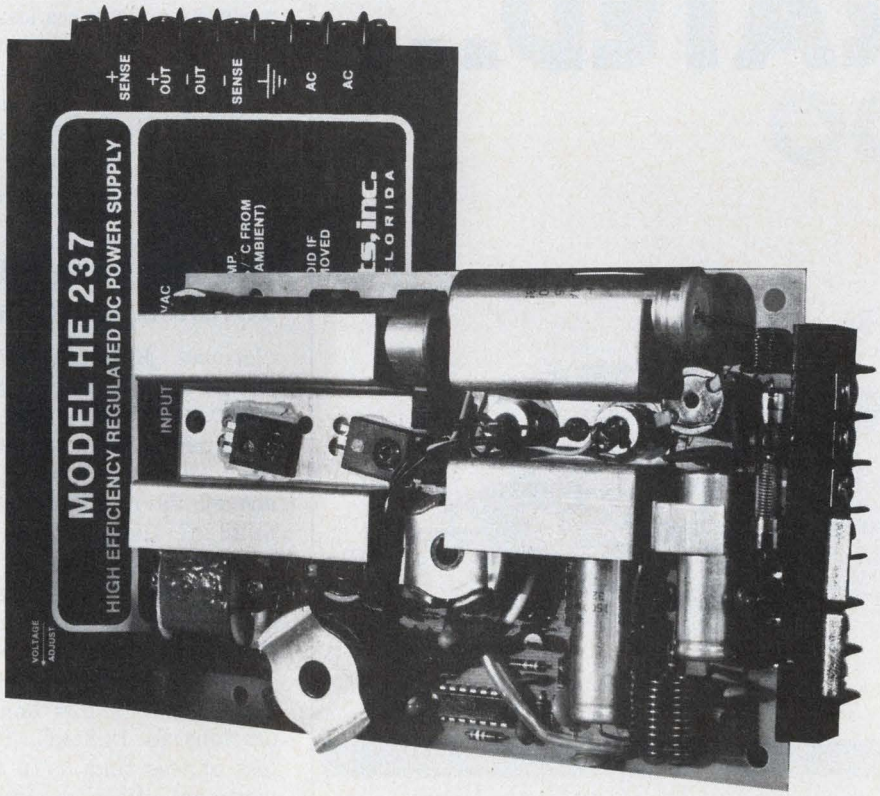
The Model HE237 Power Supply offers the design engineer, for the first time, a low cost, highly efficient alternative to the size, weight, and heat generation problems normally associated with series-pass regulated supplies. Using state-of-the-art switching techniques and CMOS logic, the HE237 achieves 75% efficiency, at a full load of 10 amps.

The HE237 has the "footprint" and mounting dimensions of the Lambda package size "B" supplies—a feature that allows the engineer to experiment with high efficiency techniques in existing designs. In new designs, the engineer can take advantage of the HE237's small size (6½" x 4½" x 1½") and light weight, (1.7 lbs).

The highly reliable HE237 Power Supply is short-circuit proof, contains over-voltage protection, and is backed by a full two year warranty.

Finally, the HE237 offers the design engineer considerable savings. It is available in both 115 and 230 VAC input models for just $195...quantity, one.

Computer Products, inc.



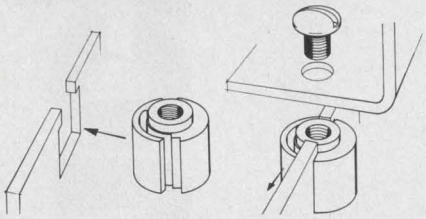
High Efficiency

1400 NW 70 Street, Fort Lauderdale, Florida 33309 • (305) 974-5500, TWX (510) 956-9895.

Distributors: Los Angeles 213-877-5518 / Albuquerque 505-255-2440

CIRCLE NUMBER 66

Insert makes it easy to screw into sheets

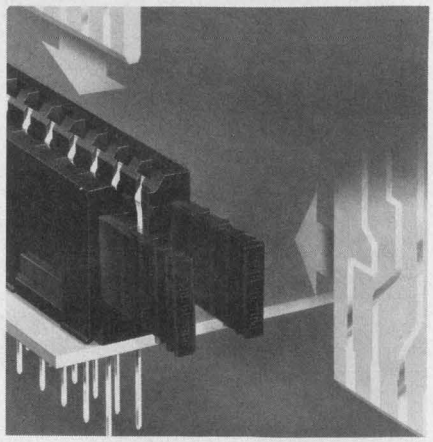


Southco Inc., Brinton Lake Rd., Concordville, PA 19331. (215) 459-4000.

The new Southco, Fl, sheet-edge insert snaps into a prepunched notch in a thin sheet and remains in place, held by a spring leg that locks behind the panel. This makes it easy to screw into the edge of a sheet without the need for flanges or riveted brackets.

Booth No. 1228-30 Circle No. 324

Card-edge connector uses zero insertion force



Amp Inc., Harrisburg, PA 17105. (717) 564-0101.

Requiring a minimum of 0.5-in. mounting width, new zero-insertion-force connectors accept PC boards inserted from either the top or the side for high-density packaging applications. Designed for use with double-sided or multilayer boards from 0.054 to 0.071-in. thick, the connectors are available with up to 280 contacts (140 dual-contact positions) on 0.125 × 0.125-in. spacing. Actuating mechanisms include lever-operated cam and push-pull slides. The activating mechanism requires less than 0.450-in. linear travel to establish electrical contact. When opened, the contacts are withdrawn behind internal housing barriers for protection during PC-board insertion.

Booth No. 1532-34 Circle No. 325

Two new magnetic alloys advance Xformer design

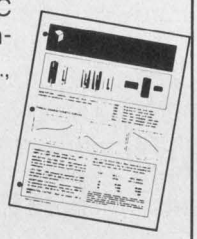
National Magnetics Corp., 13607 Pumice St., Santa Fe Springs, CA 90670. (213) 921-7517.

Cobisil, a newly developed cobalt-iron alloy, achieves a 40-to-52% energy savings and can be used to 22 kG. Its size and weight yields a reduction up to 30% and is the answer to lighter-and-smaller transformer designs, according to National Magnetics. Nicosil is a newly developed nickel alloy that attains a 75% flux density for operations to 13.8 kG. Its ultra-low loss of less than 1/10 that of conventional silicon steel fills the needs of high-frequency transformer and switching/inductor applications to 70 kHz.

Booth No. 2814 Circle No. 326

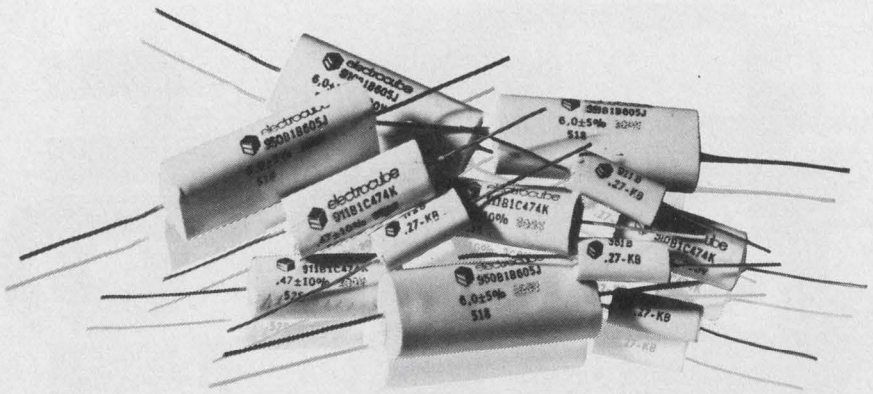
electrocube® capacitors

...are now offered in miniature AC rated models, of metallized polypropylene and with foil, in 135 VAC and 270 VAC versions with ratings to 10 mfd. Smaller than existing units, this may be the only 270 VAC dry capacitor available. And these can also be used for DC applications, to 200 VDC with 135 VAC units and to 400 VDC with 270 VAC capacitors. Get more data on these new components...write or call Electrocube, 1710 So. Del Mar Ave., San Gabriel, CA 91776; (213) 573-3300.



FREE...data file on request

AC RATED... DC, TOO



...also available in REEL PACKAGING.

CIRCLE NUMBER 67

CIRCLE NUMBER 68 ►

introducing

THE NEW WESTON AUTORANGING PORTABLE DMM

The best buy ever in a portable digital multimeter

ONLY $195 Performance, quality, reliability and price. The new Weston Model 6000 is a total value package and the best buy ever in a portable digital multimeter. Just check these performance and convenience features:

Autoranging–plus factor in a portable
The simplicity, speed and accuracy of automatic ranging is a big advantage in a low cost portable digital multimeter. And in the Model 6000, it's available for the five standard measurement functions . . . AC/DC Volts, AC/DC Amps, Resistance. . .in 26 broad ranges. . .with full overload protection. Zero adjustment for all ranges is built-in . . . automatically.

A bonus feature is a 10 Amp AC/DC current range . . . not usually available in digital instruments. And a special "Hold" input jack provides a convenient memory retention capability for remote measurements.

Superior performance in a portable
Even in a low priced portable, Weston quality proves itself. The high performance capability of the Model 6000 is typified by an accuracy of 0.35%, with resolution of 100 μv, 1 μa and 0.1 ohm.

Large, easy-to-read-anywhere display
Even in bright sunlight, it's easy to read the large 0.5" high LCD 3½ digit display. Alternate blinking of the LCD's provides an over-range indication that prevents erroneous readings. And minus polarity is measured and displayed automatically without reversing leads.

Low power operation
Power source for the Model 6000 is two inexpensive, easily available 9V transistor batteries. Long battery life is assured by special circuits designed by Weston for low power drain. And when the batteries do run low, the LCD display blinks to tell you.

Small and lightweight . . . but rugged
The Model 6000 portable is small in size and weighs less than two pounds. The rugged glass-filled Lexan® case can withstand tough treatment. A combination carry handle/display cover/tilt stand makes it convenient and practical for field or bench use.

® Trademark, General Electric Co.

Weston service back-up
The Model 6000 is backed-up with the Weston total service commitment. Complete full year warranty, with service available at any of Weston's domestic or foreign service centers. Another plus factor for a low priced portable DMM.

The new Weston Model 6000 Autoranging Portable DMM doesn't scrimp on performance, quality or reliability . . . it just brings them to you at a better price.

See the Model 6000 at any Weston Distributor. Or, write direct to Weston for additional information.

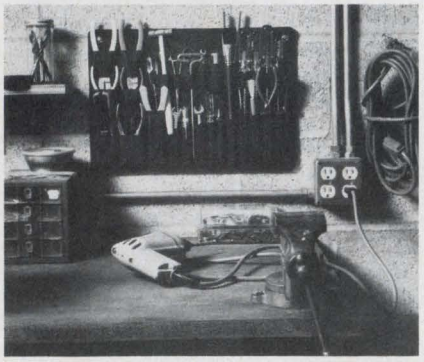
Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N.J. 07114

Canada: 1480 Dundas Highway, Mississauga, Ontario

Europe: Ingolstadter Str. 67a 8 Munchen 46, W. Germany

WESTON® WESTON Schlumberger

Tool organizer holds many tools

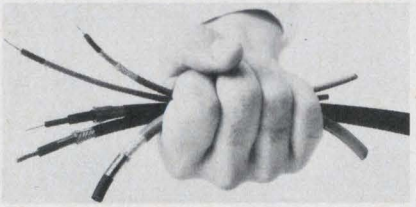


Platt Luggage Inc., 2301 S. Prairie Ave., Chicago, IL 60616. (312) 225-6670. $12.75 (1-5).

Platt pallet, molded of tough urethane, can hold a large selection of small tools. Put up over a work bench, it keeps tools out of the grit and grime of tool boxes. The organizer is molded in one piece; no stitches, seams, flaps or rivets form any of the pockets. It's unconditionally guaranteed for 5 yr.

CIRCLE NO. 327

Power cables suppress rfi to 45 GHz



Capcon Inc., 147 W. 25th St., New York, NY 10001. (212) 243-6275.

Lossyline power conductors and cables provide rfi suppression of more than 100 dB. Unwanted noise to 45 GHz is absorbed and dissipated by a lossy medium that surrounds the central conductor. In microwave ovens, the cable has been used to counteract radiation leakage when carrying 50 A at 6000 to 50,000 working volts. Cables come with standard current ratings of 1 through 100 A and standard voltage ratings of 125, 250, 440 or 550 V ac or dc at frequencies of 25, 50, 60, 400 or 1000 Hz. Operating temperature ranges from —55 to 250 C. High-voltage ratings to 100,000 V are available for transmission cabling.

CIRCLE NO. 328

Precision rf connector for low loss and VSWR

Weinschel Engineering, 1 Weinschel Rd., Gaithersburg, MD 20760. (301) 948-3434. $75 (unit qty); stock to 60 days.

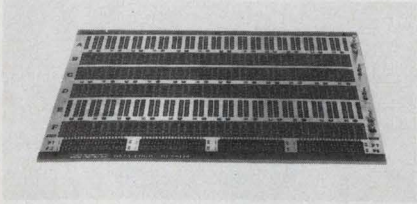
The Model 1565 precision 7-mm rf connector for use to 18 GHz is specially designed for applications where insertion-loss and VSWR-repeatability are of primary importance. It meets all requirements of IEEE STD 287, Design 2, and will mate nondestructively with other 7-mm connectors that conform to the interface dimensions of the standard. The unit features front-end replaceable mating contacts; life under normal use is 5000 matings. Replacement contacts, relatively inexpensive compared with the price of a connector, greatly extend connector life.

CIRCLE NO. 329

World's first 4-channel compact...

Dimensions (h x w x d) 154 x 316 x 410 mm. Weight just 9.6 kg.

Blank socket panels accept μPs



Data Numerics Inc., 141-A Central Ave., Farmingdale, NY 11735. (516) 293-6600. See text.

Three new blank socket panels accept microprocessors and DIP components. Model DL-8-90, an 8 × 8-1/2-in. board with three 40-pin input/output connectors, costs $45; Model DL-8-120, 8 × 11 in. with four 40-pin connectors, costs $60; and Model DL-8-180, 8 × 16 in. with six 40-pin connectors, costs $77. All three models are available with double the number of I/O connectors at extra cost. The boards accept any 14-to-40-pin configuration, and because of modular design, can be updated for newer, higher-density elements. Data Numerics will mount any socket configuration at extra cost.

CIRCLE NO. 330

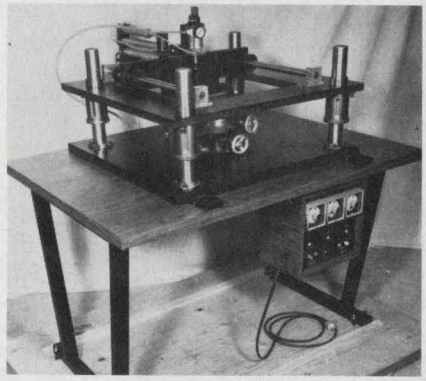
Wide selection given in repair systems

Pace Inc., 9329 Fraser St., Silver Spring, MD 20910. (301) 587-1696. See text.

A complete line of systems for the repair, rework, maintenance and salvage of electronic assemblies offers a wide choice of functional capabilities. Pace systems allow the repair of damaged or missing runs, terminals, plated-through holes, replating of damaged or worn connectors, miniature machining to repair or modify circuits, high-strength reflow soldering, accurate component forming or the removal of conforma coatings and any component. The systems range from a basic Ped-a-Vac desoldering system at $195, to a completely equipped repair/manufacturing center for $5300.

Booth No. 1112-14 Circle No. 331

Thick-film printer handles big substrates



Aremco Products, Inc., P.O. Box 429, Ossining, NY 10562. (914) 762-0685. $7990; 4 wks.

A special wide-area screen printer can print on 10 × 10-in. substrates. The printer uses a four-post die-set design and is mounted on a Formica-top console. Substrates of green-ceramic tape or glass for display work can be screened with this equipment. The registration between substrates and screen is guaranteed at 0.0003 in. The machine can operate up to 1200 cycles/h.

CIRCLE NO. 332

...with amazing triggering facilities

There's never been a spec. like this before.
☐ four 50 MHz channels plus
☐ two differentials (simultaneous display if needed) plus
☐ fully independent triggering of main and delayed time bases meaning
☐ main time base triggering on any of the four channels + composite + external + line and
☐ delayed triggering on any four channels plus composite.
☐ Moreover it all comes in a compact 9,6 kg construction.

So now you can display just about anything, for example a magnified view of any delayed section of a signal even when it is not directly related to the main time reference!

Easier to use too

One look at the PM 3244's front panel tells you everything. Controls are logically grouped and positioned to fall naturally to hand. So you study the screen and not the 'scope.

One look inside will tell you how it's done - with a Philips technique called cold switching. This means that the actual switching is performed on the boards with simple DC signals from the controls. The removal of mechanical connections eliminates layout and electrical design restraints, which in turn allows the PC boards to be designed for optimum layouts at all frequencies and for all facilities. Reliability is therefore greater, both mechanically and electrically, and servicing is made easier.

Another Philips development gives you remarkable low 29 W consumption which eliminates the need for ventilation fans and holes. It also boosts reliability and allows the PM 3244 to work from a battery pack as well as just about any voltage/frequency combination. So the world's first 4-channel compact lives up to its name. Going anywhere that 4 channels are needed. Which in todays's digital world means just about everywhere.

Find out more by contacting Philips or utilize our toll free HOT LINE number 800 645-3043. New York State residents call (516) 921-8880 collect.

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(516) 921-8880

In Canada :
6 Leswyn Road
Toronto, Ontario Canada M6A1K2
(416) 789-7188

PHILIPS

PHILIPS

CIRCLE NUMBER 69

Stainless-steel tools vacuum solder

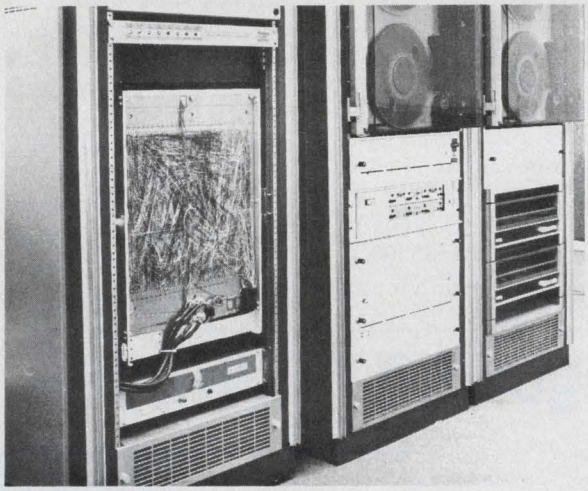
Consell, 463 Payne Dr., Cheshire, CT 06410. (203) 272-6837. Mini-Mini: $9 (unit qty); stock.

A series of three tools will remove solder from printed-circuit boards by vacuum action. One of these, the Mini-Mini, is suited for the finest PC-board repair and rework. The 6.25-in. tool is constructed of stainless steel except for the Teflon tip. The other tools, the Mini and Maxi, are used for bigger jobs. To use the tools, a soldering iron first is applied to the connection to melt the solder. The plunger on the tool is pushed in, and the suction tip is placed in contact with the molten solder puddle. The trigger button is depressed, creating a high vacuum, which then sucks up the solder.

CIRCLE NO. 333

100x Speed Improvement

FROM YOUR MINI . . . or more!



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Add our **AP-120B** Floating-Point Array Processor to your system – and leave the software and formatting to us.

The **AP-120B** is an extremely high-speed peripheral processor. It produces a 38-bit floating-point addition AND a 38-bit floating-point multiplication every 167ns! **That's 12,000,000 multiply/adds per second!**

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Vector Multiply	.75 usec per data point
Vector Divide	1.67 usec per data point
Vector Square Root	1.83 usec per data point
1024 real FFT	2.50 msec

The **AP-120B** comes with extensive software: Cross Assembler, Executive, Simulator, Diagnostics, an algorithm Library of over 80 routines and is easily programmable for custom operations.

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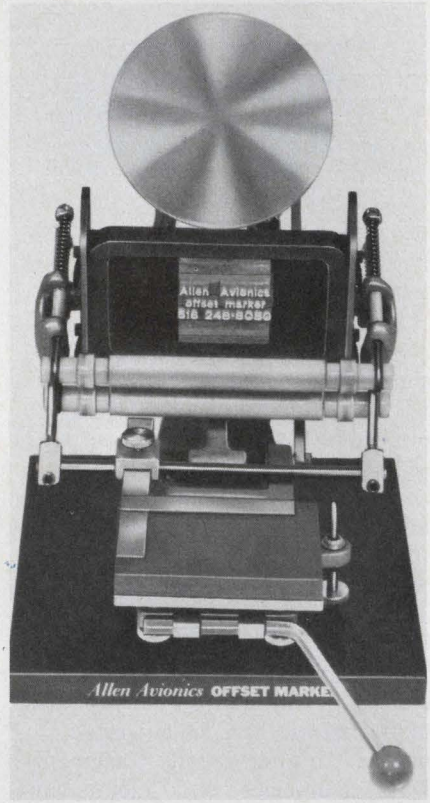
Phone: (503) 620-1980 TELEX: 360470 FLOATPOINT PTL

CIRCLE NUMBER 70

Offset marker machine imprints products



Allen Avionics Inc., 224 E. 2nd St., Mineola, NY 11501. (516) 248-8080. $275: manual model; 6 wks.

A complete line of offset marking machines including manual and air-operated models provides permanent product identification. An important feature is the ability to change copy quickly. Any novice can learn its operation quickly. The manual model weighs only 13 lb. Air-operated units come with hand or foot controls and automatic cycling.

Booth No. 1527 *Circle No. 334*

Temp test chamber spans—100 to 350 F

Thermotron Corp., Kollen Park Dr., Holland, MI 49423. (616) 392-1492. From $1645; stock.

The Mini-Max series of temperature test chambers is available with capacities from 1.2 ft^3 to 32 ft^3. The chambers operate over a temperature range of −100 to +350 F (−7 to 177 C). The controller sensitivity is ±0.25 F. Chambers are available in 220 V, 60 Hz single phase and in 220 V, 60 Hz, 3-phase models.

CIRCLE NO. 335

NEW Simpson® 360

SERIES 2 DIGITAL VOM

- Large bright 0.43" 3½ digit non-blinking auto-polarity LED display.
- Exclusive MOS-LSI circuitry, specially designed for Simpson gives high stability and reliability, immunity to noise, low power drain and permits compact design at low cost.
- Calibrated zero-center analog display gives quick indications for nulling, peaking, scanning trends.
- 29 most needed ranges including 2 "Low-power" ohms ranges.
- High accuracy. ±(0.25% of reading + 1 digit) on DC voltage ranges. Resolves 100 uV, 10 nA (DC), 100 nA (AC), and 0.1Ω.

GREAT NEW FEATURES

NEW LOW PRICE $257.

Simpson 360 Series 2 Digital Volt-Ohm Milliammeter is a compact 3½ digit instrument for field and bench use in electronic and electrical maintenance, production, and laboratory. It offers high performance and value never before possible in a medium-priced digital VOM.

360-2 Digital VOM supplied with test leads, AC charger/adapter and instruction manual (less batteries).

$257.00

Accessories available.

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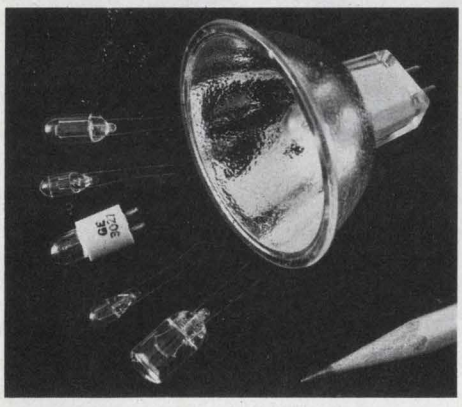
KATY INDUSTRIES
INDUSTRIAL EQUIPMENT GROUP

CIRCLE NUMBER 71

Stay current with small lamp data from General Electric. It's free.

Check these 6 halogen cycle lamps GE has added to its low-voltage line.

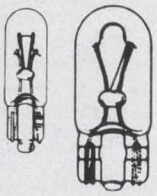


General Electric now offers over 27 halogen cycle lamps that pack high light output in small packages. (In addition, GE offers 8 sealed beam halogen lamps primarily for aircraft applications.) Bulb diameters range from 3/16" to 1/2". Lengths from .520" to 2.25". Voltages from 3.5 to 28. O.V. And candlepower from 2.15 cd up to 250 cd.

They're ideal for you if you're designing applications such as optical systems, instrumentation, illuminators, fiber optics, card readers, displays and aircraft navigation. A variety of terminals are offered.

For updated technical information circle the number below or write GE for Bulletin #3-5357.

These GE wedge base miniature lamps offer you savings in time, money and space.



These lamps are ideal for applications such as indicators, markers and general illumination where space is at a premium. Their wedge-based construction makes them easy to insert and remove. They don't require bulky, complicated sockets. And because the filament is always positioned the same in relation to the base, you get consistent illumination from lamp to lamp.

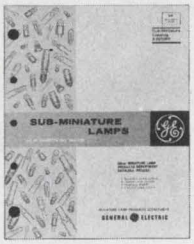
You can choose from over 25 types of GE wedge base lamps. Voltages range from 6.3 V to 28 V. Candlepower from 0.03 to 12 cd. Bulb sizes range from subminiature at 6mm to a heavy-duty bulb at 15mm.

To send for updated wedge base lamp technical information, circle number below or write GE for Bulletin #3-5259.

These three free GE catalogs include important data changes that could affect your present design. Send for yours today.

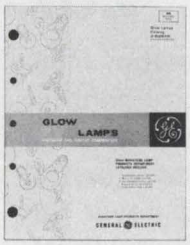
#3-5169

June '75 Miniature lamp catalog features 40 pages and 500 data changes for complete 500-lamp line.



#3-6252R1

Feb. '75 Sub-miniature lamp catalog features 24 pages and 91 changes for more than 210 lamps.



#3-6254R

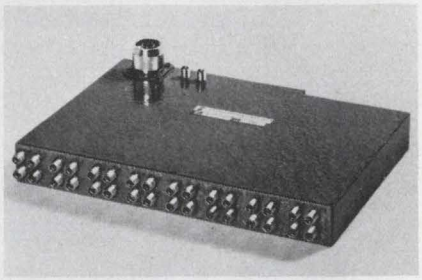
Dec. '74 Glow Lamp catalog features 8 pages and 50 changes for 83 Glow Lamp Indicator and Circuit Component lamps.

For up-to-date technical information on any of these items write: General Electric Company, Miniature Lamp Products Department #3382- L, Nela Park, Cleveland, Ohio 44112.

GENERAL ELECTRIC

CIRCLE NUMBER 72

32-way divider/combiner covers 3.4-4.2 GHz



Sage Laboratories, 3 Huron Dr., Natick, MA 01760. (617) 653-0844. $1500; 60 days.

The FP279 series of 32-way power divider/combiners is exemplified by a 3.4-to-4.2-GHz model that specifies a return loss of 19 dB minimum and insertion loss of 17.5 dB maximum. Output balance is ±0.5 dB. Isolation between outputs is 18 dB minimum. The unit employs a type N input connector and type SMA connectors for all output ports. The Model FP279 measures 8 × 5.5 × 1 in.

Booth No. 1732-1734

Circle No. 336

Synthesized sig gen spans 2 to 18 GHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $26,000; June.

A synthesized microwave signal generator, the Model 8672A, covers the 2-to-18-GHz frequency range in one solid-state package measuring only 5-1/4-in. high. The new unit offers AM/FM and calibrated output. It has a frequency resolution of 1 to 3 kHz over the frequency range. Frequency stability is better than ±5 in 10^{10} parts per day with the internal frequency standard. Spurious signals are more than 70 dB below the carrier at 6 GHz, more than 60 dB down at 18 GHz.

Booth No. 2201-2210

Circle No. 337

Totally TTL-compatible shift registers.

To make sure we're speaking the same language, let's define **total TTL compatibility:**

1. You need only one power supply (+5V).
2. I/O logic and clock levels are directly **TTL** compatible (eliminates −12V supplies).
3. On-chip clock generators—**TTL** input.

New MOS shift registers from Synertek:

Totally TTL-compatible N-channel ion implanted silicon gate static registers.									
Synertek Part No.	2533	2833	2833A	2833B	2833C	2534	2534A	2535	2535A
Description	1K x 1 1.5 MHz	1K x 1 2.0 MHz	1K x 1 3.0 MHz	1K x 1 4.0 MHz	1K x 1 5.0 MHz	512 x 2 1.5 MHz	512 x 2 3.0 MHz	480 x 2 1.5 MHz	480 x 2 3.0 MHz
Directly Replaces	SIG & AM 2533 NAT 5058	AM 2833 TI 3133	AM 2833 TI 3133	FSC 3355	Only from Synertek	SIG 2527	SIG 2527	SIG 2529	SIG 2529
Benefit	50% less power. Eliminates negative power supply.					Double density, lower cost.			

We want you to start looking to Synertek for a whole line of TTL-compatible—**totally compatible**—MOS parts. Looking for 2K dynamic shift registers, for instance? We've got 'em (sorry, but you will need one little resistor). 1K static RAMs? We've got 'em, to 150 ns! 4K and 16K ROMs? 8-bit microprocessors? They're all here and all totally TTL-compatible.

There are a lot of MOS houses. But the guys who are really making the technology **work for you** work here.

Get our new short form catalog from Jack Balletto at Synertek, 3050 Coronado Drive, Santa Clara, CA 95051. (408) 241-4300. TWX: 910-338-0135.

Totally TTL-compatible shift registers.

Synertek

CIRCLE NUMBER 73

a little A-300 goes a long way.

In high frequency transmission. RF power generation for industrial and research processes. RFI/EMI and general laboratory applications, too.

The Model A-300 is a totally solid state power amplifier, covering the frequency range of 0.3 to 35MHz with a gain of 55dB. Capable of delivering 300 watts of linear Class A power and up to 500 watts in the CW and pulse mode, the A-300 is the ultimate in reliability.

Although the unit is perfectly matched to a 50 ohm load, it will deliver its full output power to any load (from an open to a short circuit) without oscillation or damage.

Complete with power supply, RF output meter and rack mount, the A-300 weighs a mere 89 pounds and operates from ordinary single phase power.

High power portability goes a long way for $5350.

For further information or a demonstration, contact ENI, 3000 Winton Road South, Rochester, New York 14623. Call 716-473-6900 or TELEX 97-8283 E N I ROC

ENI

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SEE Electronic Design's **GOLD BOOK** FOR COMPLETE PURCHASING INFORMATION

CIRCLE NUMBER 74

4-way divider/combiner accepts 100 mW/port

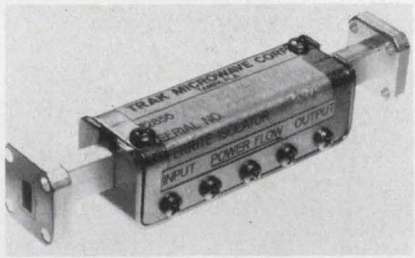
Sage Laboratories, 3 Huron Dr., Natick, MA 01760. (617) 653-0844. $325; 60 days.

A four-way matched power divider/combiner, the FP1372, covers the 3.7-to-4.2-GHz frequency range with an insertion loss of less than 0.3 dB and VSWR of less than 1.2:1. Isolation between outputs is greater than 20 dB. In combiner applications, the input power rating is 100 mW per port.

Booth No. 1732-1734

Circle No. 338

Small WG isolator covers 26 to 40 GHz



Trak Microwave, 4726 Eisenhower Blvd., Tampa, FL 33614. (813) 884-1411. $425; 10 days.

A small, compact 26-to-40-GHz waveguide isolator, the Model 2571-1810, measures only 4-1/8 × 55/64 × 13/16 in. and weighs just 5.5 oz. Isolation is 23 dB minimum with an insertion loss of 1.2 dB maximum. Flanges are UG-599/U.

CIRCLE NO. 339

1-15-GHz detector avoids bias circuitry

Omni Spectra, 21 Continental Blvd., Merrimack, NH 03054. (603) 424-4111. $175 (1-9); 90 days.

The Model 20751 Schottky detector doesn't require the power supply and associated circuitry usually needed to establish a bias level. The zero-bias 20751 detects cw or square wave, pulse or frequency-modulated signals over the range of 1 to 15 GHz. With some performance degradation, the unit can also be used up to 18 GHz. The detector measures 1.35 in. in length.

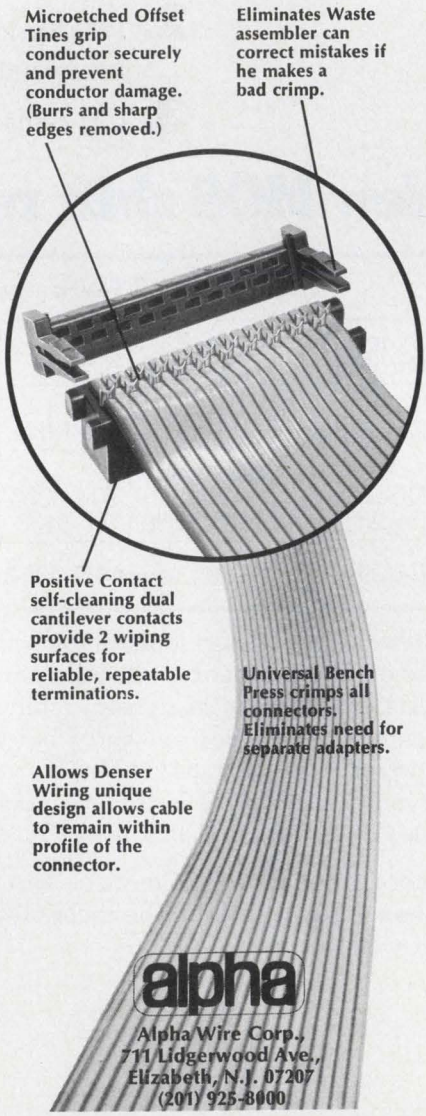
Booth No. 2813 *Circle No. 340*

New ideas from a new source for flat cable and connectors

The source: Alpha Wire, one of the oldest full-line wire and cable manufacturers.

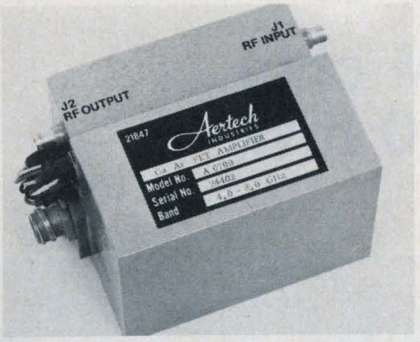
Our cable is compatible (matches all flat cable connectors designed for 0.050 in. conductor spacing). It has excellent teardown characteristics, is ultra-flexible, and UL listed. Exclusive footage indicator on the reel shows how much cable is left.

Our complete line of connectors (female sockets, headers, DIPs and PCBs) also offer some new ideas:



CIRCLE NUMBER 75

4-8 GHz FET amp has 6-dB NF

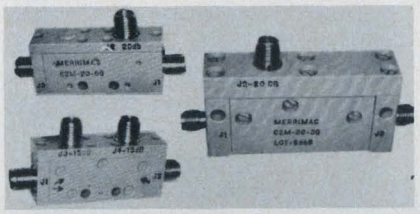


Aertech Industries, 825 Steward Dr., Sunnyvale, CA 94086. (408) 732-0880. Under $4000; 69 to 75 days.

A 4-to-8-GHz GaAs FET thin-film amplifier, the Model A6709, offers 28-dB gain, 6-dB noise figure and +10-dBm power output. A 19-dB-gain version is available in the Model A6713. Both models have either a low dc voltage bias or an optional 115-V-ac power supply.

CIRCLE NO. 341

Low-loss couplers have directivities to 30 dB



Merrimac Industries, 41 Fairfield Pl., West Caldwell, NJ 07006. (201) 228-3890. $120 to $140; 30 days.

A family of stripline directional couplers, the C2M-G and C2-G Series, combines high directivity with low loss. The C2M-G Series includes more than 20 standard models covering bands in the 1-to-18-GHz frequency range, and the C2-G Series includes more than eight standard models covering bands in the 500-MHz-to-12.4-GHz range. Models in both series are available with 6, 10, 20, and 30-dB coupling values. A typical model, the C2M-20-1.5G, has the following specs: frequency range of 1 to 2 GHz, nominal coupling of 20 ±1 dB, frequency deviation of ±0.75 dB, maximum VSWR of 1.20:1, insertion loss of 0.25 dB (over coupling loss), forward power of 50 W and reverse power of 20 W.

CIRCLE NO. 342

Radiation meter covers 0.3-to-18-GHz range

General Microwave, 155 Marine St., Farmingdale, NY 11735. (516) 694-3600. $750.

A precision battery-operated power-density meter—the Model 3—responds uniformly to potentially hazardous nonionizing energy radiating or leaking from rf and microwave sources from any direction over the frequency range of 0.3 to 18.0 GHz. The meter has three 10-dB power ranges with full scale readings of 2, 20, and 200 mW/cm^2; isotropy of ±0.05 dB; calibration accuracy of ±0.5 dB; and a recorder output jack. The sensing probe can be mounted directly on the meter, or through an extension cable that allows remote operation.

CIRCLE NO. 343

The inside story of the amazing new $31 Compact 1.

Take a close look.

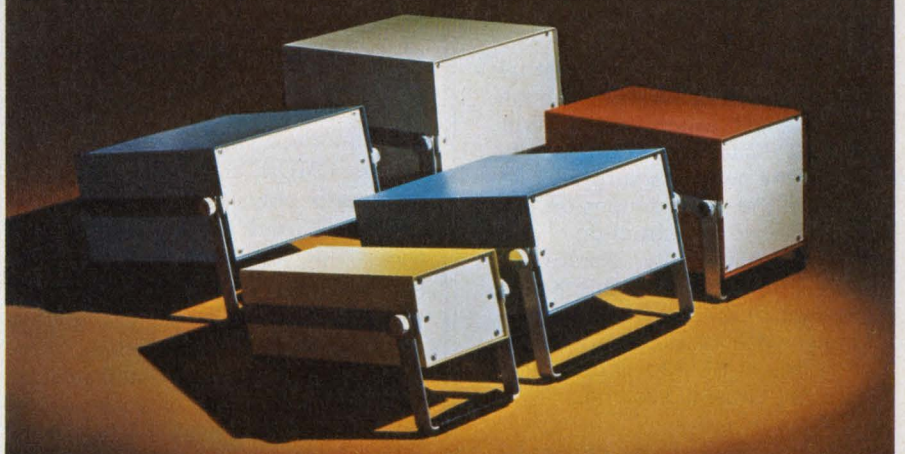
Beneath the handsome exterior of Zero's new VIP Compact 1 you'll find a feature you've never found on a $31* instrument enclosure before. Those rugged steel and aluminum panels are hiding a removable chassis. Which means you can now easily build up your equipment on the free chassis, and then simply re-assemble the enclosure around it.

A result of thorough design, Compact 1 delivers an amazing new level of quality, strength, efficiency and economy. If these are your requirements for a small instrument enclosure, you've found what you've been looking for. We're ready to ship any of the twelve standard sizes to you within two weeks.

Write for your free catalog today.

Zero®
The Final Touch

*From $30.80 to $38.65 in quantities of 50.



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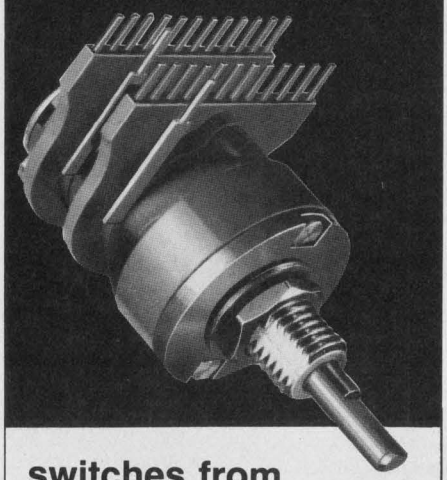
CALL ME, I'M INTERESTED CIRCLE #76

FOR MAIL CATALOG CIRCLE #77

Grayhill brings all PC terminals out one side



switches from logic levels up to ¼ amp

- ½ inch switches with 10 or 12 positions—1 or 2 poles per deck —1 to 12 decks.
- Designed for wave-soldering process—resists flux contamination
- Enclosed construction at price levels as low as or lower than open wafer switches.

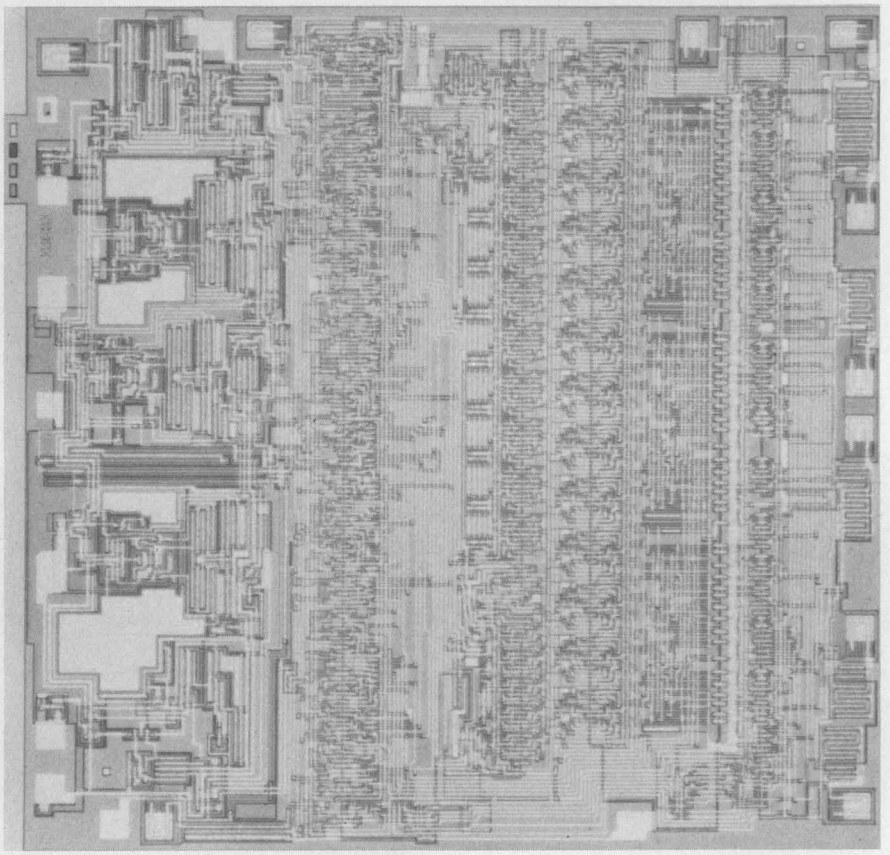
Here's a new Grayhill miniature switch specifically designed for the small loads—and the specialized mounting techniques—of low voltage circuitry. Probably the smallest switch you can find with all PC terminals in the same plane, the switch is surprisingly small in the price dimension too... for enclosed construction and Grayhill quality. For more information on this new member of the Grayhill Series 71 family, write for Bulletin #236... and consult EEM for information on other Grayhill switches.

Grayhill INC.®

561 Hillgrove Avenue • LaGrange, Illinois 60525
(312) 354-1040

CIRCLE NUMBER 78

Three-digit DVM chip requires only 30 mW



Siliconix, 2201 Laurelwood Rd., Santa Clara, CA 95054. (408) 246-8000. P&A: See text.

By combining low-power CMOS technology with proven quantized-charge feedback techniques, Siliconix has produced the LD130—the first monolithic DVM circuit in an 18-pin DIP. Analog as well as digital functions are included on a single CMOS chip that typically dissipates only 30 mW. When the LD130 is used with a display, decoder, power supply, reference source and several external capacitors it forms a complete 3-digit DVM.

The LD130 provides multiplexed BCD outputs that can drive one standard TTL load each. Overrange and underrange signals from the chip can assist in applications that require autoranging. As an additional feature, the display blinks when the input is overrange.

A signal from the chip is also available to operate a polarity indicator in a display. Interdigit blanking has been incorporated on the chip to permit interfacing with gas-discharge type displays. Four npn transistors drive the three digits and sign, and a BCD-to-seven-segment or other type of decoder must be used to decode the BCD for display driving.

Four internally compensated CMOS op amps and a comparator are included in the LD130. The signal-conditioning part of the LD-130 has a 1000-MΩ input impedance and typically a 4-pA input-bias current. The input range is ±999 mV full scale and the unit is designed to operate from ±5-V power supplies.

The on-chip clock requires only one timing capacitor of about 2.5

nF to establish a sampling rate of 10 samples per second. Two other capacitors of about 0.1 μF are required for integrating the measured voltage and storing error voltages. All three capacitors may be inexpensive disc ceramics.

The LD130 uses a single, positive 2-V ground-based reference, that could be generated by a current-limiting diode and a cermet potentiometer—or merely by the wiper of a potentiometer across a zener diode, since the input impedance at the reference terminal is 1000 MΩ.

The DVM chip performs an auto-zero function prior to each measurement cycle. The BCD reading from the previous measurement cycle is transferred into latches for the output multiplexer at the start of each auto-zero cycle. The algorithm automatically deals with inputs of either polarity.

Price of the LD130 is $12.50 in single units, and drops to $8 in 1000-unit lots. Delivery is from stock.

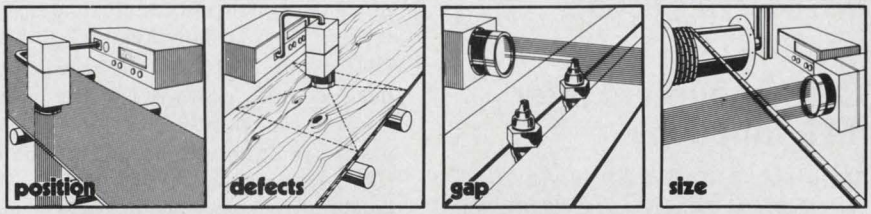
CIRCLE NO. 301

V/f/v converter works through 5 decades

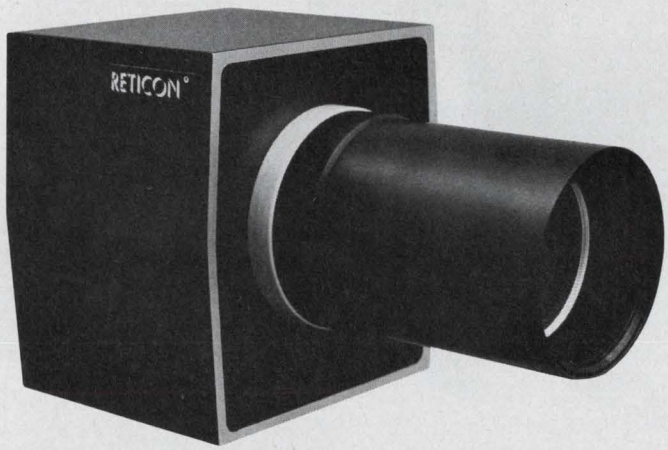
Intech, 1220 Coleman Ave., Santa Clara, CA 95050. (408) 244-0500. $15 to $20; stock.

A monolithic voltage-to-frequency-to-voltage converter, the Model A-8400, provides a simple, virtually adjustment-free component for data encoding and decoding applications. Packaged in a special 14-pin DIP, the IC uses an improved charge-balancing technique that combines high linearity over five decades along with inherent monotonicity. As a v/f converter, the A-8400 has an input voltage (current) range of 0 to 10 V (0 to 1 mA). The proportional full-scale frequency output through the 100-kHz band is established with an external resistor and capacitor. In the f/v mode, the time constant of the output integrator can be externally varied. Conversion linearity is within ±0.05% at 100-kHz full-scale and ±0.01% at 10 kHz. Temperature stability is typically ±50 ppm/°C and power-supply range is ±12 to ±17 V.

CIRCLE NO. 344



SOLID STATE IMAGE SENSING.



UNDER $700.

RETICON cameras can be found doing complex non-contact measurement and inspection jobs in practically every industry. They are used to measure hot-rolled steel, inspect glass bottles, size bolts and rivets, check packaged goods, monitor print quality and a lot more.

Our new LC64P camera makes this advanced technology now cost-effective in such simple applications as edge and width monitoring of sheets and mass produced parts.

This camera provides you with a variable-threshold, computer-compatible digital output as well as analog video with 200:1 dynamic range. It is housed in a rugged 3.5" x 3.75" x 3.5" sealed aluminum casting for reliable operation in extreme industrial environments. It requires less than 2 watts from a ±15V power supply and includes a choice of 5 different lenses. The camera is compatible with RETICON's RS600 series processors which provide automatic categorizing of parts, high/low limits, analog outputs for feedback in process control and direct measurement readout.

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Sunnyvale, California 94086
(408) 738-4266 • TWX: 910-339-9343

CIRCLE NUMBER 79

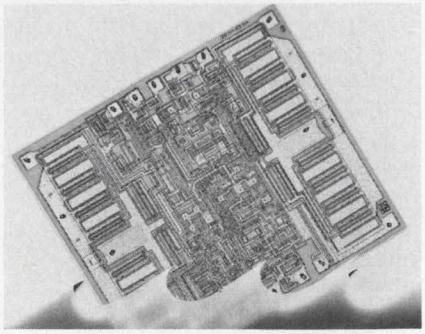
CMOS counters offer TTL functions

Motorola, 3501 Ed Bluestein Blvd., Austin, TX 78721. (512) 928-2600. $1.35 to $2.03 (100-999); stock.

Four CMOS circuits are synchronous programmable four-bit counters. The MC14160B and 162B are decade counters, offering asynchronous or synchronous clear, respectively. The other two, the MC-1416B and 163B, are four-bit hexadecimal units with the same respective options. The CMOS parts are functionally equivalent to the 74160 through 163 TTL counters and feature internal look-ahead and carry output. The counters operate from 3-to-18-V supplies and can drive a low-power Schottky-TTL load.

CIRCLE NO. 345

Sonar system comes on a chip

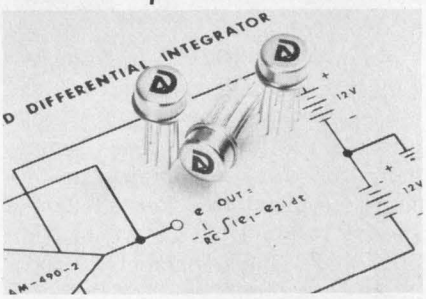


National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $12 (100); stock.

A single IC, known as the LM-1812 transceiver, contains all the elements needed in a sonar system. The new circuit consists of a 12-W ultrasonic transmitter and a selective receiver that includes a 10-W display driver. Further the package requires no heat sink. Operating from a 12-V battery, the LM1812 transmits pulses of about 200 kHz for about 800 μs through an external transducer. Between pulses, the receiver listens for an echo and drives a display with the resulting signal.

CIRCLE NO. 346

Chopper-stabilized amp has 0.1 μV/°C drift



Datel Systems, 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. $39 to $49 (1-9); stock.

Monolithic chopper-stabilized amplifiers offer inverting, noninverting and differential modes of operation. The Model AM-490-2 series has input offset errors as low as 0.1 μV/°C and 1 pA/°C and comes in a hermetically sealed, 8-pin TO-99 package. Dc common-mode rejection is 160 dB, and supplies can range from ±12 to ±20 V dc. Maximum quiescent current is 5 mA. Warmup time to rated accuracy is only 200 ms.

CIRCLE NO. 347

You select the spec, and we'll deliver the amplifier

THOUSANDS OF OPTION COMBINATIONS IN ACCURACY . . . GAIN . . . AND BANDWIDTH IN NEWPORT'S WIDEBAND DC DIFFERENTIAL AMPLIFIERS - FROM $160

Newport amplifiers and transducer conditioners are valuable for any application where extremely precise low noise wideband signals exist. They are ideal for thermocouples, load cells, DC excited strain gages and other low level sources. Outputs are useful for DAS, recording galvanometers, oscillographs, recorders and digital voltmeters. Newport's companion 80A transducer conditioner features tri-current excitation which eliminates lead wire effects from single active arm measurements.

Characteristics	Model 50A	Model 55A	Model 60A	Model 70A
300V CMR		X		X
10V CMR	X		X	
Gains from 1 to 3300	X	X		
Gains from .01 to 5000			X	X
133 dB rejection at 60 Hz cm	X	X	X	X
0.4 μ V/°C input drift	X	X	X	X
50 megohm input impedance	X	X	X	X
0.005% non-linearity	X	X	X	X
4 pole (24 dB/octave) fixed active filter	X	X		
6 pole (36 dB/octave) switchable active filter			X	X
Continuous plus commutated output	X	X		
Dual continuous plus commutated output			X	X

Newport Laboratories, Inc.
630 E. Young St.
Santa Ana, CA 92705
Call Collect: (714) 540-4686
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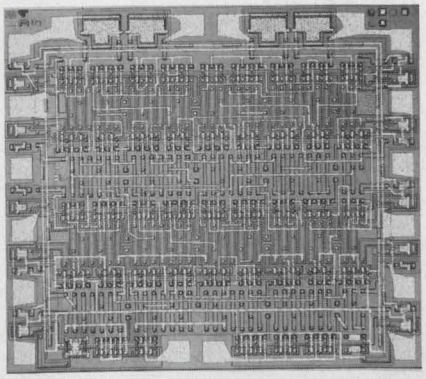
NEWPORT

"See us at Electro '76 Booth #2211"

CIRCLE NUMBER 80

Speed custom designs with CMOS masterslice

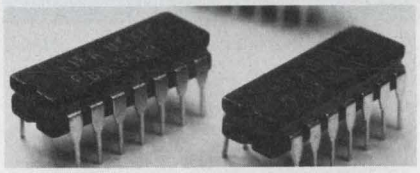


International Microcircuits, Inc., 3000 Lawrence Expressway, Santa Clara, CA 95051. (408) 735-9370.

The latest entry in a family of masterslice custom CMOS chips—the MasterMOS-S—contains the following: 106 complementary pairs of MOS transistors, along with 10 output-buffer circuits, four high-current n-channel drivers, and 18 interface pads ready to be interconnected for each custom application. Like other members of the family, the MasterMOS-S chip can cut costs and reduce development time for custom circuits of moderate complexity. Typical development charges for a custom CMOS circuit using MasterMOS-S are less than $3000, and typical production prices range from $3.50 to $2.40, depending on quantity.

CIRCLE NO. 348

ICs interface logic with inductive loads



Rifa, Fack S-161 11 Bromma, Sweden. $1.35 to $1.80 (100).

Bipolar driver circuits allow interfacing between 5-V logic and inductive loads. The PBD 3513, a dual driver in a 14-pin ceramic package, has TTL-compatible inputs and can also be fed from relay contacts in 12-V systems. The circuit is designed for 5-to-12-V supplies and can sink 300 mA. The PBD 3520, in a metal TO-99 package, can handle voltages down to −56 V. The TTL-compatible circuit sinks 150 mA with a logic ZERO input.

CIRCLE NO. 349

Disc has made it easy for the OEM using optical encoders in small quantities to realize costs in the same low range as the big users—like under $100.00.

We've maintained the same high order of resolution, accuracy, and reliability found in our more expensive units for this new EC series. "EC," obviously, is our economy model, but it could also stand for exceptional capabilities. Here's what you get for your $99 (much less in quantity):

- LED source
- 20 to 1024 pulses / revolution
- Differential electronics
- Square wave output
- ± 2.5 minutes accuracy
- Solar cell light sensors
- Instrument bearings
- ¼" shaft for interfacing

Translated into benefits, these features mean the Disc EC ROTASWITCH® Encoder gives you superior performance, a long service life, and a unit cost you just can't touch.

That's the model EC 81. It has a single channel output. If you need dual channel, we also offer the EC 82 at $125.00 in single quantities. It too plummets to well under $100.00 in quantity.

A new spec sheet is just off the press—write or call for your copy. Immediate questions can be answered by calling 714/979-5300.

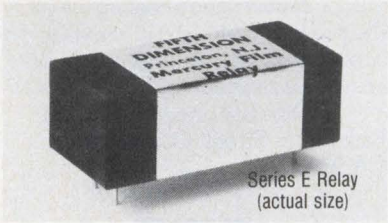
Disc Instruments, Inc., 102 East Baker Street, Costa Mesa, CA 92626.

DISC

THE PRICE OF OPTICAL ENCODERS JUST PLUMMETED.

CIRCLE NUMBER 81

1
Relay Miss every 2-Billion Cycles

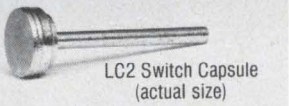


Series E Relay
(actual size)

We tested 129 of our new Series E Relays at loads from dry circuits to 3 Amps. After 35-billion operations, only 10 single-cycle misses were monitored.

Series E Relays offer:

- Indefinite life
- No contact bounce
- Operation in all positions
- Contacts stable to ±0.015 ohms over life
- Reliability at dry circuit or power loads
- Self-healing contacts
- Hermetically sealed contacts
- 1250V rms contact breakdown
- Low cost


LC2 Switch Capsule
(actual size)

Series E Relay uses a rugged LC2 welded capsule rather than a fragile glass reed switch. This patented design holds a film of mercury securely to the metal walls of the capsule. With every operation, the mercury film renews the switch contacts. You get the reliability of mercury relays, but with complete freedom of mounting orientation. LC2 welded capsule reliability is proven by hundreds-of-thousands of units in the field, as well as billions of cycles under stringent laboratory conditions.

Send for a FREE SAMPLE of the LC2 welded capsule on your letterhead. Circle the reader service card number for Series E Relay information.

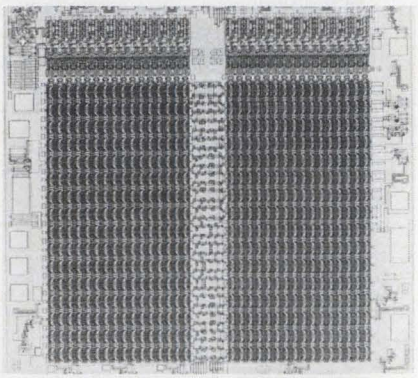
5-D

Fifth Dimension, Inc.
P.O. Box 483
Princeton, N.J. 08540
Tel: (609) 452-1200

CIRCLE NUMBER 82

INTEGRATED CIRCUITS

1-k MOS RAMs can replace bipolar types



Intel, 3065 Bowers Ave., Santa Clara, CA 95050. (408) 246-7501. $12.70 to $18.30 (100-999).

The first MOS equivalents of 1024-bit bipolar RAMs are low-voltage, silicon-gate, n-channel units—the 2115 and 2125 family. The new static RAMs can operate as fast as their bipolar counterparts, at the same supply level of 5 V and same logic levels. However, the new memories reduce power dissipation by 35% or more. The 2115 and 2125 are pin-for-pin replacements of the 93415 and 93425 1024-bit bipolar RAMs, introduced by Fairchild and currently the most widely used bipolar RAMs. All are fully decoded, 16-pin designs. The 2115 and 93415 have an open-collector output, and the 2125 and 93425 have a three-state output. Two speed grades and a low-power version are available. The 2115-2 and 2125-2 have a maximum access time of 70 ns, the same as standard bipolar versions. The 2115 and 2125 have a maximum access of 95 ns. The 2115L and 2125L versions feature maximum current of 65 mA with an access time of 95 ns.

CIRCLE NO. 350

16-k ROM has 450-ns access

General Instrument, Microelectronics Group, 600 W. John St., Hicksville, NY 11802. (516) 733-3306. $19.50 (1000); 8 wks.

A 16-k bit static ROM—a RO-3-8316B—operates from a single 5-V supply and features an access time of only 450 ns. The fully static device offers TTL compatibility and a 2-k × 8-bit organization.

CIRCLE NO. 351

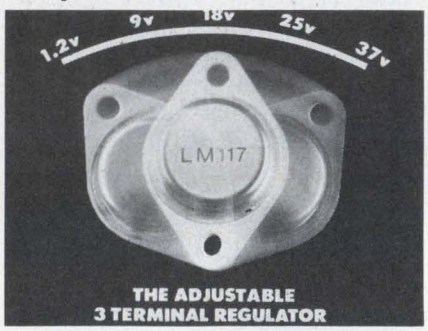
ICs select TV channels

Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. $3.50 (100).

Two sensing ICs for TV-channel selection can be driven directly from two-terminal touch plates, eliminating the need for conventional pushbuttons. The ML231B and ML232B both offer six-channel selection, direct neon drive, low-impedance drive to the tuning Varicap, and they operate from a 33-V Varicap supply. The ML231B has an additional output that goes high with no channel selected, while the ML232B has an additional input for channel-by-channel step advance. Both circuits require a maximum input current of just 1 mA, a maximum supply current of 5.5 mA, and operate over the 0-to-65-C temperature range.

CIRCLE NO. 352

3-terminal regulator outputs 1.5 A at 37 V

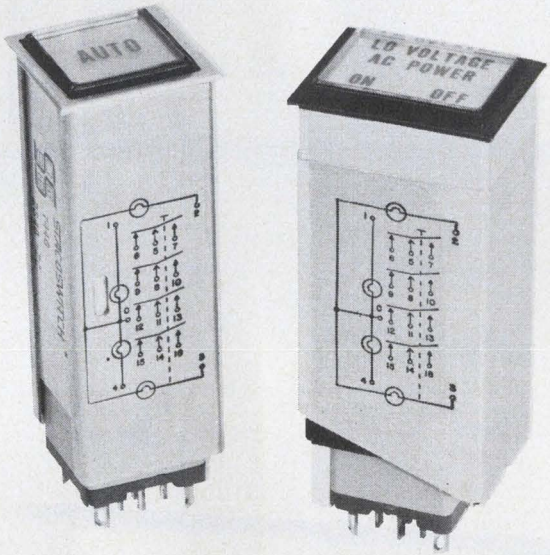


National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $3.00 to $11.00 (100).

An adjustable three-terminal IC regulator, the LM117, provides over 1.5 A of output current at any output voltage from 1.2 V to over 37 V. Packaged in standard transistor power packages, the LM117 has a line regulation of typically only 0.01%/V and load regulation of 0.1% for a 1.5-A change. Ripple rejection of 80 dB can be obtained at any output voltage. Also, full overload protection is included on the chip. Output current is limited to about 2.3 A. Thermal overload protection limits power dissipation should die temperature exceed 170 C.

CIRCLE NO. 353

New Low Price



Dependable, proven, Series 2S/2R 4-lamp illuminated pushbutton switches and indicators. The price? $8.95 for 2PDT and $9.90 for 4PDT in 1-9 quantities. In larger quantities the price is even lower. Price includes switch and pushbutton with choice of 84 standard display options. At this price you just can't get a better deal on a dependable 4-lamp switch.

Premium grade materials used throughout. Original military design built to industrial/commercial requirements. This rugged switch is inexpensive, but it certainly is not cheap. It will give you long trouble-free service life... 50,000 plus cycle life.

The Series 2S/2R offers wide flexibility with switching capability from 10 micro-amps to 5 amps. Choice of momentary or alternate switch action. Matching 4-lamp indicator at equally low price. Designed for easy installation with relamping from front of panel without use of tools. Write today for General Catalog giving complete description and specifications. When you think switch... think Stacoswitch.

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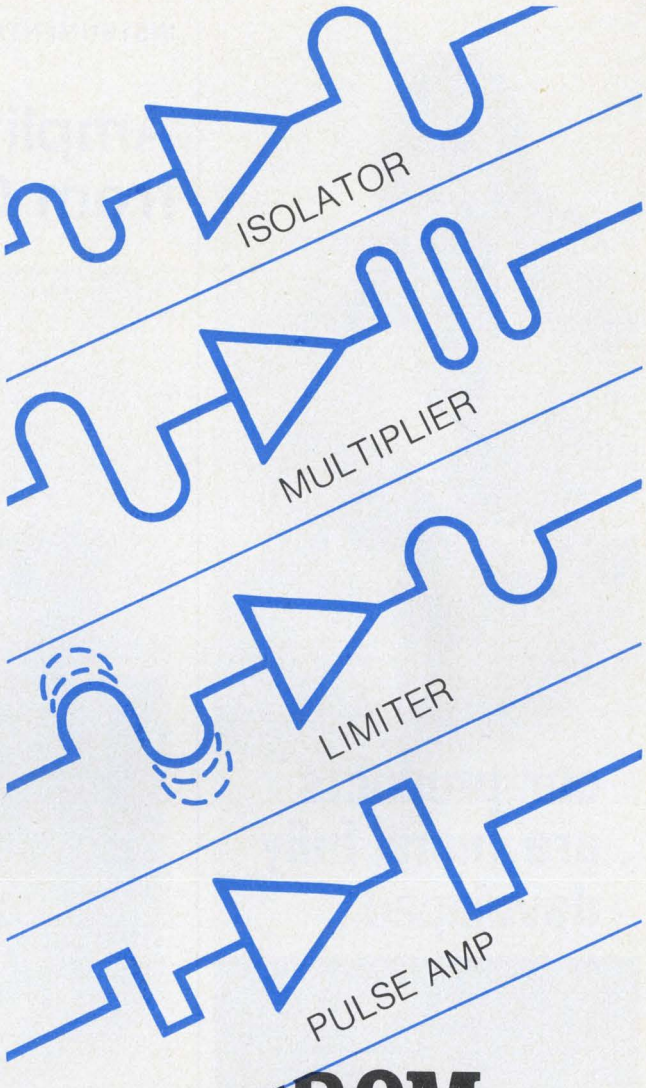
Other STACO Company products: Custom Transformers, STACO, INCORPORATED, Richmond, Indiana; Variable Transformers, STACO, INCORPORATED, Dayton, Ohio.

CIRCLE NUMBER 83



FROM A SINGLE LOW COST* AMPLIFIER

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GPD-401	5-400	13	±1.0	4.5	2.0	15	10
GPD-402	5-400	13	±1.0	6.0	2.0	15	24
GPD-403	5-400	9	±1.0	7.5	2.0	24	65

Weight, 1.0 Gram

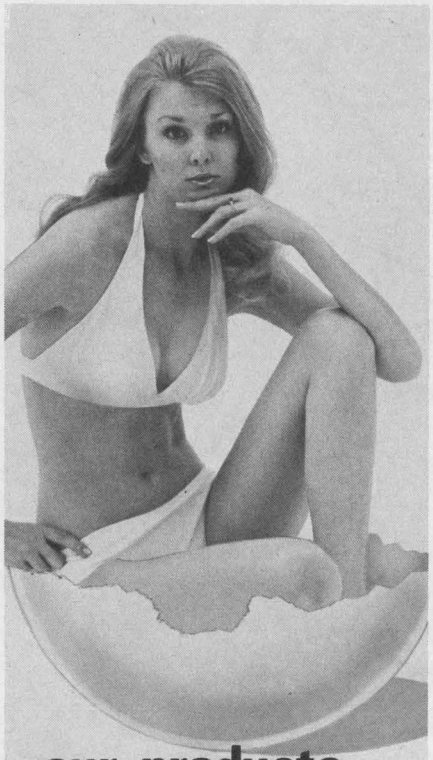
*** PRICED AS LOW AS $18**
DELIVERY FROM STOCK

Avantek

write or call for applications literature and data sheets
3175 Bowers Avenue, Santa Clara CA 95051 (408) 249-0700

*In quantities of 50-99 or as low as $27 in quantities of 1-9.

CIRCLE NUMBER 84



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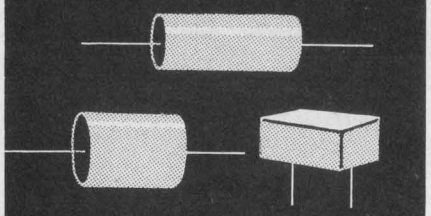

Write or phone for catalog and details.

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CIRCLE NUMBER 85

Amplifiers deliver flat output from 0.15 to 300 MHz

Electronic Navigation Industries, 3000 Winton Rd. S, Rochester, NY 14623. (716) 473-6900. See text.

One amplifier that takes the place of several: That's the benefit you get with ENI's new family of wideband Class A power amplifiers, the 400A series.

The series' flat gain characteristic of ±1.5 dB, or better, over the wide bandwidth of 150 kHz to 300 MHz—coupled with a choice of three power levels (3, 10 and 40 W)—encompasses an extensive range of applications. Thus you can avoid annoying bandswitching over several units, and you can probably save money as well.

Four models comprise the series at present, two with 3-W outputs (403LA, 400AP), one with 10 W (411LA), and the last with 40 W (440LA). Two or four units of any model can be combined to provide even higher power without affecting the other specs.

What do you trade off to get the wide band and other features? Not much. The ENI amplifier series delivers linear power to any load from an open to a short, and it's unconditionally stable. No matter what the mismatch, the 400A won't oscillate or burn out.

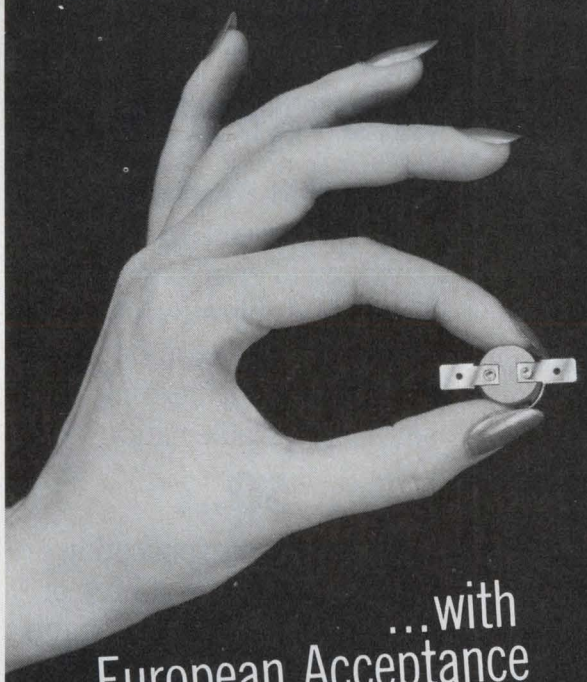
Harmonic distortion of all models is better than 25 dB down (at outputs slightly below rated power—check the spec sheets), and even better at reduced power. Noise figure is 9 or 10 dB, depending on the model.

Nominal gain of the 3-W models is 37 dB; those of the 10 and 40-W units are 40 and 45 dB, respectively. Input/output impedance of all models is 50 Ω; input VSWR is 1.4 or 1.6 max, depending on the model; output VSWR stays below 2.3.

Prices of the 403LA, 411LA and 440LA are $795, $1725 and $3990, respectively. The 400AP costs $575. Delivery time is 30 days.

CIRCLE NO. 302

New Hi-Temp Thermostat



...with European Acceptance

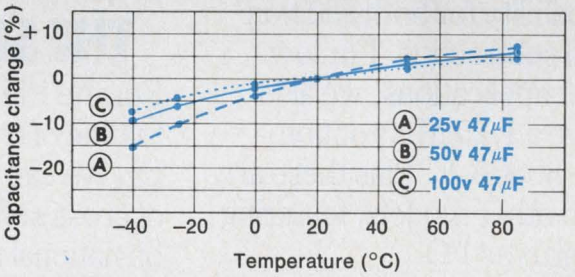
Ideal for a variety of high temperature applications! Elmwood's new snap-action RC thermostats include a glass-bonded mica (ceramo-plastic) base that allows set points to 550°F (290°C). The patented metal sleeve insert and rivet construction permit listings by European agencies as well as U.L. and C.S.A. The RC's are SPST, pre-set, tamperproof, and available with mountings, terminals and brackets to suit. Want more? Call or write Elmwood Sensors, Inc., 1659 Elmwood Ave., Cranston, R. I. 02907. Phone 401/781-6500. European Div., Elmwood Sensors Ltd., North Shields, England.

ELMWOOD SENSORS

CIRCLE NUMBER 145

Check the operating temperature range. Make sure it's from —40°C to +85°C. Check the capacitance and tolerance. I ask you, how many **axial and radial miniature aluminum electrolytic capacitors** can a person inspect? Check the leakage current and the dissipation factor. Double check the low temperature characteristics. Study the life test results. Check and eliminate any units not living up to Nichicon shelf life test requirements. Sometimes I ask myself, "Hawkeye, is it worth it?" But after all, it's my work that assures reliability and that's what helps to **keep your world turned on.** So grab a sheet of your letterhead and write for your free catalog today.

NLA SERIES—CAPACITANCE CHANGE vs. TEMPERATURE



Production items include: electrolytic capacitors • ceramic capacitors • computer grade electrolytics • film capacitors • oil filled capacitors—without P.C.B.'s • metallized paper capacitors • wax paper capacitors • mica capacitors

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CIRCLE NUMBER 146

ALL 8080As DON'T COME FROM THE SAME PLACE.

Meet the μPD8080A. From NEC Microcomputers, Inc. The microprocessor that's both fully software and pin compatible with Intel's new 8080A. And it's backed by all the chips, support systems, software, and service you need to make it into a complete microcomputer system — the μCOM-8.

THE CHIPS.

We start with not one, but four 8080-type microprocessors.

At the top of the line is the μPD8080A. It gives you everything their 8080A does, plus extras like full BCD capability for both addition and subtraction. For low-cost applications, we also have a 1.25 MHz option — the 8080A-E. Plus there are two other models, featuring improved I/O.

In addition, we can give you the best in RAMs, ROMs, and PROMs, including the only Electrically Alterable PROM with the speed to match the processor.

THE SUPPORT SYSTEMS.

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AND THE SERVICE.

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SO...

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NEC microcomputers, inc.

INSTRUMENTATION

DMM promises rock-steady performance

Dana Laboratories, 2401 Campus Dr., Irvine, CA 92713. (714) 833-1234. $549; 30 days.

Model 4600 4-1/2-digit DMM is said to provide accuracies equal to that of many 5-1/2-digit DVMs. It combines this accuracy with full autoranging over each of its five functions and high six-month stability. Other specs include NMR of 80 dB, 10,000-MΩ input impedance, and optional BCD output or battery-powered operation. The five functions are: ac and dc volts (10 μV to 1000 V), ohms (10 mΩ to 20,000 kΩ), dc and ac current (10 nA to 2 A). The dc accuracy of the 4600 is within 0.01% rdg ±1 digit for six months and is maintained over 20 to 30 C and up to 80% relative humidity.

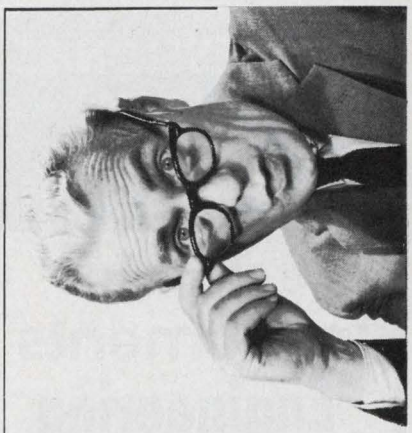
Booth No. 2710 Circle No. 354

IC tester programs with magnetic cards

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. 16 pins, $9000; 24 pins, $11,000.

Just insert a preprogrammed magnetic card into the slot of the 5045A IC tester, and the unit will do the rest. Dc parametric and functional tests are performed on a wide variety of logic families and functions up to 16 pins (24 pins optional). Diagnostic tests are run, and a thermal printout tells the user the type of failure, pins failed, voltage/current analysis of failed pins and other data. Test patterns can be generated by algorithmic techniques or by storing a truth table in memory.

Booth No. 2201-10 Circle No. 355



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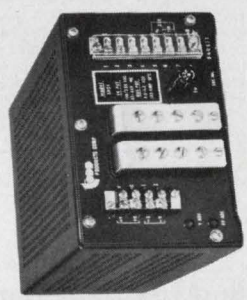
123 Milbar Blvd., Farmingdale, N.Y. 11735. (516) 293-3440.



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CIRCLE NUMBER 88

OEM recorder module meets UL544 specs

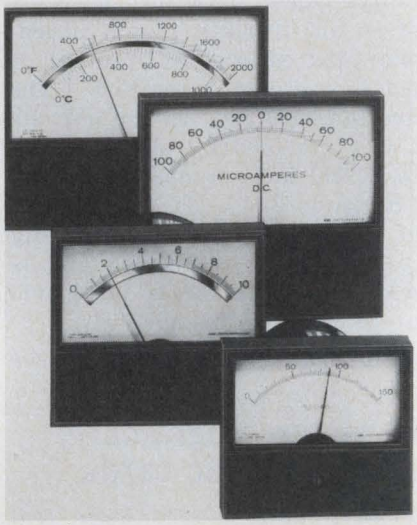
MFE Corp., Keewaydin Dr., Salem, NH 03079. (603) 893-1921. $430; stock.

M2-AHAUL single-channel recorder is recognized under the component program of Underwriters Lab. Inc. (UL544). The OEM recorder module is a completely self-contained, lightweight instrument. The inkless, heated-stylus method of recording provides a clear, high-resolution trace that will not smudge or fade.

Booth No. 2420-2422

Circle No. 358

Indicators come in host of sizes and ranges

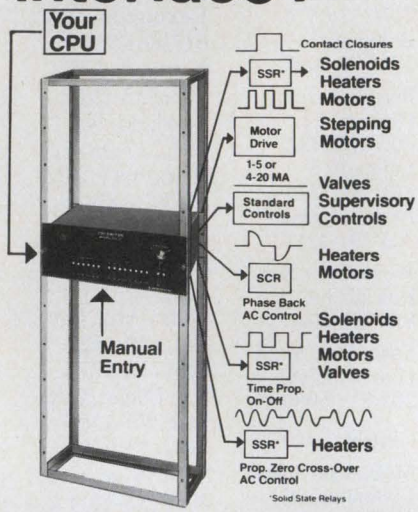


LFE Process Control Div., 1601 Trapelo Rd., Waltham, MA 02154. (617) 890-2000. From $22.50.

Serie 7000 analog panel instruments offer distinctive style and functional flexibility in four sizes: 2-1/2, 3-1/2, 4-1/2, and 5-1/2 in. The three-way choice of mounting (front, bezel and lens), the front-panel decorator plates, and the slide-out scales allow a maximum selection from inventory. Taut-band mechanisms and 1% tracking are standard in many ranges. Series 7000 is available in ac and dc current and voltage ranges, as well as thermocouple temperature indicators and VU meters.

Booth No. 2502, 04 Circle No. 359

Here's all you need for computer/ process interface!



UNI-DRIVER, the one *stand-alone* interface between your computer and *all* commonly used final control elements. It maintains process control at the last command level, even with the computer shut down, and provides "back up" manual control.

Mix or match any combination of control cards to drive contactors, heaters, motors, pumps, power controllers, valves, set points, motor speeds, solenoids, shutters, louvers, fans, lamps, stepping motors, you call the shots. Up to 64 proportional outputs or 512 on-off outputs per Uni-Driver.

Eliminate a rack full of "black boxes!" Call collect (612) 941-3300 and ask for UNI-DRIVER! Also, ask about ANA-PLEXER. That's our combination Mux & A/D converter for sampling process control signals of almost any analog transducer or sensor. Directly interfaces with your CPU without external I/O.

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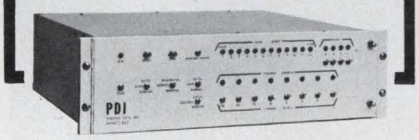
PHONE (612) 941-3300

CIRCLE NUMBER 89

NEW APPROACH TO LOW LEVEL DATA ACQUISITION



Phoenix Data's new 8000 Series

Phoenix Data's floating point 8000 Series data acquisition system features adaptability to virtually any analog input signal currently in use—offering automatic or programmed gain selection with 11 binary ranges from ±10 millivolts to ±10.24 volts full scale. The data word (12 binary bits) is combined with the range data (4 binary bits) for a 16 bit output word in the automatic ranging mode. The system will resolve input changes of 5 microvolts on the ±10 millivolt range for an overall analog dynamic range of 132 db.

FEATURES:

- ADC resolution of 12 binary bits.
- 11 binary gain ranges.
- ±10 mv to ±10.24V input ranges.
- Solid state MOSFET multiplexing.
- Thruput rates from 1 to 20 KHz.
- Auto or programmable gains.
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- System accuracy of .05% of reading.
- System T.C.: 0.001%FSR±1μ volt RTI/°C.

If it's stability, accuracy, speed, or all-around quality you need in Data Conversion, contact Ron Brunnemer, director of marketing, or the representative in your area.

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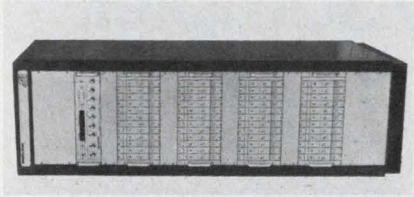
CIRCLE NUMBER 90

Freq synthesizer expands to 48 channels

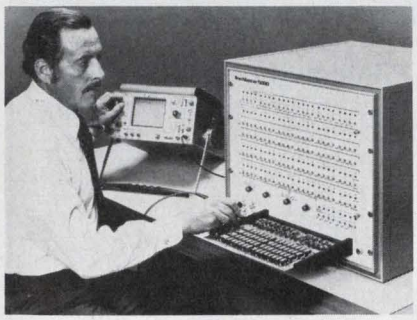


Rockland Systems, 230 W. Nyack Rd., West Nyack, NY 10994. (914) 623-6666. $27,500 (12 channels); 120 days.

System 51 provides up to 48 channels of spectrally pure and highly stable frequencies from dc to 3 MHz with 1-Hz resolution throughout the range. High speed programming (5 μs) is accomplished while maintaining amplitude and phase continuity. The system is self-contained in its own forced-air-cooled rack and consists of the Model 5196 controller, Model 5112 mainframe, and Model 5101 synthesizer channels. Outputs include: 1) sine wave, 1-V rms, 50-Ω source impedance; 2) square wave, TTL level, 30-TTL load capability; 3) square wave, TTL level, complementary, 30-TTL load capability.

Booth No. 2520 *Circle No. 360*

Memory tester cycles in 100 ns

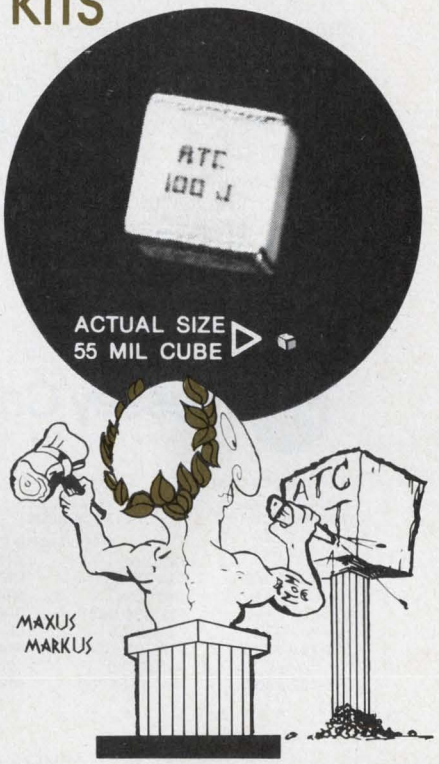


Technology Marketing, 3170 Red Hill Ave., Costa Mesa, CA 92626. (714) 979-1100. Start at $17,000; 12 wks.

Series 5000 semiconductor memory and LSI tester is said to be the first to offer 100-ns cycle time for all test patterns. The tester features specialized processors with either a ROM or an optional RAM for program storage. The RAM option provides maximum flexibility to alter test programs. Seven configurations offer a variety of choices.

Booth No. 1326 *Circle No. 361*

LASER MARKED UHF/MICROWAVE CHIP CAPACITOR KITS



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BUY ANY DESIGN VALUE KIT OF 100 ATC 100 LOW LOSS PORCELAIN CHIP CAPACITORS FOR $77.00.

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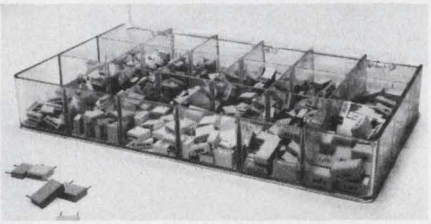

Call the Plessey Distributor nearest you, or contact Plessey Capacitors directly. For only $15.00, you'll receive our Series 160 Minibox Capacitor Sampler containing over 300 pieces to assist with your design requirements.

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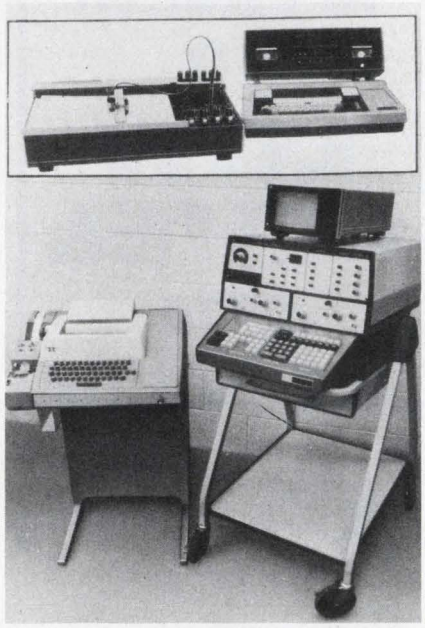
CIRCLE NUMBER 93

Six options expand scope of digital scope



Norland Instruments, Norland Dr., Fort Atkinson, WI 53538. (414) 563-8456.

Six new options for use with the NI 2001 programmable calculating oscilloscope extend the application and interfacing of the unit in digital data acquisition and reduction. Included are a serial asynchronous digital I/O, a file option, an X-Y plotter option, a computer link option, an 8-bit parallel digital I/O and a 12-bit DAC output.

Booth No. 2608-2610

Circle No. 362

Instruments keep eye on process functions

Doric Scientific, 3883 Ruffin Rd., San Diego, CA 92123. (714) 565-4415. Start at $299; 60 days.

Series 400A digital trendicators are for monitoring process functions—such as temperature, pressure, and voltage—from thermocouples, RTDs, current transmitters and other low-voltage transducers. They are available with resolutions of ±0.01 degree for temperature, to ±0.01% for current, and to ±1 μV for voltage readings, in nine thermocouple ranges, two platinum RTD ranges, two current transmitter ranges and four voltage ranges.

Booth No. 2601-2603

Circle No. 363

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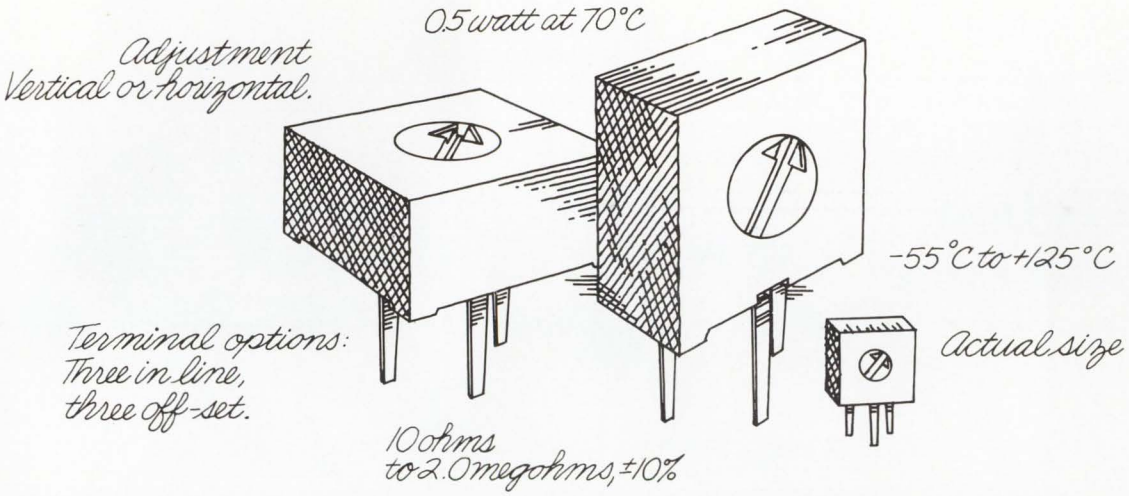
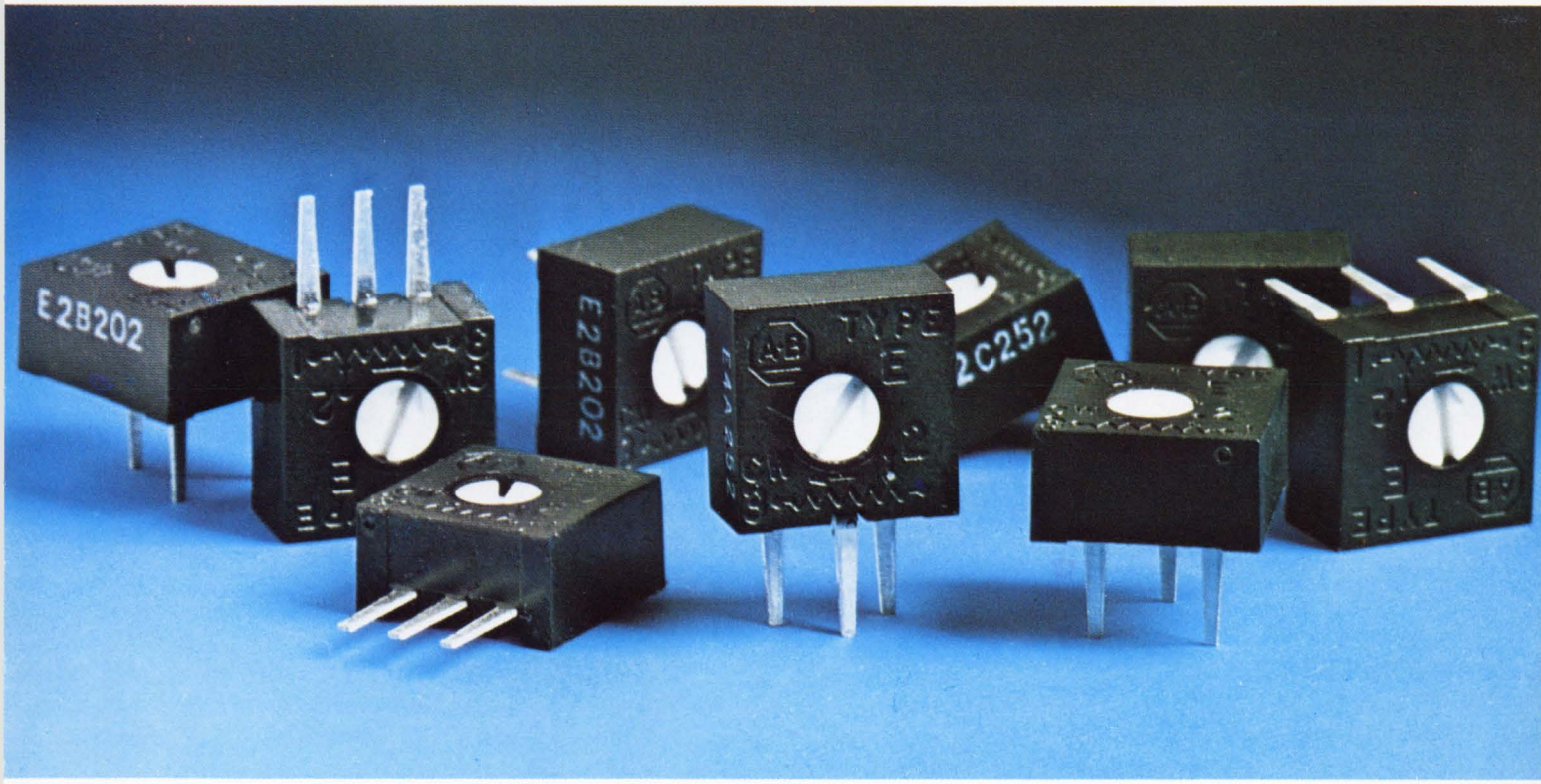
Our new TYPE E trimmer is a high performer with a realistic price. It has some important advantages: • Immersion seal is tested in 85°C water (not 50° or 70°). • Temperature characteristic is 100 PPM/°C for stability. • Multifingered contact for excellent adjustability. • $0.49 each—1000 piece price. For more information call your A-B distributor or write for Publication 5219.





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EC108

CIRCLE NUMBER 141

New from Centralab...

CERBON™ TRIMMER RESISTORS

Affordable Stability... 300% More Stable Than Carbon... at a Carbon Trimmer Price!

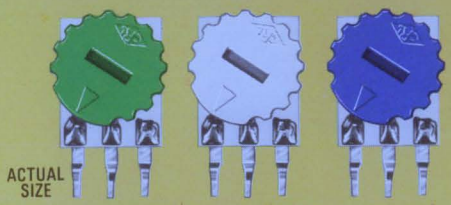
Why pay more? With Centralab's new *CERBON* trimmers you get stability approaching cermet and at carbon prices ...As little as 28¢ in distributor 1,000 quantities; as low as 10¢ in high volume orders.

The secret of *CERBON* superior performance? A totally new thick film resistor element, which combines both potentiometer and conventional thick film technologies, *plus* a heat stable ceramic substrate, *plus* a dual-tine contact spring, *plus* "Fluxgard" protection from dust and wave soldering contaminants. In short, a totally balanced electromechanical system.

Look at these benefits:
• TCR less than −400 ppm/°C. • CRV less than 2% of maximum resistance. • Rotational life exceeds 500 cycles. • Adjustability (typical)—0.05% of total voltage. • High overload capability—1 watt at 25°C ambient for 1,000 hours exhibits less than 2% cumulative resistance change. • Maximum stability in humid environment—Resistors exposed to an atmosphere of 40°C at 95% relative humidity for 300 hours return within four hours to +2.5% of their initial readings.

CERBON trimmers are offered in a resistance range of 1 K ohm to 1 megohm with a choice of standard PC terminal configurations. They fit universally accepted circuit board mounting patterns. And they're ready now for fast delivery in any quantity.

Write for complete technical data on Centralab's new *CERBON* trimmer resistors. Or call (915) 799-3961 for a free evaluation sample. Move up to *CERBON* and save!



Knob colors available in white, blue, red and green for ease in assembly operations.

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Electronics Division
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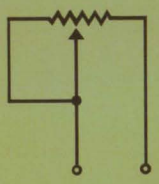
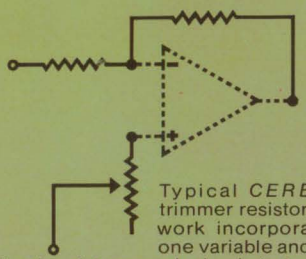
AVAILABLE CIRCUIT OPTIONS

Thanks to their ceramic substrate, Centralab *CERBON* trimmers permit a variety of screen printed circuit options. Here are three typical circuits:



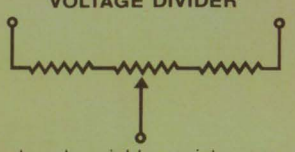
TERMINAL SHORTING
One of five electrical termination options available.

OPERATIONAL AMPLIFIER NETWORK



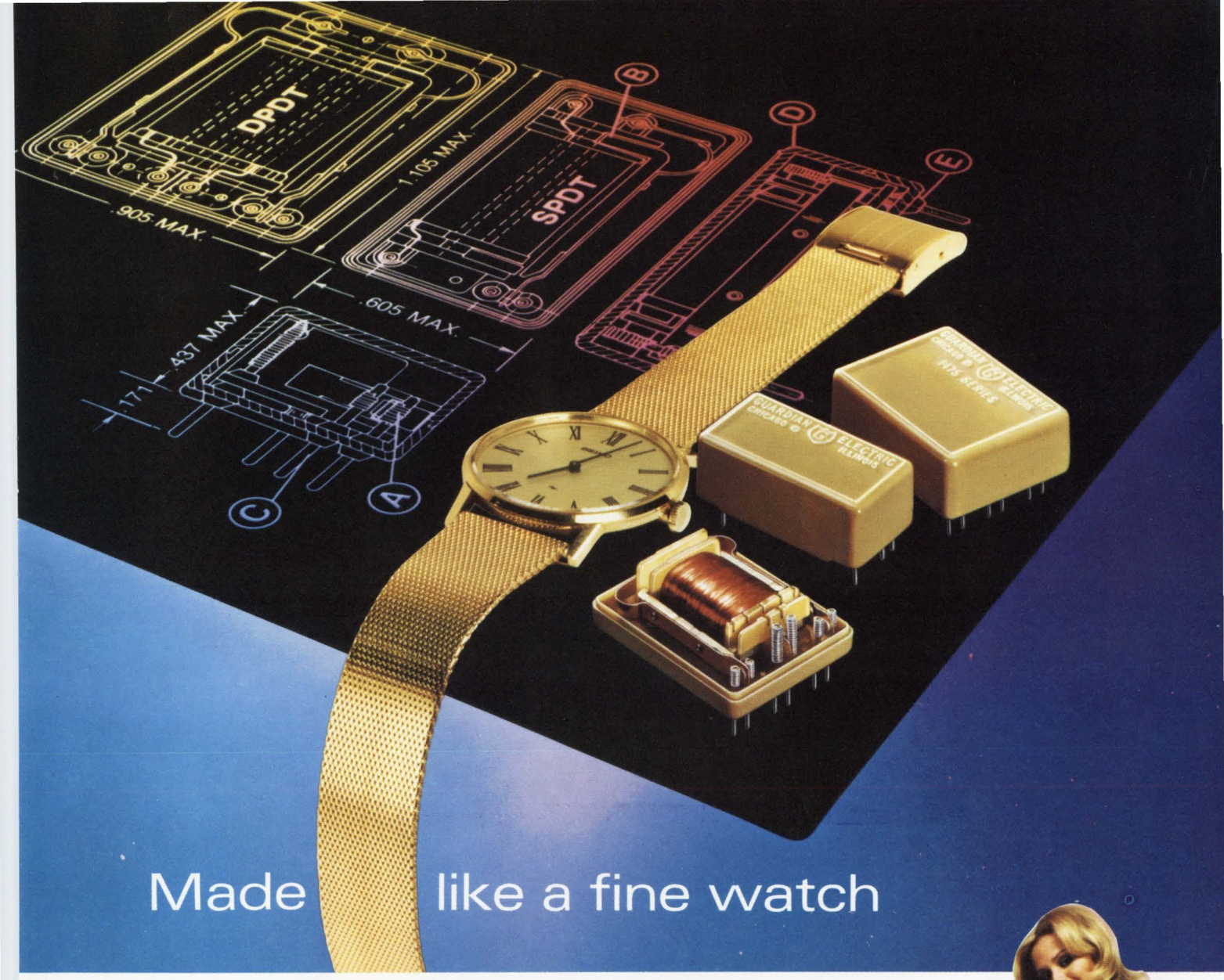
Typical *CERBON* trimmer resistor network incorporating one variable and two fixed resistors on dual substrate configuration.

VOLTAGE DIVIDER



Fixed and variable resistors can be ratio matched for precise values and to insure temperature tracking. Eliminates need for costly discrete resistor selection.

CIRCLE NUMBER 142



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Inspired design... meticulous craftsmanship in a very low cost, very low profile relay

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Each relay's performance and reliability are proven by nine—yes, nine!—individual tests. *(Operation at normal, specified pick up and release voltages; time delay limits on attract and release; contact resistance limits; contact gap and pressure; and ground test.)* The nine testing sequences are automatic on *every* relay. A single failure? Automatic rejection. To the scrap pile.

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1 ☐ **Title:** *(Insert letter)*

- A President
- B Vice President
- C Vice President of Engineering
- D Technical Director
- E Chief Engineer
- F Principal Engineer
- G Research Director
- H Section Head
- J Project Engineer
- K Senior Engineer
- L Group Leader
- M Dept. Head
- N MTS
- O Engineer
- P Consultant
- R Scientist
- S Physicist

2 ☐ **Your principal job function:** *(Insert code)*

1 General and Corporate Management
2 Design and Development Engineering (circuits, components, equipment systems)
3 Engineering Services (evaluation, quality control, reliability, standards, test)
4 Basic Research
5 Manufacturing and Production
6 Engineering Assistants (draftsman, lab assistant, technician)
7 Purchasing and Procurement
8 Marketing including Sales
9 Other Personnel (explain) _____

3 Plant ☐ Your own work ☐ **The primary end product (or service performed) at your plant, and the product (or service) that is your own work.** *(Insert code in each box even if the same)*

Plant	Your own work	
A	A	Large Computers
B	B	Mini-Computers
C	C	Computer Peripheral Equipment
D	D	Data Processing Systems (Systems Integration)
T	T	Office and Business Machines
E	E	Test, Measurement and Instrumentation Equipment
F	F	Communications Systems and Equipment
H	H	Navigation and Guidance Systems and Equipment
J	J	Consumer Entertainment Electronic Equipment
G	G	Consumer Electronic Appliances
N	N	Other Consumr Electronics
K	K	Industrial Controls, Systems and Equipment
L	L	Components and Sub Assemblies
M	M	Materials and Hardware
Q	Q	Aircraft, Missiles, Space and Ground Support Equipment
P	P	Oceanography and Support Equipment
R	R	Medical Electronics
U	U	Industrial Companies within the OEM incorporating Electronic Equipment in their end product, not elsewhere classified
V	V	Independent Research, Test and Design Laboratory and Consultant. (Only if you are not connected with a manufacturing company.)
X	X	Government Agency and Military
2	2	Industrial Companies using and/or incorporating any Electronic products in their manufacturing, research or development activities.
1	1	Commercial Users of Electronic Equipment
3	3	Distributor
4	4	School, University or Library
5	5	Other (explain) _____

4 ☐☐☐ **Your design function:** *(Insert each letter that applies)*

A I do electronic design or development engineering work
B I supervise electronic design or development engineering work
C I set standards for, or evaluate electronic design components, systems and materials

5 ☐ **Your principal responsibility:** *(Insert code)*

1 Management other than Engineering
2 Engineering Management
3 Engineering

6 ☐ **Please estimate:** *(Insert letter)*

The numer of electronic engineers at this address:
(A) 1 (B) 2-5 (C) 6-19 (D) 20-49 (E) 50-99
(F) 100-249 (G) 250-499 (H) 500-999 (J) Over 1000

8 **Products you specify or authorize purchase of:** *(Check all codes that apply.)*

- ☐ 1 Resistors and Capacitors
- ☐ 2 Connectors
- ☐ 3 Switches and Relays
- ☐ 4 Function Modules: Op Amps, Converters, etc.
- ☐ 5 Potentiometers
- ☐ 6 Test and Measurement Equipment
- ☐ 7 Computers, Medium and Large
- ☐ 8 Electronic Power Supplies
- ☐ 9 ICs and Semiconductors
- ☐ 10 Microwave Devices
- ☐ 11 Minicomputers
- ☐ 12 Computer Peripherals
- ☐ 13 Computer Components
- ☐ 14 Cabinets and Enclosures
- ☐ 15 Panel Meters, Analog or Digital
- ☐ 16 Readout and Display Devices
- ☐ 17 Rotating Components
- ☐ 18 Cooling Products
- ☐ 19 Printed Circuits
- ☐ 20 Calculators
- ☐ 21 Indicators including LEDs
- ☐ 22 Materials, Potting and Stripping
- ☐ 23 Communications Equipment

7 ☐ **Please write in box total number (other than self) to be served by this subscription at this address and list individuals and their titles below. If no other person is served please indicate "0" in the box at left.**

Name (Please Print)	Title

9 **Do you specify or buy through distributors?** ☐ YES ☐ NO

10 **Minicomputers at this address:**

		Model	Qty.	Model	Qty.
3	Cincinnati Milacron				
C	Computer Automation				
D	Control Data				
E	Data General				
F	Digital Equipment				
I	General Automation				
K	Hewlett Packard				
M	Honeywell				
O	IBM				
N	Interdata				
7	Microdata				
	Modular Computer				
	ROLM				
V	Systems Engineering Labs				
9	Texas Instruments				
x	Varian				
	Other				

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ED # 10

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Two units measure L: One digital, one analog

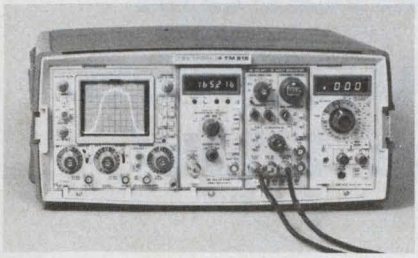
Boonton Electronics, Rte. 287 at Smith Rd., Parsippany, NJ 07054. (201) 887-5110. $1050 (62A); 2 wks.

Two new Model 62 series inductance meters provide two-terminal, series-inductance measurements at 1 MHz with low test current. The analog Model 62A has full-scale manual ranges of 1 to 3000 μH in a 1-3-10 sequence; the digital 62AD has four decade ranges, manually selected or autoranged, from 2 to 2000 μH full scale. Basic accuracies are $\pm$(0.5% rdg + 0.5% fs) for analog and $\pm$(0.5% rdg +0.2% fs) for digital display.

Booth No. 2301-2303

Circle No. 364

Compact rf sweepers join modular test line



Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $1400; stock.

SW 503 (50-Ω) and the SW 503 option 1 (75 Ω) rf sweep generators are compact units designed to operate in the company's TM 500 series power module. Both units cover a frequency range of 1 to 400 MHz, have a variable sweep rate, step attenuator, 20-dB vernier attenuator, and a crystal-controlled marker generator that provides comb type markers at 1, 10 and 50 MHz.

Booth No. 2801-2810

Circle No. 365

Spectrum analyzer shows 72-dB range

Kay Elemetrics, 12 Maple Ave., Pine Brook, NJ 07058. (201) 227-2000. $2585.

1-to-300-MHz spectrum analyzer features a spurious-free 72-dB dynamic range with phase-locked 1-kHz resolution. Internal calibration for frequency and amplitude is included. The P9040 is available with power supply for independent use with any oscilloscope. Input signal sensitivity is —100 dBm for the 50-Ω version and —50 dBmv for the 75-Ω.

Booth No. 2316-2318

Circle No. 366

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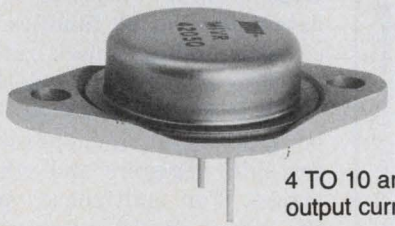

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CIRCLE NUMBER 94

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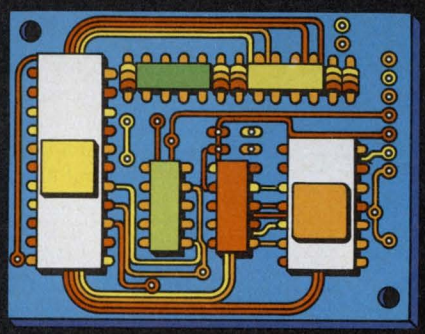

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CIRCLE NUMBER 97

Function gens deliver 'high-voltage' outputs

Interstate Electronics, 707 E. Vermont Ave., P.O. Box 3117, Anaheim, CA 92803. (714) 772-2811. Model F44, $595; F47, $675.

Series 40 function generator is said to be the first with sweep markers and high-voltage output. Two generators deliver an output to 40 V, open circuit, and produce waveforms from 0.004 Hz to 4 MHz. Model F44 provides linear sweep capability, and Model F47 adds logarithmic/linear sweep and operator-controlled step-frequency calibration between main dial frequency settings. Both multifunction generators also feature frequency markers. Additionally, the selection of waveforms offered on both models includes bipolar and unipolar, positive and negative, variable-width pulses down to 120 ns, all with offset control.

Booth No. 2320-2322

Circle No. 367

Pulse generators drive MOS circuits

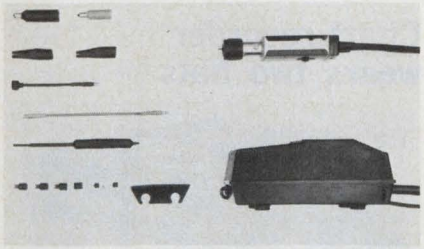
E-H Research Labs, 515 11th St., Box 1289, Oakland, CA 94604. (415) 834-3030. Approx. $600.

Model G725 MOS driver is the latest in the company's Generation 70 series of pulse generators. The G725 is ideal for use as a clock or data driver for all families of MOS circuits. Internal clock rates from 1 Hz to 10 MHz and widths from 50 ns to 500 ms allow the G725 to be used as a single-phase driver for shift registers and other logic arrays. For multiphase operation, the two buffered trigger outputs allow several G725s to be combined while maintaining phase relationships. Two remote-probe units for normal and complementary output allow the G725's output to be connected directly to a wafer probe, test fixture, or test circuit. The probe will drive a capacitive load of 100 pF with a rise time of 1 ns/V. Average output current is limited to 20 mA for probe protection.

Booth No. 2302-2312

Circle No. 368

Scope probes snap apart



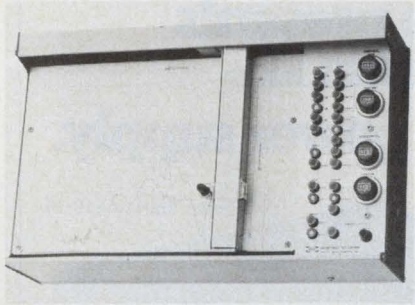
Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. 01, $30; 05, $60; 08, $45; stock.

A new modular concept divides scope probes into three parts (probe heads, cables, and connectors/compensation boxes) that snap together, making maintenance and repair less expensive, faster and much easier. The P6101, P6105 and P6108 are modular, miniature, general-purpose probes. The P6101 is a 1X, 1-MΩ probe, P6105 is a 10X, 10-MΩ probe; and the P6108 is a 10X, 10-MΩ probe when used with a 1-MΩ input scope.

Booth No. 2801-2810

Circle No. 369

X-Y recorder makes spectral curves



Pacific Measurements, 470 San Antonio Rd., Palo Alto, CA 94306. (415) 494-2900. $1920; stock-30 days.

Model 1044 response recorder works with the 1038 measurement system to make permanent high-definition response curves on special calibrated 8-1/2 × 11-in. paper. The 1038 system measures swept-frequency gain, insertion loss, and return loss in either one or two channels over the frequency range from 1 MHz to above 40 GHz. The 1038 also analyzes spectrum content from 1 to 20 GHz.

Booth No. 2820 *Circle No. 370*

Scope, DMM and counter get together

Vu-Data Corp., 7170 Convoy Ct., San Diego, CA 92111. (714) 279-6572. $1250; 30 days.

Model PS915/975 is the only test instrument that includes a digital multimeter (DMM), a frequency counter and an oscilloscope packaged together in a single unit with all three measuring devices possessing their own dedicated displays. All three can be used simultaneously or independently. Model PS915 mini-scope is a 20-MHz, triggered sweep, single-trace scope. Vertical sensitivity is 10 mV/div. Model 975 DMM-counter is a 3-1/2-digit, autoranging meter (ac volts, dc volts, and kΩ), as well as a 4-digit, 20-MHz frequency counter.

Booth No. 2707 *Circle No. 371*

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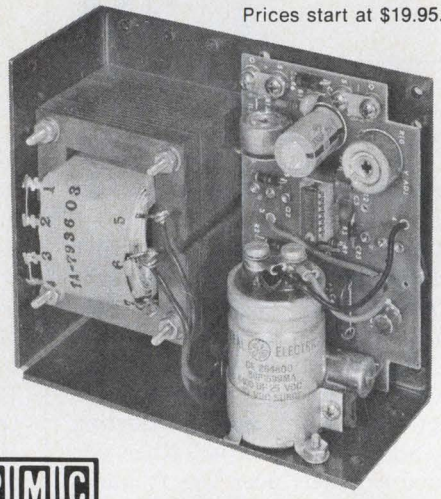

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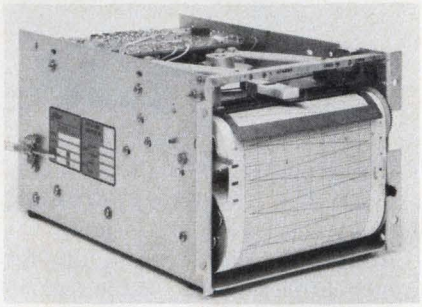
CIRCLE NUMBER 102

Chart recorder wears two hats



Gulton Industries, Gulton Industrial Park, East Greenwich, RI 02818. (401) 884-6800. About $290.

Rustrak Model 500 series of servo chart recorders is available as both an OEM unit and as a laboratory recorder. A wide selection of sensitivities, chart speeds, and custom OEM packaging features are available. Calibrated chart width is 100 mm, and writing is accomplished by an easily changed fiber-tip cartridge, positioned by a null balance, potentiometric rotary servo motor. Sensitivity is 0 to 100 mV dc full scale with other sensitivities available.

Booth No. 2507-2509

Circle No. 372

Calibrator offers remote or keyboard control

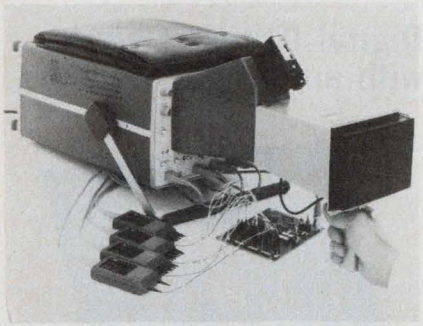
United Systems Corp., 918 Woodley Rd., Dayton, OH 45403. (513) 254-6251. 3210, $1795; 3220, $1595.

Two precision calibrators join the company's HT Series (High Technology) instrumentation line. Model 3210 keyboard controlled unit and Model 3220 programmable unit are designed to function as both constant-voltage and constant-current sources. Model 3210 has a keyboard unit that replaces front-panel controls and permits operation from remote locations by semiautomatic testing systems. Model 3220 is designed for fully automatic systems and can be programmed to accept TTL BCD logic or other codes. Both models can supply precise voltage to ±200 V and current to ±200 mA.

Booth No. 2506, 2508

Circle No. 373

Scope camera takes the pain out of printmaking



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $250; 2-6 wks.

Model 124A is an inexpensive, easy-to-use oscilloscope camera. To use the 124A, place the camera hood over the scope bezel—no adapters needed—and press the trigger. The camera is prefocused and framed without adjustments. The f-stop is fixed, as is the shutter speed. An electronic flash, powered by two AA batteries, provides graticule illumination if the scope lacks it.

Booth No. 2201-2210

Circle No. 374

Backplane tester handles 16,000 points

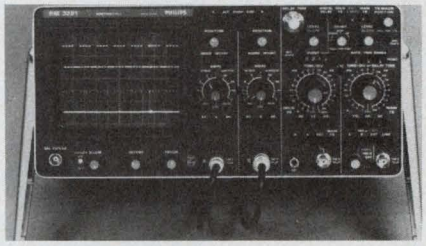
Teradyne, 183 Essex St., Boston, MA 02111. (617) 482-2700. $15,000; 20 wks.

N123 is a bench-top tester for performing continuity tests on backplanes with up to 16,000 points, although it is usually most economical for units with fewer than about 5000 points. The self-contained unit includes a CRT display, a magnetic-tape-cartridge unit and a strip printer. The N123 is capable of self-learning an interconnection scheme and will find all wiring errors in a single pass.

Booth No. 1117-1124

Circle No. 375

Scope offers built-in digitally delayed base



Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. $2495; June.

A digitially delayed time base that enables accurate location of events in pulse trains is a key feature of the PM3261 oscilloscope. Other specs include: 120-MHz bandwidth, 3-ns rise time vertical amplifiers; main and delayed time bases with 5 ns/div maximum sweep speeds; clear front-panel design giving proven ease of operation; high-speed, high-sensitivity triggering beyond 200 MHz; and 20-lb weight, making the unit highly portable.

Booth No. 1033, 1037 1134, 1136

Circle No. 376

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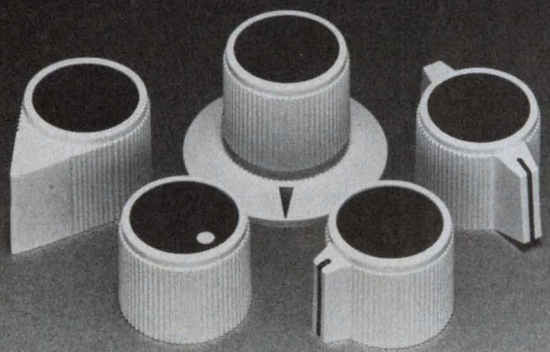

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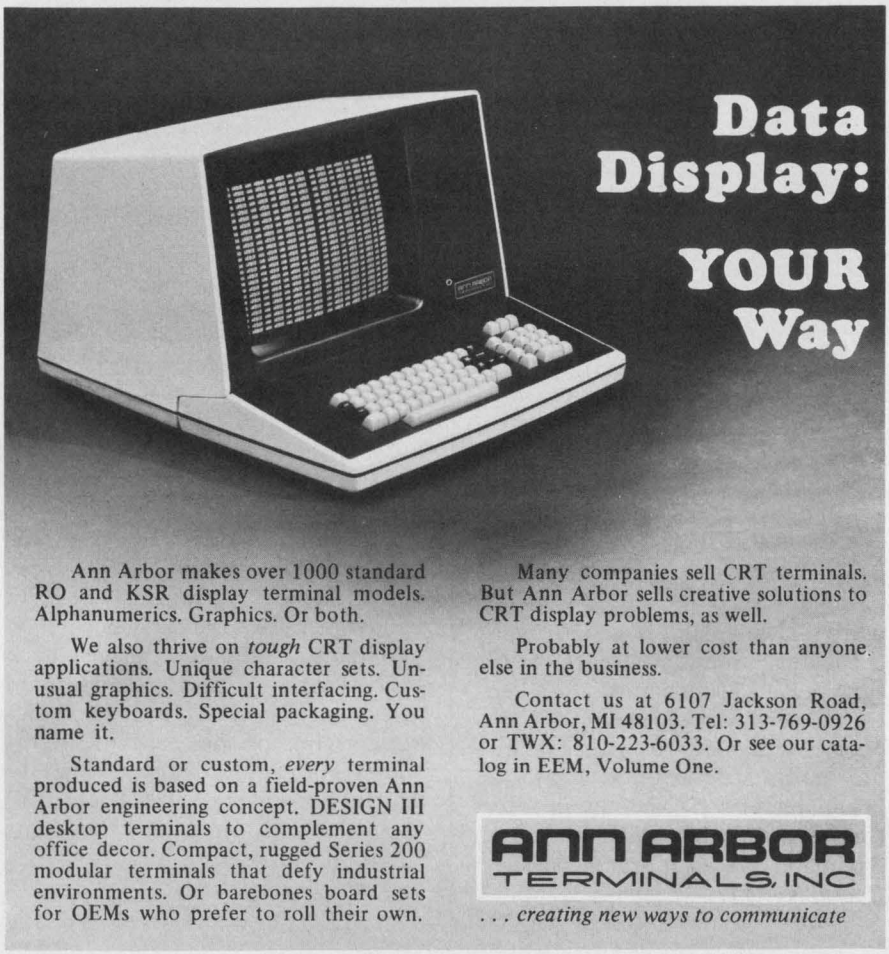

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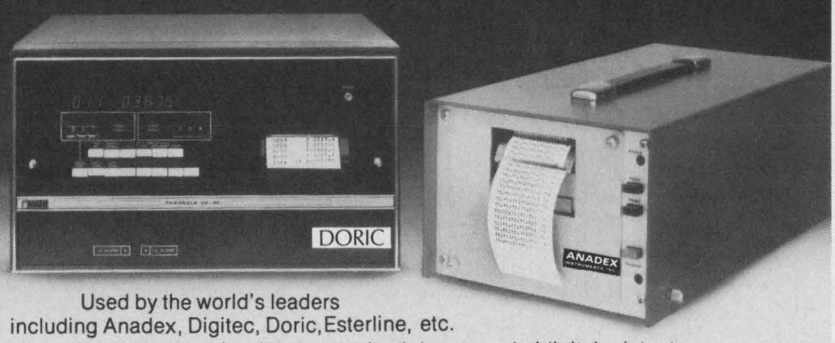

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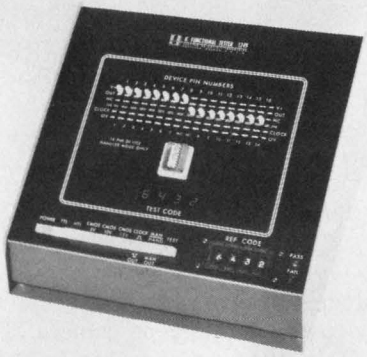
CIRCLE NUMBER 106

Digital IC tester works with automatic handlers



Electro Scientific, 13900 N.W. Science Park Dr., Portland, OR 97229. (503) 646-4141. $1195; stock-90 days.

Model 1249 digital IC functional tester interfaces with automatic DIP handlers and offers selectable test voltages. The unit checks ICs in the DTL, TTL, HTL, and CMOS families without requiring a comparison device. A built-in test code comparator checks the test result against a preset nominal and signals the handler. A special feature is the selection of test voltages for CMOS devices. Three levels are offered: 5, 10 and 15 V.

Booth No. 2406 *Circle No. 377*

Digital scope stores signals

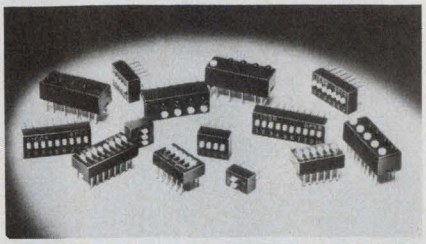
Nicolet Instrument, 5225 Verona Rd., Madison, WI 53711. (608) 271-3333. $6200 to $7200; 90 days.

The second generation EXPLORER digital oscilloscope uses an a/d converter to digitize the input signal and store it in a solid-state memory. The stored signal is then reconstructed through d/a conversion on the cathode ray tube (CRT). Since the signal is stored in memory, the waveform can be manipulated during or after recording for closer examination. Bandwidth is dc to 5 MHz (with 94A plug-in). Memory is 4096, 12-bit words, which can be used in halves or quarters for measurement, display or readout to peripherals.

Booth No. 2414-2416

Circle No. 378

Multiple switches in DIP have 2 to 10 poles



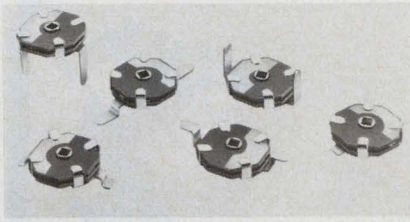
Licon, 6615 Irving Park Rd., Chicago, IL 60634. (312) 282-4040. From $1.37 (1000-up); stock to 6 wks.

A slide-detent latching switch prevents accidental actuation and provides quick visual indication of open and closed positions. The switches are housed in DIPs and are available in 2 to 10 poles. The package measures 0.28 in. high and has a terminal spacing of 0.1 × 0.2 in. for PC board insertion. Optional snap-on dust covers are available.

Booth No. 1615-1617

Circle No. 379

Trimming capacitors fit tiny hybrids

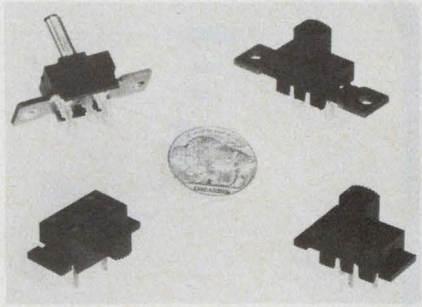


Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, NJ 07005. (201) 334-2676. $1.95 (1000 up); 2 wks.

The Johanson 9410 series trimming capacitors are now available in a variety of mounting configurations including stripline, stripline-offset, PC and bottom-tuning types. Their small size, only 0.2-in. square and 0.045-in. thick, allow applications in tiny hybrid circuits such as in electronic-watch, crystal-oscillator and uhf-microwave applications. Capacitance values range from 1.0 to 4.5 and 7 to 45 pF and working voltages up to 250 V dc.

Booth No. 1236 *Circle No. 380*

Slide switches made without metal shells



AMF Inc., UID Electronics Div., 4105 Pembroke Rd., Hollywood, FL 33021. (305) 981-1211. $0.055 (OEM qty).

New shell-less sliding-contact switches, the SL series, offer less weight—50% of the weight of most slide switches is in the shell. The shell has been eliminated. Safety also is increased—the absence of a conductive shell is inherently electrically safer. Average mechanical life is 100,000 operations, and UL and CSA-rated switches are tested for 6000 operations.

Booth No. 1613 *Circle No. 381*

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CIRCLE NUMBER 107

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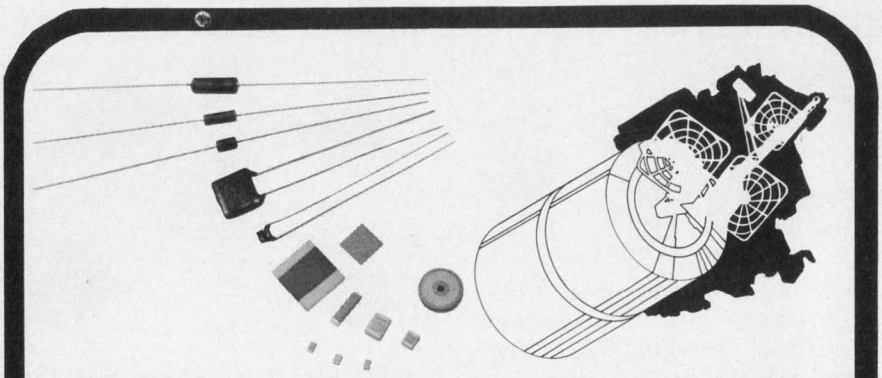
CIRCLE NUMBER 108



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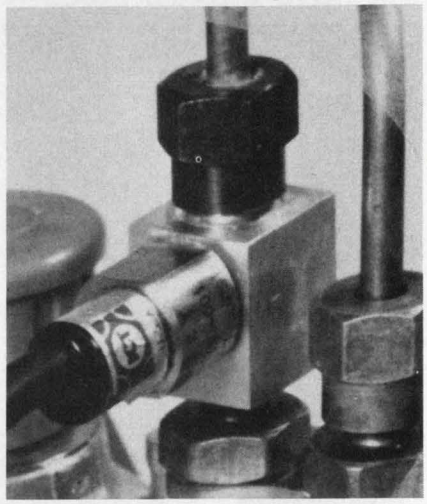
CIRCLE NUMBER 109

CIRCLE NUMBER 110

COMPONENTS

Pressure transducers handle 10,000 psig



I. C. Transducers, Inc., 1750 Junction Ave., San Jose, CA 95112. (408) 998-8720. $95 (1 to 9); stock.

The Series 750 solid-state pressure transducers are designed for very high pressure applications. It is claimed to be able to handle more than 5×10^9 pressure pulses of 0 to 10,000 psig at 2400 pulses/min. A variation of the 750, the Series 900, features a flush-mounted diaphragm for measuring high frequency pressure phenomena. Outputs of the two series of transducers are 0-to-100-mV full scale. Other specifications include a repeatability of 0.05% FS, an excitation of 12 or 24 V ac; an overpressure range of 200% and an operating temperature range of −40 to +250 F.

Booth No. 2601-2603
Circle No. 382

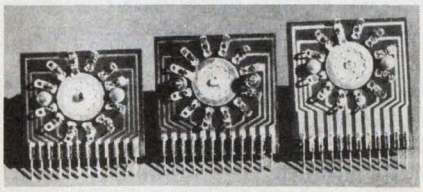
Chip capacitor adjustable 1 to 55 pF

Vitramon North America, P.O. Box 544, Bridgeport, CT 06601. (203) 268-6261.

A new version of the Vee Cal adjustable/fixed chip capacitor enables NPO parts users to add or subtract capacitance by connecting adjustment points, while retaining the integrity and stability of a fixed capacitor. The new VC2A has adjustment points on the top plane over a capacitance range of 1 to 55 pF in 0.5-pF steps. The chip measures 0.12 × 0.10 in.

Booth No. 2424 *Circle No. 383*

PCB rotary switches come in many heights



Standard Grigsby, Inc., 920 Rathbone Ave., Aurora, IL 60507. (312) 897-8417.

A line of PC-board rotary switches for perpendicular mounting includes the SM-PCB Series in profile heights of 0.625, 0.742 and 0.875 in. However, where space and height are a prime consideration, any variable in height between 0.625 minimum and 0.742-in. standard may be specified. The SK-PCB series is a slightly larger, lower-cost switch and is available in a mounting height of 0.875 in. All the switches are available as single or multideck assemblies and with levers. Circuit components can be added to individual switches to provide a complete switching system. Many options are available.

CIRCLE NO. 384

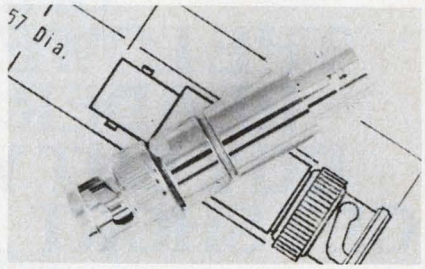
Solid-state relays protected for shorts

Heinemann Electric Co., Magnetic Dr., Trenton, NJ 08602. (609) 882-4800. $14.50 (100-up); stock.

A new line of solid-state relays, presently rated to 10 A at 120 and 250 V ac, is optically isolated, operates with an extended control-voltage range from 3 to 32 V dc and is TTL, DTL and MOS-logic compatible. To prolong life and increase reliability, the relays contain a built-in snubber network to protect against high dv/dt; fused output triacs protect against short circuits. Their operating range is −40 to 100 C with either zero-voltage or nonzero-voltage switching models. Actuation time is 9-ms max in the zero-voltage switching model, and 2-ms max in the nonzero-switching model. Release time is 8.3-ms max in both configurations. Isolation resistance is at least 10^9 Ω. The relays can handle a one-cycle nonrepetitive peak surge of 1000% of the relay's current rating.

Booth No. 2119 *Circle No. 385*

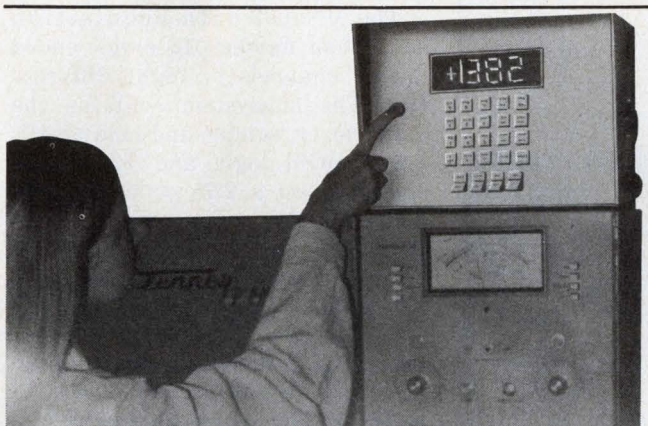
50-Ω attenuators fit BNC connectors



ITT Pomona Electronics, 1500 E. 9th St., P.O. Box 2767, Pomona, CA 91766. (714) 623-3463. $24.95 (unit qty); 2 wk.

A BNC 50-Ω attenuator, Model 4108, for use with pulse, microwave or uhf instruments, has a female BNC on one end and male on the other. It has a nontarnish finish, Teflon insulation and gold-plated contacts. It is 1.97-in. long and 0.57 in. in diameter. Five different versions provide attenuation of 3, 6, 10, 14 or 20 dB. Attenuation tolerances run from ±0.4 dB up to 1 GHz for the 3-dB unit; ±0.9 dB to 8 GHz for the 20-dB unit.

Booth No. 1525 *Circle No. 386*



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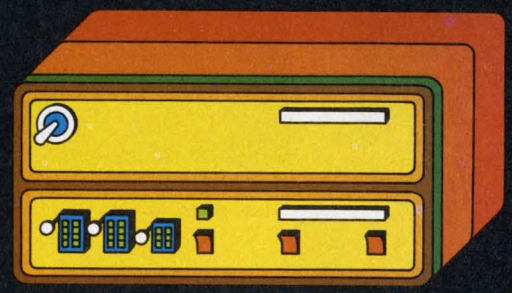

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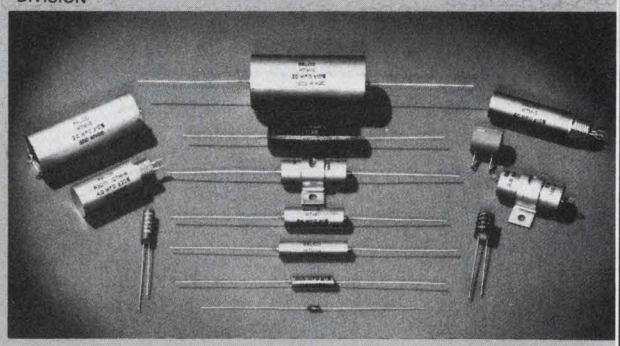

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CIRCLE NUMBER 114

Programmable display driver handles 8 colors

Kinetic Systems, Maryknoll Dr., Lockport, IL 60441. (815) 838-0005, $3850; stock.

A complete programmable color display system (less the CRT display) is housed in two 2-unit width CAMAC modules. The Model 3232 system is a character oriented module set that generates an eight-color display on any red-blue-green, 525 line, raster scan CRT monitor. The system can handle a maximum of 2048 characters and inputs are available for a joystick, pushbuttons or a trackball to move the cursor. Each character can be any of the eight possible colors as can the space between characters.

Booth No. 2214-2216

Circle No. 387

Data-acquisition system expands to 256 channels

Micro Networks, 324 Clark St., Worcester, MA 01606. (617) 852-5400. See text.

The MN7002 data-acquisition subsystem handles 16 single-ended analog channels or eight differential. The subsystem contains the multiplexer, sample-and-hold amplifier, control logic and 12-bit a/d converter on a 2.75 × 4.5-in. circuit card. Expansion of the system is possible up to a maximum of 256 channels. Each channel input has an impedance of 100 MΩ, minimum and can handle ±10-V common-mode. The over-all system linearity over the full 0-to-70-C operating range is within ±1 LSB. Absolute accuracy of the system is ±0.5% of full scale range, including zero error over the full range and the CMRR is 72 dB, minimum, for dc-to-1-kHz inputs. Crosstalk between channels is 80 dB (for a 1-kHz signal and adjacent off and on channels). Data can go through the system at a 40-kHz rate when the MN7002 operates in an overlap mode (new channel addressed while a/d converter is performing conversion on previous data). Price of the MN7002 starts at $495 for 1 to 24 units. A MIL-temperature version—the MN7002H—is also available for $865.

Booth No. 2005 *Circle No. 388*

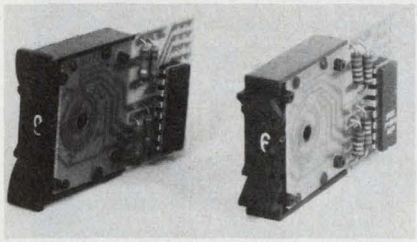
Programmable amps use 3-bit digital control

Preston Scientific, 805 E. Cerritos Ave., Anaheim, CA 92805. (714) 776-6400. See text.

Wideband programmable-gain amplifiers permit a 16-to-1 range of digitally selectable gain settings. The GMD-PG programmable amplifiers can be set to any of five preestablished gain levels of 1, 2, 4, 8 and 16. The GMD-PG requires a 3-bit digital control while the GMD-AGC has automatic gain ranging and a 3-bit digital output code for data logging. Gain accuracy for either unit is ±0.01% and the gain stability is ±0.01%. Both amplifiers have a gain tempco of 10 ppm/°C and a linearity of ±0.01%. Also, both amplifiers have a 20 μs settling time for the output to reach within 0.01% of its final value after a gain change and only 10 μs if there is no gain change. The GMD-PG costs $395 and the GMD-AGC $1045. Delivery of either model (with an a/d conversion system) is 10 to 12 weeks.

Booth No. 2304, 06, 08, 10, 12
Circle No. 389

Thumbwheel switch includes counter/timer



International Microtronics, 4016 E. Tennessee St., Tucson, AZ 85714. (602) 748-7900. $7.50 (TTL); $9.50 (CMOS); stock to 2 wks.

A counter-timer switch consists of a thumbwheel switch with a decade counter (SN7490 or MM74C90) built-in. It accepts a train of pulses and when the counter's content equals the number displayed on the thumbwheel switch an "equal" output is generated. Any number of switches can be cascaded to form a multidecade counter-timer. The units have provisions for clock-in, reset, carry, equal-out and preset. Both front (SF) and rear (SR) mount models are available with either TTL or CMOS compatible logic.

CIRCLE NO. 390

Synchro-to-BCD modules offer scale adjust

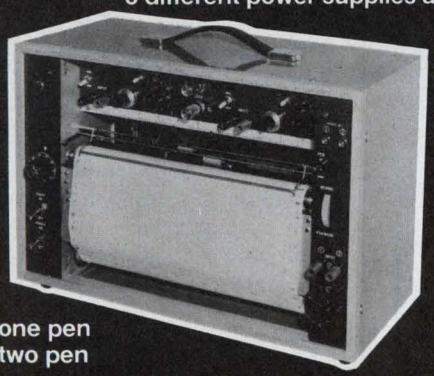
Computer Conversions, 6 Dunton Ct., East Northport, NY 11731. (516) 261-3300. $375 (large qty.); 4 wks.

A series of three or four-decade, synchro-to-BCD-converter modules is available with a choice of scale factor. The modules measure 2.6 × 3.1 × 0.82 in. and are designed for PC board mounting. They convert synchro or resolver inputs of 11.8 or 90 V, 400 Hz or 90 V, 60 Hz into three or four-decade BCD data, representing angle with an accuracy of ±6 or ±30 minutes of arc. Unipolar and bipolar (±180°) models are available. The converters have isolated reference and synchro inputs and an optional zero-offset adjustment. The digital outputs are DTL/TTL compatible and bidirectional input data are accepted. Model SBC40 requires a 26 or 115-V, 400-Hz ac reference input, +15 V dc at 40 mA and +5 V dc at 600 mA, max. Operating temperature ranges are 0 to +70 C or −55 to +85 C.

CIRCLE NO. 391

SP-G10, H-10 SPEEDEX RECORDER

3 different power supplies available!!



G10...one pen
H10...two pen

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CIRCLE NUMBER 115

MICROPROCESSOR SERIES NO. 6

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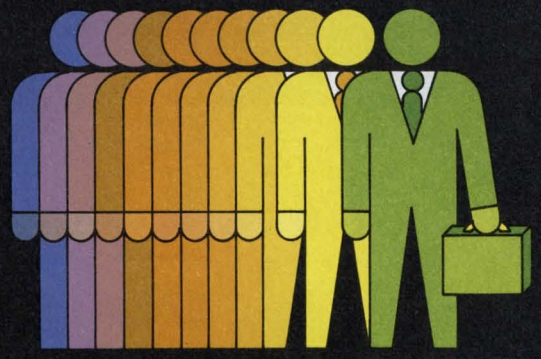

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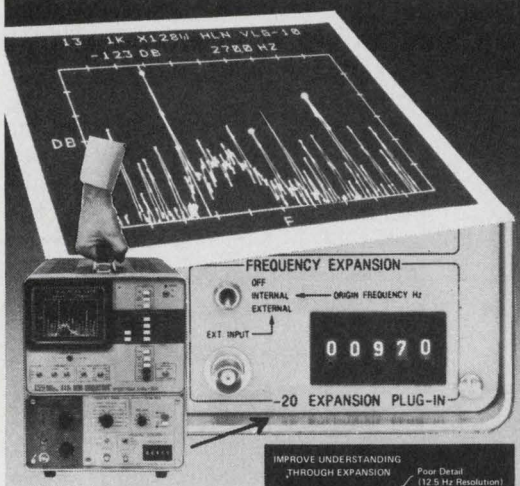

New Expansion Plug-in (-2 Option) magnifies frequency spectrum detail up to 400:1 by separating closely spaced frequency peaks with resolution as fine as .125 Hz; expands 20 kHz coverage to 100 kHz. Any one analysis band—50 Hz, 100 Hz, 500 Hz, 1 kHz, or 2 kHz—can be positioned in 10-Hz steps to 100 kHz. Extra plug-in cards provide any of the other ranges.

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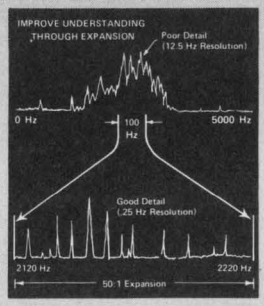

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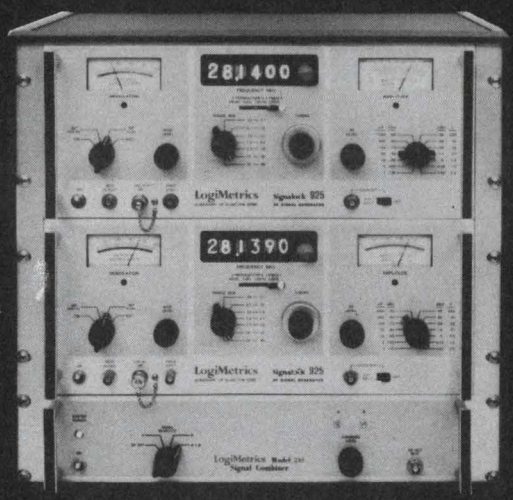
Model 315 combines two Model 925 RF Signal Generators having "Signalock" with a Model 210 Signal Combiner, resulting in a two-tone test set with unsurpassed stability from 50 kHz to 80 MHz. Signal level of each tone or combined tones is adjustable from 0.1 μv to 2 volts with ± 10 Hz stability. Signal spacing is from 100 Hz to almost 80 MHz. Intermodulation distortion is 60 dB down at full output: better at lower outputs. Write or call today for complete specifications and pricing.



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RF Signal Generators, Frequency Synthesizers, Traveling Wave Tube Amplifiers

CIRCLE NUMBER 118

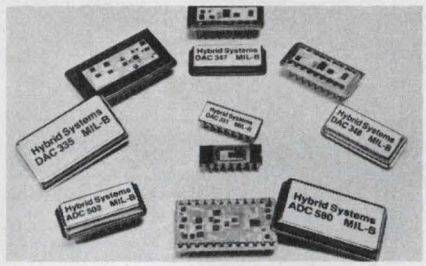
Log amp accepts bipolar input signals

Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1434. 100-up prices; $26 (4127J); $31 (4127K); stock.

The 4127 hybrid log amp accepts input signals of either polarity. It has a wide dynamic range—up to six decades of current and four decades of voltage. The unit is available with initial accuracies (log conformity) of 0.5% full scale (4127K) or 1% full scale (4127J). It operates over an ambient temperature range of −10 to +70 C and is housed in a ceramic DIP that measures only 1.4 × 0.8 × 0.25 in.

CIRCLE NO. 392

MIL-spec converters offer wide choice



Hybrid Systems, Crosby Dr., Bedford Research Dr., Bedford, MA 01730. (617) 275-1570. From $49 (1 to 9); stock to 8 wks.

A family of over 20 hybrid data conversion devices is designed to meet full MIL-STD-883 specifications. Included are general-purpose d/a converters, multiplying a/d converters, sample/hold amplifiers and multiplexers. Converter resolution ranges from 8 through 12 bits. All of the converters are processed to class B or C requirements of MIL-Standard 38510. The family includes: 8, 10 and 12-bit multiplying DACs (DA331 and 348 series); 10 and 12-bit general-purpose DACs (DAC335 series); 10 and 12-bit low-power DACs (DAC347 series); 8, 10 and 12-bit successive-approximation a/d converters (ADC503 and 580 series); a fast sample-and-hold amplifier (SH702); and an 8-channel analog multiplexer (MUX202).

Booth No. 1523 *Circle No. 393*

LED indicators offer versatile mounting

Data Display Products, 5428 W. 104 St., Los Angeles, CA 90045. (213) 641-1232. $0.79 (1000 up); stock to 4 wks.

Packaged for vertical or horizontal viewing, the PCV-200 and PCH-200 series of LED indicators are available with T-1-3/4 cases and clear-tinted or diffused encapsulation. Three colors are available, of which only the red can be purchased with built-in resistors for 5-V applications. For applications that require a smaller package, the PCX125 series of LEDs is available, in T-1 diffused cases. In addition, other types, such as the PCL units, have an elongated horizontal package for greater mounting stability, while the PCO series has a horizontal package with offset, bent terminals. All diodes in these sereis are rated at 50 mcd at 20 mA (typical red, with clear-tinted encapsulation).

Booth No. 2119-21 Circle No. 510

SCR power modules deliver 110 A at 1200 V

Gentron Corp., 6667 N. Sidney Pl., Milwaukee, WI 53209. (414) 351-1660. $50 (100-up); 3 to 4 wks.

The 5100 series of Powertherm power control modules handles 1200 V at 110 A. Two basic circuits are available: an anti-parallel SCR circuit, and SCR and diode arrangements. The modules have a thermal resistance of 0.4 C/W, maximum.

CIRCLE NO. 511

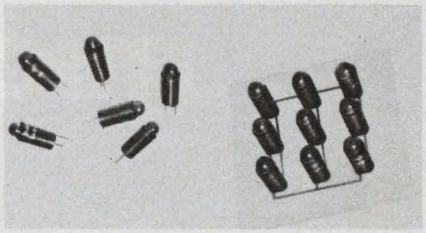
Germanium transistors handle currents to 35 A

Germanium Power Devices, P.O. Box 65, Shawsheen Village Station, Andover, MA 01810. (617) 475-5982. See text.

The 2N1520 and 2N1521 pnp germanium transistors can handle 35 A at up to 80 V. The devices are housed in TO-36 packages and cost from $3 to $5, depending upon quantity. Delivery is four weeks.

CIRCLE NO. 512

LED lamps can replace T-1-3/4 incandescents



Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. For 1000-up quantities: $0.54 (without resistor); $0.69 (with resistor); stock.

Developed as a direct replacement for the T-1-3/4 incandescent lamp, the series 549 Bi-Pin LEDs come in two models. One has an integral resistor for direct use at 5 V and 16 mA, and the other, a 1.7-V unit, requires an external series resistor that makes possible a wide range of operating voltages and currents. Pins are molded into the black plastic case, which has a flat for indexing to establish correct polarity. Terminations are 0.025-in.-square leads with gold plating.

CIRCLE NO. 513

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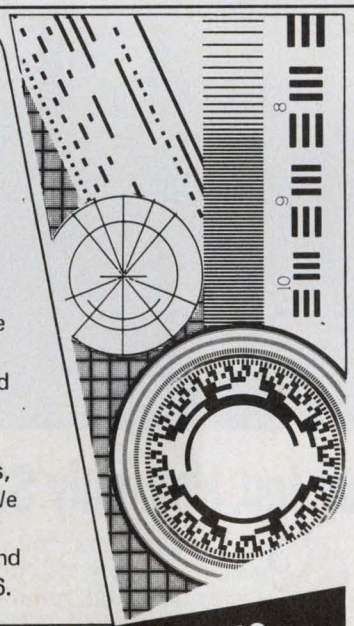
the world's most accurate rulings using vacuum deposit chrome, etch and fill or emulsion processes. They're produced on the worlds largest 1 micro inch numerically controlled ruling engine with interferometric feedback controls. Need precision scales, grids, slits, reticles, Ronchis numbers, letters, circles, dots, or nickel mesh? We stock many items for immediate delivery. Send for brochure No. 38-36.



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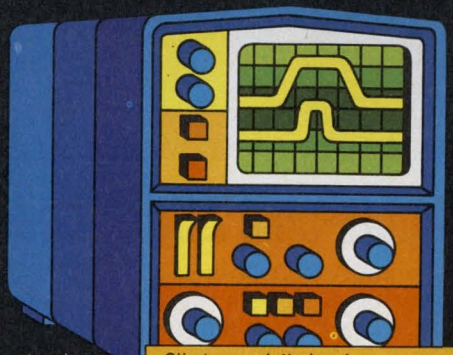
CIRCLE NUMBER 119

MICROPROCESSOR SERIES NO. 7

BY SEPTEMBER THE 2650 IS OVER 30% FASTER.



Your system's features can be extended with the speedier 2650. Current 2650 software will apply.

Clip to your letterhead.
Put me on your reservation list for the first mailing of the faster 2650 data sheet.

Name Title

Tel. M.S.

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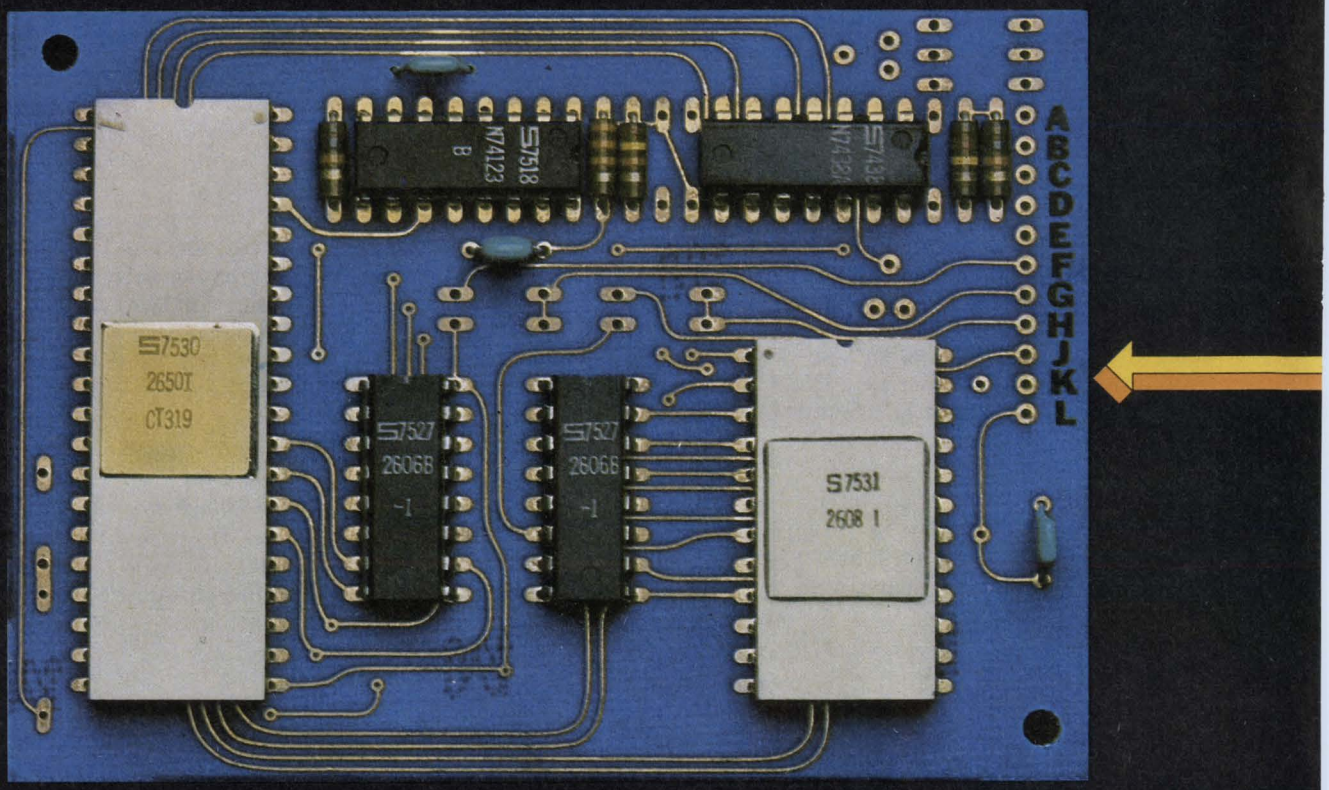
THINK signetics μP
a subsidiary of U.S. Philips Corporation

CIRCLE NUMBER 120

The easiest-to-use microprocessor



(Photograph approximately 2x actual size.)

The single-chip 2650 is easiest-to-buy, too. Now only $21.50 (100-up).

Full support of customer and product is the key to ease of development with the 2650. Applications engineers in the U.S. and abroad are at your beck and call at every stage. Software for almost anyone's requirements and machines. Development hardware is versatile and inexpensive. All circuits are multi-sourced.

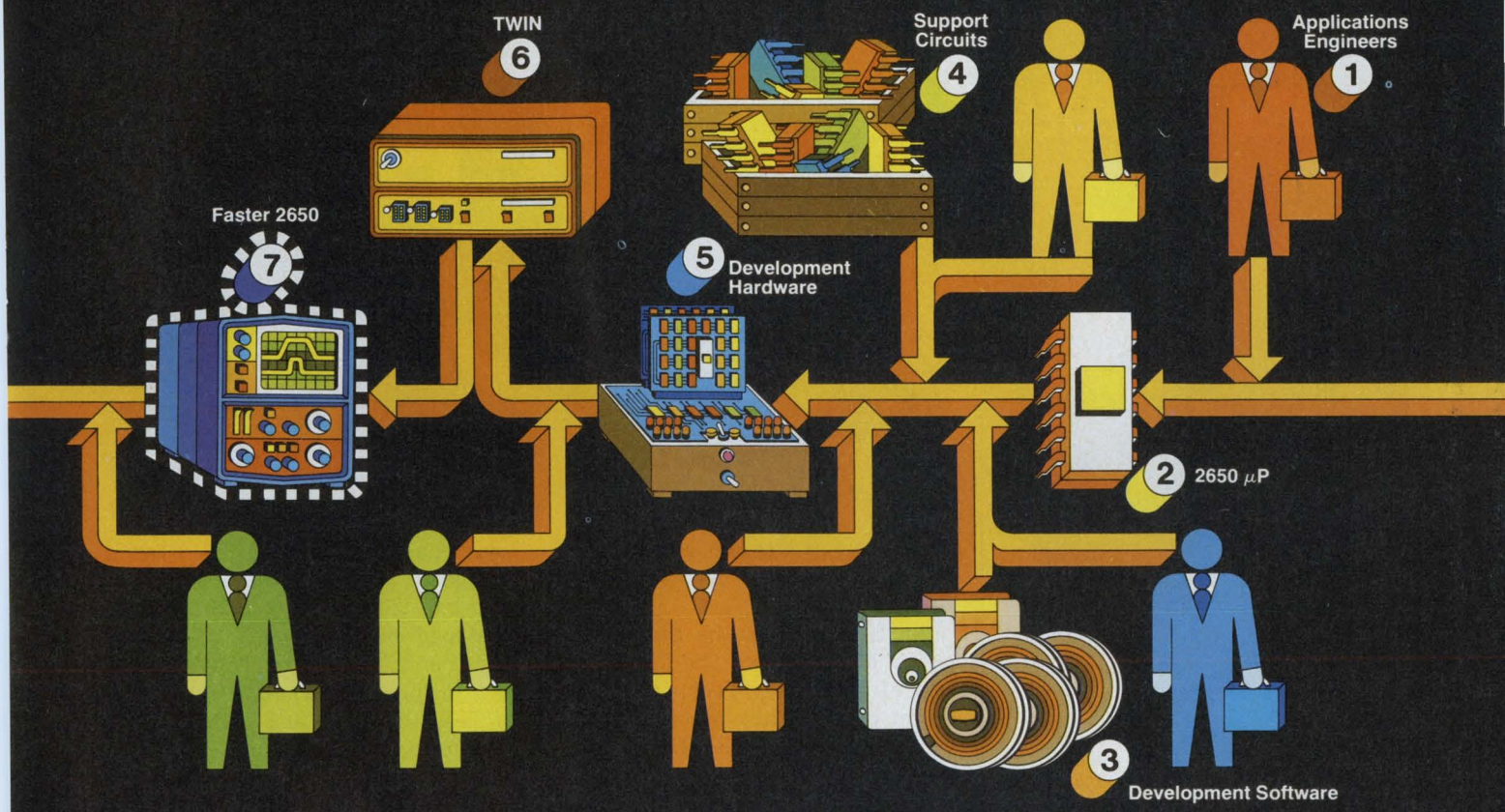
Flow Chart: How to travel safely and quickly from spec sheet to your μC.

1. Applications Engineers — in the field now, more coming. Specific assistance to you is available around the USA, and in Belgium, Holland, Germany, France, Sweden, Britain, Italy, etc.

2. Multi-sourced 2650 — available in any quantity from Signetics, at the unprecedented low price of $21.50. Also available from AMS and Philips, and from Signetics' authorized distributors.

3. Development Software — includes the PL μS, an extremely efficient High Level Language (compiler) that reduces programming effort and cuts development time. ANSI standard Fortran IV executes on most machines without alteration. 2650AS1000/1100 Assembler and 2650SM1000/1100 Simulator are available in both 32- and 16-bit, on GE and NCSS time-sharing.

4. Multi-sourced Support Circuits — You'll need MOS and/or Bipolar Memories, Interface and Logic. Signetics has *everything* for a complete system. Back up any item from other sources. Coming soon from Signetics are: Programmable Peripheral Interface and Communications Interface, A-D Converters, Synchronous Data Link Controller, 16k NMOS & Bipolar ROMs, 4k & 8k NMOS EROMs, and 8k Bipolar PROMs.



makes the easiest-to-develop microcomputer.

5 Development Hardware — Design/develop/prototype with a variety of cost/capability levels of hardware support. Including prototyping cards and kits, smart typewriter demo card, 4k-byte RAM card, and more. Applications help if you need it.

6 TWIN With Floppy Disks — "crashproofs" your system checkout. With DOS, Resident Assembler, and Text Editor. You develop programs and circuits together in an actual system environment with TWICE (*T*estWare *I*n *C*ircuit *E*mulator). PROM programming, too.

7 Over 30% Faster 2650 — By the time you've proven out your μC, you'll have available a faster 2650 if you want it. Uses the same software. For still higher speeds, call Signetics Bipolar Microprocessor Marketing about our 2650 emulator using 3000 series μP.

You go from gleam-in-your-eye to proven prototype in less time for less cost, and the μC you develop is easier and cheaper to produce in quantity, when you start with the 2650. Start now by mailing the coupon.

Attach this to your letterhead for fast response.

☐ Send me complete 2650 short form catalog.
☐ Have a Field Applications Engineer call me for appointment.
My need is: ☐ immediate ☐ 6 months ☐ information only

My application is _____

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Telephone _____ Mail Stop _____

THINK **Signetics μP**
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CIRCLE NUMBER 121

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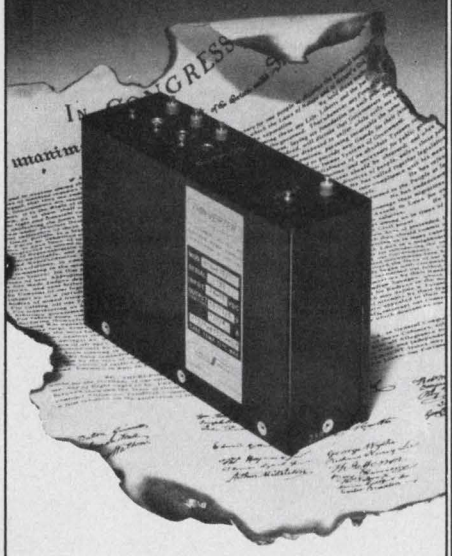

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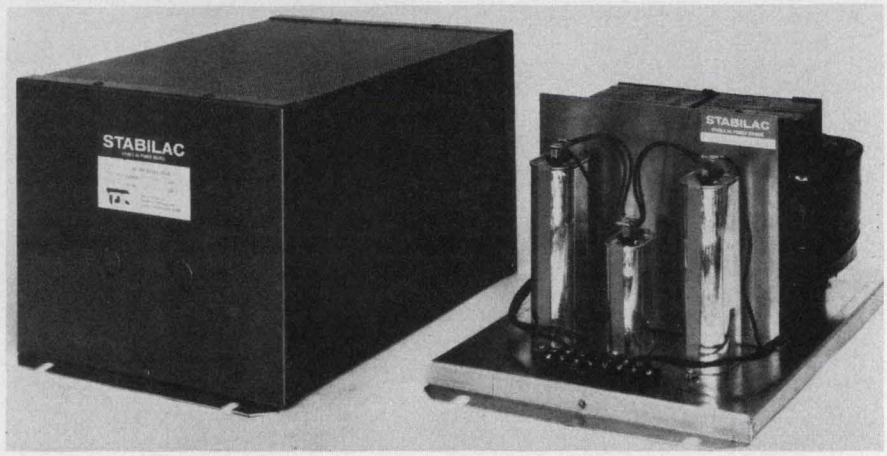
CIRCLE NUMBER 122

Ac source regulates output as both line and load change



TDC Div., Whitcomb Ave., Littleton, MA 01460. (617) 456-3374. See text.

At first glance, the Stabilac ac power source, from the TDC division of Frequency Technology Inc., might look like any other constant-voltage transformer (CVT). But look further:

The Stabilac delivers up to 50 kVA. The CVT can't.

The Stabilac gives good regulation under simultaneous line and load variations. The CVT doesn't.

The Stabilac isolates the load from the line and suppresses input spikes. Not the CVT.

And if these aren't enough, the Stabilac is said to be 20 to 40% smaller, lighter and less expensive than a CVT of equal power rating. Surprisingly, the Stabilac is passive; it uses no electronic feedback or SCRs to maintain the output voltage.

How well does it regulate? Output stays within ±2-1/2% from no load to full load with a simultaneous line-voltage change of ±15%. If the line remains constant, a no-load-to-full-load swing affects the output by −3%. Or, with constant load and input variations of ±10% or −20%, regulation is ±1-1/2%. Note: these are all typical figures.

You also get some regulation during short-term (15 min or less) overloads. The voltage drop during overload ranges from 6% (for a 1/2-load to 150% full-load variation) to 25% for 1/2-load to 250% full-load change.

Other key specs of TDC's Stabilac include a harmonic distortion of less than 5% and efficiency of better than 80% at full load. (Another version offers a square-wave output for subsequent rectification.)

Although the Stabilac's spec sheet doesn't list a figure for isolation or fully characterize the noise-suppression capabilities, it does state that "over 95% of a 500-V spike superimposed on a 230-V line will be filtered out."

Both single and three-phase models are available, in ratings ranging from 0.25 kVA to 50 kVA (1 ϕ), and 6 to 150 kVA (3 ϕ). Primary and load voltages are 120, 240 or 480 V, depending on the model. Some units offer more than one output winding.

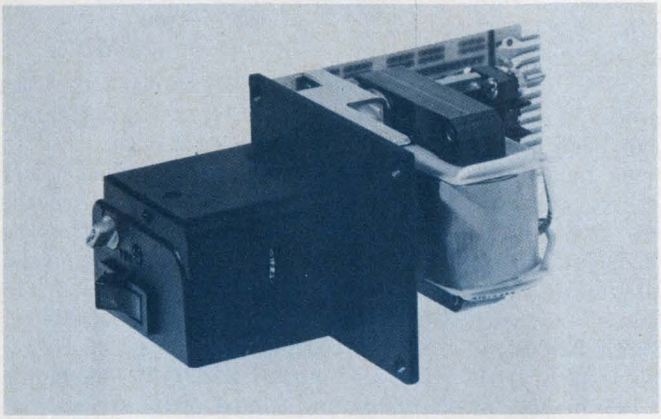
Typical weights and prices are as follows: In the single-phase Stabilacs, which are of open construction, the 0.5-kVA model weighs 18 lb and sells for $155; the 20-kVA unit weighs-in at 470 lb and costs $1740.

The 3-ϕ models come in a metal cabinet. Representative weights range from 235 lb for 6 kVA to 1500 lb for 60 kVA. Prices are $1330 and $5190, respectively.

CIRCLE NO. 303

New! Model 640 Low Cost*Loader Reads 350 Characters per Second

All solid state photo-electronic components. Reads all standard 5,6,7 or 8 level tapes. Smooth, quiet, AC drive.



Provides reliable, high speed data entry. Data amplifiers and "character ready" output available for CMOS or TTL interfaces. Fanfold box available.

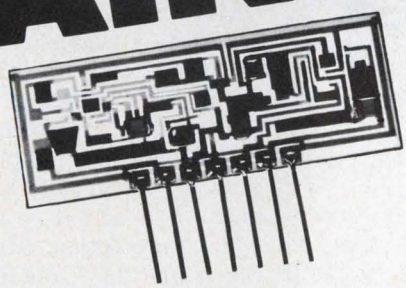
The Model 640 is the newest addition to the Addmaster line of quality paper tape equipment.

*only $151! (1-49 units; substantial quantity discounts available.

Addmaster Corporation, 416 Junipero Serra Drive, San Gabriel, California 91776. Telephone: (213) 285-1121.

CIRCLE NUMBER 123

GROWING PAINS?



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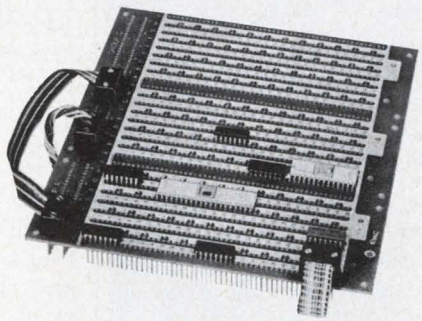
Interested? Call Allan Klepper (401) 769-3800 or contact Electronic Molding Corp., 96 Mill Street, Woonsocket, Rhode Island 02895.



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For Data Processing, Industrial Control and Instrument Application

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P.O. Box 743, Skokie, Illinois 60076
(312) 679-7180

CIRCLE NUMBER 126

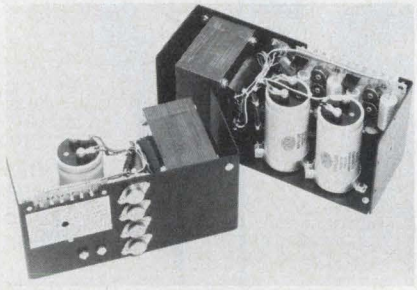
Converters come in various configurations

Bikor Corp., 1228 253rd St., Harbor City, CA 90710. (213) 325-2820. Price starts at $127.00; stock to 3 wks.

Three new families of power supplies are being unveiled by the company. DDU Series consists of 48 models and are dc-to-dc unregulated converters for voltage transformation and isolation. Input and output voltages available are 12, 24, 48 and 110 V dc with a choice of 48 through 220 W of output. Ripple is 0.5% max. DDR Series consists of 136 models of dc-to-dc regulated converters, and the ADR Series of 34 models of ac-to-dc regulated converters. Both series offer linear or switching regulators with 0.2% regulation and 0.3% max ripple. Single through four-output models are standard. Input voltages available are 12, 24, 48 and 110 V dc and 115 V ac, 50 to 400 Hz. Outputs range from 5 through 250 V dc with up to 180 W per output. Overvoltage protection is optional.

Booth No. 2515 Circle No. 514

Dual-output units deliver up to 120 W

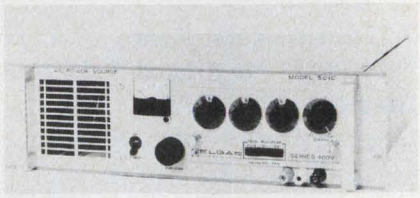


Abbott Transistor Labs, 1224 Anderson Ave., Fort Lee, NJ 07024. (201) 224-6900. $62 to $119; stock.

This OEM "LC" series converts 115 V ac, 47 to 420 Hz to dual outputs of 5, 12, 15, 24, 28, ±12, ±15 V dc. These models can deliver 15, 30, or 60 W per output. Line and load regulation are less than 0.1%, and ripple is 10 mV rms, 30 mV pk-pk. Full output power is available up to 50 C with no derating, forced-air cooling, or heat sinking needed.

Booth No. 2112 Circle No. 515

Frequency converters shrink in size

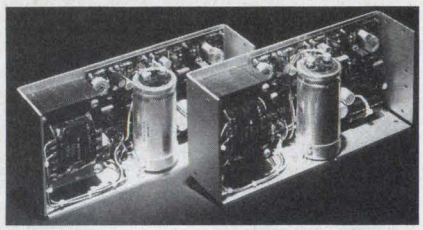


Elgar, 8225 Mercury Ct., San Diego, CA 92111. (714) 565-1155. Model 501, $1050; 4 wks.

The new "C" series of ac power sources is said to be one-third the size and one-half the weight of the company's conventional ac sources. Typical "C" series specs are 115 V ac or 230 V ac, 50 or 60-Hz input; 115, 230 or 26 V ac, 45-Hz-to-10-kHz output with 0.5% harmonic distortion. Model 501C is rated at 500 VA, is 5.25 × 19 × 17 in. in measurements and weighs 60 lb.

Booth No. 2713 Circle No. 516

Supplies aim at floppy-disc drives



Power-One, 531 Dawson Dr., Camarillo, CA 93010. (805) 484-2806. $120; stock-2 wks.

This new series is designed to power floppy-disc drive systems, including controller/formatter circuitry, from manufacturers such as Pertec, Diablo, CDC, Shugart, etc. First to be offered in the series is Model CP-162, a triple-output unit capable of powering two individual systems simultaneously. Outputs are 24 V at 5 A, 5 V at 3 A, and −5 V at 0.6 A, all with overvoltage protection. Of special interest is the 24-V regulator, capable of delivering up to 6-A output current for 500 ms upon initial system power-up. Following power-up, 5 A is available on a steady-state basis. Standard features include 115/230 V ac input, built-in overload and overvoltage protection, ±0.05% regulation, and remote sensing. Maximum ripple is 1.5 mV pk-pk, and transient response is specified at 30 μs for a 50% load change.

Booth No. 1619 Circle No. 517

The IMSAI 8080.

A commercial yet personally affordable computer.

If you thought you could never afford a computer at home, think again. The IMSAI 8080 is built for rugged industrial performance. Yet its prices are competitive with Altair's hobbyist kit. Fully assembled, the 8080 is $931. Unassembled, it's $599.

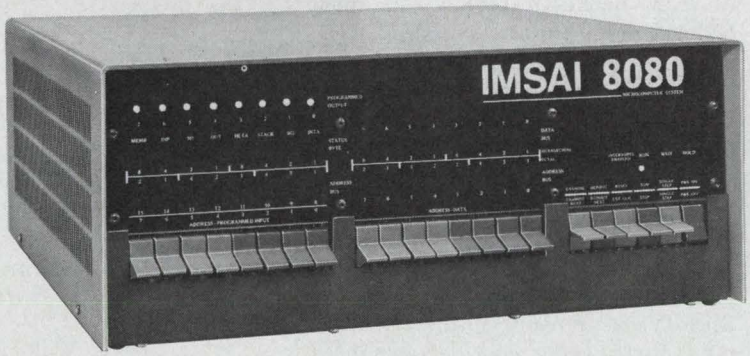
The IMSAI 8080 is made for commercial users, and it looks it. Inside and out. The cabinet is attractive, heavy gauge aluminum. The heavy duty lucite front panel has an extra 8 program controlled LED's. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches are backed up by reliable debouncing circuits.

The system is optionally expandable to a substantial system with 22 slots in a single printed circuit board. And the durable card cage is made of commercial-grade anodized aluminum.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system. You can expand to a powerful system with 64K of software protectable memory plus an intelligent floppy disk controller. You can add an audio tape cassette input device, a printer plus a video terminal and a teletype. And these peripherals will function with an 8-level priority interrupt system. BASIC software is available in 4K, 8K and 12K.

Get a complete illustrated brochure describing the IMSAI 8080, options, peripherals, software, prices and specifications. Send one dollar to cover handling to IMS. The IMSAI 8080. From the same technology that developed the HYPERCUBE Computer architecture and Intelligent Disk systems.

Dealer inquiries invited.



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CIRCLE NUMBER 127

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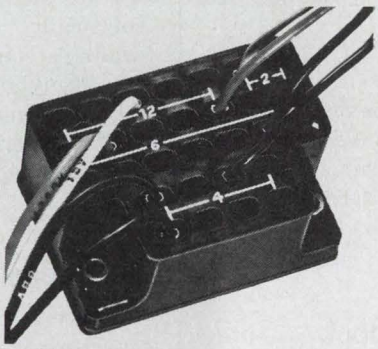

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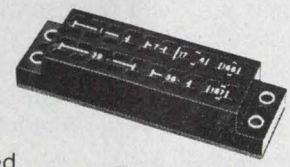

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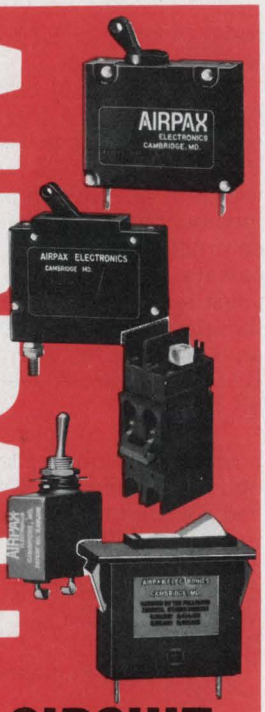

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CIRCLE NUMBER 130

Application Notes

Logic state analyzers

Two application notes describe the Model 1600A logic-state analyzer map-display capabilities. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 518

Display power supplies

Power-supply configurations for driving Beckman planar gas discharge displays are covered in a six-page note. Illustrated are basic designs of dc converters. Beckman Instruments, Information Displays Operations, Scottsdale, AZ

CIRCLE NO. 519

Pulse transformers

"Taking the Confusion Out of Specifying Power Transformers" puts forth some cost-performance guidelines derived from practical design and manufacturing experience. Inglot Electronics, Chicago, IL

CIRCLE NO. 520

Rectifiers

An application note describes the use of rectifiers in security systems. General Instrument, Semiconductor Products Group, Hicksville, NY

CIRCLE NO. 521

Solid-state handbook

"Handbook for Applying Solid State Hall Effect Sensors," an 84-page book, contains an illustrated section on actual "application assistance." The handbook devotes chapters to describing the Hall effect, sensor variations, magnetic considerations, electrical interfacing and other solid-state sensing technologies. Appendixes on terminology, Hall-effect theory and basic magnetics complete the book. For a copy, write on company letterhead to Sales Promotion Manager, Micro Switch, 11 W. Spring St., Freeport, IL 61032

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Charting and graphic art tapes come in solid colors, lines, patterns, solid and Benday point size rules and decorative borders. Circle the number for a free full size roll of Formaline tape and a 16-page catalog, which shows each tape in actual width, color and pattern. Graphic Products.

CIRCLE NO. 522

Strip terminals

Strip terminals and application tooling include plain or pretinned brass rings, spades, locking spades, quick disconnects and splices for wire sizes from 10 to 24 AWG. Terminal presses or applicators also are offered. Hoffman Industrial Products.

CIRCLE NO. 523

Ring tongue terminals

Heavy duty ring tongue terminals are made of 0.05-in.-thick electrolytically refined copper. The terminals come in #16 to 12 AWG sizes in nylon insulated, vinyl insulated and noninsulated types. Six stud sizes from #6 to 3/8 in. are offered in each type. Panduit Corp.

CIRCLE NO. 524

Single-position header

Discrete components, resistors, capacitors, diodes, etc., can be mounted on 0.3-in. centers with this single-position header. It can be plugged into any DIP socket. Its high-forked spring-tempered brass contact permits easy attachment of components. Aries Electronics.

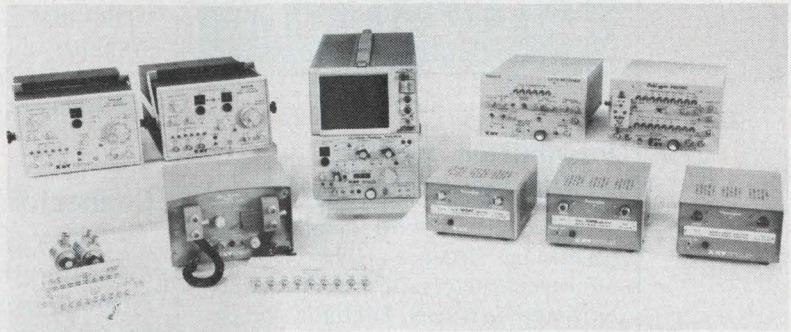
CIRCLE NO. 525

Adhesive sheets

Double-sided pressure-sensitive adhesive sheets mount anywhere quickly, cleanly and permanently. The sheets come in 18 × 24-in. and 24 × 36-in. sizes. Ulano Graphic Arts Supplies.

CIRCLE NO. 526

Just A Step Above The Rest



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New Half Rack Sweep Generators featuring a range of 1 to 1500 MHz in just **TWO** bands:
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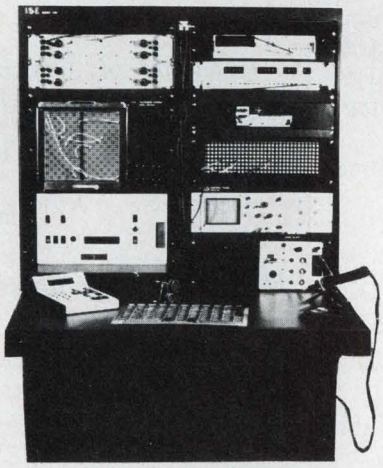

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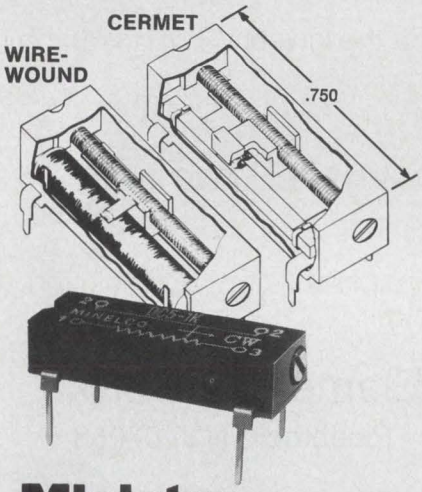

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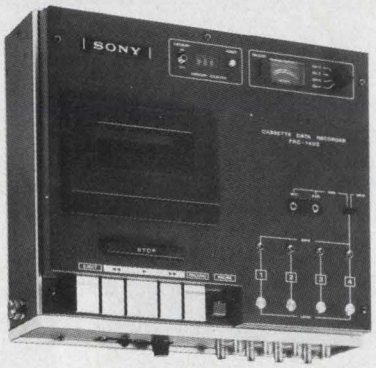

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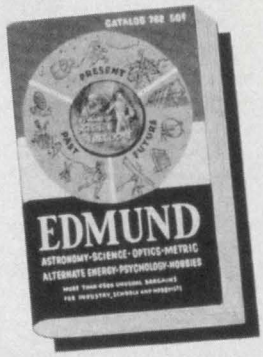

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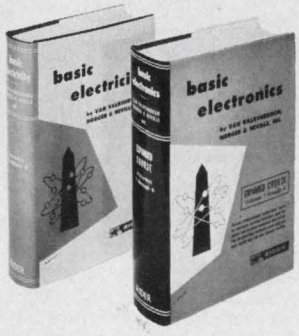

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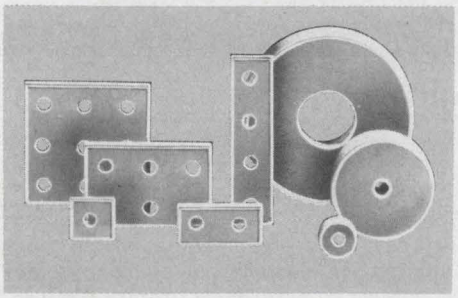

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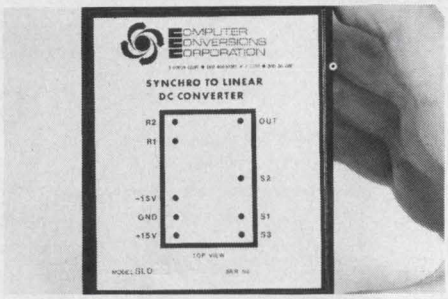

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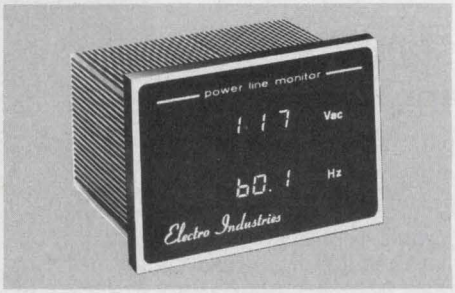

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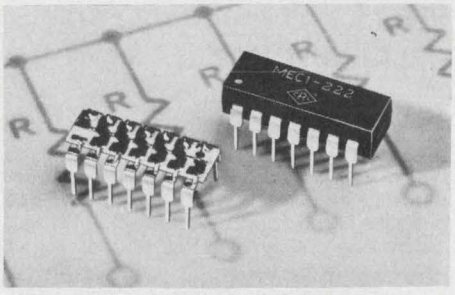

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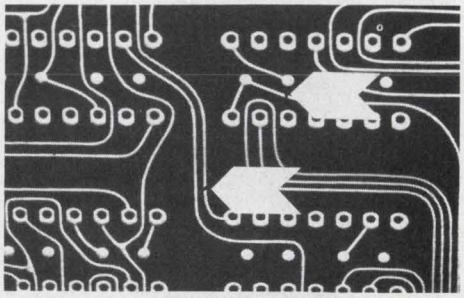

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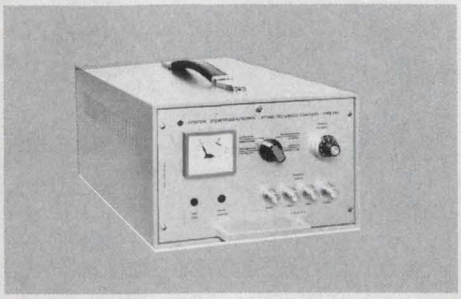

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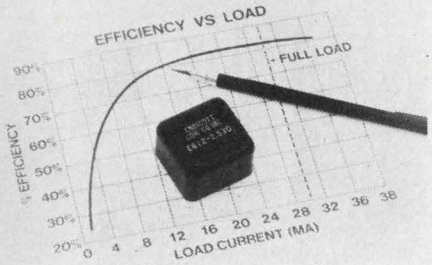

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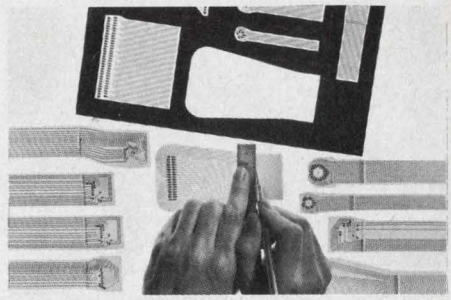

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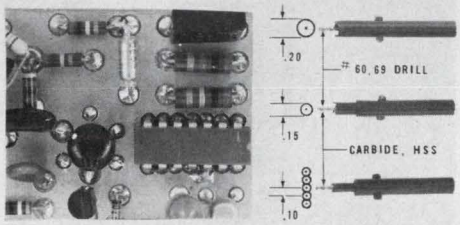

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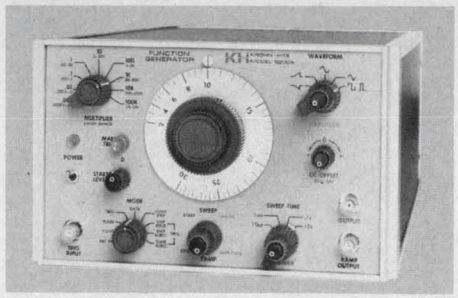

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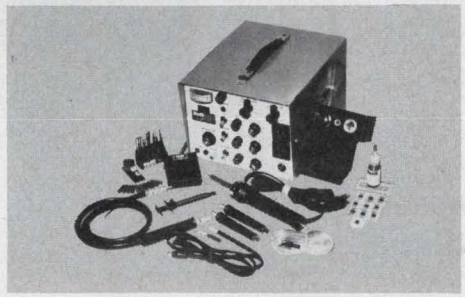

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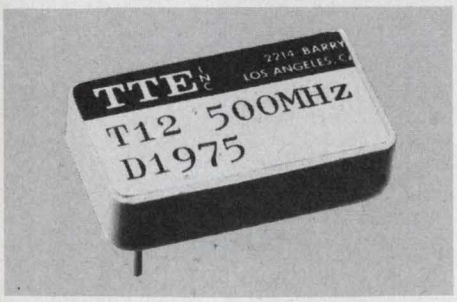

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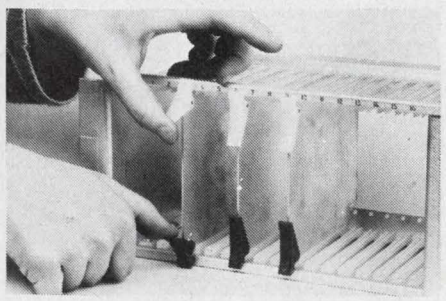
MINIATURE FILTERS **212**



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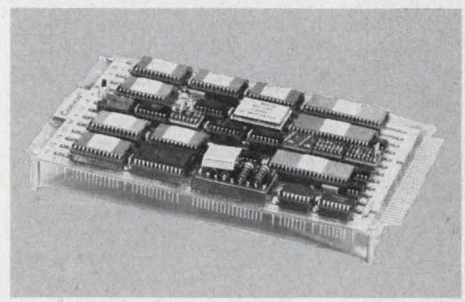

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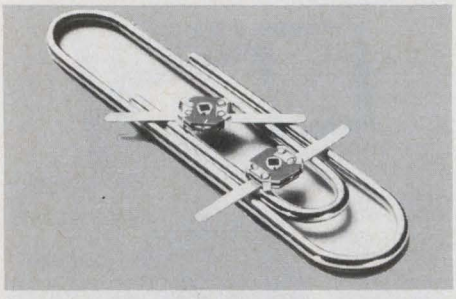

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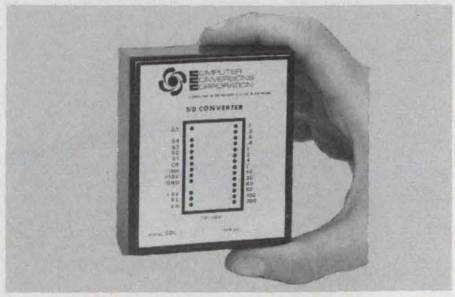
THIN-TRIM CAPACITORS 181



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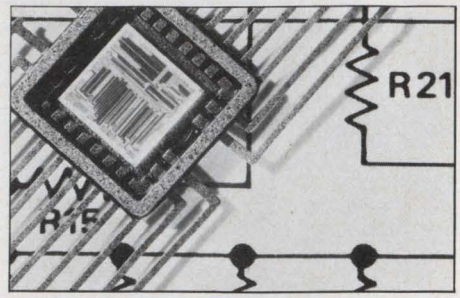

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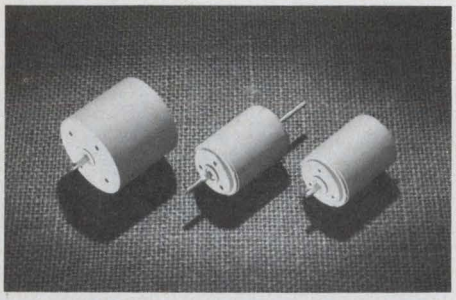

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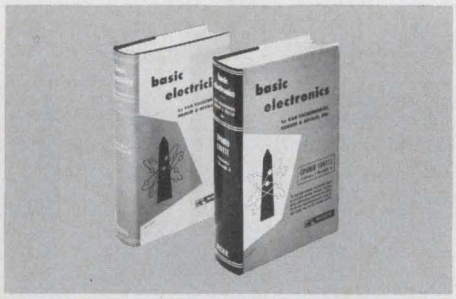

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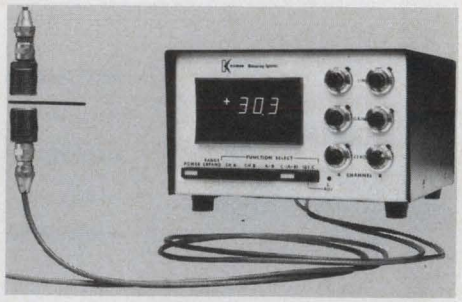

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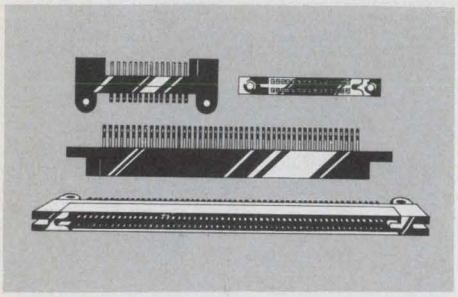

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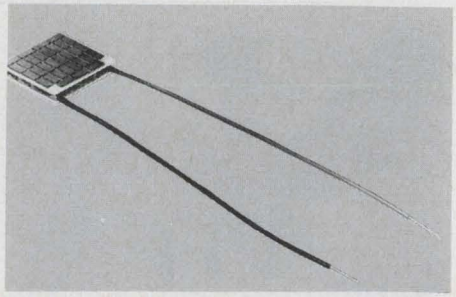

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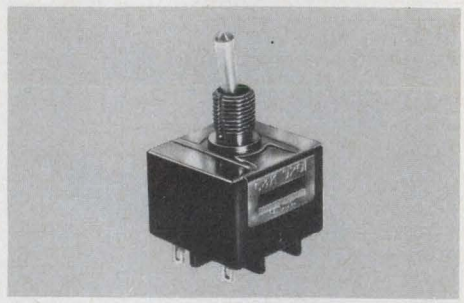

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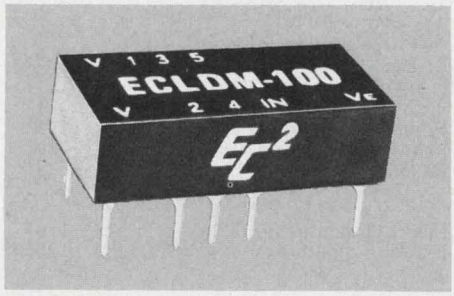

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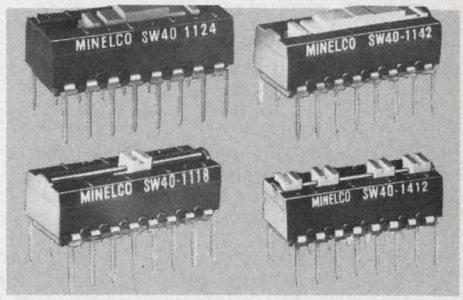

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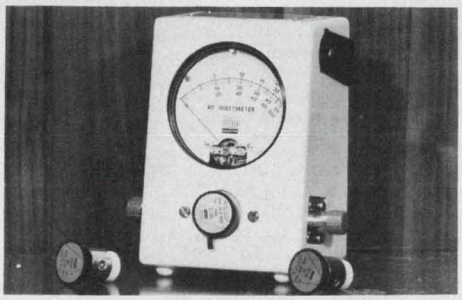

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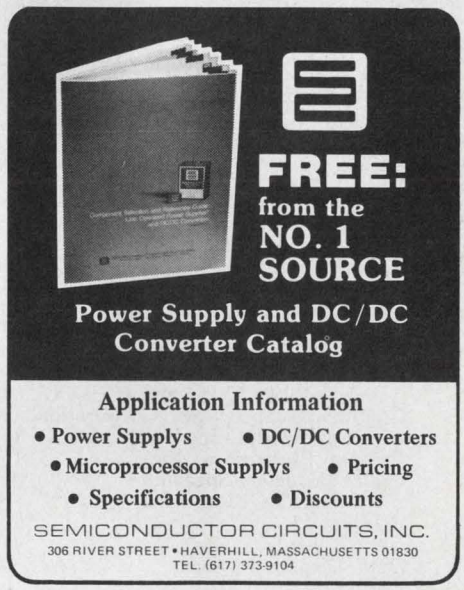

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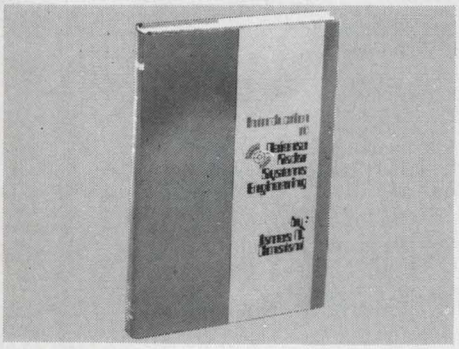

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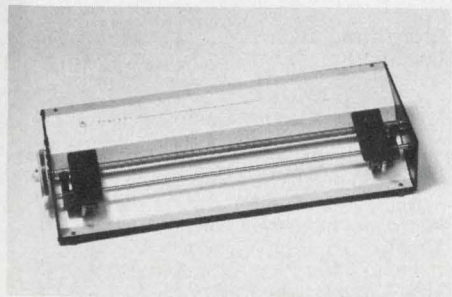

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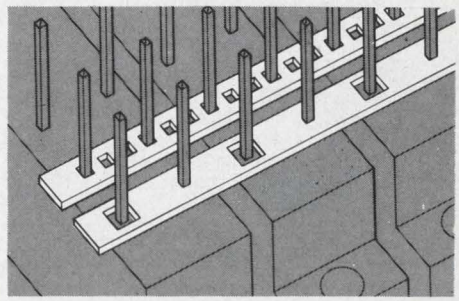

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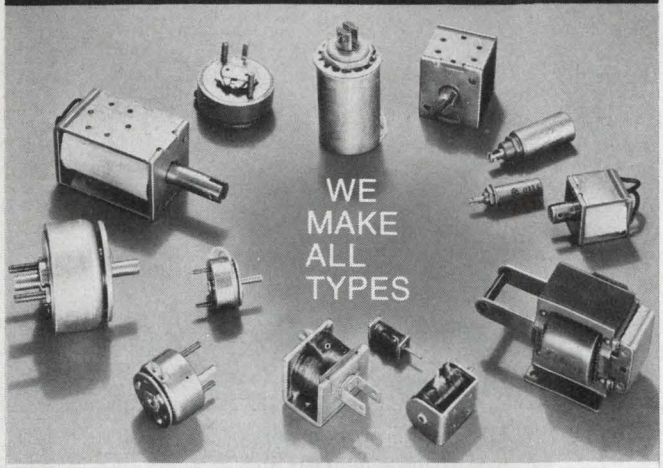

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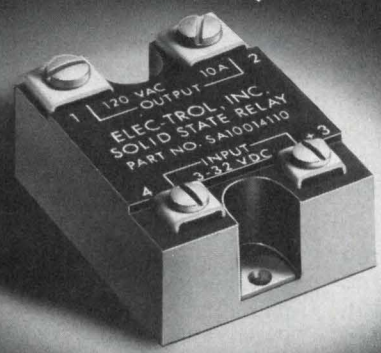

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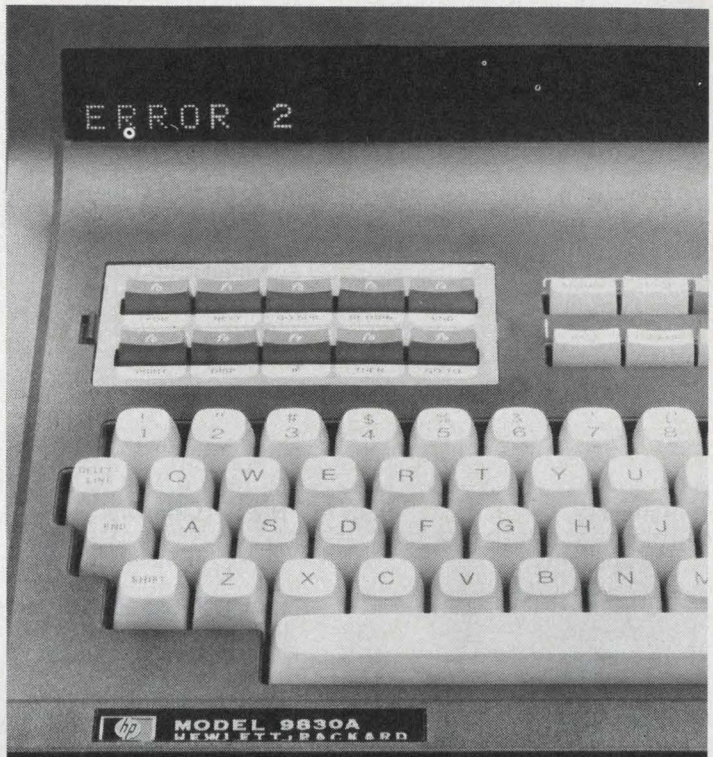

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CIRCLE NUMBER 139

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Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

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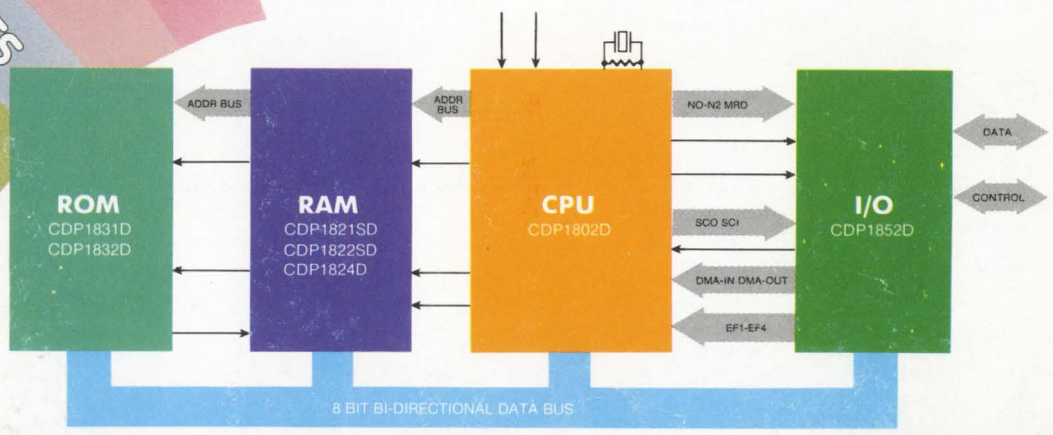

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