VOL. 24 NO. 1

Electronic Design®

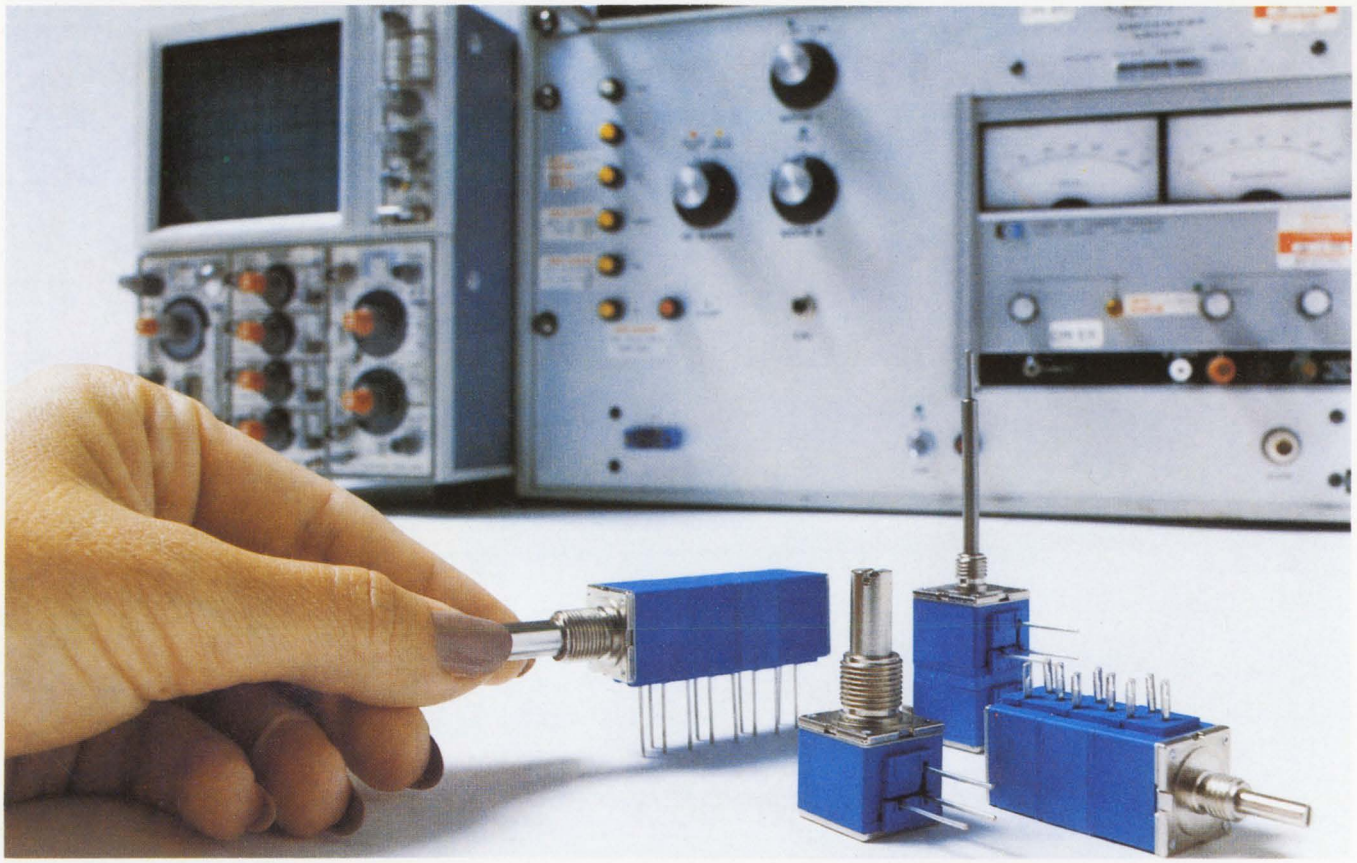
FOR ENGINEERS AND ENGINEERING MANAGERS

JAN. 5, 1976

What's likely to develop in '76? Microprocessors, PROMs and PLAs will be in the picture in a host of new products. Next year the focus will be on logic analyzers and calculator-based systems. Also, keep a sharp eye on low-cost mini and μP peripherals. For the big picture on electronics, turn to page 26.

Top Ten Contest!
Important you Enter
See Page 192

So good...
you can actually feel the difference!



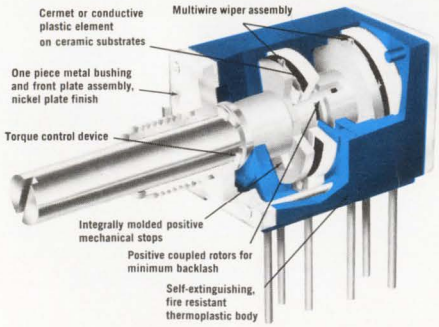
BOURNS announces an ADVANCED building-block potentiometer...

... with a velvety smooth control feel that will enhance the quality image of your equipment. It's BOURNS® new Model 80 Building-Block potentiometer.

The Model 80 incorporates a unique new shaft torque control device which enables us to produce an advanced modular potentiometer with a smooth, consistent high quality "feel" ... regardless of the number of modules ganged on a single shaft (shaft torque only .3 to 2.0 oz.-in.).

MODULAR VERSATILITY, FACTORY ASSEMBLY

Bourns modular concept combines the design versatility of advanced building-block construction ... with factory assembled reliability and quality control. All Model 80 potentiometers are built to your "prescription" by full-time production personnel, under the supervision and control of the industry's most respected quality assurance organization. High-volume assembly techniques, plus mass-produced modular components stock means fast delivery ... at competitive prices.

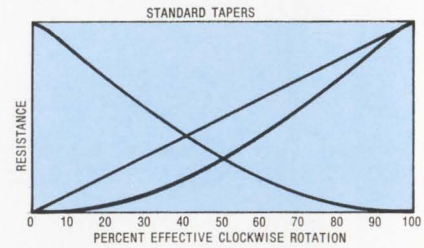


CERMET OR CONDUCTIVE PLASTIC

Bourns Model 80 is available with either cermet or conductive plastic elements in virtually all linear and non-linear tapers. Element types may be mixed in multiple section units. INDEPENDENT LINEARITY IS ±5% ... offering more precise phasing of potentiometer output to panel calibration.

SUPER SETABILITY

A multifinger wiper and precise resistive ink formulations provide tight 1% CRV in both cermet and conductive plastic elements. This – combined with a smooth, no backlash feel — makes for easy, accurate operator settings.



NO SHARP KNEE ON TAPERS

Model 80 audio tapers provide a smooth "knee", which allows improved setability within the crossover area on both cermet and conductive plastic.

FREE SAMPLES

Write on your company letterhead and tell us about your application. We'll send you the Model 80 that best suits your needs.

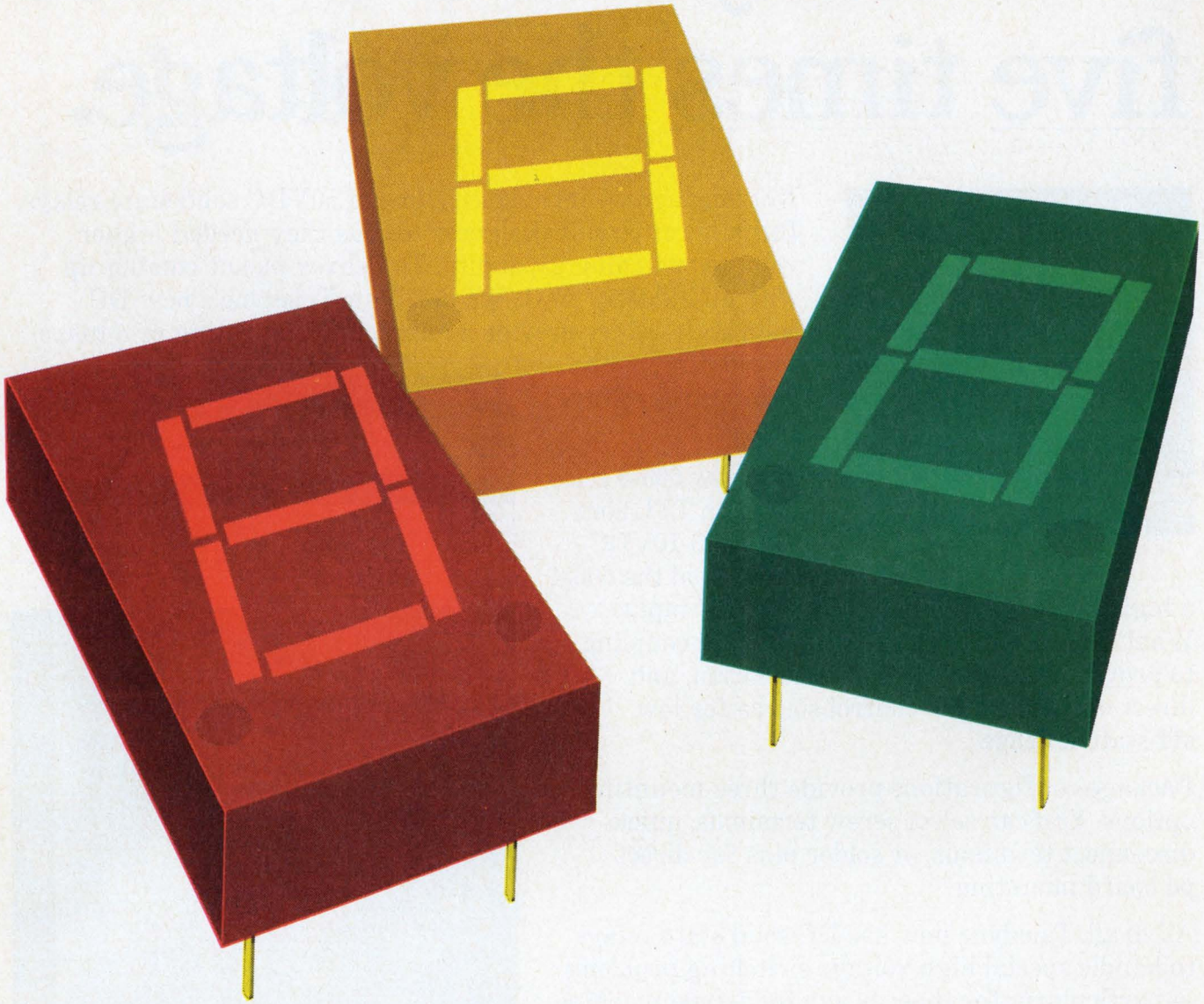
BOURNS INC

TRIMPOT PRODUCTS DIVISION

1200 COLUMBIA AVENUE, RIVERSIDE, CALIFORNIA 92507
PHONE 714 684-1700 TWX 910 332-1252 CABLE BOURNSINC

INFORMATION RETRIEVAL NUMBER 246

SURPRISE!



HP's 5 times brighter display!

At 20mA our new High-Efficiency red display is 5 times brighter than our standard red displays. Just 3mA per segment gives you all the brightness you need and makes it ideal for battery powered applications. These large .43" displays are offered in High Efficiency Red, Yellow, or Green and are readable up to 20 feet. The 5082-7650 (High-Efficiency Red), -7660 (Yellow), -7670 (Green) are available in standard DIP packages with left-hand d.p. and common anode configuration. Just $3.95* each in quantities of 100.

Contact Hall-Mark, Schweber, Wilshire or the Wyle Distribution Group (Liberty/Elmar) for immediate delivery, or write us for more information and our new application note on contrast enhancement.

01503 *Domestic USA price only.

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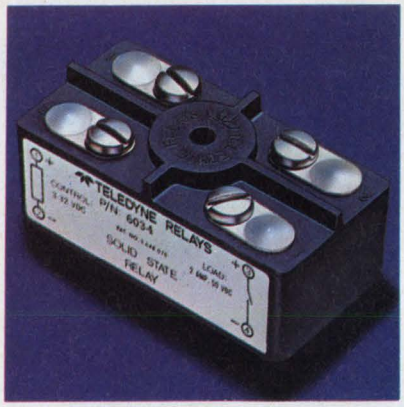
Sales and service from 172 offices in 65 countries.
1501 Page Mill Road, Palo Alto, California 94304

INFORMATION RETRIEVAL NUMBER 2

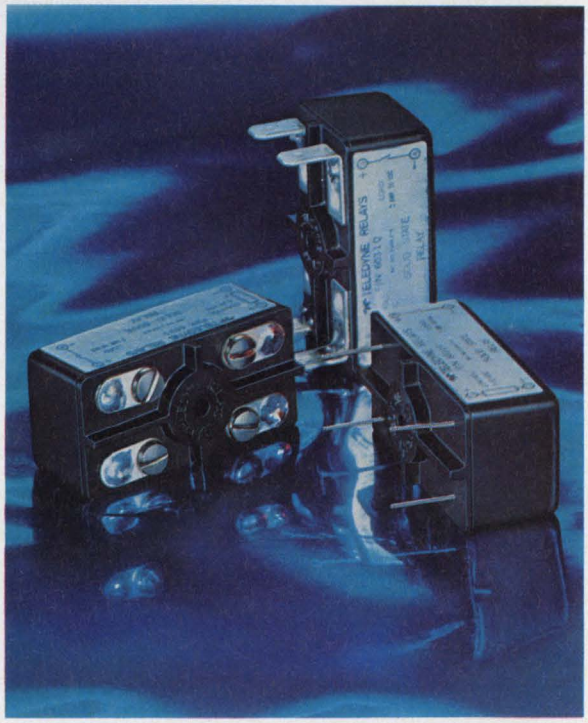
DC solid state update: new relays now handle five times the voltage.



Not long ago we introduced a line of 50VDC solid state relays. But a lot of circuit designers told us they needed higher voltage switching capability. To deliver meant coming up with an industry *first.* We did. Now Teledyne's new DC solid state relays provide a maximum load rating of *5 amps at 250VDC,* with two control voltage ranges.

PART NUMBER	OUTPUT CURRENT RATING (AMPS)	OUTPUT VOLTAGE RATING (VDC)	
603-1	2	50	
603-2	5	50	
603-3, -4	5	250	
603-21	2	50	Controlled Rise and Fall Time
603-22	5	50	

Our new 603-3 relay offers a TTL compatible 3-10VDC input, and the 603-4 a high level logic compatible 10-32VDC input. What's more, they feature transformer coupling to provide 1500V input/output isolation, and direct drive from the control source for low off-state leakage.



Package configurations provide three mounting options. You can select screw terminals, quick-disconnect terminals, or solder pins for direct pc board mounting.

All in all, Teledyne now has DC solid state relays to handle special high voltage switching problems — particularly for those heavy industrial machine and process control jobs.

For detailed information or applications help, contact your local Teledyne Relays people. They're sure to bring you up-to-date on high voltage DC switching.

TELEDYNE RELAYS

3155 West El Segundo Boulevard, Hawthorne, California 90250
Telephone (213) 973-4545

INFORMATION RETRIEVAL NUMBER 3

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

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JAN. 5, 1976

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34 **More memory in store for minicomputers** along with new and improved mini peripherals.

38 **Digital controls and dedicated microprocessor technology** are infiltrating all areas of consumer electronics.

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96 **Incorporate a calculator chip,** instead of a microprocessor, into your number-processing data system, and avoid software for math functions.

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Circuit converts voltages to 4-20 mA for industrial current-control loops.
Versatile analog multiplier/divider built with three standard ICs.
Expand a system's memory capacity without mounting hardware and board space.

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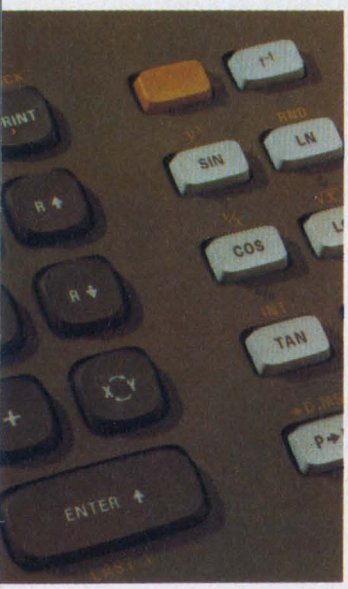
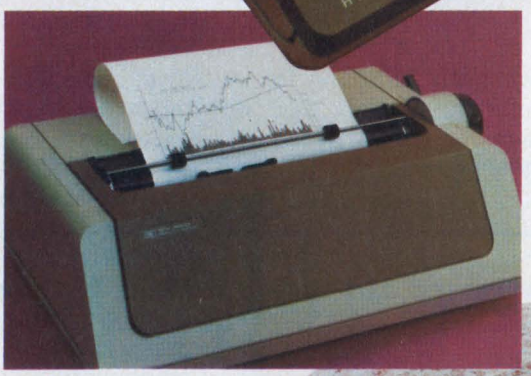




◂ ***Also new from HP:*** *The HP 9871 Page-width Printer/Plotter. Its unique bi-directional platen and 96-character printing disk let you run program-formulated charts and graphs; tables and text. Works with all HP 9800 series computing calculators.*

Announcing the HP9815. Look what your bucks will buy now.

High-speed data cartridge provides up to 96,384 bytes of program and data storage. Dual-track, 140 foot magnetic tape can be searched bi-directionally at 60 inches a second.

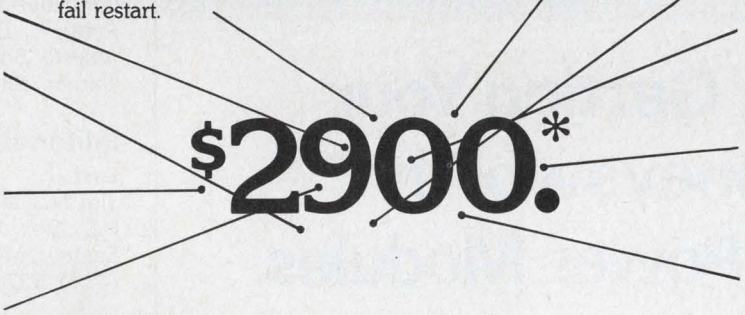
Thermal printer has full set of alphanumeric characters. Prints up to 16 characters per line at 2.8 lines a second.

Easy-on-the-eyes display can display up to 16 numeric characters or up to 10 digits in scientific notation.

15 user definable keys allow single keystroke execution of programmed routines.

Auto-Start switch initializes programs so an operator need only switch on the power and Auto-Start, and begin interacting with programs. It also provides power-fail restart.

Simplified programming, based on easy-to-understand logic and easy-to-remember mnemonics, lets you write powerful, complex programs easily.



Powerful editing features allow you to modify and update programs quickly and accurately.

Built-in math and trig functions provide simple, convenient keystroke calculations—just like you get from HP hand-held calculators.

HP stack-oriented notation is the efficient, powerful method for arithmetic operations. It reduces equations to a few easily-handled steps.

Compact and portable, the 13 pound HP 9815 is just 13½" x 13½" x 4".

*U.S. domestic price only. Does not include options, programs or peripherals.

And that's just for starters.

At its base-price, the new HP 9815 computing calculator is a price/performance leader. And the powerful 9815 becomes a uniquely versatile performer as you add optional features.

Interfacing capability is provided through an optional $200* two-channel I/O module. It allows a choice of seven different HP peripherals to work with the 9815, including the new 9871 page printer. You just plug them in, and they're ready to go. HP interface cards and cables allow the 9815 to control, gather and process data from a variety of instruments. And by adding an HP-Interface Bus, up to 14 instruments can be monitored simultaneously.

HP general-purpose programs are now available for statistics, electrical engineering design, surveying and radioimmunoassay. With them, problem solving is reduced to data entry.

Power, versatility, simplicity, low-cost—these are the characteristics of the new 9815. We call it a four-dimensional machine. Call your local HP sales office, or write for a copy of the HP 9815 brochure, and you'll see why.

HP computing calculators put the power where the problems are.

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095/17

Sales and service from 172 offices in 65 countries.
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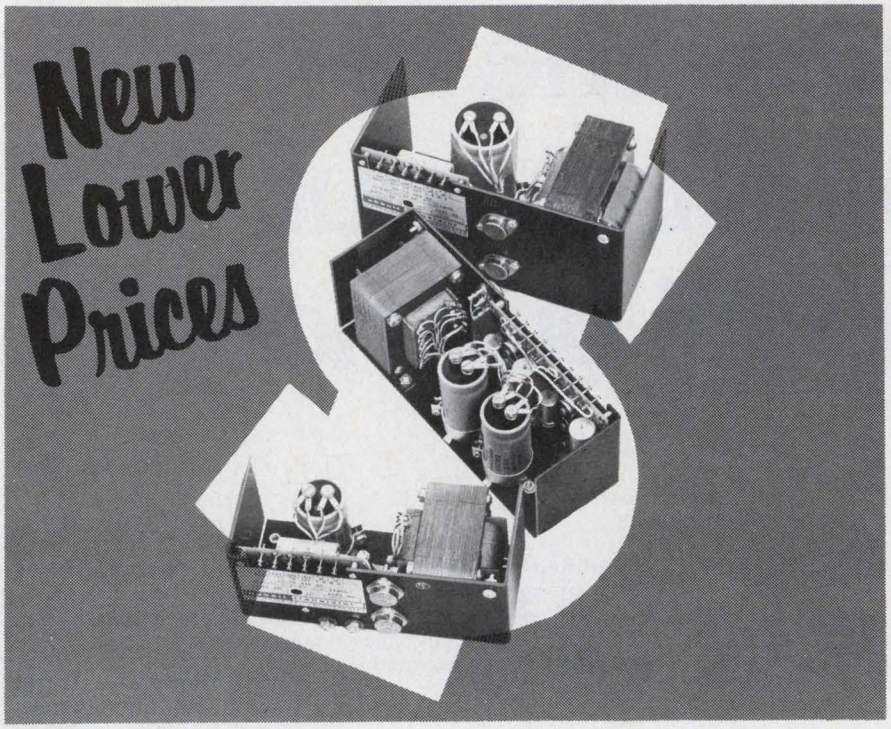
INFORMATION RETRIEVAL NUMBER 4



Start Getting Your Money$worth Out of Power Modules

Now, you can really start getting your moneysworth out of power modules with Abbott's new LOW COST series. Designed to give you 100,000 hours of trouble-free operation (that's 11½ years), these reliable units meet the needs of OEM engineers. Their purchase price is about $7 per year of service. The model LC series feature:

- 47-420 Hz Input Frequency
- 0.1% Regulation
- +60°C. Ambient Operation
- Single and Dual Outputs
- 1 Day Stock Delivery

These units provide more quality per dollar compared to similar items on the market. See table below for prices on some of our LC models. Many other LC models are listed in our catalog.

If analyzing the many similar power supplies on the market is confusing; if you are concerned about the long-term reliability of those units, then decide on an Abbott power supply for your system. Your best buy in OEM power modules is ABBOTT.

Abbott also manufactures 3,000 other models of power supplies with output voltages from 5 to 740 VDC and with output currents from 2 milliamps to 20 amps. They are all listed with prices in the new Abbott Catalog with various inputs:

60 ~ to DC
400 ~ to DC
28 VDC to DC
28 VDC to 400 ~
12-38 VDC to 60 ~

5V @ 6 Amps	5V @ 10 Amps	12V @ 10 Amps	15V @ 4 Amps	28V @ 1 Amp	±12V @ 1.2 Amps	±15V @ 4 Amps
LC5T6	LC5T10	LC12T10	LC15T4	LC28T1	LLC12T1.2	LLC15T4
$62	$73	$99	$73	$62	$87	$119.00

Please see pages 1054-1056 Volume 1 of your 1975-76 EEM (ELECTRONIC ENGINEERS MASTER Catalog) or pages 612-613 and 620 Volume 2 of your 1975-76 GOLD BOOK for complete information on Abbott Modules.

Send for our new 60 page FREE catalog.

abbott transistor

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Across the Desk

A 'terrific' idea, but—

In "Two Components Added to CMOS Flip-Flop Convert It to One-Shot or Level Detector" (ED No. 17, Aug. 16, 1975, p. 76), the idea of using a CMOS flip-flop as a one-shot is terrific. But not so terrific is its use as a level detector. Moreover the ideas are not so new; they've been around for years.

The authors, Gordon Silverman and Michelangelo Rossetto, also left out some important warnings and improvements:

- The poor transition quality of the $\overline{Q}$ output makes this signal often unusable.
- The duty cycle of the one-shot must be less than 50%, since it takes as long (or longer) to discharge the capacitor as it does to charge it. The recovery time can be reduced considerably by the addition of a diode, as shown in Fig. 1.
- The diode in Fig. 2 makes the one-shot retriggerable.

When the circuit is used as a level detector, the 4013's specified maximum clock rise and fall times of 15 μs may be violated and result in unreliable operation.

Marvin G. Edelstein
Senior Engineer
Pacific Telephone and Telegraph Co.
450 Mission St.
San Francisco, CA 94105

Correction on address

The address and telephone number given for Jonard Industries in the Oct. 11, 1975 issue of ELECTRONIC DESIGN (p. 138) is incorrect. The new address and phone number of this manufacturer of wrapping and unwrapping tools are as follows:

Jonard Industries, 134 Marbledale Rd., Tuckahoe, NY 10707. (914) 793-0700.

For readers interested in Jonard tools,

CIRCLE NO. 318

Wanted: Crystal clock for HP-45 calculator

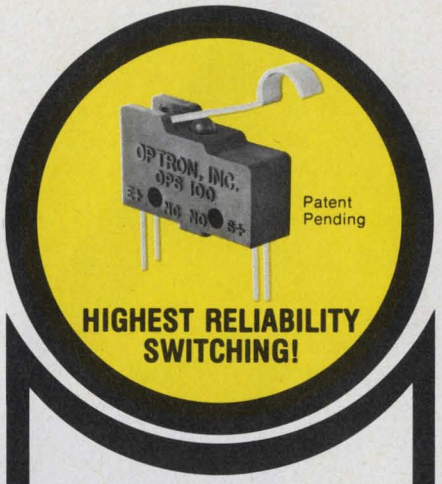
I found out that my HP-45 calculator has a feature that I didn't know about. It has a timer circuit built in, but the circuitry was not featured because of the lack of an accurate crystal clock. However, you can activate this feature by pressing the RCL key, then pressing CHS, 7 and 8 simultaneously. The display will then show: 00.00 00 00. This represents hours, minutes, seconds and hundredths of seconds.

In addition upper limits must be programmed for each of these two digit values. You do this by keying in HH.MMSSUU before you activate the above sequence and set the limits—HH $\leq$ 13, MM $\leq$ 59, SS $\leq$ 59, UU $\leq$ 99.

CHS starts or stops the timer program, CLX clears the timer to show all zeros, and EEX alternately blanks and unblanks the 1/100-s digits. ENTER stops the timer, clears the display and takes the calculator out of the timing mode. Pressing the decimal point key (.) does the same, except it preserves

(continued on page 17)

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.



OPTICALLY COUPLED LIMIT SWITCHES

OPTRON OPS-100 SWITCH LIFE FIVE TIMES THAT OF CONVENTIONAL SWITCH

OPTRON's new subminiature high reliability optically coupled limit switch features switch life exceeding 25,000,000 cycles, five times that of conventional switches.

The new OPS-100 limit switch combines the non-contact switching feature of popular optically coupled interrupter modules with the mechanical characteristics of conventional smaller limit switches. It consists of an infrared LED optically coupled to a phototransistor to provide solid state reliability in a conventional mechanical switch package.

The switch lever arm of the OPS-100 actuates an optical shutter mechanism to interrupt the light beam changing the state of the switch. The shutter is unique in that the switch can be converted at any time by the user from "normally open" to "normally closed" or vice versa. In addition, the OPS-100 eliminates contact bounce and RFI while offering an input-to-output isolation voltage exceeding 5 kV.

The optically coupled limit switch has a guaranteed minimum current output of 0.4 mA and is specified for interfacing directly with low power TTL or CMOS circuits. Selected units are available for interfacing with standard TTL circuits.

New OPS-100 limit switches are available from stock.

Detailed technical data on the OPS-100 limit switch and other OPTRON optoelectronic products . . . chips, discrete components, isolators, assemblies, and PC board arrays . . . is available from your nearest OPTRON sales representative or the factory direct.

OPTRON, INC.
1201 Tappan Circle
Carrollton, Texas 75006, U.S.A.
214/242-6571 • TELEX-73-0701
TWX-910-860-5958

INFORMATION RETRIEVAL NUMBER 6

Nobody has an easier to apply line of no-strip, no-solder, round-conductor flat-cable connectors than AMP.

Quick, easy terminating. The new AMP shuttle-tool is designed for reliable and repeatable production. Loading is easy. The operator simply pulls out the shuttle to load the cable and housing, and then pushes the shuttle in, to terminate. Alignment is automatic and positive. Pneumatic tooling is also available.

AMP Latch connectors terminate 10 through 60 leads on multi-conductor flat cable. Simultaneously. They mate with two rows of .025 posts on .100-inch centers. Our 14- and 16-position AMP Latch connectors mate with standard DIP sockets. There's also a family of edge connectors in the line.

Fail-safe. Dual camming and latching ears on the unique AMP Latch folding contacts provide a four-point electrical contact and mechanical grip for each conductor—not just two points—to provide true redundancy. You can inspect the termination itself before the cover is applied. After termination, inspection ports in the connector cover allow visual checkout of each fork-type contact for proper locking and latching. The latching of individual contacts prevents bowing or parting of the covers. The connectors can also be probed under electrical load via the inspection ports. To insure integrity, the cover also locks to both ends of the connector housing with auxiliary latches.

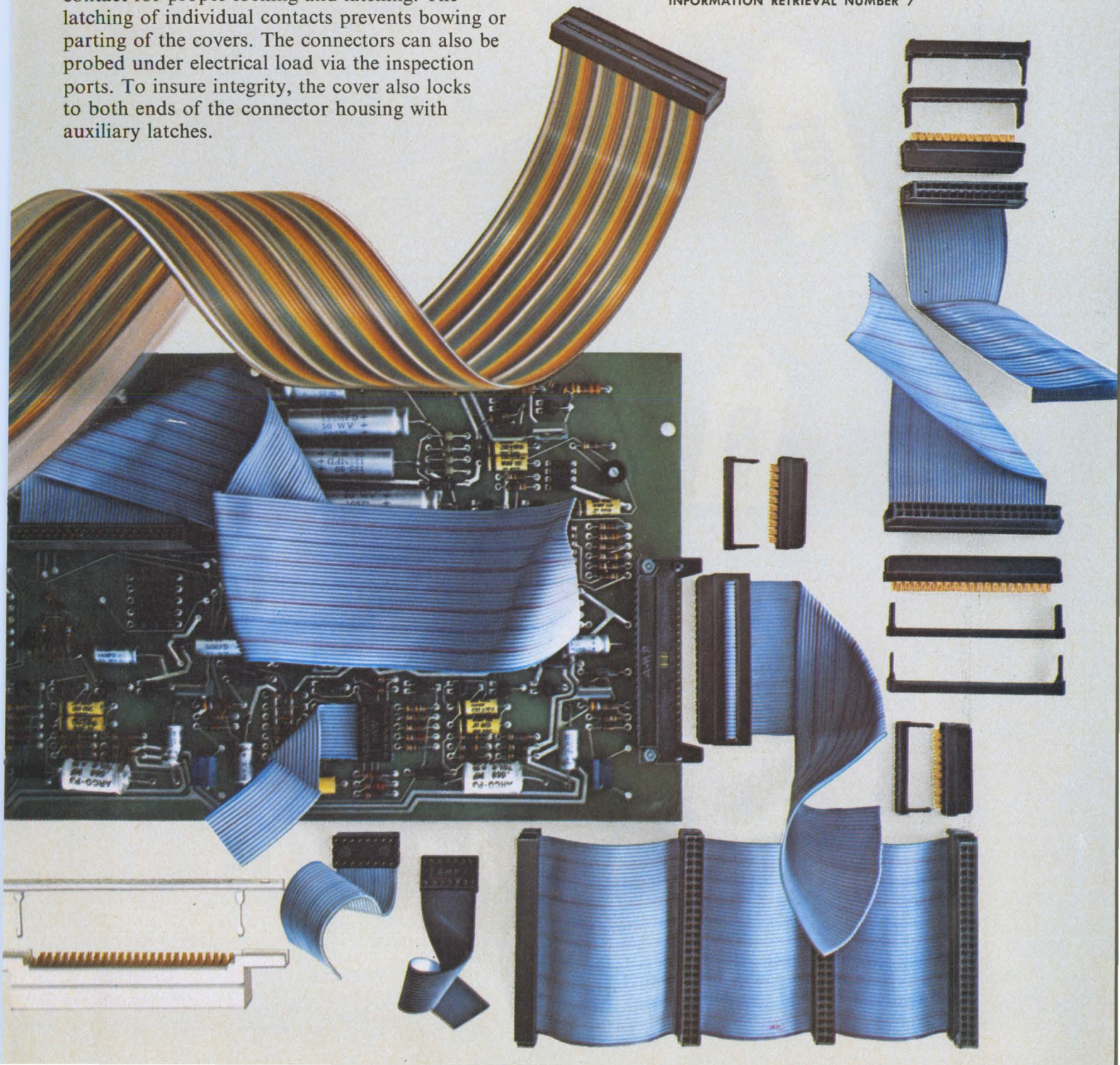
Connects three ways. With AMP Latch, you can interconnect to pc board spring sockets, directly to the board itself, or to DIP sockets—anywhere you want to interface on high-density, .100-inch patterns.

Ask your AMP representative for an in-plant demonstration. Or write for AMP Latch connector literature. AMP Incorporated, Harrisburg, Pa. 17105.

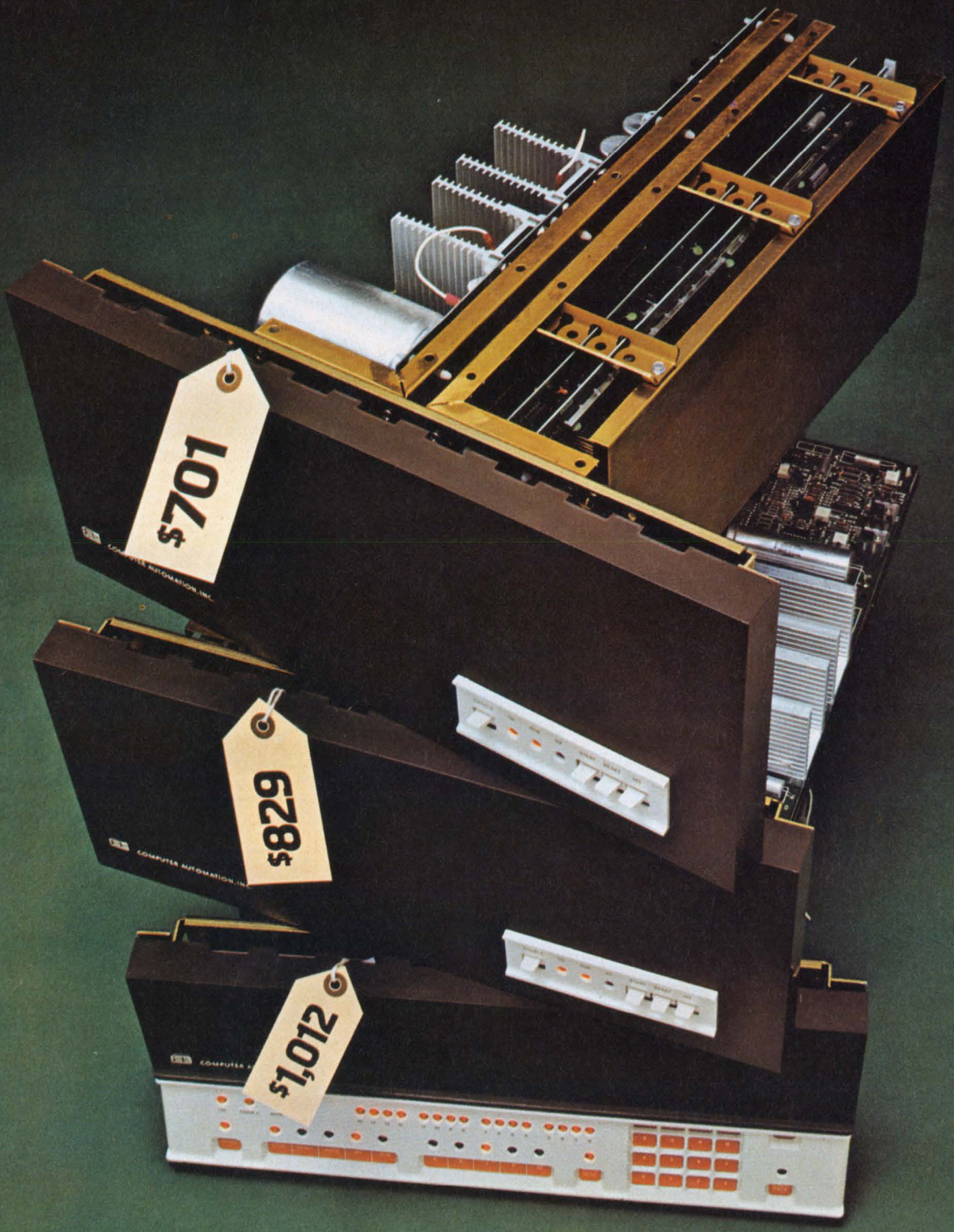
AMP is a trademark of AMP Incorporated.

AMP
INCORPORATED

INFORMATION RETRIEVAL NUMBER 7



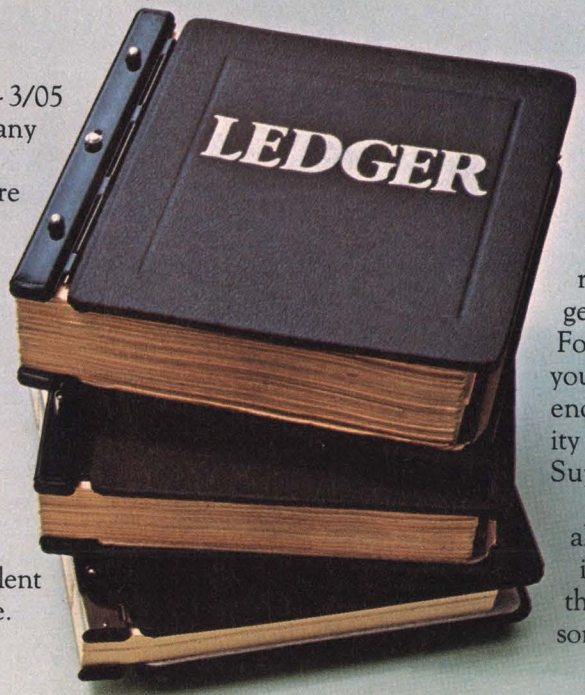
What our bottom-of-the-line



The New ALPHA™ LSI-3/05

Introducing the lowest priced, 16-bit, full-scale, fully compatible, packaged computers in the world.

can do for your bottom line.



Stack the new ALPHA LSI-3/05 millicomputer up against any other low-end computer.

Preferably while you're sitting down, because on price alone, you're bound to be astounded.

Ready? $701 total packaged price. And that's complete with 256 words of MOS RAM, and a CPU that offers a really powerful instruction set, Power Fail Restart, Real-Time Clock and Autoload capability.

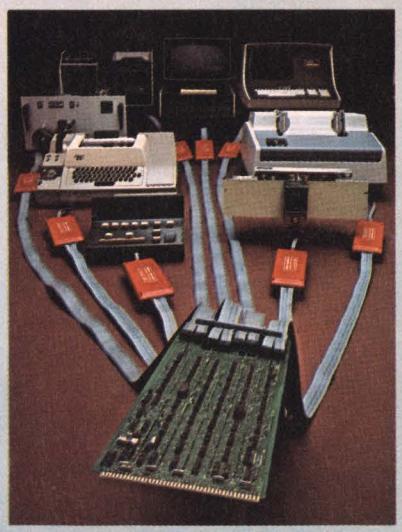
Try to buy an equivalent computer at twice the price.

Have it your way.

You also get the capability to configure your computer pretty well the way you want it. A choice of packaging, of course, that includes either the Operator's or the Programmer's Console, power supplies and so on.

A choice of two standard I/O options.

And a choice of optional memory configurations that include RAM/ROM, RAM/EPROM and RAM-only in sizes from 256 words all the way up to 32K words. Totally addressable.



Maxi-Bus compatible ALPHA LSI-3/05 achieves unprecedented cost-effectiveness with ComputerAutomation's new Distributed I/O System.

Family connections save you still more money.

So far, what we've been talking about could easily add another five or six figures to the bottom line of your ledger.

But there's more. Really big savings on off-the-shelf software, peripheral controllers and I/O interfaces.

The reason is that the ALPHA LSI-3/05 millicomputer is a full-fledged member of ComputerAutomation's LSI Family... Maxi-Bus compatibility and the whole works. So, every piece of Family hardware we've ever developed will work like it was made for the ALPHA LSI-3/05. Including ComputerAutomation's exclusive new Distributed I/O System... just like you see it in the picture.

With this versatile interface system, you can interface virtually any kind or combination of peripherals. Parallel or serial. Just by plugging them in.

Your cost? Probably less than $200 per interface.

The pros know.

Computer-wise OEM's will tell you that product requirements sooner or later get ahead of the hardware. For instance, the computer you buy today may not have enough I/O or memory capacity for tomorrow's Mark II Super Widget.

Then you'll have to scrap all your software and your interface designs, because they're not about to work on some other machine.

You lose.

Of course, with our LSI Family of compatible computers you don't.

You can switch to a different CPU or a different memory anytime. Faster, slower, bigger, smaller. The electrical interface will still be the same; the original programming will still work.

You win.

From the people who brought you the NAKED MINI.®

And the NAKED™ MILLI. And the Distributed I/O System. And the PICOPROCESSOR.

And now the ALPHA LSI-3/05 millicomputer.

One cost breakthrough after another. Breakthroughs that didn't just happen... a lot of profits got plowed back into R&D.

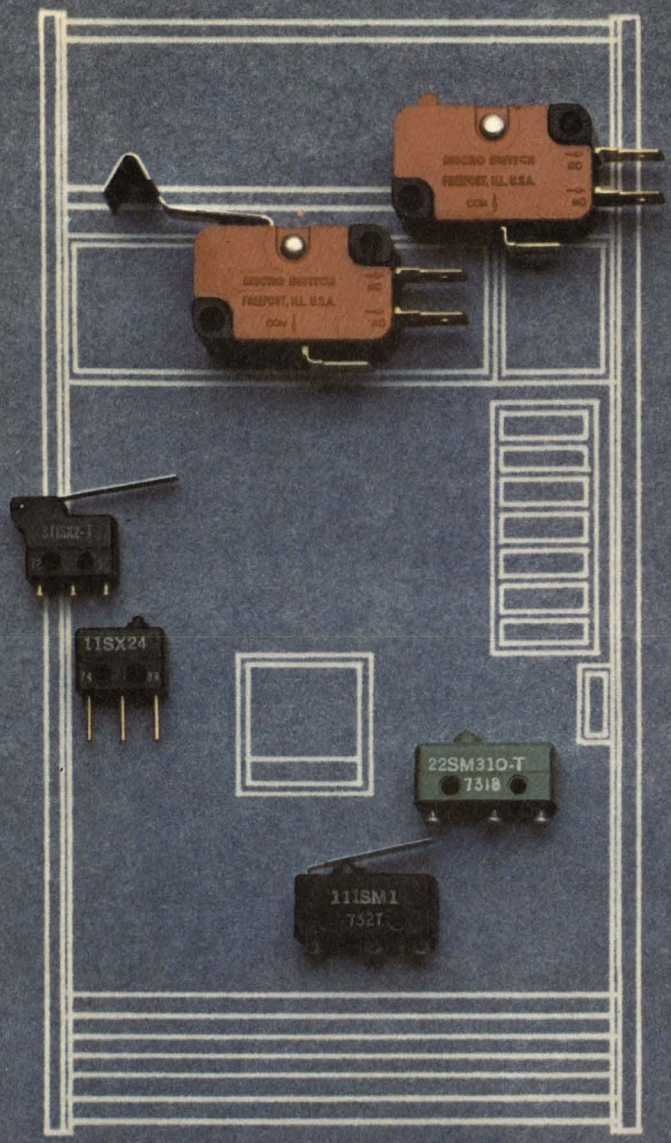
But then, that's the price of leadership.

ComputerAutomation
NAKED MINI Division

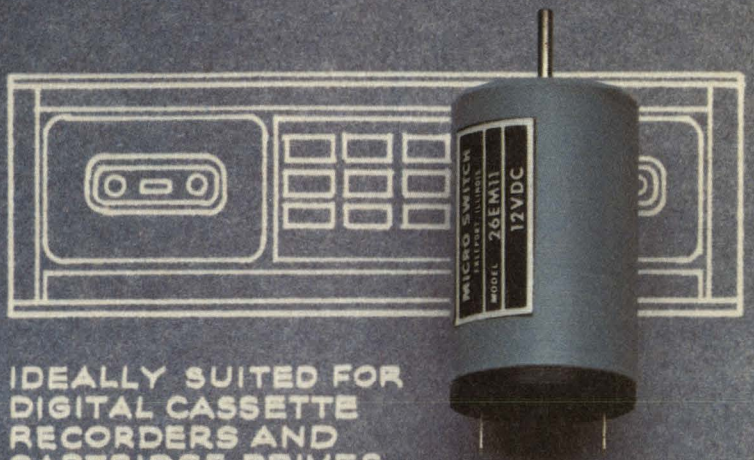
U.S.A. 18651 Von Karman, Irvine, CA 92664
(714) 833-8830
EUROPE 31/35 Clarendon Road, Watford, Hertfordshire, WD1, 1JA England (0923) 39627

All prices shown are for lots of 100 (U.S.A. only).

Some of these components will probably

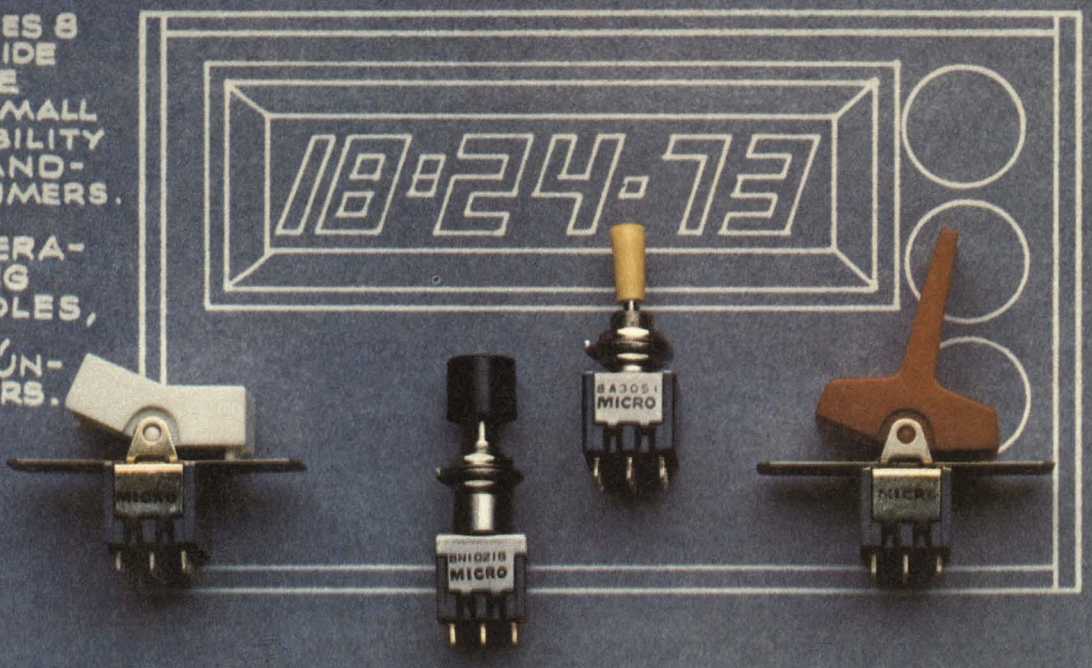


SNAP-ACTION V3, SM AND SX SWITCHES PROVIDE HIGH RELIABILITY AND ARE CAPABLE OF HANDLING HIGH OR LOW ENERGY CIRCUITS; PROVIDE OUTSTANDING PERFORMANCE FOR SELECTION, TIMING AND DISPENSING FUNCTIONS IN VENDING MACHINES.

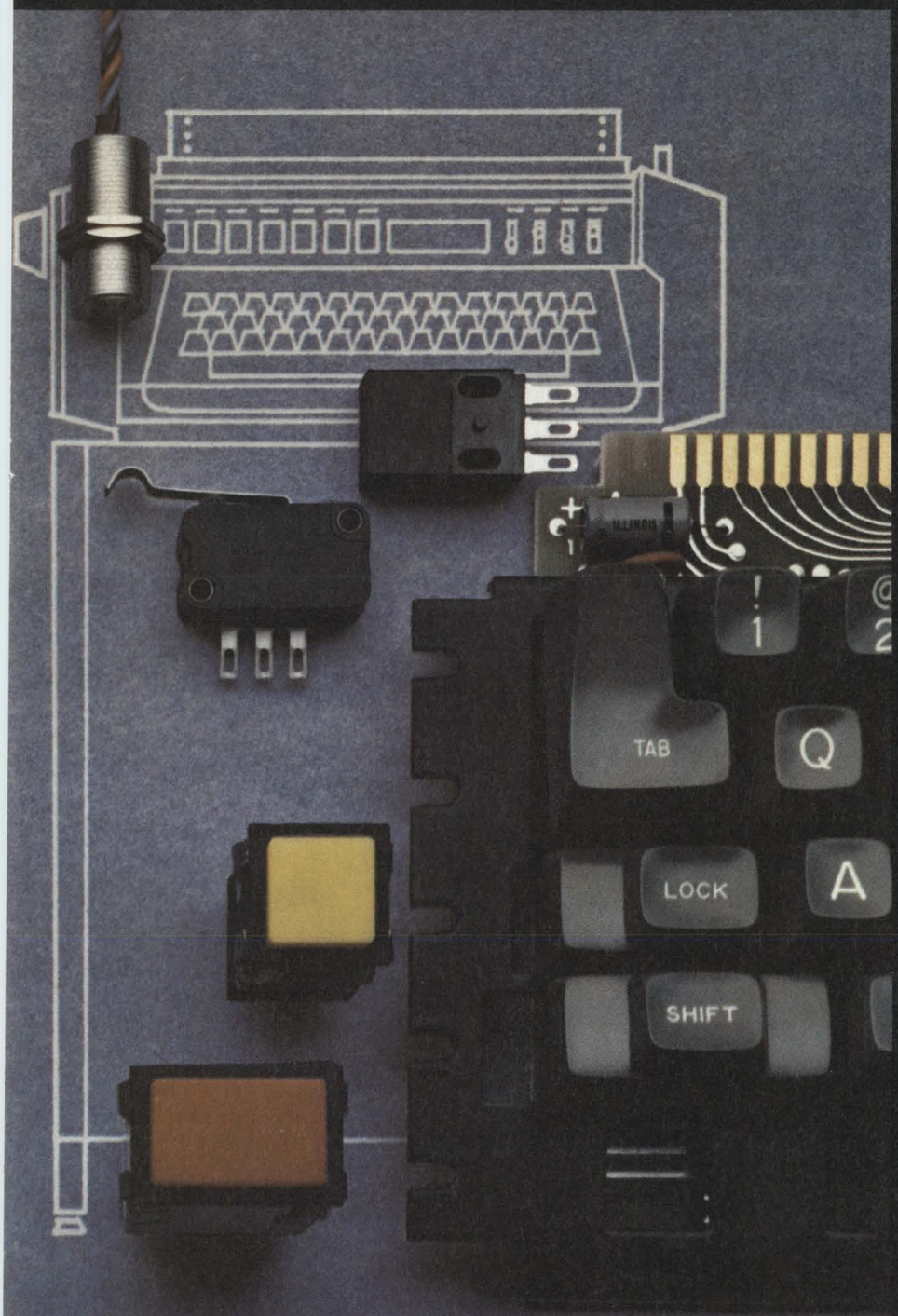


IDEALLY SUITED FOR DIGITAL CASSETTE RECORDERS AND CARTRIDGE DRIVES, THE 26 EM MOTOR USES A HOLLOW ROTOR TO PROVIDE THE LOWEST POSSIBLE ROTOR MASS, RESULTING IN VERY LOW INERTIA. DIRECTLY INTERCHANGEABLE WITH MOTORS MADE OUTSIDE USA.

MINIATURE SERIES 8 SWITCHES PROVIDE THE ATTRACTIVE APPEARANCE, SMALL SIZE AND RELIABILITY NEEDED FOR HAND-HELD DIGITAL TIMERS. OFFER A WIDE VARIETY OF OPERATORS INCLUDING TOGGLES, PADDLES, PUSHBUTTONS, LIGHTED AND UNLIGHTED ROCKERS.



never wear out. The others will just come close.



MICRO SWITCH COMPONENTS ARE IDEALLY SUITED FOR APPLICATIONS LIKE THIS PRINTER AND OTHER COMPUTER PERIPHERAL EQUIPMENT. FOR INSTANCE, THE SD KEYBOARD OFFERING HIGH RELIABILITY, LOW PROFILE AND LOW COST; THE AML LIGHTED PUSHBUTTONS, FEATURING QUALITY APPEARANCE AT A LOW COST, ELECTRICAL FLEXIBILITY, INCLUDING SOLID STATE VERSIONS; PLUS A COMPLETE LINE OF SOLID STATE POSITION SENSORS OFFERING ALMOST INFINITE LIFE AND COMPATIBILITY WITH COMPUTER LOGIC.

The solid state keyboard, AML lighted pushbuttons and solid state position sensors you see here will probably never wear out. Because they're all solid state.

Each is based on a Hall effect integrated circuit. A circuit that's been tested through billions of operations without failing. Even once. And proven by performance in a variety of applications. The other components you see here come close. Simply because of the way they're designed and put together.

Like the long-life versions of our snap-action V3, SM and SX precision switches. Available in a wide variety of sizes, electrical capabilities and ratings, terminals, actuators, contact forms and operating characteristics—they've been tested to a mechanical life of over 10,000,000 operations.

Or the Series 8 miniature manual switches. Designed with epoxy-sealed terminals on most versions for extra reliability. And offered with virtually any operator you might need. Plus terminals that include solder, quick-connect, printed circuit or wire-wrap.

The same standards of quality and product flexibility go into the 26EM DC motor. It's a miniature motor designed with low inertia operational characteristics. And just one of a line that ranges up to the 500VM, a motor capable of accelerating to 4000 RPM and stopping over 1000 times per second.

If you'd like more information on any of these components, contact your nearest MICRO SWITCH Branch Office or Authorized Distributor.

And find out how you can get a component that goes on forever. Or at least comes very, very close.

MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

MICRO SWITCH products are available worldwide through Honeywell International.

CIRCLE 231 FOR DATA
CIRCLE 232 FOR SALESMAN CALL

OK, who's the smart guy that just ran off with the power tab market?

We did. Motorola.
There's a couple reasons why.
"Firsts," actually.

One is we figured out exactly what sharp designers want in a transistor somewhere between TO-92 and TO-220.

2 watts. An honest-to-goodness, rugged, *conservatively-rated in-free-air* 2 watts.

Not a feeble, 1.67 or 1.75 others say theirs give.

Another's the lowest free-air Θ_{JC} in the industry. 62.5°C/W. Check the data sheets.

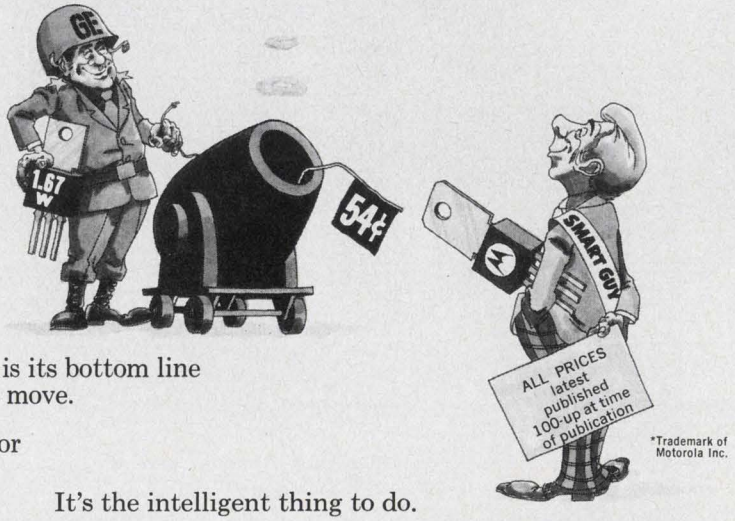
That's for lower junction stress levels and a real edge in reliability and long life.

A third's our new second-generation epoxy molding with lower resistance to heat, higher resistance to moisture and greater strength than others' dumb stuff.

(If you want to see documented results of epoxy's super-low failure rate after 600 cycles thermal shocking, just holler.)

And a fourth is heavy-duty leads and 2-mil gold wire.

We're so proud of our new family of general-purpose, Darlington and high voltage Duowatts* we 2N-registered it. JEDEC still hasn't received application from anyone else on a comparable product. If there is such a thing.



But enough technical brilliance.

What you bottom-line people will like is its bottom line runs about 10% less. Our most sensible move.

Contact your authorized Motorola distributor for 2-watt Duowatts.

Wise up.

It's the intelligent thing to do.

*Trademark of Motorola Inc.

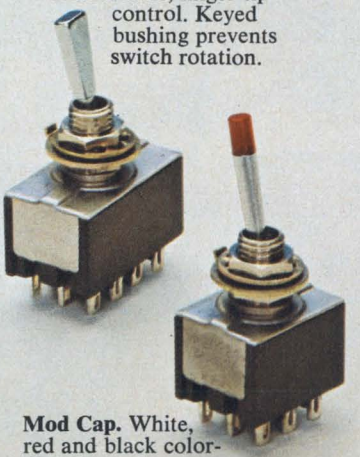
Motorola Doing It Better In Discrete

INFORMATION RETRIEVAL NUMBER 10

New "Cricket" sub-miniatures: Interchangeability plus full 6 amp rating.

Cutler-Hammer introduces a broad new line of quality sub-miniature switches whose specifications meet industry standards for size, terminal spacing and bushing height. They're rated 6 amps. They're fully interchangeable. They feature high torque bushings. They're competitively priced. And they're available right now. For more information on new, interchangeable sub-miniature switches, call your Cutler-Hammer sales office or Stocking Distributor. Just ask for "Cricket."

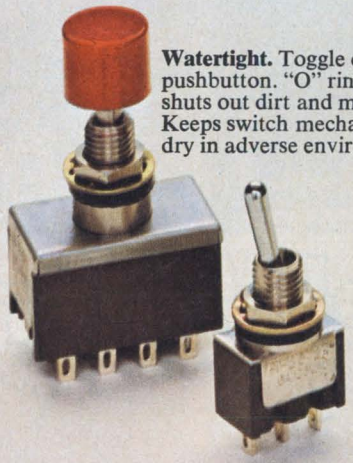
Flat Lever. Designed for comfortable, finger-tip control. Keyed bushing prevents switch rotation.

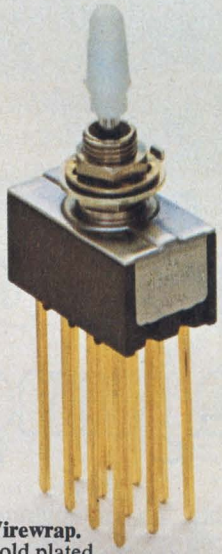


Lever Lock. Locks in position to assure precise control of vital or sensitive functions and equipment. No accidental operation.

Mod Cap. White, red and black color-tipped caps let you choose and vary your operational coding.

Watertight. Toggle or pushbutton. "O" ring seal shuts out dirt and moisture. Keeps switch mechanism dry in adverse environments.

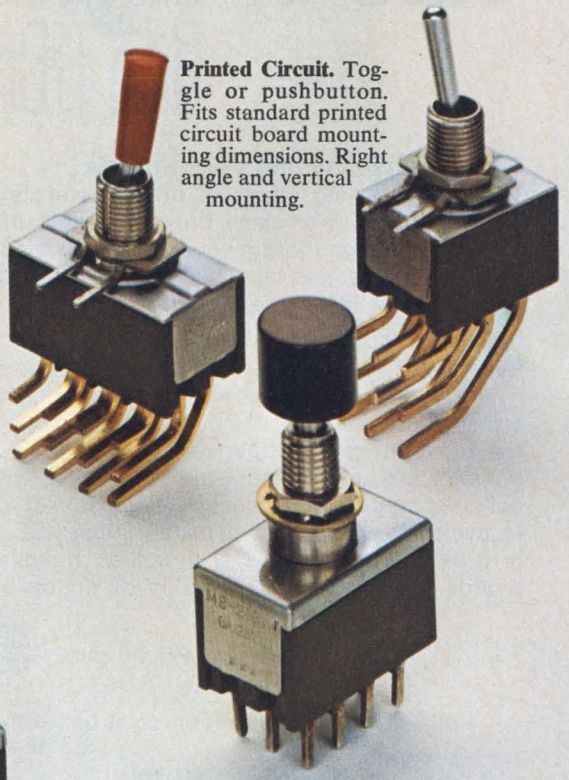




Wirewrap. Gold plated terminals in .750 and .964" lengths to satisfy power or dry circuit requirements.

Rockers. Sub-panel or snap-in. Variety of paddle or low-profile styles. With decorative bezels. Also with L.E.D. for illuminated functions.

Printed Circuit. Toggle or pushbutton. Fits standard printed circuit board mounting dimensions. Right angle and vertical mounting.



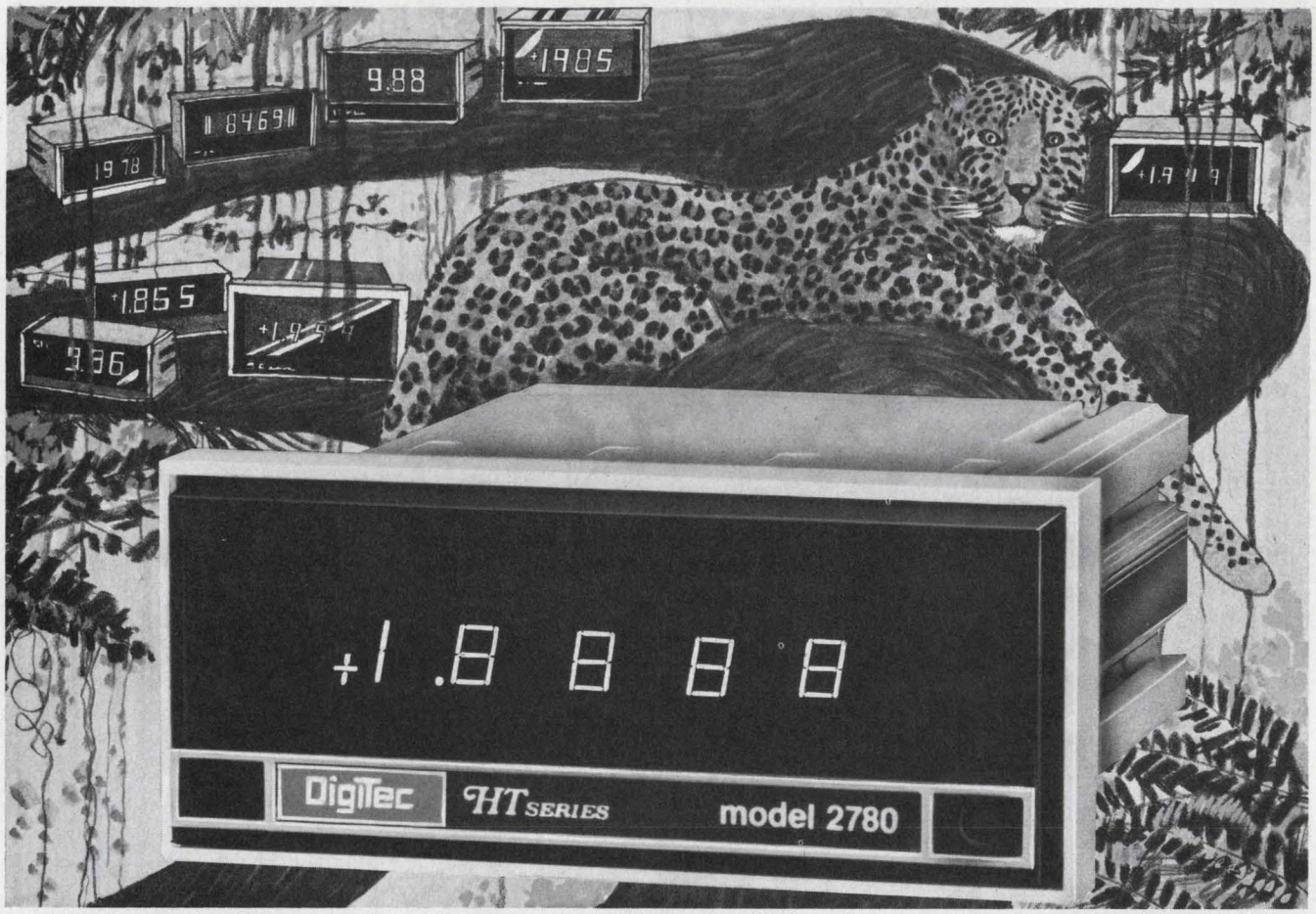
Standard. Toggle or pushbutton. One to four poles. Eight circuits. Two decorator cap styles in a variety of colors. Dry circuit capability, too.

Switch to No.1

CUTLER-HAMMER
SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

CONTROL

INFORMATION RETRIEVAL NUMBER 11



The 'toughest' Panel Meter in the jungle!

Fierce Reliability and Performance
There's a teeming jungle of panel meters available today. You need to slash thru the tangle of prices and specifications to the very roots. You must find a panel meter that can take anything while it gives continuous reliability and accuracy.

Lean, muscular stamina
Every DigiTec panel meter is bred to survive and deliver under any conditions. Proprietary CMOS LSI circuitry gives a lean component count with 5 times the reliability of competitive TTL models. All components are selected for savage stamina, with critical components 100% inspected and socket mounted to avoid assembly heat damage. Every LED display is pre-tested and rated at 1 million hours. Circuit boards are immune to humidity or floods because they're conformally coated on both sides. Shock, vibration and corrosion damage have been eliminated by extra mechanical reinforcement and gold plated connectors.

Endurance tested and certified
All DigiTec panel meters are subjected to a minimum 168 consecutive hours of failure free burn-in at temperatures that vary from +25°C to +55°C. Before and after burn-in, each meter is visually inspected and electrically tested. When a DigiTec panel meter goes into that jungle . . . it's ready for anything and tough enough to last 9 lifetimes!

Model 2780 — 4½ digits, 0.01% accuracy (shown)
* **Model 276** — 3½ digits, unipolar, 0.1% accuracy
Model 277 — 3½ digits, bipolar, 0.05% accuracy
Optional buffered, BCD output available - field installable.

Priced under **$100.*** in OEM quantities

Call your nearest United Systems representative for complete specifications.
All models available from stock.

DigiTec UNITED SYSTEMS CORPORATION

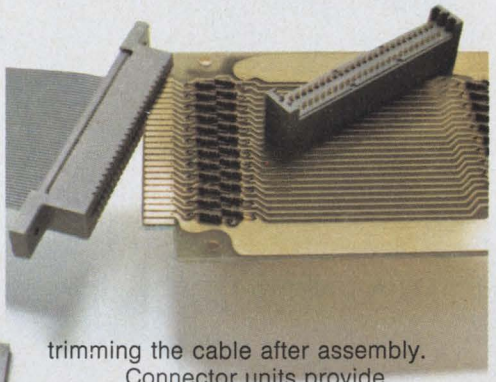
918 Woodley Road • Dayton, Ohio 45403 • Ph: (513) 254-6251 • TWX: (810) 459-1728

These instruments available under GSA Contract GS-OOS-27741

INFORMATION ONLY CIRCLE # 281

DEMONSTRATION ONLY CIRCLE # 282

Design with the complete flat cable/connector system.



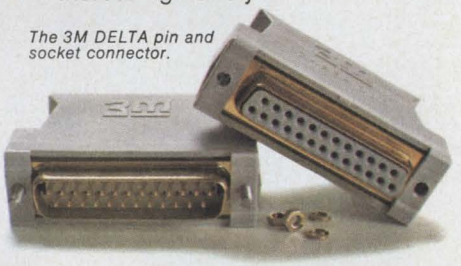
trimming the cable after assembly.

Connector units provide positive alignment with precisely spaced conductors in 3M's flat, flexible PVC cable. The connector contacts strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

With cable, connectors and assembly tools from one design and manufacturing source, you have added assurance the connection will be made surely, with no shorts or "opens."

And "Scotchflex" now offers you more design freedom than ever. From stock you can choose shielded and non-shielded 24-30 AWG cable with 10 to 50 conductors, and an ever-increasing variety of more than

The 3M DELTA pin and socket connector.



100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.

Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable *plus* connectors *plus* the inexpensive assembly aids that crimp the connections quickly and securely (with no special operator training required).

The fast, simple "Scotchflex" assembly sequence makes as many as 50 simultaneous multiple connections in seconds, without stripping, soldering or

3M COMPANY

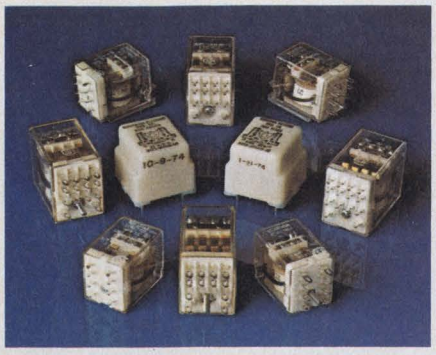
3M's "Scotchflex" line.

"Scotchflex" is a registered trademark of 3M Co.

INFORMATION RETRIEVAL NUMBER 14

Thirteen

just became your lucky number!

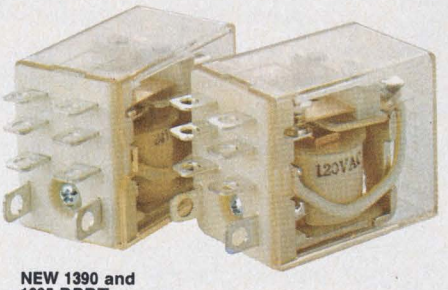


Three new 10 amp relays give you 13 small enclosed relays from which to choose.

Your Guardian Angel calls them the 1300 series, of course.

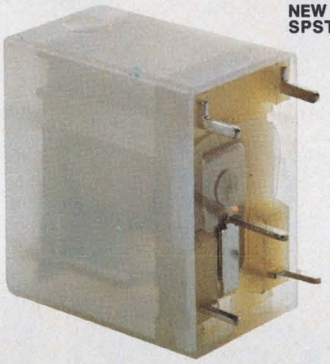
Amazing. Versatile. Small. Enclosed. Multi-pole. These five words sum up Guardian's 1300 line of 13 basic models . . . in hundreds of variations. Each relay in a choice of AC or DC, solder lug or printed circuit termination. Each with its own mating socket. Each your ideal spec for any application requiring uncompromising high quality at low, affordable price.

NEW! 1345DC relay in your choice of SPST-NO, SPST-NC or SPDT. Small in size but built to take hard knocks. Just over a cubic inch small, yet specifically designed for a minimum of 50,000 miles of maintenance free operation in automotive controls . . . or an equally amazing trouble-free life anywhere you need small size, long life and low, competitive price.



NEW 1390 and 1395 DPDT

NEW! 1390AC and 1395DC relays, DPDT with 10 amp rating in a space-saving, compact new design. To give you large control capacity in a package about half the size of competitive relays that do the same job. The cost? Just about the same as competitive units . . . in many cases quite a few cents *less.*



NEW 1345 SPST-NO, SPST-NC, SPDT

SEND FOR THE BOOK THAT TELLS IT ALL:
Guardian's 48 page relays catalog. Full of facts and specs to make selecting a relay a snap. Yours free for the asking.

GUARDIAN®

GUARDIAN ELECTRIC MANUFACTURING CO. • 1572 West Carroll Ave., Chicago, Illinois 60607

INFORMATION RETRIEVAL NUMBER 13

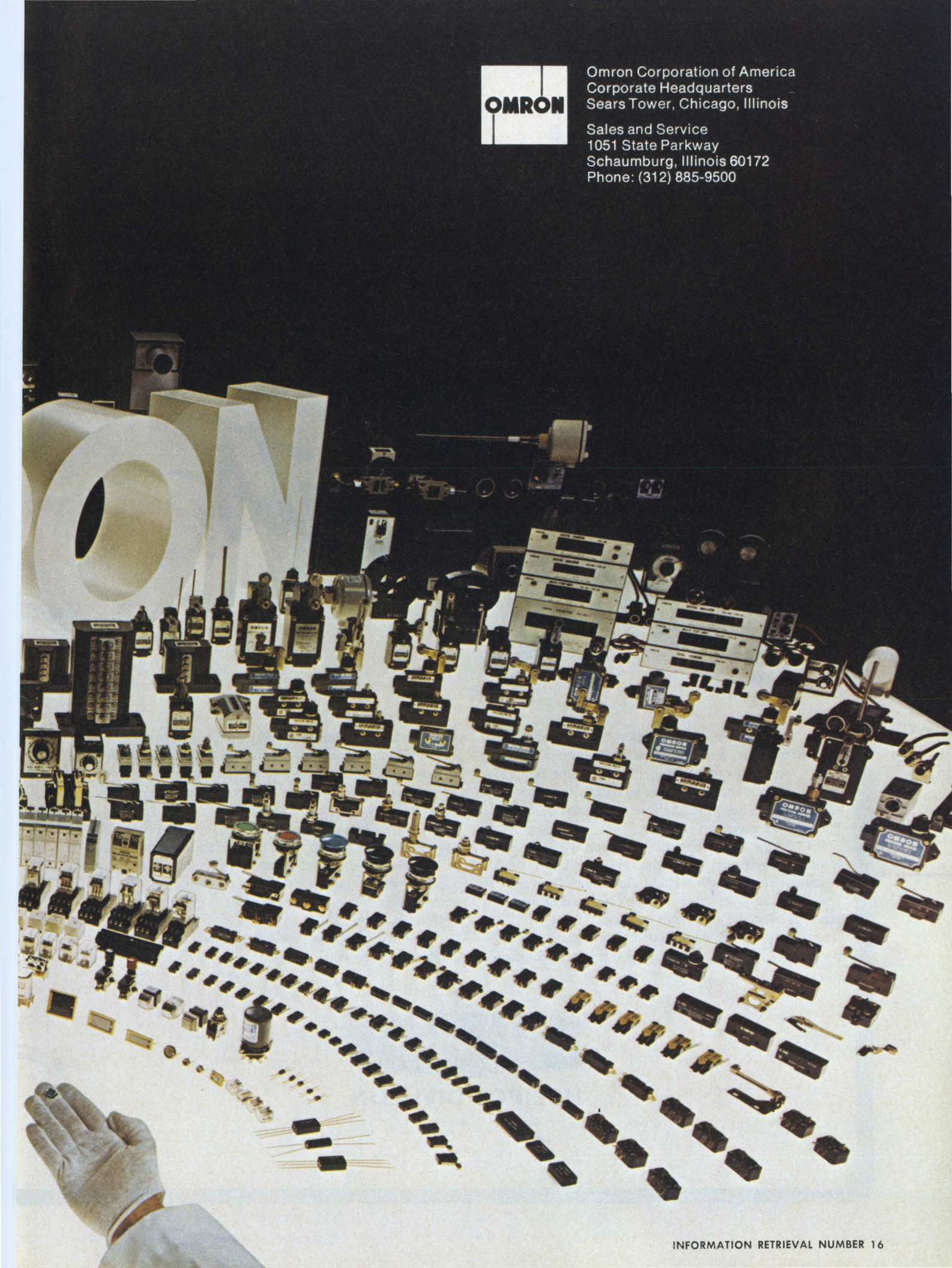
Through Omron's 43-year history, each product has been designed and built as we have seen needs and filled them. One by one, year after year, as your needs grew, so did our family. And our family continues to grow—so that today Omron offers some of the broadest lines of control components available.

Omron enjoys a worldwide position of leadership—a position built on excellence in engineering, manufacturing, and marketing. And Omron's commitment to quality products and service means you'll get *what* you need, *when* you need it.

So welcome Omron as your component supplier. Tell us your needs. Our applications engineering department will respond to your phone inquiries for key performance data within 48 hours.

Omron will prove—you're not alone anymore!

Welcome to the family, little fella


OMRON
Omron Corporation of America
Corporate Headquarters
Sears Tower, Chicago, Illinois
Sales and Service
1051 State Parkway
Schaumburg, Illinois 60172
Phone: (312) 885-9500
INFORMATION RETRIEVAL NUMBER 16

Pick your precision pot for its particular strong points.

All precision potentiometers are not created equal. Each kind has its strengths, its particular advantages.

And that's why you should look to the Helipot® precision potentiometer line to find exactly the kind of pot that will suit your application best. We make pots—fine ones—for any application.

There are strong reasons for that: We're the oldest leading manufacturer of precision pots. We know customers' needs, and we know applications from the ground up. And we make excellent, highly reliable products to handle almost any problem.

In standards, you can pick from a variety of wirewound, conductive plastic, hybrid, or cermet elements. Our standards, in Helipot tradition, are available for fast delivery from our national network of distributors. And if a standard doesn't fit the job, we can build exceptional custom pots very fast, regardless of the complexity required.

Of course, our applications and service people are always available to help with any questions and problems.

But first, consider the special strengths of different kinds of pots, and note that in most cases you can trade-off less important specs in order to get the strong performance you need.

On the next page are some general guidelines on how to pick a pot.

Beckman®

HELIPOT DIVISION

Things To Consider. The rating chart below gives you a glimpse of comparative strong points of four types of pots, rated from "4—Good" to "1—Excellent." And here are some specific examples of pots you could choose from.

Wirewound. Say you need a low-cost, low tempco pot with good noise characteristics. You'd want one of our wirewounds. We have them in sizes from ⅞" up to 3⁵⁄₁₆" diameters; from single-turn up to 40-turn. Most have ±20 ppm/°C wire for low tempco, and standard resistance ranges from 100 ohms to 100K ohms. Also, independent linearities are available to ±.025%, and power capacities range from 0.75 to 20 watts. Also, you have choice of shaft sizes, torques, and various electrical specs.

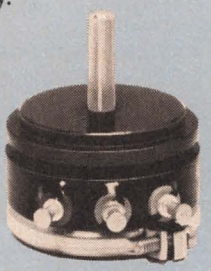
For example, if you need a low-cost ⅞" pot with a 2-watt power rating, 125°C maximum operating temperature, linearity of ±0.25%, resistance range of 100 ohms to 100K ohms, and a life expectancy of about 2 million shaft revolutions, you'd have your answer with our 10-turn Model 7286—it would be ideal for the application. And the price: just $4.95 in 25-piece quantity.

Conductive Plastic. Suppose, however, you need very long life, infinite resolution, and high tolerance to "dither." A Beckman single-turn conductive plastic pot, for example, gives excellent output smoothness (0.1% max.) over a life of 10 or more million shaft rotations.

The 1⁵⁄₁₆"-diameter Model 3371 (shown here) has a 1-watt power rating at 65°C, linearity of ±0.5%, 105°C operating temperature, standard resistances of 2K ohms to 390K ohms, stainless steel shaft, and essentially infinite resolution. The price: $10.80 in 25-piece quantity.

Cermet. Our rugged cermet-resistance-element pots answer your needs for those specialized applications requiring high power (up to 10 watts at 85°C), high temperature (up to 150°C) and high resistance applications (up to 1 megohm).

Our ⅞"-diameter, single-turn Model 6103 is a versatile example. It has exceptional resistance to environmental stresses, power rating of 3.0 watts at 85°C, linearity available to ±0.3%, wide standard resistance range from 150 ohms to 1 megohm, 150°C (max.) operating temperature, and essentially infinite resolution. Price: $29.70 in 25-piece quantity.



Hybrids. For best setability, resolution and performance over rotational life, consider our hybrid pots. Along with their excellent setability and infinite resolution, they give you most of the benefits of wirewound pots but much longer life—about 5 million shaft revolutions. They're priced slightly higher than wirewounds, but they're less expensive than conductive plastic.

One of our typical hybrids, Model 8146 shown here, is a 10-turn, ⅞"-diameter pot with 2-watt power rating at 70°C, 125°C (max.) operating temperature, linearity well within 0.25%, standard resistance from 1K ohms to 100K ohms, multiple-welded end terminations, metal sleeve bearing, and other features that improve life and temperature characteristics. The price: $7.20 in 25-piece quantity.

Customs. Finally, you should know that our standard pots are highly "spec-able," that is, easily modified to fit your particular application. Modifications for tighter linearity, special taps, special mechanical features, ganged sections, torque levels, electrical angles and many nonlinear functions, as well.

Also, we've had 40 years' experience building custom pots for such demanding applications as satellites, missile systems, and extreme environments. Our staff of application specialists and design engineers—who have built literally thousands of different custom pots—are ready to serve you at any time.

So, if precision pots—standard or custom—are in your plans, get full technical data on the Helipot line now.

Element Type	Wirewound	Conductive Plastic	Hybrid (CP Over WW Coil)	Cermet
Resistance Range	3	2	4	1
Wattage	4	2	3	1
Temperature Coefficient	1	4	2	3
Best Linearity	2	1	3	4
Setability/ Resolution	4	2	1	3
Noise or Output Smoothness	1	3	2	4
Performance Over Life	4	2	1	3
High Temperature	4	2	3	1
Relative Cost	1	3	2	4

To order, or for more information, call your Beckman Helipot distributor, or (714) 871-4848, Extension 1776.

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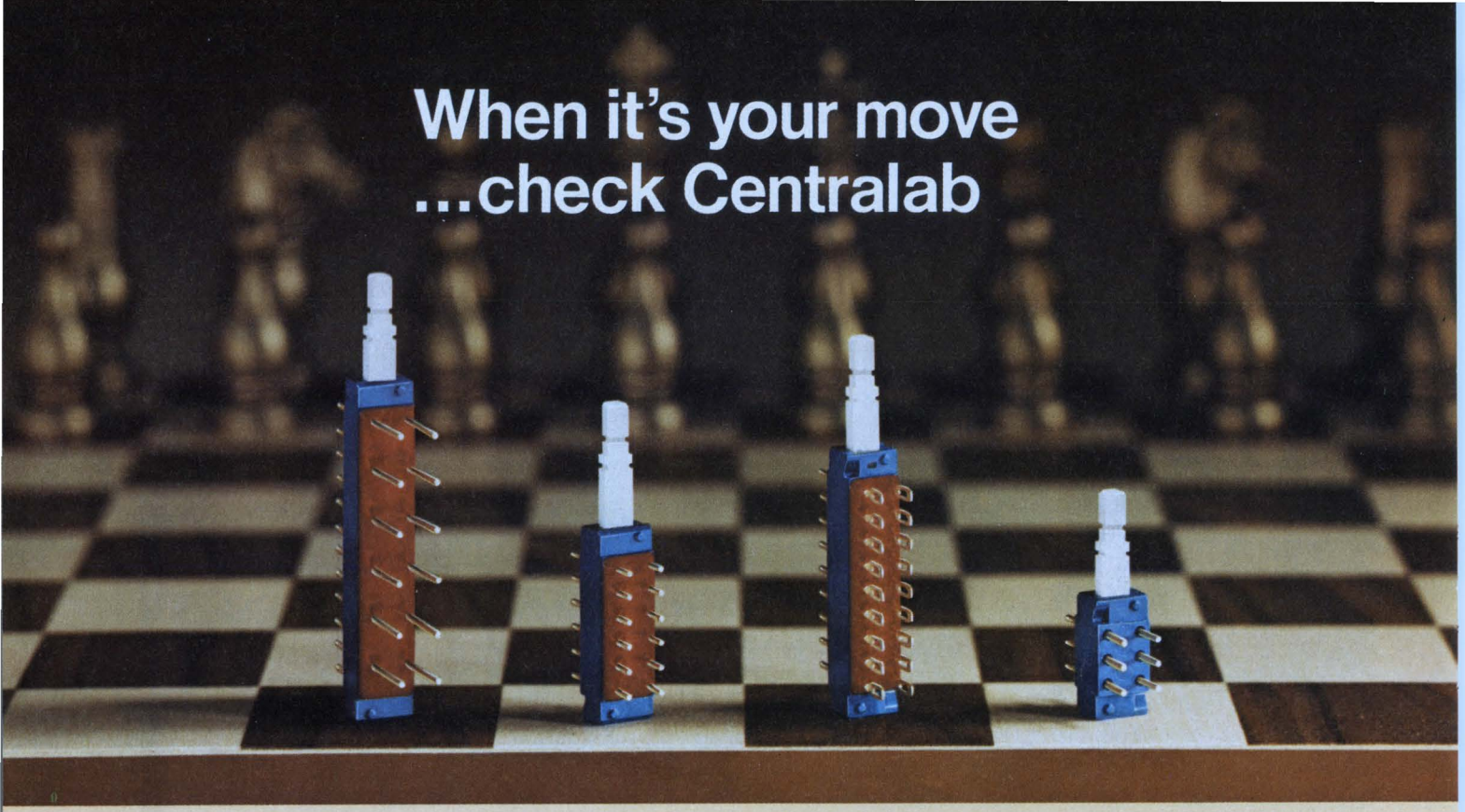
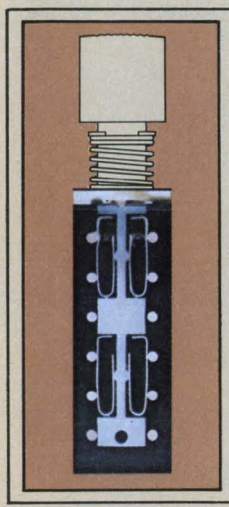
INFORMATION RETRIEVAL NUMBER 17



Best pushbutton switch for your board

Don't be checkmated. Only Centralab offers you the best low-cost switch module, plus so many extra-quality options.

THE BEST SWITCH—The basic Centralab pushbutton switch module is unique because of its inherently simple and rugged construction. High speed machinery produces the parts and performs assembly operations simultaneously, ensuring that the parts always fit the assembly perfectly. Stationary and movable contacts are enclosed in a high-dielectric thermoset housing to protect the smooth, positive wiping action of the slider bar and contacts. And Centralab switches are 100% tested.



Unretouched cutaway view of Centralab 4 PDT module showing positive spring force for superior contact wiping action.

Centralab pushbutton switches meet these demanding specifications:

Insulation Resistance: Up to 10^{12} ohms.

Dielectric strength: 1,500 volts.

Contact resistance: .004 ohms.

Life and reliability: Up to 250,000 MTBF in ganged assemblies. Over 500,000 operations on contact systems.

Shock and Vibration: 100g's and 10g's low frequency.

Electrical rating: Covers range from dry circuits to 1 ampere, and low millivolts to 120 volts.

If your requirements go beyond the basic Centralab module, consider these optional moves:

HIGHEST INSULATION RESISTANCE—Centralab offers diallyl phthalate housing material, in addition to phenolic.

BEST CONTACT RESISTANCE—Gold contacts and terminals are standard options. Best for dry circuit applications and contaminating environments.

NO INTERNAL CONTAMINATION—Epoxy sealed terminals prevent failure from solder flux and other contaminants.

Proven in use by more quality-conscious users, Centralab 2, 4, 6 and 8 pole pushbutton switches are available in four types of lockout for momentary, push-push or interlocking action. Both PC and solder lug terminals are available. PC terminals can be selectively cut to your desired lengths.

PLUS THESE NEWEST ADDITIONS—A new 5 amp line switch, a new low-cost lighted switch and a new visual display for non-lighted switches.

Get all the technical help you need from our 19 assembly distributors or network of experienced sales engineers. They'll help you select the best pushbutton switch for your board. Now it's your move!

Isostat Licensed

CENTRALAB

Electronics Division
GLOBE-UNION INC.
P.O. BOX 858
FORT DODGE, IOWA 50501

INFORMATION RETRIEVAL NUMBER 18

(continued from page 7)

the timer display in the HH.MM-SSUU format.

The problem with this useful feature is that it is not accurate. Is there a way to install a crystal clock?

Leonard K. Berger
378 Delta Rd.
Highland Park, IL 60035

Misplaced Caption Dept.

"These extended coffee breaks are great for morale."

Sorry. That's Pierre-Auguste Renoir's "The Nymphs," which hangs in the Louvre in Paris.

There are large triacs and large triacs

With reference to the special report on discretes ("Slowly but Surely, Power Semis Are Getting Faster, Heftier, Cheaper," ED No. 18, Sept. 1, 1975, pp. 28-32), I would like to point out that the International Rectifier triacs mentioned on p. 30 are not the largest available units. Silec-Semi-Conducteurs has been selling 200-A, 1400-V triacs for the last few years.

Marc Strechinsky
Silec-Semi-Conducteurs
Siege Social:69
Rue De Monceau 75008
Paris

Ed. Note: Larger triacs are available, yes. But Mr. Strechinsky appears to have overlooked the qualifier at the end of that sentence on p. 30: ". . . . the largest available units in standard TO-65 packages."

For information about the Silec triacs,

CIRCLE NO. 319

'Complete multiplier' offered–well, nearly

As an addition to David J. Wilson's excellent article on multipliers ("Which Multiplier?" ED No. 21, Oct. 11, 1975, p. 88), we should like to point out that the Clarke-Hess Model 200 provides all of the parts of the "complete multiplier" (Fig. 6) except the "readout device."

Since multipliers are often used as high-quality amplitude or suppressed carrier modulators; as synchronous detectors; as frequency translators or as phase detectors, the desired readout device is often something quite different from an oscilloscope. (The Model 200 will, of course, also be happy to drive the user's oscilloscope.)

The Model 200 offers 100-k input impedances, 50-Ω output impedances, internal attenuators and offsets and relative channel delays matched to within 2 ns.

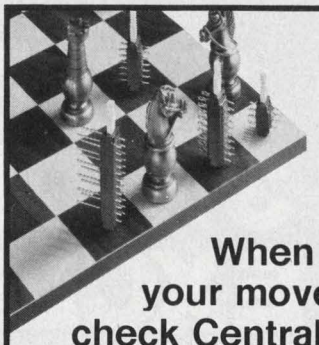
Kenneth K. Clarke
President
Clarke-Hess Communication
Research Corp.
43 W. 16th St.
New York, NY 10011

Management training —a myth perhaps?

Re: John Fluke's article "Training Engineering Managers" (ED No. 11, May 24, 1975, p. 88) and George Pristach's letter, "Management Training by Experts Defended" (ED No. 22, Oct. 25, 1975, p. 7).

Further insight on this subject may be obtained from the article "Myth of the Well Educated Manager," by J. Sterling Livingston (Harvard Business Review, Vol. 49, No. 1, January-February, 1971, pp. 79-89). The gist of the article is that managerial ability is not something that can be taught academically (although tools for being a better manager can be). Three characteristics are useful in predicting future managers: (1) the need to manage; (2) the need for power, and (3) the capacity for empathy.

John C. Sproul
Technical Writer
Eastman Kodak Co.
Rochester, NY 14650



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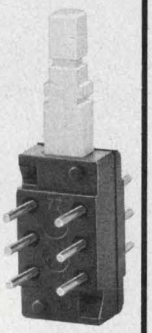

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INFORMATION RETRIEVAL NUMBER 19

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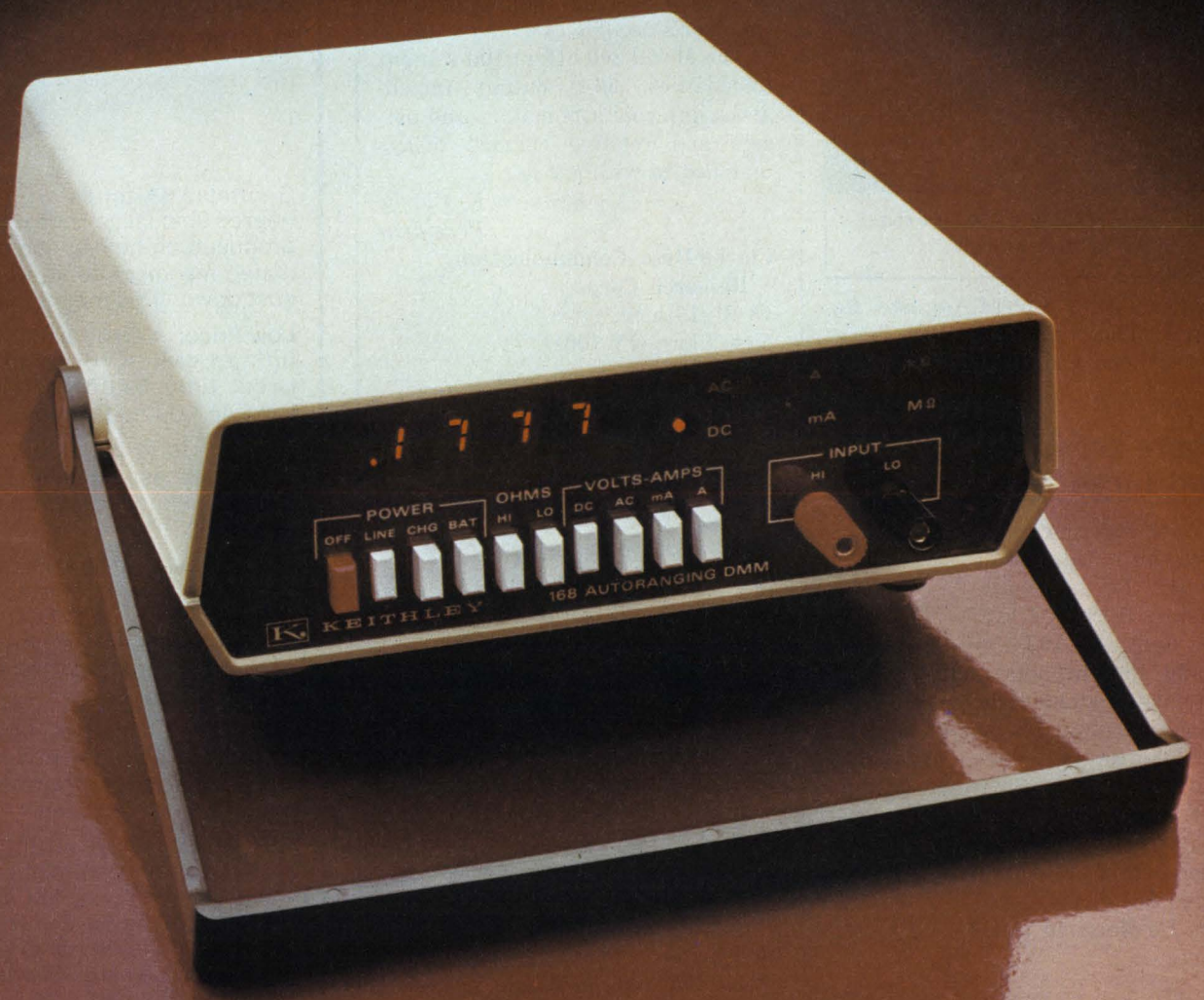

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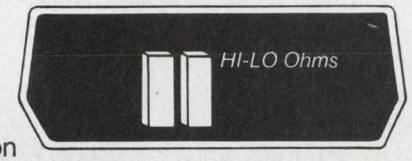

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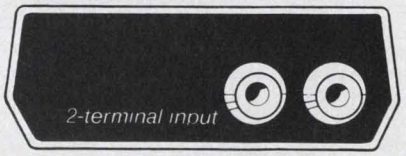

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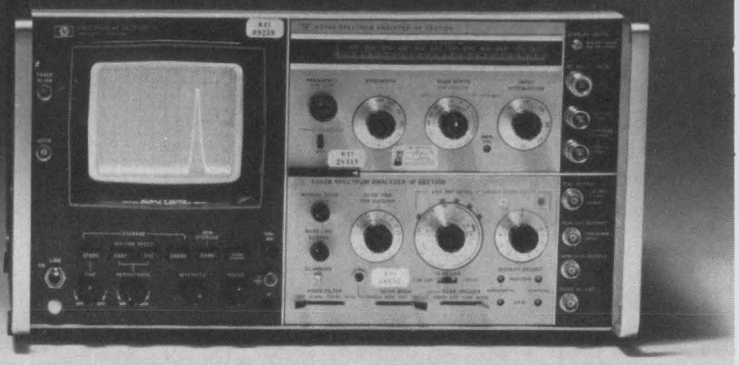

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INFORMATION RETRIEVAL NUMBER 21

News Scope

JANUARY 5, 1976

Fiber-optic telephone link to be field tested

Optical communications will move one step closer to reality later this year when field tests begin on an experimental telephone link using fiber-optic cables. The tests will be conducted by Bell Laboratories at its Atlanta, GA, facility.

Fiber-optic communications links have been tested previously, but this test program is unique because it will span a longer distance than ever before, and will involve more realistic environmental conditions.

The optical system consists of three basic components: a pulsed-light source (laser or light-emitting diode), a 2000-foot connecting cable containing over 100 thin glass fibers (approximately 0.004 in. diameter) and a silicon-optical detector as the receiver. The experimental system, still in its development stage, is designed to carry high-speed multiplexed telephone information for relatively short distances, such as the few miles between telephone switching offices in any one city.

Currently, such interoffice links use twisted-pair copper conductors, a transmission process that requires the placement of an electric repeater approximately every mile. Since signal attenuation is lower in fiber-optic cable this system won't require field repeaters, a Bell Labs spokesman says. Additional benefits, he cites, include greater message-handling capability due to the very wide bandwidth, a potentially lower cost than conventional systems, and conservation of natural resources (primarily copper).

Two signal data rates will be used. The higher rate (44.7 Mbits/sec) is transmitted by a miniature laser that uses a chip of aluminum gallium arsenide no larger than a grain of table salt. The lower rate (1.544 Mbits/sec) uses a light-emitting diode.

According to the Bell Labs representative, both types of light source, as well as the silicon-optical detector, are packaged so that a field technician can easily connect them to an individual strand of the fiber-optic coupling cable. Joining the two hair-thin fibers end-to-end by means of a simple connector, was an important engineering achievement, he added.

Multiprocessor system claims to be 'fail safe'

A "virtually fail safe" μP-based computer has been announced by the newly formed Tandem Computers Inc., in Santa Clara, CA.

"The redundant architecture of our multiprocessor system makes it virtually fail safe," says company president James G. Treybig. "We can operate with a minimum of two and a maximum of 16 processors in the same system."

The Tandem 16 NonStop system uses the company's T16 processor which is built around a pipelined microprocessor that has a cycle time and clocking of 100 ns. The μP is controlled by 32-bit microinstructions and has 15 microinterrupt levels. Just 2-k bytes of the 8-k bytes of microprogram storage provided are used for the basic instruction set. To enhance performance, a second μP is dedicated to I/O functions.

Each processor has eight general purpose registers normally used as a stack. The 122 basic instructions include string manipulation instructions to enhance the processing of communications lines or terminal-entered data. The Tandem 16 system is called the NonStop system because of its fail-safe features. For example, all peripherals are connected in a star pattern, so that if one device fails the others will still hold.

Each NonStop system comes with standard semiconductor main memory that can support up to 512-k bytes arranged as 22-bit words (16 data bits plus 6 error correction bits). All single bit errors are automatically corrected and all double bit errors are detected. Semiconductor memory cycle time is 500 ns, including time for mapping and error correction or detection.

Memory protection is assured by memory mapping. Four memory maps are provided, for system code, system data, user code and user data. In fact, the memory mapping capability automatically reallocates user code to alternate physical memory pages upon detection of a parity or uncorrectable memory error. Such errors cause most other systems to halt rather than remain running.

NonStop's I/O structure is a μP-controlled, block-multiplexed channel able to handle variable length transfers to buffered dual-port controllers. One processor can handle up to 32 dual-port controllers. All controllers have two ports so that they can be connected to two processors to prevent isolation through the loss of a processor or its I/O bus.

Computer-on-a-wrist also tells time and date

A limited edition gold wristwatch-calculator combination with a 6-figure LED display was announced by Time Computer, Inc., in time for Christmas, 1975. The Pulsar Time Computer Calculator is being marketed by the Lancaster, PA, firm three years after they introduced the world's first solid-state digital watch.

The calculator has four functions, and is complete with a memory, floating decimal point and an overflow indicator. It can handle 12-figure calculations, but displays only the first six figures. In addition to the digit keys the calculator has a percent key, an add-to-memory key, a recall-memory key, and a subtract-from-memory key. Clear-entry and clear-calculator keys are also provided.

The initial version is housed in an 18-kt. gold case with a matching gold bracelet and sells for

$3950. The company plans to offer the same device in a less expensive case, perhaps stainless steel, later this year at a price under $600.

"The design of the calculator keyboard is unique," says Time Computer president John M. Bergey, "because it is the only product of its kind that is sealed from the environment. It can be dropped in a glass of water without harm."

The device has two main chips —a calculator and a watch chip— as well as a number of drive and interface chips to enable the two primary chips to talk to each other.

For timekeeping, a command button is depressed to display hours and minutes, or seconds, or month and date, in that sequence. The wearer can change from timekeeping to the calculator function by pushing the "0" key.

Two other watch-calculators have been produced. One, by Uranus Electronics, Port Chester, NY, is solar-powered, with an 8-digit LED display. Present sales, at $800 each, are restricted to Europe.

Another by Optel Corp., Princeton, NJ, uses an 8-digit liquid-crystal display, and has been produced only in limited quantities at $500 each. The keyboard is presently being redesigned.

Telemetry link to home will control power loads

A study to determine the most efficient off-peak-load hours to use electricity in high-demand units (such as hot-water heating systems for home) is being conducted by the Green Mountain Power Co., Burlington, VT, under a grant from the Federal Energy Administration.

For some 100 volunteer customers with electrically heated water storage systems in the South Burlington area, special telemetering receivers and controls will be installed in their homes to turn power to heat-storage units on and off at various times of the day and night.

The system, which is not under control of the customer, will send out from a substation, a 10-bit, 383-Hz signal on the power lines in bursts of five seconds, according to Robert Tumulty, superintendent of production and maintenance.

The system will be programmed to send out coded commands at different times of the day. Some codes turn the hot water heaters on, others turn them off. An emergency code is provided to cut off all controlled equipment during peak-load emergencies.

Inefficient generation of electricity normally occurs during hours of maximum load, when additional equipment is required to handle the increase.

Such peak loading increases the use of fuel required per kW/hr over generation at other times and consequently raises costs to both the utility and its customers.

For recording purposes, the customers participating in the test will have a two-register meter, Tumulty explains. One register is for off-peak use, the other for on-peak kilowatt hours. These will also be controlled via the line telemetering system.

The heat-storage systems, which have been installed by the customer for their own building heat, have demands ranging from 14 kW to 21 kW and 28 kW, with heat inputs of 48,000, 72,000 and 95,000 Btu hours.

Computerized system to unsnarl Rio's traffic

Automobile drivers in Rio de Janeiro, traditionally plagued by frenetic traffic conditions, will be aided early this year by the installation of an advanced traffic surveillance and control system.

Developed by the Eagle Signal Co. of Davenport, IA, the computer-controlled system will monitor and direct the flow of traffic along a major artery linking Rio to the rest of Brazil, the six-lane, 8.6-mile-long Rio-Niteroi bridge.

The Rio-Niteroi project is said to represent a significant advance in traffic control by providing the following features:

- Individual computer control of each of the 34 traffic signs along the bridge and on the approaches.
- Fog-and-wind sensors placed along the bridge.
- Electrical signal multiplexing to reduce the amount of cabling necessary.

The system consists of a digital computer linked to a CRT display, a high-speed paper-tape reader, a line printer, and a map with electrical display—all located in a central office. The computer, a Nova 840, manufactured by Data General Corp., contains a 32-k core memory as well as a 256-k disc memory. It accepts real-time information on wind and fog conditions and on traffic flow (vehicular speed, occupancy level, blockage of any lane). Based on these data the computer selects an optimum traffic pattern and transmits control instructions to each of the roadway traffic signals. There is also provision for manual operation.

It was not necessary to design the individual vehicle sensors, according to Patrick Short, project systems manager, because existing inductive-loop-type pickup devices were satisfactory.

What was essential, he says, was careful consideration in determining the placement of these sensors. Special care was made necessary by the effect of the steel used in the bridge structure and the large amounts of metal used in electrical substations mounted at intervals underneath the bridge.

RCA's Satcom looks for new kinds of customers

RCA Global Communications made a major transition from dependence to competitiveness by launching a communications satellite of its own design last month. Until now the firm had been leasing domestic channels from Western Union and Telsat of Canada.

Known as Satcom I, the 24-channel, 2000-lb. geosynchronous orbiter will link all 50 states.

Each communications channel is designed to carry 1000 voice-grade circuits, one FM/color TV transmission, or computer data—at the rate of 64-million bits per second. Previously, the maximum capacity of any of the domestic communications satellites was only 12 channels.

RCA will be able to use seven of the satellite's 24 channels for its present customers, who include Alaskan pipeline constructors and cable TV. New business is expected to come from organizations leasing such private services for the first time because of the system's relatively low cost.

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INFORMATION RETRIEVAL NUMBER 22

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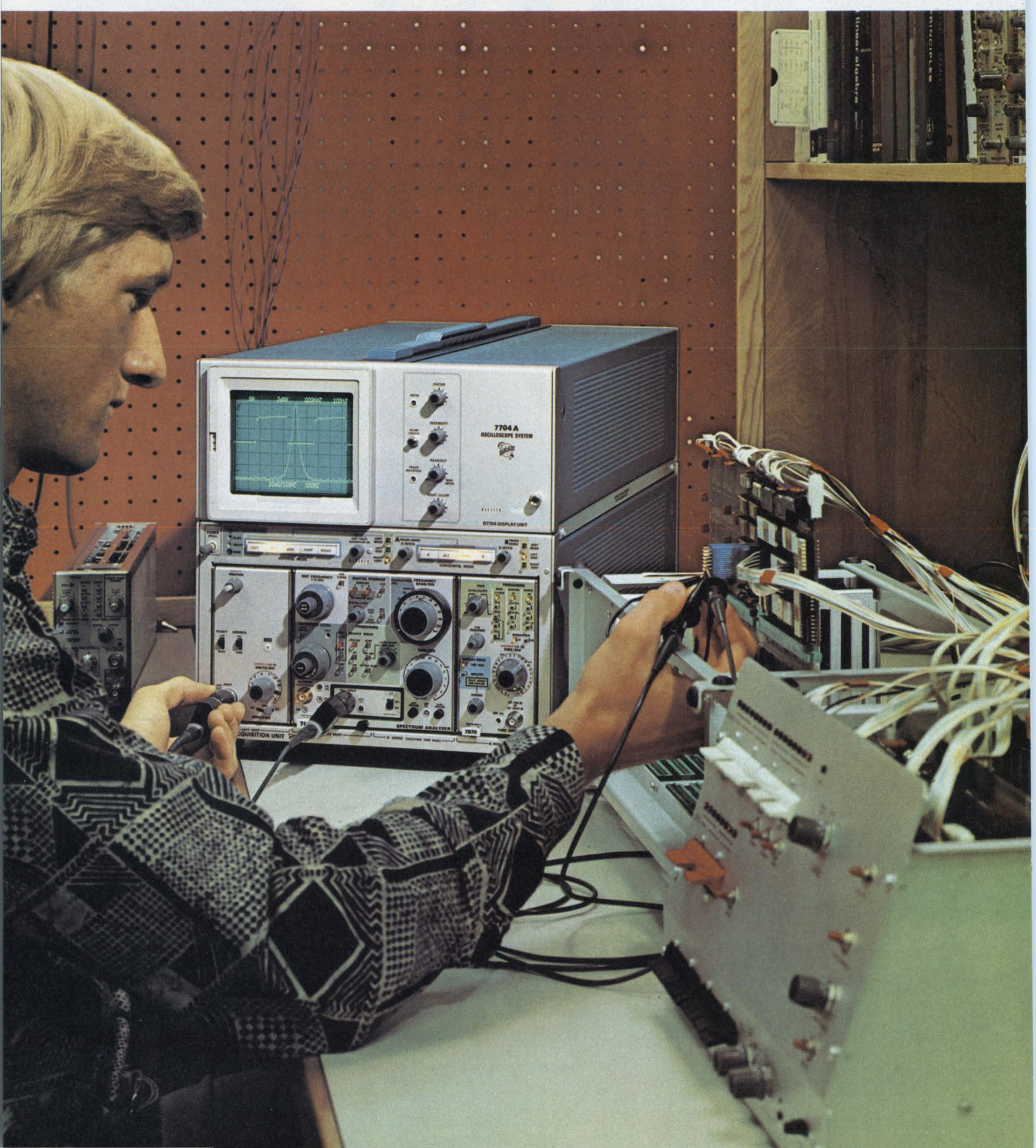


Measurement Flexibility

In today's research and development laboratory your work calls for measurements of many different types. For example, in integrated circuit development you most likely need a real time oscilloscope, a sampling oscilloscope, a digital multimeter and digital counters/timers. Or in communications R & D you probably use a spectrum analyzer in addition to all of or most of the instruments mentioned for the IC lab.

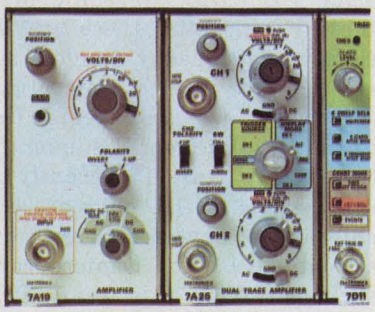
However, your space limitations, budget considerations and operator's convenience all demand that you get the maximum measurement flexibility from each instrument package.

The TEKTRONIX 7000 Series offers just such flexibility in a system of laboratory instruments. Its flexibility allows you to tailor the oscilloscope-based measurement system that most closely fits your needs. You select the measurement parameters—and the measurement techniques—you need, and combine them into interchangeable mainframe and plug-in packages.

Here are a few examples of 7000-Series flexibility:

BANDWIDTH RANGE—Whether your maximum bandwidth requirement is less than 100 MHz or up to 500 MHz (or even up to 1 GHz in some circumstances), there is a mainframe to match your needs. Eleven amplifier plug-ins and five time-base plug-ins (with sweep speeds to 0.5 ns per division) further help you tailor your system.

INPUT CHANNELS—Whether you need only one trace or up to four inputs, you can select just as many amplifier channels as you need.



SIGNAL ACCESS—For special signal access or processing such as Z-axis input, sweep gate and sawtooth, remote reset input, or vertical amplifier output, the interconnection scheme of the plug-in scope gives you convenient access points.

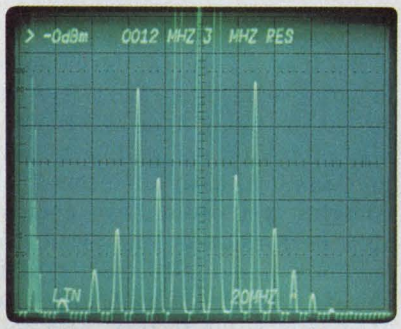
DELAYED SWEEPS—For complex measurements requiring delayed sweep, the 7000 Series offers both analog and digital techniques for delaying and expanding sweeps.

DIGITAL ACCURACY—For digital accuracy to measure selected portions of complex signals, Tektronix's unique capability to interconnect an oscilloscope with digital voltmeters, counters, and timers provides convenient measurement solutions.

DIFFERENTIAL INPUTS—When common mode noise inhibits your measurement of low level signals, differential amplifiers (with up to 100,000:1 cmrr) can be included in your system.

SAMPLING DISPLAYS—When you need to display high-frequency repetitive signals, sampling plug-ins give your system up to 14 GHz of equivalent bandwidth.

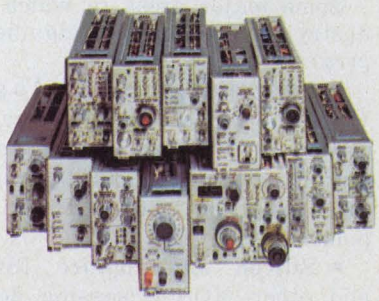
What about your measurement needs that are outside the realm of a conventional oscilloscope, such as spectrum analysis, curve tracing and rapid scan spectrometry? Three spectrum analyzer plug-ins handle up to 1.8 GHz with 30 Hz resolution. A curve tracer plug-in displays dynamic parameters of devices up to one-half watt. And the RSS plug-in scans 400 nm in just 4 ms. (RSS available in U. S. only.)



One more thing about 7000-Series flexibility: with a choice of more than 30 plug-ins and 17 mainframes in a continually evolving family, you can be assured of a long-lived oscilloscope system that will continue to accommodate your needs.

For a catalog describing all the 7000-Series instrument mainframes and their plug-ins, call your local Tektronix Field Engineer, or write Tektronix, Inc., P.O. Box 500, Beaverton, OR. 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

The 7000 Series . . . more than an oscilloscope



Microprocessor designer uses time domain plug-ins (7A16A/7B70) and spectrum analyzer plug-in (7L5) to give a combined display on 7704A mainframe. While the oscilloscope displays pulse characteristics, the spectrum analyzer identifies clock jitter down to 10 Hz and measures system noise directly in dB.

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FOR TECHNICAL DATA CIRCLE # 241

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News

WHAT'S AHEAD IN 1976

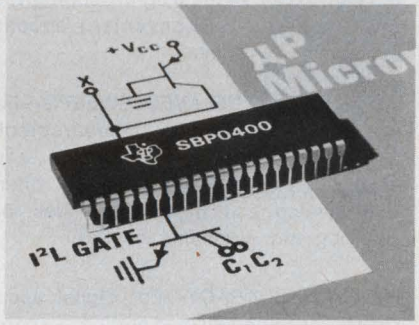
Deluge of LSI circuits may cause logjams in systems design

Because of rapid development in large-scale integration, systems designers today face a bewildering choice of competing circuits that employ vastly different technologies, yet often have comparable performance and price. Not only are the LSI circuits difficult to specify; they're often almost impossible to test. And complicated new tradeoffs must be considered: hardware vs software for microprocessor systems and digital vs analog processing for analog subsystems.

It's likely, therefore, that IC industry progress this year will be somewhat less dramatic than in the recent past. Though research will continue at a fast clip, manufacturers won't introduce new products until they can be manufactured and sold in volume. Successful products will be alternate-sourced and unsuccessful ones will be discontinued. In short, this will be a year in which the industry consolidates its recent gains and cuts its losses.

Some major areas in which industry experts predict significant progress are as follows:

- **Integrated injection logic (I^2L)** will be used in a wide range of new circuits, usually in combination with other circuit technologies, such as TTL, ECL and bipolar linear.
- **Silicon on sapphire (SOS)** and other MOS processing developments will give memories and microprocessors a speed boost to ward off the bipolar threat.
- **Schottky TTL and ECL** will continue their speed race. This year the arena will be bit-slice microprocessors, and there may be some dark horses, like fast I^2L, to compound the confusion.
- **New high-density MOS** techniques will lead to volume production of 16-k RAMs and 64-k charge-coupled device (CCD) memories.
- **Programmable logic arrays** (PLAs) and programmable ROMs (PROMs) will provide much of the "glue" that's needed to build complete systems using LSI chips.
- **Automatic laser trimming** and mixed device technologies, with FET and bipolar devices on the same chip, will yield further performance improvements for monolithic linear and interface circuits.



The SBP0400 from Texas Instruments is the first microprocessor to use I^2L logic. Organized as a 4-bit slice, the processor is slower than competing Schottky-TTL and ECL versions, but it has low power consumption.

Everybody's looking at I^2L

Because of is many advantages most IC manufacturers are evaluating and developing I^2L, and several have already announced products that employ the new technology. The circuit technique allows chip densities that are comparable to MOS, yet it offers higher speed and lower dissipation. As a further advantage, it can be readily combined with other bipolar configurations—TTL, ECL and linear circuits—on a monolithic chip. Also, in its simplest configuration, I^2L is relatively inexpensive because it requires only four or five masking steps and uses conventional bipolar processes.

Most of the I^2L circuits announced so far have been for consumer products. About a year ago Texas Instruments introduced an I^2L chip for digital watches, and recently TI started marketing its own line of wristwatches using the chip.

Because I^2L was originally developed in Europe, and because of the consumer-product emphasis, it's not surprising that most of the commercially available circuits come from overseas. For example, an ITT Semiconductors group in West Germany is about to start selling I^2L chips for electronic organs and alarm clocks. A new British digital watch from Sinclair Radionics uses an ITT-made I^2L chip. Panasonic offers three I^2L circuits; these are flip-flops and frequency dividers suitable for use in electronic organs.

However, we can expect a flood of I^2L circuits from U.S. manufacturers this year. TI recently announced a 4-bit I^2L microprocessor chip and is expected to introduce a complete 16-bit I^2L microprocessor some time this year. Other companies are said to be working on I^2L microprocessors. Motorola may introduce one that uses the same instructions and development tools as its popular MC6800

Michael Elphick
Managing Editor

MOS chip.

Motorola definitely has three I^2L circuits slated for introduction within a few months. These are an 8-by-8 multiplier, a DMA controller and a programmable delay module. The chips are intended as peripheral circuits for the 6800 and other microprocessors. Several companies are working on I^2L 4-k RAMs, and Fairchild is reported to be the frontrunner in this area. These memories are expected to have access times of 50 to 100 ns and thus will be about twice as fast as existing MOS versions.

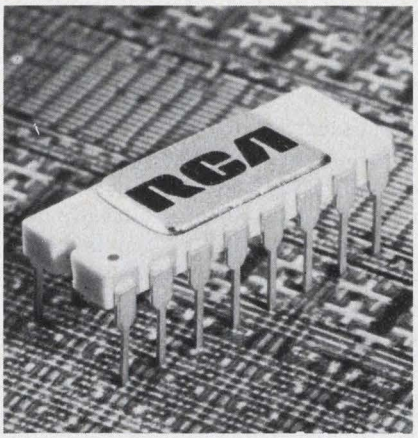
Though the original developers of I^2L emphasized speed-power product rather than pure speed, recent refinements have boosted speed to the point where I^2L can be as fast as other bipolar technologies, like Schottky TTL. Some manufacturers have already added ion implantation, passive isolation and Schottky clamps to the basic I^2L process. And at last month's International Electron Devices Meeting, we had a glimpse of some new gimmicks. Engineers at ITT Semiconductors have developed a method of anodizing the silicon wafer to isolate active elements. Applied to I^2L, this technique should double chip density, more than double speed and perhaps cut costs by eliminating one or more mask steps.

Mitsubishi in Japan has developed what it calls vertical injection logic (VIL). This is similar to I^2L, except that the pnp injector transistor is fabricated vertically instead of laterally, thus allowing it to be made narrower. Compared with conventional I^2L, the new configuration has about four times the gate speed and much lower power dissipation. In another Japanese development, researchers at Nippon Electric have discovered a new LSI technique called gold transistor logic (GTL) that boasts five times the speed of I^2L while yielding comparable packing density and speed-power product.

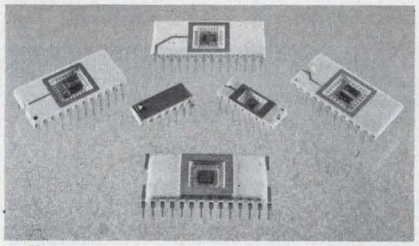
No more logic families?

Despite its many advantages, it's not likely that I^2L will evolve into a broad family of logic circuits as CMOS and TTL did. In fact, it may turn out that Fairchild's subnanosecond ECL 100K was the last of the conventional logic families. Manufacturers will probably take a cue from Motorola and market their I^2L circuits as part of a mixed technology bipolar LSI family. Motorola's Megalogic family embraces several bipolar technologies and includes I^2L circuits along with TTL and TRL (a simplified form of the old RTL). Similarly Fairchild's Macrologic family, though currently limited to Schottky TTL, may soon include other technologies.

There are several reasons why I^2L may not be able to start a family. First, of course, there's the risk that it may be shoved aside by some new glamor technology—say, Nippon's GTL. Second, it's primarily suited to LSI, and LSI circuits most naturally group themselves by function (microprocessor chip sets, for example) rather than technology. And third, I^2L—despite all the hoopla—does have some serious drawbacks.



A 1-k static RAM from RCA uses SOS/CMOS technology. With a typical access time of 150 ns and standby power dissipation of 0.1 μW per bit, the circuit competes with both bipolar and MOS designs.



A family of a/d and d/a converters from Analog Devices includes both monolithic and dual-chip types. Newer versions interface directly with microprocessors. Bipolar, CMOS and thin-film technologies are used to meet a wide range of performance and cost requirements.

Though it rivals CMOS in power dissipation, basically it has inferior noise immunity. Of course, TTL buffers can be added to the chip. But if there are too many buffers they can eat up valuable chip space. Thus I^2L is most useful when there are only a few interfaces to the chip.

Also, I^2L isn't well suited to dynamic circuits like shift registers. Because you can build transmission gates with MOS but not with I^2L, MOS can usually achieve superior density in dynamic circuits.

The most immediate threat to I^2L is probably CMOS/SOS. This combines the low power dissipation of CMOS with the speed of SOS. Until recently CMOS/SOS tended to be expensive because of the cost of the sapphire wafer material; hence the circuits were largely restricted to high-performance military applications. Recently costs have dropped because of the development of a new ribbon process for making the substrate material and because new processing techniques allow higher circuit density on the chip. As a result, more and more commercial circuits are starting to appear.

For example, three companies —RCA, Solid State Scientific and Bell-Northern—are manufacturing 1-k RAMs using CMOS/SOS. Rockwell International has a smaller 500-bit unit. Several other companies, including Hewlett-Packard and Siemens, have 1-k SOS memories under development.

Other techniques besides SOS may allow MOS memories to catch up with the speed of bipolar circuits. Engineers at Mitsubishi have used a diffusion self-alignment (DMOS) process to build a prototype dynamic 1-k memory that has 50-ns access time and 230-mW power consumption. Thus it has bipolar speed and MOS power consumption.

Today most IC manufacturers have an abundance of powerful processing weapons. So they can build several different prototypes and select the one that's easiest to manufacture. For example,

RCA is developing a fast single-chip version of its two-chip COSMAC microprocessor. The company has built both silicon-gate and SOS prototypes but hasn't yet decided which version to use for volume production.

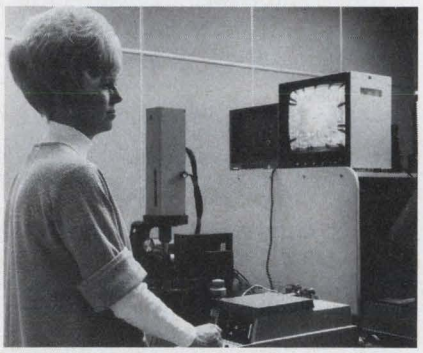
Bipolar speed race continues

While MOS memories are catching up with the speeds of high-density bipolar memories, bipolar LSI technology isn't standing still. Of course, for all-out speed—in communications and instrumentation—subnanosecond ECL reigns supreme. But for high density, yet fast, digital circuits, the main event is being fought between ECL and Schottky TTL, with I^2L as a rising contender. And the arena for this bout is bit-slice μPs. For these circuits, currently used mainly in minicomputers, speed is important so they can be microprogrammed and still cycle fast enough to work efficiently with available n-channel MOS memories. And as memories get faster, the μPs will be forced to stay one jump ahead.

The current list of companies making bipolar μP slices includes Advanced Micro Devices, Intel, Monolithic Memories, Motorola, Raytheon, Signetics and Texas Instruments. With the exception of an ECL circuit from Motorola and the I^2L chip from TI, all the bit-slice chips use Schottky-TTL processing. All are 4-bit slices, except for Intel's 2-bit version.

Motorola's ECL processor is the fastest available, with a cycle time of around 55 ns. Other μPs have cycle times of 100 ns or more, and Advanced Micro Devices' version is the fastest of the Schottky TTL contenders. Packaging, wiring and interfacing, of course, are always problems with ECL. To solve some of the interconnection problems, Motorola uses a newly developed QUIL package for its M10800 bipolar processor family. This package houses a 48-pin lead frame in a 24-pin sized area, and it can dissipate 4 W. The ECL processor, however, may still run into customer resistance because of its awkward ECL levels and wiring constraints. This possibility is no doubt what motivated Motorola to second-source the Advanced Micro Devices Schottky-TTL part, along with Raytheon.

Though TI's SBP0400 I^2L microprocessor is one of the slowest bipolar versions around, it does demonstrate the viability of the new process. TI has already announced that the design is being upgraded and that faster versions, perhaps competitive with Schottky TTL, will soon be available. But the most significant feature of the I^2L process is that it allows much higher chip densities. It's probable, therefore, that TI and other companies are working on larger, 8 or 16-bit, I^2L microprocessors. But these circuits will need high-level software, so manufacturers may delay hardware introduction until they can offer complete hardware/software packages.



Motorola laser trims diffused resistors to adjust the ladder network of the MC3510 10-bit d/a converter. The operator follows a bright spot on the TV display to position the laser beam on the chip. The resulting IC converter has a maximum linearity of ±0.05%.

The trend in microprocessors is towards higher speeds, and one company—Scientific Micro Systems—already has an 8-bit monolithic Schottky-TTL μP. However, this μP has a simplified instruction set and is intended for control, rather than arithmetic, operations.

MOS leads for high density

Most 8 and 16-bit μPs, however, are MOS types. Despite the enormous potential of I^2L and Schottky TTL, MOS still yields the highest device densities on the chip. At present over 20 companies are selling MOS μPs, and several more are making them for in-house use. This year the trend will be more to alternate-sourcing of popular designs, rather than a proliferation of new types. Also, there will be increased emphasis on software availability. New designs are likely to be software-compatible with existing μPs and minicomputers.

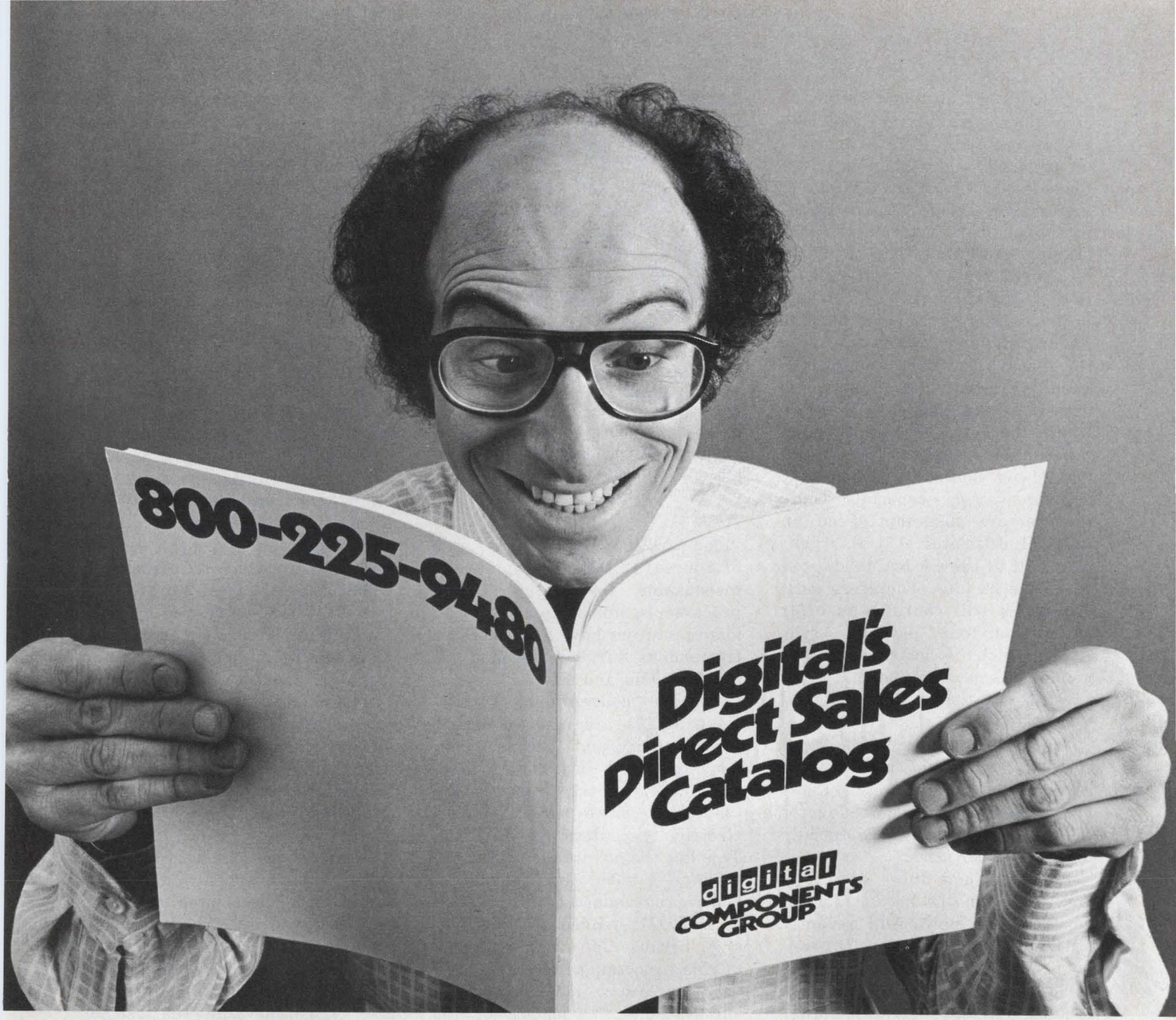
The real market payoff for today's high-density MOS, though, will be in memories rather than μPs. The industry is expanding its capacity for volume production of 4-k RAMs, and 16-k versions will begin to appear this year.

Many of the high-density techniques, such as silicon-gate processing and single-transistor cell structure, were developed for 4-k memories and have since been refined for larger designs. New techniques, like a folded gate structure, and electron-beam lithography should yield further advances. And some new twists were disclosed at last month's International Electron Devices meeting.

For example, Toshiba engineers have developed a wet-gate oxidation process that increases silicon-gate densities and eliminates one mask step. TI engineers described a new MOS dynamic RAM cell concept that employs charge coupling and is said to be simpler than the conventional one-transistor cell.

Already one company, Four-Phase Systems, is using a 16-k MOS RAM in its own computer—the NP/80. The n-channel silicon-gate chips are made by the company in its semiconductor plant in Cupertino, CA. And developmental 16-k RAMs from a couple of major semiconductor manufacturers are reportedly being sampled by potential customers.

Manufacturers are moving cautiously with their 16-k RAM introductions, because they want to avoid the anarchic lack of standardization that accompanied the introduction of the 4-k RAMs. In fact, the competing companies recently held a secret summit conference in Colorado to see if they could agree on a standard package and pinout configuration for 16-k memories. The first 16-k RAMs will probably be in a 16-pin package similar to Mostek's current 4-k design. But this scheme hasn't been universally



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accepted by all potential 16-k manufacturers. Because the 16-pin design will necessarily have multiplexed addressing, it's unlikely to have an access time of better than about 350 ns. Therefore some manufacturers—TI, for example—feel that there will still be a need for a faster 16-k RAM in a larger package.

Meanwhile it's probably too late for any standardization to emerge for 4-k RAMs. Even though the 16-pin version will find extensive use in large memory systems, where the extra cost of interfacing can be amortized, the 22-pin and 18-pin versions will dominate smaller systems—especially those that require maximum speed. In fact, TI estimates that this year over half of the 4-k RAMs shipped will have 22 pins. Therefore most companies will continue to offer more than one package style. RCA, which is gearing up for volume 4-k production this year, says it eventually will offer all three package configurations.

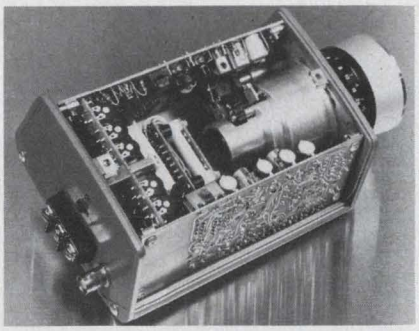
Another contender in the semiconductor memory race is, of course, the CCD. Though CCDs are slower than semiconductor RAMs, they offer potentially higher bit densities.

Fairchild and Intel have had 16-k CCDs on the market for almost a year now. And recently Mnemonics of Cupertino, CA, announced a 64-k CCD memory for internal use in a disc-interface system. We can expect to see other companies introduce 64-k CCDs this year, but it will probably take more than a 4-to-1 density advantage over RAMs to take the industry by storm.

Gluing the system together

Though memories and μPs capture most of the headlines, many more types of ICs are needed to build a complete system. Large computer systems need random logic; microcomputers need ROMs and peripheral interfaces; and analog systems need analog/digital interfaces. So significant progress can be expected in these secondary areas as they catch up with the LSI bandwagon.

Much of the random-logic "glue" for computer systems will be provided by PROMs and PLAs. And, of course, PROMs are almost indispensable for coding microprocessor systems. As a result, IC manufacturers have experienced a tremendous surge in demand for both PROMs and PLAs.



A tubeless TV camera from RCA uses a CCD as the image sensor. The type S1D51232 CCD detects 163,840 separate picture elements. Though CCDs have made their greatest progress as imaging devices, they also have important applications in data storage and signal processing.

Because conventional fusible-link PROMs are often awkward to program, and because they can't be tested until they're actually used, recent interest has tended to center heavily on the electrically alterable EAROM. This has the advantage that it can be erased with ultraviolet light and reprogrammed at will. Initially EAROMs tended to be expensive because of their complex nitride processing. Recently, however, prices have fallen. And Intel and National, the leaders in this technology, have announced larger devices. Intel has an 8-k part, and National is up to 4 k. This year we can expect to see a wider choice of parts and probably more vendors in this important market.

In fusible-link bipolar PROMs, the latest development is Harris Semiconductor's introduction of what it calls the Generic family. All PROMs in the family have the same programming requirements and standard dc parameters. Harris hopes that its new family will become a de-facto standard for this segment of the industry. Despite the obvious advantages of EAROMs in low-volume applications, bipolar PROMs will continue to hold an important share of the market because of their superior operating speed.

For random logic, PLAs often give a substantial compression of truth tables with fewer IC packages than ROMs. But mask-programmed PLAs have long been stymied by their high cost and slow turnaround time. Today, however, field-programmable FPLAs are revolutionizing computer-system design. Now, as with PROMs, the engineer can breadboard a system within days, using FPLAs to fill the circuit gaps between standard LSI parts.

Within the last few months, six manufacturers have either announced FPLA products or have said they will do so: Advanced Micro Devices, Harris, Intersil, Monolithic Memories, National and Signetics. We can expect to see more vendors offering a wider range of parts. But progress in FPLAs may be slowed by some nagging problems. Often the devices are difficult to program and test, and there's an urgent need for more software and hardware design aids. Also, FPLAs are not always directly interchangeable with their mask-programmed counterparts. Because the programming links occupy chip area, there may be less active circuitry in the FPLA version than a PLA of the same package size and pin configuration. These problem areas are likely to receive increasing attention this year.

Two important production trends for linear and interface ICs are laser trimming and the use of mixed technologies—FETs and bipolars, for example—on a single chip. Analog Devices, Motorola and other companies now employ automatic laser trimming for production of high-resolution converters and precision amplifiers. RCA has a family of op amps that use MOS combined with bipolar circuitry, National uses JFETs along with bipolar devices, while Analog Devices makes extensive use of thin-film resistors in monolithic ICs. And, of course, several companies combine I^2L digital circuits with conventional bipolar analog circuitry. So, even in pure analog circuits, we can expect to see substantial gains this year as manufacturers continue to harness a wealth of new technology. ■■

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Say goodbye to the 'traditional' as instruments change in 3 ways

The subtle currents of technological change that began in instruments a few years ago are continuing, and though 1976 surely will see a speedup in the flow, it remains to be seen whether the year will be marked with the stamp of revolution or evolution.

In general, the movements appear to be confined along three distinct channels leading away from traditional mainstreams of instrument design. The motions are:

- Away from individual instruments and toward integrated systems or packages.
- Away from ever increasing performance and toward economical, easy-to-use equipment.
- Away from basic, point-by-point measurements and toward equipment that churns raw data into final answers.

The winds behind the currents are being stirred, among other things, by progress in LSI technology and by the changing needs of a drastically changing economy. If one word could summarize the most significant and outstanding trend, it would be: microprocessor.

The μP explosion

In the past two years alone, practically every category of instrument has been touched by the μP—signal sources, oscilloscopes, DVMs, data loggers, terminals, analytical equipment and more. And the surface has been barely broken.

Dr. Eberhardt Rechtin, chief engineer at Hewlett-Packard, Palo Alto, CA, notes that the trend toward smart instruments accelerated in 1975 and will pick up even more speed in 1976. And Dr. Rechtin points out that rapidly improving displays, printers and plotters will strengthen the trend.

Another strong trend seen by Rechtin—one stimulated by the plunging cost of and technical developments in computers and calculators—is the movement toward networks: instruments, terminals, plotters, calculators, production machines, all tied together by data busses. One thing that will certainly promote the marriage of assorted equipment is IEEE Standard 488—the standard digital interface for programmable instrumentation.

Published early last year, and now close to adoption by the IEC (International Electrotechnical Commission), the standard is the first attempt to bring order to instrument interfacing. But whether 488 will become a universal standard isn't quite definite.

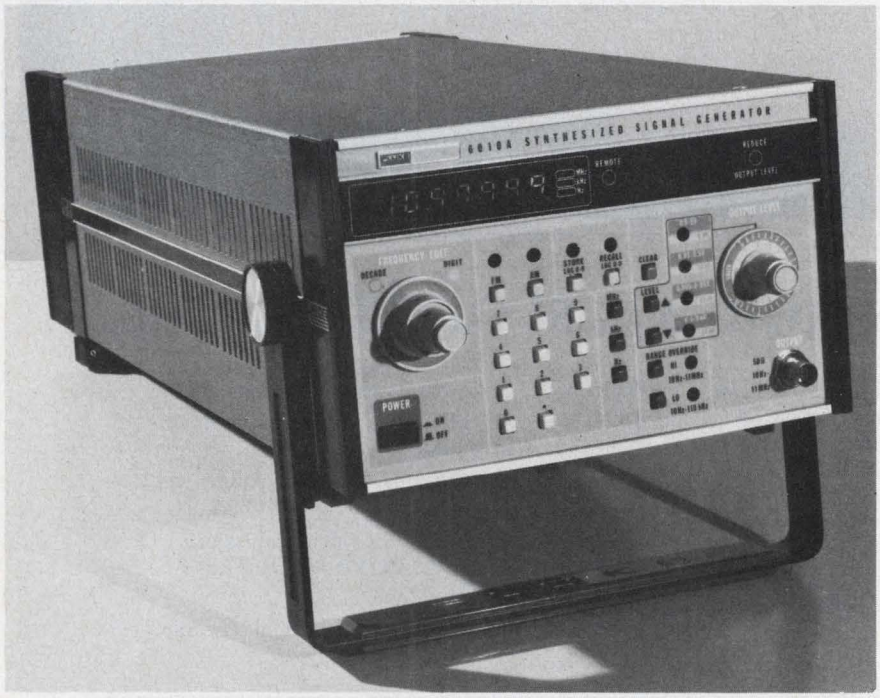
Fred Hume, manager of product planning for the John Fluke Manufacturing Co., Seattle—a pioneer in the use of μPs in instruments—is one who sees 488 as just one of many interfaces.

Hume analyzes the situation this way: "Once you've got a μP in an instrument, it becomes easy to build several interfaces. For example, one product we've got right now offers any of three interfaces: straight ASCII, 488 or RS232. The latter is particularly nice because, with it, you can hang a signal generator at the end of a phone line and run it from a time-shared computer."

Hume continues: "So contrary to the trend that some people see—that everybody's going to go to one interface, like 488—I think because of the μP we're going to see a proliferation of interfaces. There will be so many, in fact, it will boggle the mind."

And to prove his point, Hume

Stanley Runyon
Associate Editor



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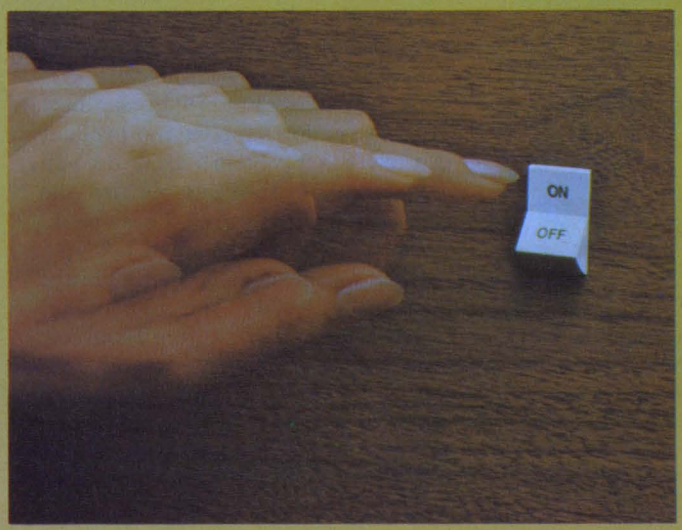

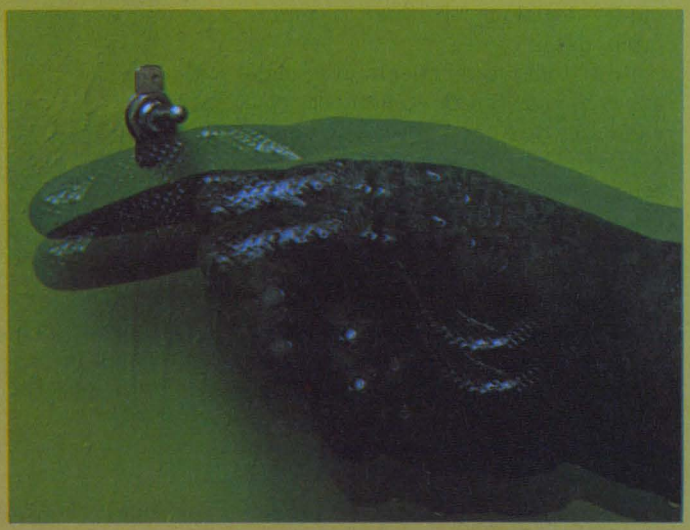

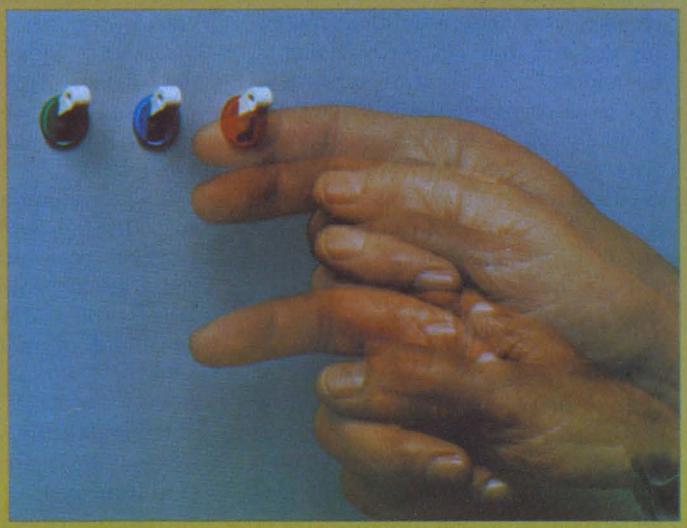

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points to a box already being offered by HP that converts the 488 standard to 232.

Intelligent clusters ahead

But Hume is careful to indicate that there still will be a lot of standardization around 488, particularly those applications involving series or sequential operations.

Arguments for one interface over another may become academic if the predictions of Henry Reinecke, Wavetek's vice president of engineering, come true. He sees a new look in systems, in which individual, stand-alone instruments are discarded for what may be termed "intelligent clusters."

Reinecke explains the concept: "With the IEEE bus, you can take standard equipment—voltmeters, counters and the like—and put them together to do something. Typically you would poke these things into a universal card cage under minicomputer control. In the past this type of system rarely made decisions—it just accumulated data.

"But today components are small enough and smart enough so you can integrate the equipment under one roof. The μP can take over the mini's role and perform a considerably more dedicated function with far less software—or maybe none.

"You may even retain the bus, but it will be buried deep in the system, so the user will never see it. The communication is done inside the wrapping rather than by cables connecting the parts together."

With such a system, Reinecke notes, intelligence is within the cluster, not the individual instruments, and you get measurements, decisions and evaluation of data in far greater detail than in the past. A likely spot for such a cluster? Any production line where routine, repetitive measurements are made and where parameters aren't changed often, Reinecke says.

The trend toward economy

Hume also sights a tremendous change in systems. "Again, because of the μP, dedicated automatic test systems will appear in the $20,000-to-$30,000 price range," he predicts, "but with performance rivaling the $100,000 tester of today. The low price will open up entirely new markets: those with low test volumes that couldn't previously justify the purchase or lease of a high-priced tester."

Low price has been the key to sales in many instrument areas since the series of economic nosedives of the early 70s. Before the downturn, much activity in design centered on ever-increasing performance—the wider the bandwidth, the higher the frequency, the more front-panel frills, the better. In the booming 60s, little attention was paid to economy.

Typical of what's happening today in DMMs is this model from B and K Precision. The unit sells for just $99.95.

Today, however, low cost is a prime design target, and sophistication for its own sake takes a back seat. This is not to say that low price necessarily equates to low performance or that sophistication in instruments is dead. Far from it.

The development of LSI and low-cost displays—plus the concentration on cost—has produced some remarkable equipment. Look at DVMs and DMMs. You can buy an awful lot of meter today for just $200 or $300, or even less in some cases.

Paradoxically, because the μP lets a designer cut costs while simultaneously broadening performance, we may yet see a return to the performance spiral of yesteryear. But the μP can't push oscilloscope bandwidths higher or cut noise in signal sources. So this time around, look for new manifestations of the struggle to squeeze more and more capabilities into one housing.

A $5 microprocessor?

What form will instruments then take? It's anybody's guess. But Fluke's Hume speculates on the ramifications of low-cost μPs.

"It's inevitable," he postulates, "that we'll see a $5 μP in instruments that cost $500. We don't know exactly what role the μP will play. But it's going to replace a lot of dedicated logic and allow the design of special instruments that otherwise would be hard to build with all-dedicated circuitry.

"Conceptually, it's possible to build an instrument in which the user has access to the μP. We've been playing around with that idea. The user's benefit is, of course, that he can reprogram to get not just one but any of a number of instruments. But this creates problems. For instance, how can the vendor support the product if there's a problem? How do you determine if the bug is in the firmware or hardware? These problems haven't been touched yet."

What other developments might there be in 1976? One area of activity centers on signal sources, with function generators and synthesizers a good bet for new products or improvements. We can expect the advances to take the shape of better spectral purity and frequency accuracy, rather than a boost in frequency range.

In function generators—which now bear a top frequency of about 30 MHz—expect about a 30% increase, but look for the more significant changes to occur in spurious outputs and in signal purity. Look also for an extension of versatility—better sweeps and synthesizer-like precision.

In synthesizers, the promise of new frequency standards or fundamental oscillators will be realized in sources with lower noise levels than ever. The μP has already invaded one synthesizer to bring hitherto unavailable features, and more such sources are likely to follow. ■■

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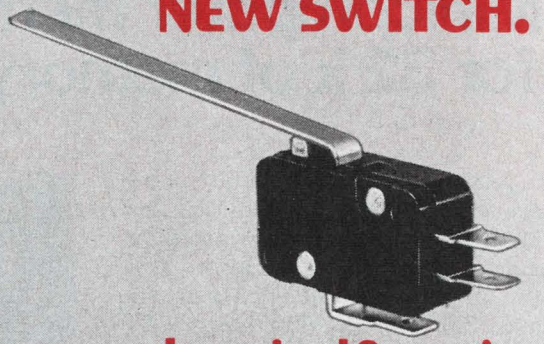

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INFORMATION RETRIEVAL NUMBER 27

Minicomputer memories pushing for 32 k of memory—and more

Next year minicomputer users are going to continue to look for more memory for their systems. In many cases they're going to ask for 32 k or more of main memory and disc drives with up to 80 Mbytes of storage.

Here are other trends in the mini/peripheral area:

- The performance of minis and associated hardware will continue to improve, with prices dropping significantly.
- New minis and peripherals will have designed-in μPs.
- Double-density and two-sided floppy discs will become available in quantities.

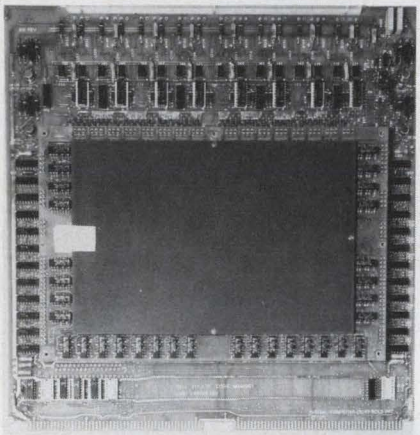
More main memory

"Customers want more and more main memory," says Paul C. Ely, general manager of Hewlett-Packard's Computer Systems Group in Cupertino, CA. "Whereas they might have been satisfied with 16 to 20 k a year ago, now they ask for 32 k or more."

In addition they also want huge amounts of disc storage, Ely says, adding: "Production of high-data-rate, 80-Mbyte disc drives should accelerate in '76."

John N. Ackley, president of Digital Computer Controls, Fairfield, NJ, echoes these statements. "It is becoming easier to add main memory," he observes. "We can now put 32 k of main memory on a single PC card. We offer either core or semiconductor memory. Our customers continue to prefer core. Reliability and nonvolatility are still attractive."

William C. Rosser, director of corporate planning at Interdata, Oceanport, NJ, comments: "Although core and semiconductor memory are still competitive, we think that '76 will see semiconductor memory finally overtaking core."



An entire 16-bit computer, including an LSI bipolar microprogrammed CPU and 32 k of core memory, has been placed on a single 15-in-square board by Digital Computer Controls.

The need for more main memory is leading semiconductor manufacturers toward premature marketing of 16-k RAMs. Although the market for 4-k RAMs is still in its formative stages, the first computer with a 16-k RAM has already been introduced. It is the NP/80 from Four-Phase Systems, Cupertino, CA.

When the memory is not main, it is peripheral. It usually comes in the form of disc systems, principally in two areas. The first is the development of increased-capacity hard disc drives for minicomputer systems, and the second is floppy-disc development.

Most disc drive manufacturers are developing drives similar to the Storage Module from Control Data, Minneapolis, and the Trident from Calcomp, Anaheim, CA. These have up to 80 Mbytes of storage in a removable disc pack. Control Data also has models with up to 300 Mbytes of storage. Drives in this class have track densities of up to 600 tpi and bit densities of over 4000 bpi.

Michael Shebanow, vice president of engineering at Pertec, Chatsworth, CA, notes: "Next year will also see small drives with 400 tpi and 4400 bpi densities. The 400 tpi performance will require a feedback or servo positioning system. We will also see drives with a combination of head per track and moving head readout on the same drive. Also, I see a trend this year toward small nonremovable disc drives and combination drives with a large nonremovable disc and a small removable disc."

Floppies take off

"Floppies are really taking off," says Phil Kaufman, director of corporate product planning at Computer Automation, Irvine, CA, "and we can't ship them as fast as our customers want."

The long promise of cheap random-access storage for minicomputer systems with flexible discs is finally about to be fulfilled. IBM-compatible floppies have already found a place in the market. This is going to be the year of the increased-capacity, non-IBM-compatible floppy. As Shebanow of Pertec points out:

"In floppies, '76 will be the year of double density. Double density is being achieved through the use of modified frequency-modulation recording. But the number of flux reversals is the same. New technology increasing the number of flux reversals will probably come in '76. Also two-sided recording will come this year."

In two-sided recording, both sides of the disc are coated, and each side is in contact with its own head.

Stephen Teicher, product manager for the LSI/11 at Digital Equipment in Maynard, MA, feels that the main market for floppies in '76 will be replacement of paper-

David N. Kaye
Senior Western Editor

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tape equipment.

Mag tape systems for minis will progress to 6250 bpi densities and speeds in excess of 100 ips. But most of the peripheral memory activity is in discs.

The age of the μP

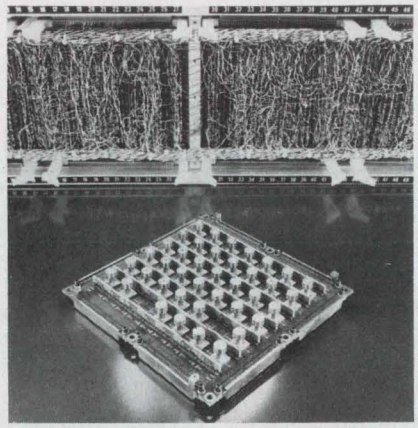
Microprocessors are being designed into a raft of new minicomputers, most of which will be introduced this year. Already several minis are on the market with μP CPUs. Last year Digital Equipment introduced the LSI/11, the heart of which is a MOS/LSI μP. Recently three minis have been introduced with bipolar bit-slice μPs for CPUs. The minis have come from Interdata, Digital Computer Controls and Monolithic Memories, Sunnyvale, CA.

Mini printers abound

For the last few years, pressure has been building to increase the performance and lower the price for minicomputer printers. The main areas of activity have been and will continue to be in low-speed, full-character printers and 200-to-400-lpm line printers.

In the low-speed area, continued penetration in word processing systems seems inevitable for the daisy-wheel printers from Diablo Systems and Qume, both in Hayward, CA. They have pushed the speed up to 55 cps, and this seems destined to go higher in '76.

In the 200-to-400-lpm area, the market is split between dot-matrix printers and full-character printers. According to Irving L. Wieselman, vice president of product programs at Dataproducts, Woodland Hills, CA: "The 300-lpm printers should finally settled down in OEM quantities to under $3000. Dot matrix heads are improving in reliability and should make important progress in '76. But for good-looking printing, dot-matrix will never replace full-character."



Amdahl's multi-chip carrier is shown against a conventional computer back panel. The carrier is a 10-layer PC board containing up to 42 ICs. Each IC has an amount of circuitry equivalent to one of the large PCs in the back panel. Each Amdahl multiple-chip carrier contains up to 4200 circuits, yet measures only 7 × 7 in. There are 51 multiple-chip carriers in the 470V/6 system.

Three new trendsetters

Three products have been introduced that promise to be trendsetters in '76. They are the 5100 Portable Computer from IBM's General Systems Div., Atlanta; the 470V/6 super computer from Amdahl Corp., Sunnyvale, CA, and the Tandem 16 NonStop computer system from Tandem Computers in Santa Clara, CA.

With the 5100 from IBM, there is further blurring of the difference between small computers, programmable calculators and intelligent terminals. The machine qualifies as any one of these, and it can be programmed in Basic.

Amdahl's fourth-generation computer takes a giant leap forward in integrated-circuit technology. It uses ECL/LSI technology with a switching speed of better than 600 ps. And Amdahl's computer servicing is unique; there's a room in the company's headquarters building where a team of diagnostic experts maintain a watch over every 470V/6 installed in North America. Their special equipment allows them to check on the status of all their systems, diagnose operating difficulties and issue instructions for repair or adjustment.

Tandem's system is a multiprocessing one with from two to 16 processors interconnected by a redundant bus. The system is capable of supporting up to 1000 terminals and is said to provide fail-safe operation. It heralds a trend toward the use of many small computers to do the work of one large one. And not only that, but to do it better and more reliably.

Another trend that is expected to accelerate substantially this year is distributed computing as more and more companies develop networking software.

"Our computers can all communicate with each other in data communications networks," says Teicher of DEC. "We and others have developed special line protocols to aid this process. Distributed computing allows for sharing of special peripheral resources," he adds. ■■

Digital controls and μPs to infiltrate all areas of consumer electronics

Breakthroughs in electronics for consumer devices appear unlikely in the coming year or two. But a major influence on design will be the invasion of all areas of consumer electronics by digital controls and dedicated microprocessor technology. The effect will be felt in TV, watches, appliances, automobiles and even hobby kits.

In TV sets this will mean more complex electronic tuning systems and automatic color controls, as well as more interaction between the user and his set. The interaction will take the form of digital and alphanumeric information on the screen—channel numbers, the time of day, even subtitles—along with the picture.

Jim McDermott
Eastern Editor

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Electronic TV games—such as the Odyssey, first produced by Magnavox—will be developed. In watches, the incorporation of microprocessors will permit the addition of nontiming functions, such as the calculator in Pulsar's new $3950 model. In appliances, electromechanical controls and timers will give way to electronic brains, like the microprocessor in Amana's newest microwave oven—an LSI central processing unit, ROM, RAMs and I/O devices.

In other consumer areas electronics will eliminate mechanical components and simplify mechanical design. Consider Singer's new Athena 2000 sewing machine. Here, an American Microsystems microprocessor has eliminated some 350 mechanical parts and given the user pushbutton control of 24 stitch patterns, including figures like dogs and tulips.

For hobbyists, the rapidly growing availability of relatively low-cost microcomputer kits will make the computer in the home a reality.

Digital technology, according to television-set manufacturers surveyed—Admiral, General Electric, Magnavox, RCA and Sylvania—will provide design advantages in several areas. One is electronic tuners.

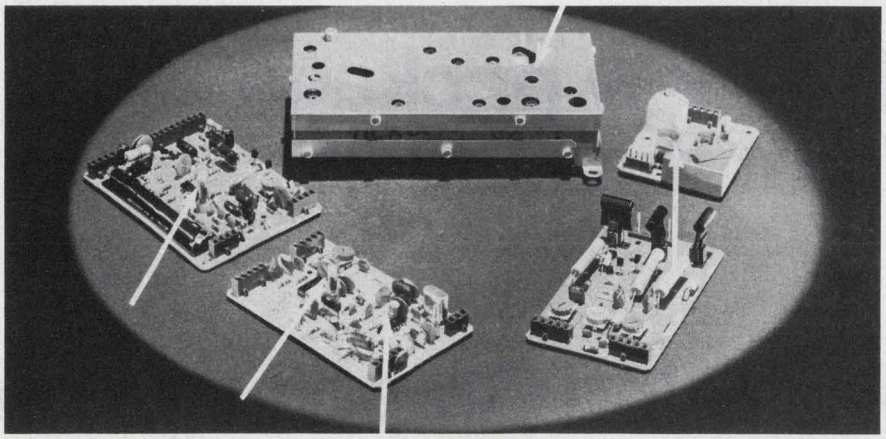
"There is a significant swing to varactor tuning," says William Newell, product manager of color TV at Magnavox, Fort Wayne, IN. "Varactor tuners are admirably suited for digital tuning systems.

"With the advent of IC tuning systems there will be considerable innovation over the next few years, not only in methods of tuning, but addressing and programming the tuner. In the case of our Star system it is not programmed but there will be lower-cost versions with various levels of sophistication. While our Star system is not a true microprocessor, we have work going on in that area.

Newell predicts a big future for TV games like the Odyssey.

"We'll have two new models this year" he says, "and others will be arriving on the scene with such features as a wider variety of games, on-screen scoring and a color background. And the use of microprocessors in these games will allow more player interaction, such as playing the game against itself."

Admiral in Chicago, a group of Rockwell International, will be using a complete one-chip microprocessor for a tuning system, according to William Slavik, director of advanced research and design.



Increasing use of digital technology in TV sets permits digital addressing and display of channel numbers on screen. Other digital MSI circuits, like these from RCA's new ColorTrak Receiver, control tint and color. Arrows indicate the ICs used in the five modules of the RCA package.

"We're looking at the PPS-4/1, a new Rockwell microprocessor," Slavik says. "We'll be using a smaller version of the 4/1, which will be powerful enough for any tuning system."

"The emphasis on reducing the energy consumed by TV sets will continue for the foreseeable future," says Dan Schuster, vice president of engineering for Sylvania Entertainment Products, Batavia, NY. "We've made tremendous strides in reducing power from 375 W some five years ago to from 90 to 130 W today. We're continuing to look for 5 and 10 W more savings."

In electronic watches, a trend to incorporating more circuitry than that required for timekeeping will be a major industry effort, according to John Bergey, president of Pulsar Time Computer, Lancaster, PA. The Pulsar Time Computer Calculator has a six-digit calculator built into the wristwatch.

As to the outlook for watch circuitry, Bergey sees "a rather substantial and increasing investment in I^2L technology." The high packing density of I^2L is a substantial advantage as more features are added to the watch.

A more conservative view is taken by George Smith, vice president of R & D for Litronix, Cupertino, CA.

"I don't see any massive rush from CMOS to I^2L," he says. "While I think that problems with I^2L will be resolved eventually, they remain to be solved."

One problem, Smith points out, is in driving displays. For greatest efficiency and brightness, the best way to drive a LED display is to turn on one segment at a time, he explains.

"But this requires segment drivers as powerful as the digit drivers," he notes. "And to do that, it's difficult to see what you're going to do for drivers on the I^2L chip."

Another thing, Smith says, "people I've talked to feel that there is no advantage whatever in the use of I^2L for a liquid-crystal watch."

On the other hand, Intersil believes there will be a renewed interest in liquid-crystal displays.

"They've shown a remarkable improvement in reliability and quality," says Murray Siegel, director of special projects and systems for Intersil, Cupertino, CA.

A year ago there was a general furor about using AT-cut, high frequency (3 to 6 MHz) watch crystals, but that has died down.

"The people pushing for the AT-cut were making assumptions that weren't valid," Smith says. "Crystal manufacturers don't know of any way to make an AT-cut crystal that's low enough in frequency to work with MOS, is small enough to go into a watch, and is cheaper than the standard 32-kHz X-Y crystals. The 32-kHz crystal is going to be around a long time." ■■

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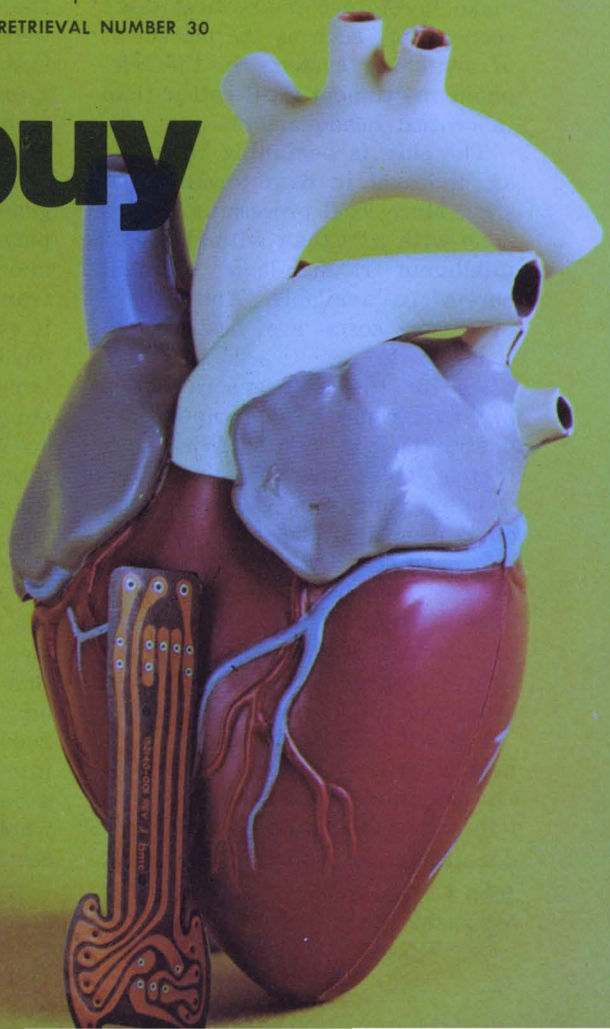

From data to process systems, μPs are reshaping designs

It is generally agreed that the emergence of the microprocessor is going to have a major impact on industrial electronics. But precisely how, when and to what extent specific industries will be affected are matters of opinion—and the opinions are regarded as valuable competitive tools and are therefore highly guarded.

The microprocessor has already changed instrumentation design—test, measurement and analytical. The chip is going to have a continuing impact on process controls and machine controls. And very shortly it should move into office equipment. The μP is already beginning to reshape the data-communications and computer industries.

Communications systems will be operated at much lower costs and higher efficiencies because of μPs. And new techniques will permit the creation of equipment that will make heretofore impractical tasks economical—such as the placement of switching systems in the telephone instrument itself rather than in central headquarters.

The chip is beginning to create an upheaval in data terminal design. More local processing can be done with μPs than with the most intelligent random-logic terminal heretofore available. And microprocessor costs are destined to come down.

As for the next generation of big mainframes? One computer industry official asks: "Who says there's going to be one?" Distributed computing, he says, may obviate most of the need for more big machines. "At the same time," he says, "there could be a new generation of mainframes of exotic architecture. And for those who are fully aware of these trends, there are powerful market advantages."

Hewlett-Packard's chief engineer, Eberhardt Rechtin says: "Decentralized computing—or distributed information processing—is a natural match to naturally decentralized organizations and operations. As time goes on, more and more electronic products—instruments, terminals, plotters, printers, desk calculators, handheld calculators and production machines—are likely to be networked as the costs of reliabilities of electronics data transfer improve relative to manual operation."

Other industry sources agree.

Distributed computation will be an important trend in process-control systems in 1976, says Bruce H. Baldridge, director of corporate marketing and product planning for Foxboro Co., Foxboro, MA.

"In the past," he notes, "computerized functions were performed in a single, large digital computer, such as the Fox 1 or Fox 2. Now we see a requirement for users to be able to split these functions into smaller pieces. The solution will be the use of systems such as Honeywell's Total Distributed Control system, the TDC 2000. This is typical of the systems that will be going into process-control rooms next year."

The Honeywell TDC 2000 integrates μP controllers, CRT displays that each use the CP 1600 μP and a data bus for information transfer. The system is flexible; it can be combined with computer hardware and software for controlling processes from the most simple to the most advanced.

"What we've done is to tie the total system together," explains Robert W. Moe, vice president and general manager of Honeywell's Process Control Div. in Fort Washington, PA. "The microprocessor is the key to the system. We've handled functions by local loop control that previously could be managed only by a computer. With the TDC 2000, we can put 28 algorithms into the system with one punch of a button. We've also simplified the whole installation and reduced the cost by using data busses."

Baldridge reports: "We at Foxboro will be building on our Spec 200 and Interspec systems." Spec 200 is an analog control system built in modules that can be combined into any system size. Interspec is an analog/digital interface package that allows the Spec 200 to be mated with any process-control computer.

"We plan to field-test some of this equipment—which will be microprocessor-based—early this year, both in the U. S. and Europe," Baldridge says. "We plan to give particular emphasis to the interface of the process operator—to provide him ease of input and easy assimilation of output."

Lowering automation costs

The aim at Measurex Corp., Cupertino, CA, has been to provide equipment that is cheap enough and small enough to make it worthwhile to automate facilities that haven't been worth the cost of automation. The company's 2000/Gemini, a digital multi-process control for the paper and pulp industry, is a twin-computer system that costs little more than its single-computer predecessor. It occupies only slightly more space.

One key development is a core memory card storing 16-k compared with the previous 8-k on a card of the same size. The system's interactive video generator subsystem, which offers three channels that provide seven different colors for the display formats, uses a powerful μP.

Intel also hopes to open doors. "We're going after new customers in 1976, people who've used electromechanical products up till now—like scale manufacturers for the supermarkets," says Howard Raphael, product manager for Intel, Santa Clara, CA.

"We're going to give them equipment that's easier to operate. It will be more integrated—more functions in a single digital chip. And we'll offer support systems as well as all the training and handholding they need to feel comfortable with the product." ■■

John F. Mason
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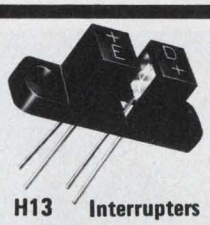

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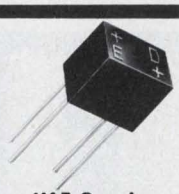

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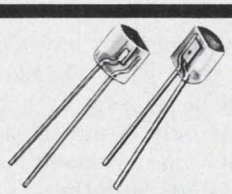

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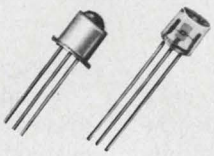

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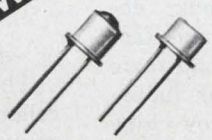

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GENERAL ELECTRIC

Just getting into microprocessors? Odds are you'll end up with a kit

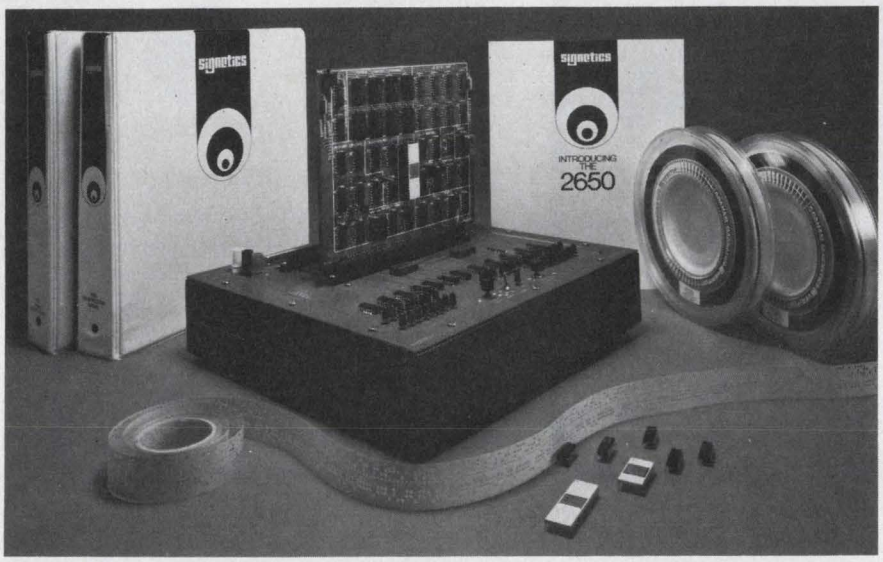
If you plan to buy a microprocessor this year, chances are that it will be as part of a design kit. Increasingly designers are turning to this do-it-yourself μP system because it lets them get started painlessly and inexpensively. And just about all microprocessor manufacturers have introduced kits or expect to.

Hobby manufacturers were the first to see the value of kits. The largest manufacturer—MITS in Albuquerque, NM—was so successful that it became one of Intel's largest customers. But under pressure from OEM designers seeking an easy, low-cost way to get a μP system up and running, kits have now been embraced by semiconductor manufacturers.

Actually kits intended for the hobbyist outwardly resemble those being used by the "serious" designer. Semiconductor manufacturers, though, contend that their units are better suited for industrial uses. OEM kits employ chips that don't exhibit the temperature and voltage limitations of ICs used in some hobbyist kits. These limitations aren't necessarily bad for the home experimenter, but they could be disastrous in an industrial application. Further, OEM kits have longer warranties, the micro makers say, than do their hobbyist counterparts.

Significantly manufacturers of both MOS and bipolar μPs indicate that kits are here to stay. They provide a convenient way to introduce additional or modified versions of a microprocessor family. A designer can use a kit to learn about the micro and even build a small system prototype. Then he can move on to more sophisticated development systems or employ computer services.

Edward A. Torrero
Associate Editor



A $155 kit for the 2650 microprocessor includes the CPU, PROMs, interface circuits and a board. Signetics offers the kit along with other design aids (some are shown) for the company's 8-bit NMOS micro.

The simplest kit consists of a collection of ICs that include the microprocessor, key peripheral circuits and some memory. Application manuals that are included tell how to interconnect the parts to form a working microcomputer and how to communicate with it. Many of these simple kits are priced at about $100.

Higher-priced units—costing up to $500 or so—may include a PC board, with sockets for the various components and space for expansion, or firmware packages for program development and debugging. They may have a control panel and case or the interface circuitry needed for system expansion.

All of the low-cost kits, however, require hand assembly for program entry. This may not be a problem if the program is only a few hundred words long, but manual assembly rapidly becomes unwieldly for much larger programs if the kit has sufficient memory to store the programs.

A more serious problem can arise if the kit doesn't come with adequate monitor and debug programs. A monitor program provides the means to drive a control panel or operate the system through a teletypewriter. A debug program lets you examine memory, insert breakpoints and single-step the system one instruction at a time. If an error has been made, you can go back and correct it. Often the debug and monitor programs are combined in ROM and offered as firmware.

"These programs are essential," asserts Joseph McDowell, American Microsystems' director of microcomputer products. "Without them, it's all a lot of magic. The teletypewriter doesn't work. Nothing works. The designer just has a lot of signals running around."

Still, the price of kits is hard to beat. Not only are they much cheaper than full-fledged development systems—like Intel's MDS

or Motorola's Exorciser, both of which cost several thousand dollars for a basic system. The components are cheaper than if they were bought individually. Savings of 50% or more tend to be the rule. And the cost of an assembled and tested system is usually only about $100 or so more than the price of the loose kit.

For example, Motorola's MEK 6800D sells for $149. The kit includes the 6800 CPU chip—which costs $69, if bought by itself—six memory chips, a peripheral interface adapter and a data-communication circuit. Also, Motorola provides a set of manuals that normally sells for $50 and a PC board that alone has a price of $65. The total price of all kit items, if they were purchased separately, would be over $300, or more than twice the price of the kit.

Memory limits prototyping

What you can prototype with a kit depends largely on how much memory comes with it. Capacity ranges from 256 bytes up to 8 k, though most kits don't have more than about 1-k words of storage.

Nevertheless a number of simple systems can be built. A motor driver, for example, may need only 50 to 100 instructions. The short program would be able to turn the motor on and off and monitor its speed.

A kit could be made to count and do simple arithmetic, like adding two decimal numbers and showing the result on a row of control-panel lights. The simple routines could be used in various controller applications.

But storage space can rapidly become a problem for a computer-peripheral controller, which needs about 1000 words of code, or a traffic-light controller, which may take 1800 words.

Further, these applications make hand assembly a tedious chore, and their programs can't be debugged easily.

A hand-assembled program that has errors may need to be redone. Program correction must be done one step at a time, unless a series of NO OP instructions have been entered. These, in effect, reserve spaces in the program for corrections.

Another possible problem may be the time needed to develop a system from the kit. A calculator that performs such functions as arithmetic, subtraction, multiplication and division can be fashioned from a kit. "But it could take two weeks or so for a designer to do it," says Mel Kutzin, manager of Schweber's MPU design center. Kutzin estimates that the same calculator can be simulated in an hour or less with a full-fledged, though higher priced, development system.

Some kits aren't easy to put together into a working system. Many of the simpler ones have been described as a "sack of parts with at most a little PC card." They contain a μP, clock, buffer to a data bus and some kind of interface. They may also have some debug programs in PROMs and a small amount of RAM.

"But these kits take a designer only halfway," asserts Phil Roybal, microprocessor marketing manager at National Semiconductor. "The designer still has to come up with his own I/O devices, assuming he's knowledgeable about I/O operations. And he has no easy way to program the micro. So he has a lot of things to do at a time when he's least capable of doing it."

One solution is to have a kit that provides a keyboard and a digital display. The keyboard allows data entry in hex or octal code, rather than in binary through switches, while the display shows the entered code or the result of debug operations. The assembled kit can be programmed easily, and sample routines can be run on it within a short time.

Though most microprocessor makers have yet to incorporate keyboards and digital displays into their kits, companies like Martin Research (Northbrook, IL) and Mycro-tek (Wichita, KS) among others, offer these features in kits based on popular μPs. The Martin Research entry, called the Mike series, has a base price of less than $300. The modular system allows easy expansion, and it features interchangeable cards. Memory and I/O cards for one Mike unit can be used with the μP card of another.

The unit that started the current popularity in kits—the Altair 8800 from MITS—is based on Intel's 8080 μP. One reason for the kit's acceptance: Programming can be done in Basic.

Expanding kit-based systems

One kit that avoids packaging altogether—but makes up for it in expandability and interfacing ease—is the Cramer kit. Priced at $495, this unit comes with 1-k words each of RAM and PROM, and it includes system monitor and self-test programs. Versions of the Cramer kit are offered for the 8080, 6800, F8 and Cosmac microprocessors. An upcoming Cramer kit will be based on Texas Instruments' new TM 9900, a 16-bit μP.

The basic Cramer kit doesn't have a PC board or power supply, though these are available as options. However, the basic kit does contain sufficient circuitry for the direct connection of a teletypewriter, RS-232 interface or audio-

cassette recorder. It also provides six control switches.

Further, address and data busses are fully buffered, so that memory can be added without sacrificing performance.

"This is important in prototyping," notes Scott McPhillips, vp of Microcomputer Technique (Reston, VA), the company that developed the Cramer kits. "Memory requirements may be larger than what is actually available."

Kits that don't have sufficient buffering can't always be expanded by the addition of external buffers. These can add unwanted capacitances that lead to troublesome delays.

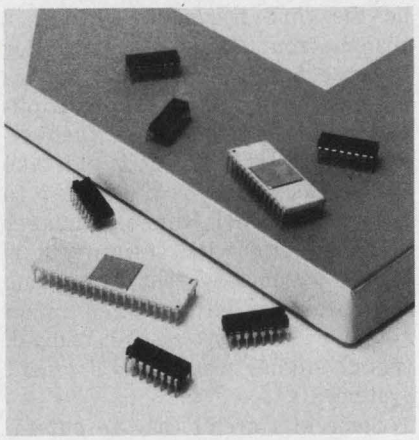
An alternative means for system expansion is to reduce the clock rate—a "solution" that limits the performance of the prototype.

Kits and μC development systems

Manufacturers that already have μC development systems tend to view kits as natural complements to their larger systems. "A designer can use our kit in conjunction with MDS," observes Intel's Hal Feeney, referring to the company's microcomputer development system. MDS features in-circuit emulation, or ICE, which permits both hardware and software development to be combined at an early design phase.

The kit board forms the prototype on which the ICE module is used. A designer carries out basic program development on the kit board, which is connected to whatever peripheral or interface is needed. Then an ICE module and MDS are used to debug the expanded kit system, now put together and customized for an application.

Like other manufacturers, Intel has employed kits as ways to introduce new or improved μPs. The company's latest entry—the MCS-80 Microcomputer System Design Kit—costs $350. It is based on the 8080A, a higher-speed version of Intel's high-flying 8080. The kit includes software-programmable peripheral circuits, erasable PROMs and a PC board with space for additional memory and I/O. One erasable PROM contains the system monitor, a system-operating program.



A set of chips and PC board make up Advance Micro Devices' $99.95 kit for the 2901 4-bit bipolar slice.

A complete system based on the 8080A can be built with an Intel kit priced at $350.

Similar programs come with kits based on the F8. These are offered by Fairchild and Mostek, among others.

Firmware can be stored in an F8 peripheral circuit—the program storage unit, or PSU—rather than in a separate PROM. The Model 3851 PSU has 16 bits of I/O and 1 k $\times$ 8 bits of ROM. The PSU combines features of a peripheral interface adapter, a timer and, of course, memory.

In the Mostek kits, the PSU memory holds firmware called DDT-1, a combination bootstrap-diagnostic package with limited editing capability. It can be used to copy, modify memory, dump, list and set breakpoints.

Mostek calls its entry the Survival kit and retails it for $297. But that price includes an F8 cross-assembler written in Fortran. The portable assembler can run on popular minicomputers as well as larger machines.

For Mostek, the initial Survival kit represents the first in a series of design aids that will culminate in a full-fledged microcomputer development system. The next offering will be a CRT-controller board (for $395), to be followed by a tape-cassette controller kit (under $300). The latter will be followed by a floppy-disc controller kit.

"We expect to have four different controllers, with documentation, by year's end," says Van Lewing, Mostek's manager for microcomputers. And each kit will show how to use the F8 in a different controller application.

With the hobbyist in mind, Mostek will also offer a chess game stored in the 1-k words of a PSU's ROM. The F8-based system will hook up to a home TV set. How smart a move the micro makes will depend on how much time you allow for the system to respond. A 5-minute response gives the μP enough time to make an "intelligent" move.

Kits from two manufacturers of CMOS μPs—Intersil and RCA—are available in factory-assembled and tested form. However, Intersil says it will offer its system as individual parts and board if the demand warrants. The RCA offering, called the Microtutor, is intended primarily as a training device rather than a prototyping unit. RCA also has a Microkit, which isn't a kit at all but a full-fledged microcomputer development system on the same level as the Exorciser.

The RCA Microtutor, priced at $349, comes as a small 4 $\times$ 5-in. box with eight binary inputs. All signal lines are brought out to a socket, enabling the designer to add memory, keyboard, teletypewriter or other peripheral.

The Intersil board retails for $295, a price that covers the 6100 CMOS μP, 1 k $\times$ 12 bits of CMOS memory and a control panel. The kit can interface to a teletypewriter, and its board contains sockets for PROMs. Data can be entered in octal or binary code. A user need only plug the board into a standard ac supply line.

The 6100 is a CMOS/LSI equivalent of Digital Equipment Corp.'s popular PDP-8 mini. Thus designers using the μP can benefit from the sizable support available for the mini. However, those software packages go only so far. Differences in signal requirements, timing and waveshapes between the

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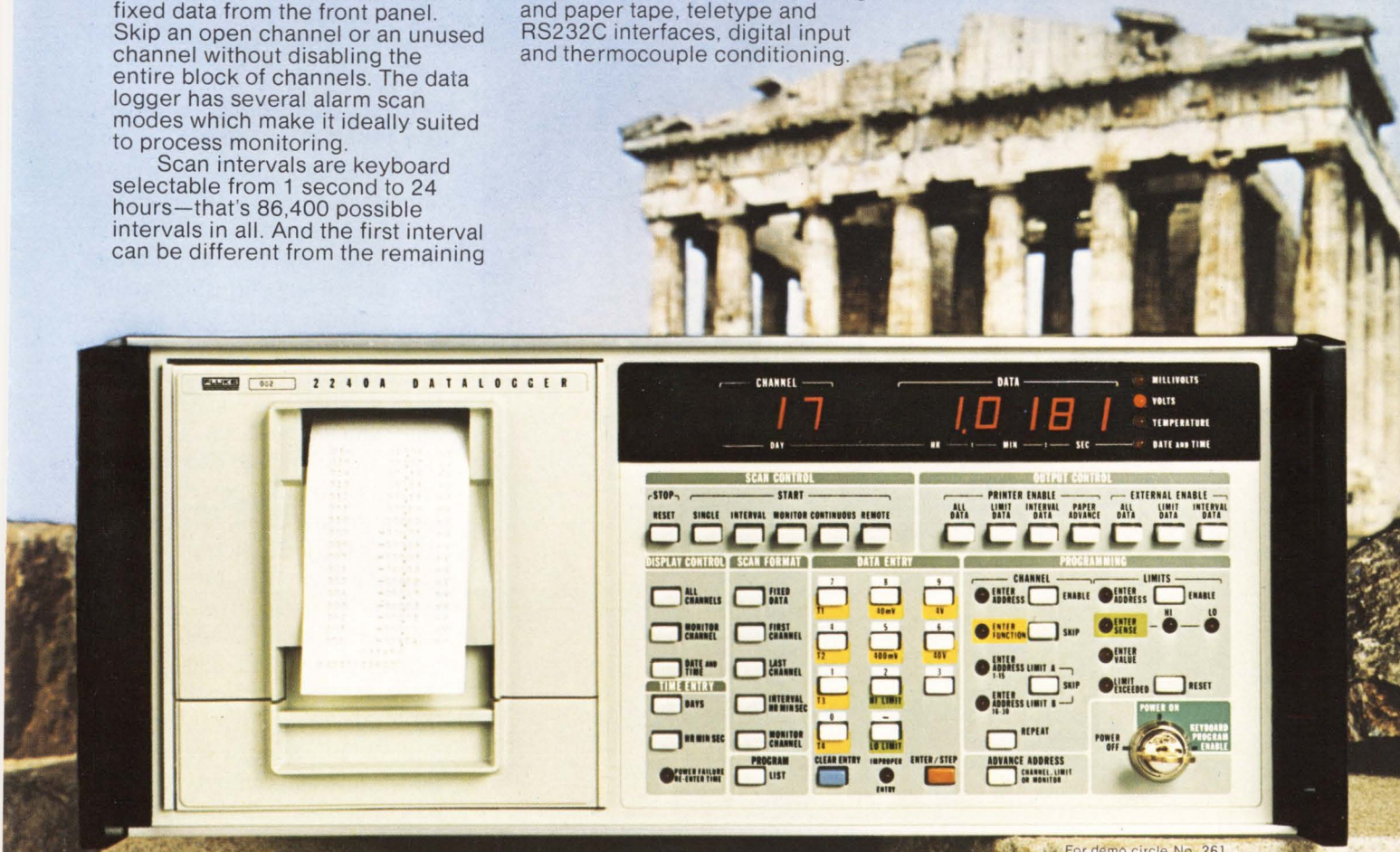

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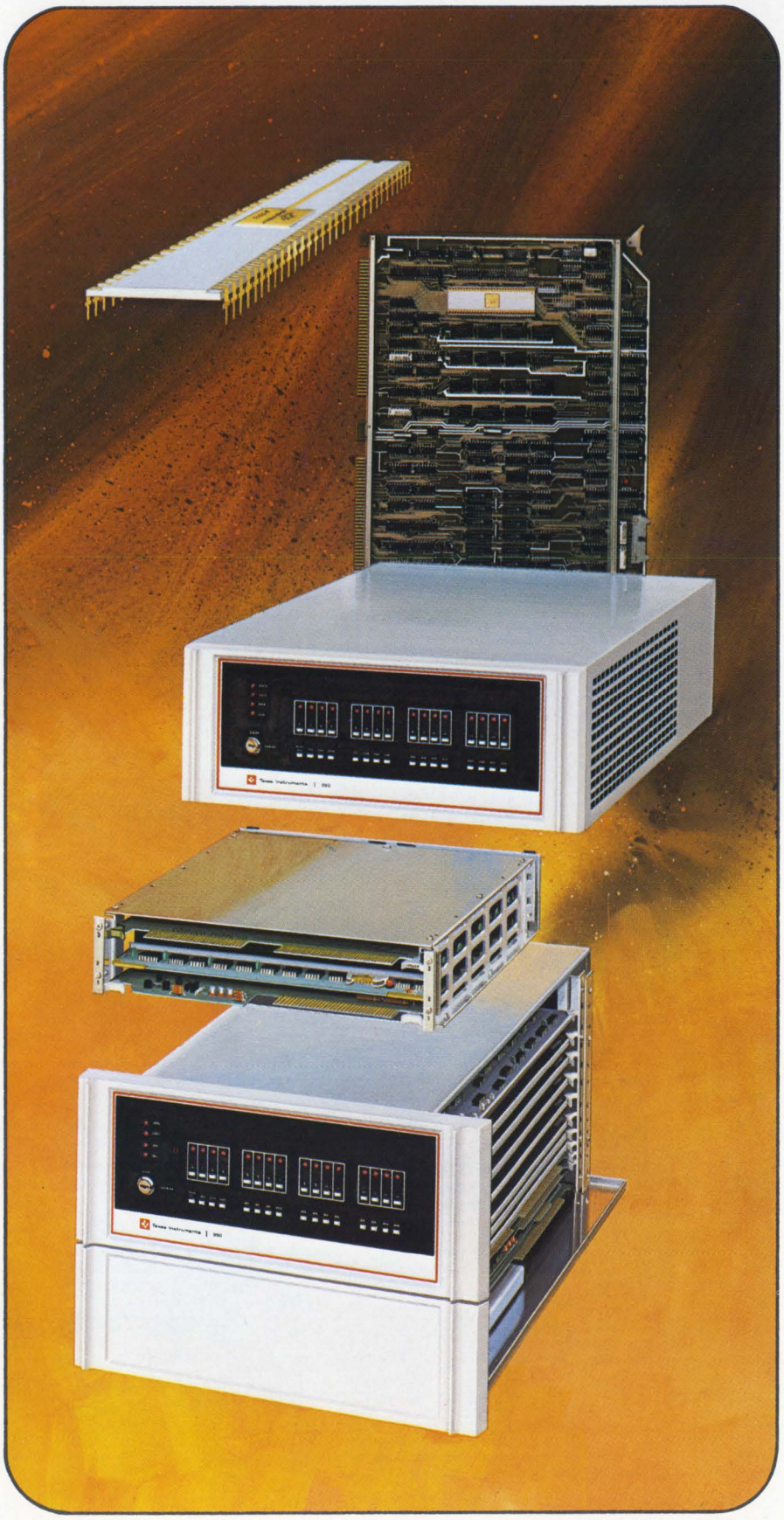
TI's 990 computer family...



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the 990/10 minicomputer with the disc-based DX10 operating system and an extensive set of software development tools. The standard package includes the 990/10 minicomputer with 64K bytes of error-correcting memory, ROM loader and diagnostics, 3.1-million byte removable disc kit with accompanying peripherals, and a complete software development package. And, at $24,500, this system costs at least 20% less than comparable equipment from other manufacturers.

For developing firmware modules, there is a $5950 prototyping system which includes a 990/4 computer with 16K bytes of memory and programmer's front panel, and a "Silent 700*" twin-cassette ASR data terminal. Also, an optional PROM programming kit is available for developing read-only memory.

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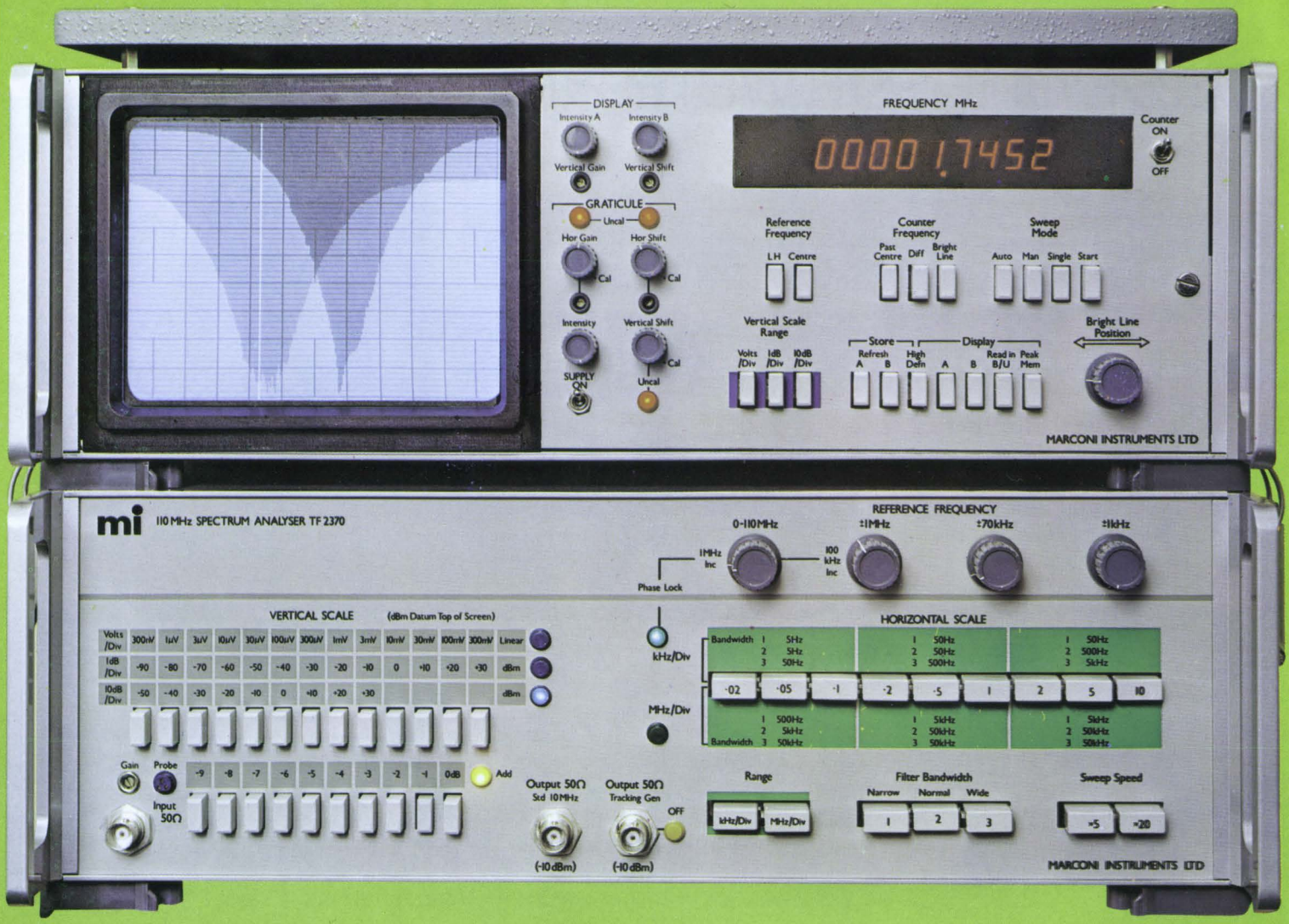

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chip and the mini dictate the use of a hardware development system.

Hobbyist kits attract OEMs, too

A number of kits have emerged from manufacturers that don't make ICs. The kit makers include MITS (Albuquerque, NM), Microcomputer Associates (Los Altos, CA), Southwest Technical Products (San Antonio, TX), Sphere (Bountiful, UT), V Digital Group (Denver, CO), and the list is growing rapidly.

Though a number of the systems offered have been directed at hobbyists, their ease of use and ready availability have attracted industrial designers seeking a quick and inexpensive way to get a working prototype.

One of the first kits, and the one that led the way for their wide acceptance, was MITS' Altair 8800, based on Intel's 8080 chip. A key factor in its acceptance is the fact that hobbyists using the Altair can employ Basic for programming. And the MITS version of the high-level language uses only 5 k or so words of memory. A base price of $439 for the Altair 8800 buys a CPU card, control panel, power supply and case. Up to 16 cards can be accommodated in the main case, so the microcomputer can be developed in a myriad of directions.

More recently, MITS has come out with the 6800-based Altair 680. A barebones kit for $180 consists just of the CPU board. But a complete microcomputer can be bought for $293. This version includes power supply, front panel, case, 1 k of RAM and a built-in RS-232 or 20-mA current-loop interface.

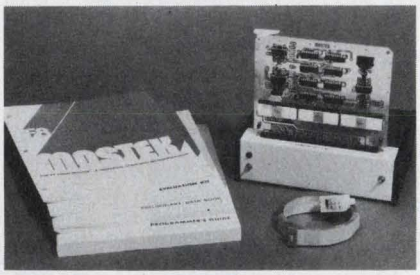
Another 6800 computer kit has been introduced by Southwest Technical Products. Like the MITS version, this unit comes with supply and case. In addition it contains 128 words of static scratchpad RAM, a main memory board with 2-k words and a special Mikbug ROM. The ROM contains a program that allows data to be entered the moment power is turned on—a feature not yet available in the MITS version. The entire kit costs $450.

The Jolt computer from Microcomputer Associates employs the 6502 μP, an 8-bit micro from MOS Technology. The 6502 is similar to Motorola's 6800, but it has a much lower price tag. Also, unlike the 6800, the 6502 has a built-in clock generator.

The Microcomputer Associates' computer comes with debug and monitor ROM (called Demon) and 512 bytes of memory. A special self-adapting interface in Jolt can adjust to any terminal speed from 10 to 30 characters per second. A 20-mA and EIA interface are also included in the kit, which started out with a $249 price tag. Now it's going for $159.

Bipolar μPs have kits, too

Unlike kits based on MOS microprocessors, the smaller but growing number of kits using bipolar



Controller kits based on the F8 show how to apply the μP. Mostek retails its Survival kits for $297.

μPs are available at present only from μP manufacturers. And the bipolar-μP kits are intended primarily for industrial designers seeking to emulate existing systems with higher-speed versions.

Most bipolar micros aren't complete microprocessors. Fixed instruction sets—which come with MOS μPs—must be developed through microprogramming. Thus bipolar micros have been aimed more for the computer architect than the random-logic designer.

The only bipolar processor that isn't a slice is Scientific Micro Systems' SMS 300, a complete 8-bit bipolar μP with a macro instruction set. The SMS 300 had been available only as part of the company's Microcontroller system. Recently though Scientific Micro Systems unbundled the Microcontroller, making the system available in kit form. A starter kit priced at $495 includes one SMS 300, six 512 $\times$ 8-bit PROMs and four I/O circuits.

Going in the other direction, Monolithic Memories has packaged its 6701—a 4-bit bipolar slice—into a kit that forms a 16-bit stripped-down, general-purpose mini. Priced under $300, the kit has microcode stored in PROM; so a designer doesn't have to microprogram the machine.

The 6701-based kit also has 1-k words of RAM, a debug routine in ROM, and 2-k words of PROM—some of which is factory-programmed with sample routines. However, the computer can be programmed further in assembly language. A user has to provide teletypewriter, power supply and a clock crystal.

"He'll also need some SSI and MSI, but the most costly parts will be in the kit," concludes Ed Barnett, Monolithic Memories' product marketing manager for computer logic products. Barnett estimates that a designer could get the computer up and running in an hour.

In contrast, the initial entry from Advanced Micro Devices is intended to be a simple evaluation and demonstration kit rather than a complete computer system. The manufacturer makes the 2901, a 4-bit slice that architecturally resembles Monolithic Memories' slower speed 6701.

The key elements of the 2901-based kit are a single 4-bit slice, microprogram-address generator and RAM as the microprogram memory. The RAM can handle 16 words, each 20 bits wide, and its use in place of the more usual PROM simplifies changes in the microcode. The manufacturer also provides a PC board that makes internal signals externally available through a 100-pin edge connector. The kit costs just $99.95.

Two different kits are available for the 3000-series processor. The one from Intel—the company that introduced the 2-bit bipolar slice—contains sufficient components to form a 16-bit system. The other, from alternate-source Signetics, forms an 8-bit system, and the kit retails for only $100.

Not too far down the pike are bipolar-μP kits that will emulate popular MOS processors, like the 8080 and 6800. These kits will come programmed with macro instruction sets. ■■

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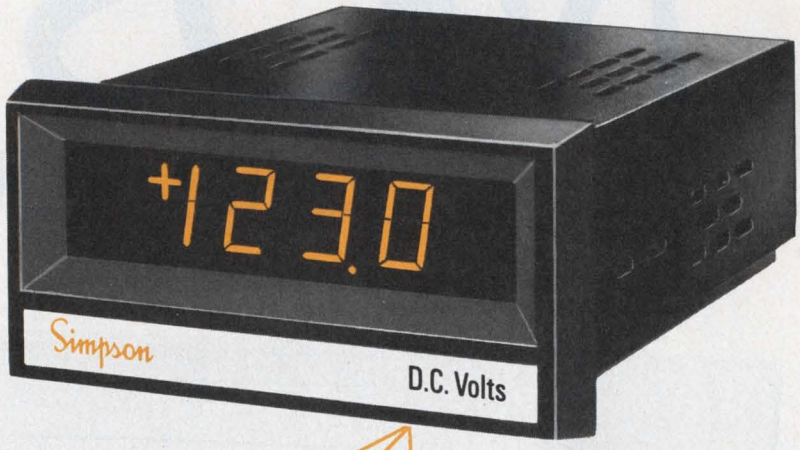

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INFORMATION RETRIEVAL NUMBER 34

MOSTEK'S
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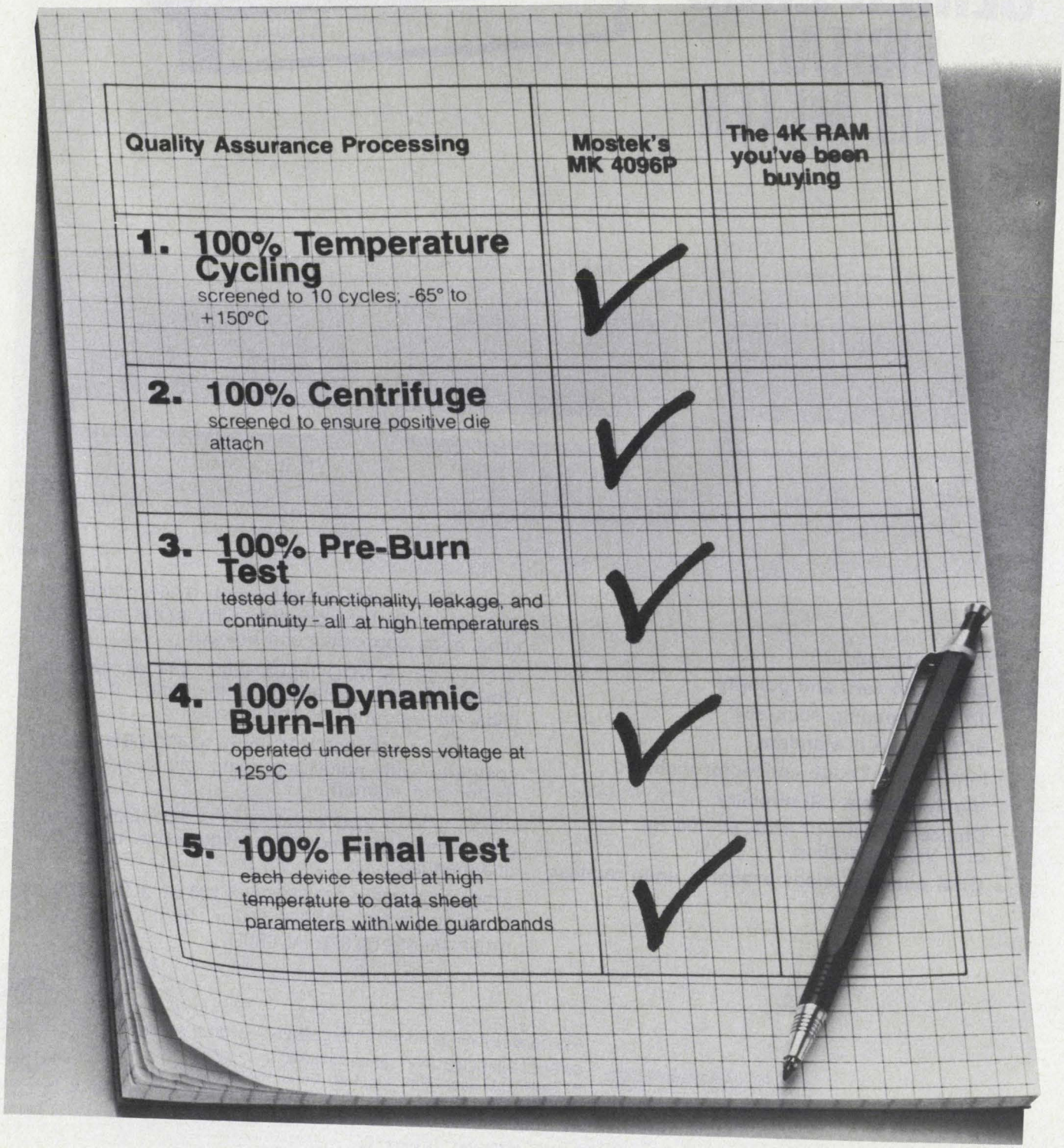

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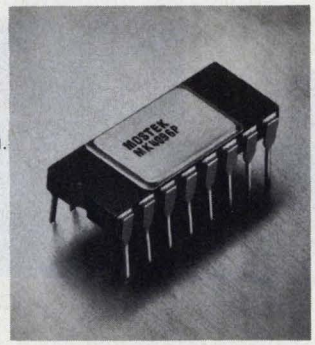

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INFORMATION RETRIEVAL NUMBER 36

Washington Report

Design-to-Cost program looks promising

The moment of truth for the Defense Dept.'s Design-to-Cost program will come in the next two or three years when actual production costs, plus maintainability and reliability data, become available on the early projects operating under the concept. The biggest "if" that threatens to distort the results is inflation, warns George R. Sutherland, assistant director of Defense Research and Engineering for system-acquisition management. But he's optimistic.

Speaking to a Government-industry seminar recently in San Francisco, Sutherland said that despite inflation, the projects were showing less rise in costs, in "real terms," than similar programs of prior years. If economic conditions become more stable for two or three years, he is confident that the Defense Dept. will be able to prove conclusively that Design-to-Cost will have reversed the spending patterns of the past.

Sixty-four major defense systems are already under the program or slated to be included. A year ago the total stood at 54.

Defense Dept. clamps down on gratuities

Even if the official is a close personal friend or a relative, you can't give him even a small gift under new restrictions announced by Deputy Secretary of Defense William P. Clements, Jr. They apply if you are engaged in, or trying to engage in, business with the Defense Dept.; if you conduct operations or activities regulated by any defense agency; or if you have interests that may be substantially affected by the official performance or nonperformance of the defense personnel involved.

After the recent furor over such things as goose hunts, Clements had Directive 5500.7, "Standards of Conduct," reviewed and has now closed several loopholes under the section dealing with "gratuities." Deleted are: "customary exchange of social amenities between personal friends and relatives when motivated by such relationships on a personal basis" and "transactions between and among relatives which are personal and consistent with the relationships."

FAA plans radio control of airport lighting

The Federal Aviation Administration has adopted standard radio control systems for airport lighting and plans to install them at more than 300 airports by the end of 1976. These are systems that allow pilots to actuate the lighting systems at unattended airports by keying the microphone a specified number of times with the radio tuned to a discrete

frequency.

The air-to-ground control system is on an automatic timer, and the lights automatically turn off after 15 minutes. The sequence can be restarted at any time by keying the mike again. Some airports have been using the system since 1972 as a means of conserving electricity.

Also being installed are ground-to-ground radio control systems at airports where full or part-time air controllers are on duty. When they are in the tower, they will activate the system for the pilot via radio for approaches and landings.

Boeing scores 100% in AF incentive program

For its performance on the B-1 bomber avionics system, the Boeing Co. becomes the first ever to score a 100 per cent rating in the Air Force incentive program, which awards cash for above-average performance. Boeing took home an extra $325,000 as associate contractor for avionics integration from August 1974 through the delivery of the first set of offensive avionics in July 1975, which is the third of five periods designated for incentive awards. In the first two of the $200-million contract, Boeing scored 80 per cent and 87 per cent.

Another plum that the company is eying on the B-1 program is a possible contract for aerial tankers for the new bomber. The Ford Administration is reported looking favorably at Air Force proposals to build a new tanker fleet that eventually could consist of 300 aircraft.

Capital Capsules:

The Electronic Industries Association has **new standards on the testing of power transistors and on optical characteristics of cathode-ray-tube screens**. . . . The Aircraft Owners and Pilots Association has petitioned the Federal Communications Commission to add 122.7 MHz as a primary frequency at airports without traffic control towers. Now in use are 122.8 MHz and 123.0 MHz, but heavy use, AOPA officials say, necessitates use of another channel. . . . The National Aeronautics and Space Administration **has selected Lockheed Missile and Space Co. to design and manufacture Seasat-A, the new ocean survey satellite.** The satellites, product of a $20-million contract, will observe ocean surfaces with a radar altimeter, a synthetic aperture imaging radar, a wind-field scatterometer, a scanning multifrequency microwave radiometer and a visible and infrared scanning radiometer. . . . The National Electrical Manufacturers Association **has started moving staffers to Washington.** Full move is to be completed by April 30, 1977. . . . The Federal Communications Commission has given **a tentative green light on allowing 12 clear-channel AM band stations to operate with more than 50,000 W of power** and permitting lower-power local stations to operate on those 12 channels. The commission will ask for public comment on such things as allowing transmitters of up to 500,000 W. The object is to expand radio coverage to rural areas, but that power was once tried by WLW in Cincinnati and it caused such problems as unwanted reception by fillings in teeth and glowing in light bulbs near the transmitter. As an alternate, the FCC is asking for a study of expansion of FM service in rural areas. . . . The Army has a program under way **to design and develop a C-band, 12-W power transistor.** The Army Electronics Command wants the 4.4-to-5-GHz device for use in phased-array communications, radar and jammer transmitter applications. . . . A lightweight, low-cost **radar missile for the F-15 and F-16** is on the Air Force shopping list. The missile would also be suitable for similar Navy aircraft.

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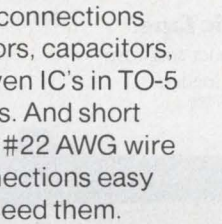

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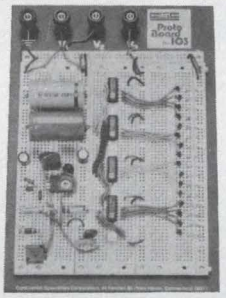

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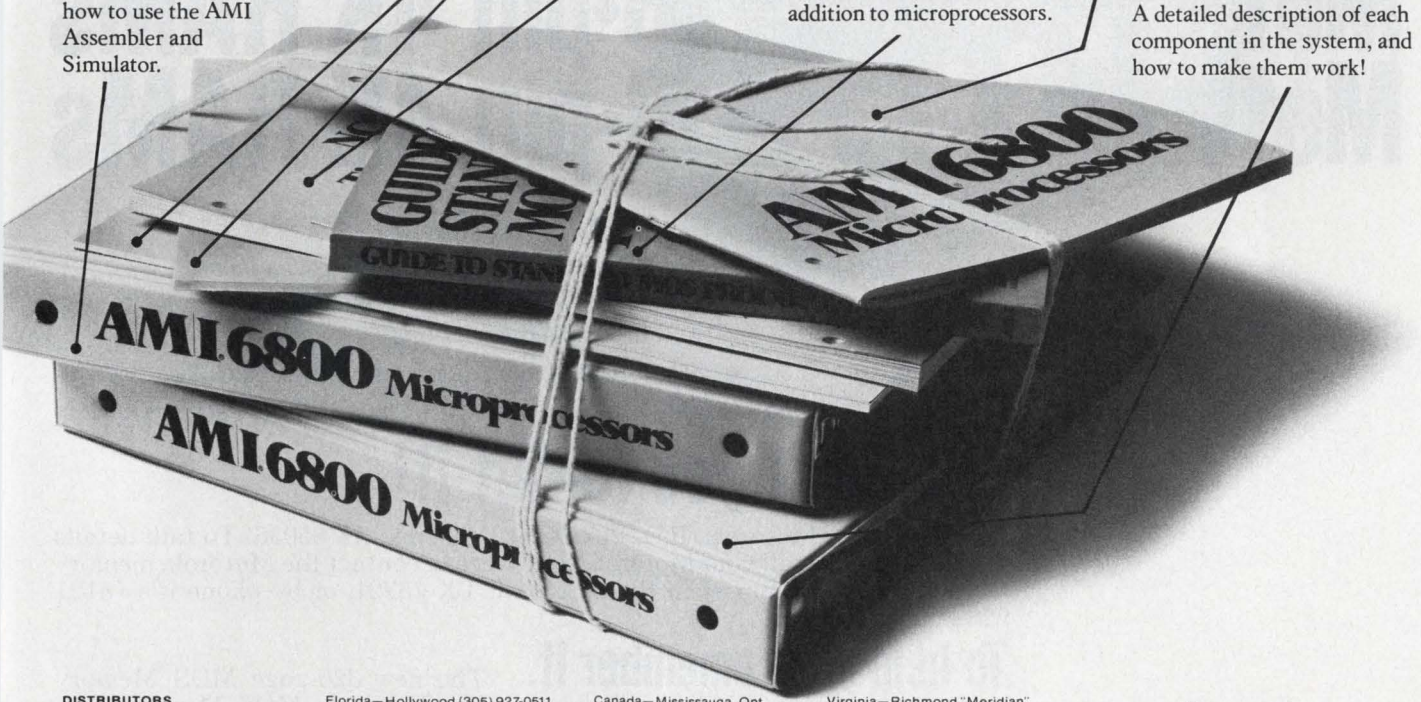

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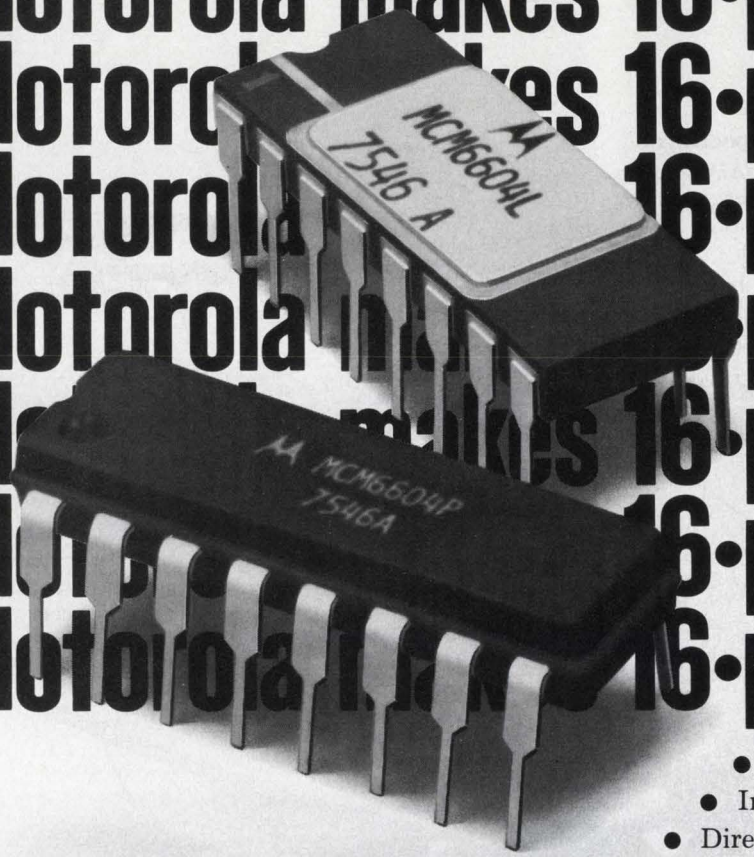

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Motorola makes 16-pin 4K RAMs

Microprocessor turns up for first time as the key part of time-sharing system

A microprocessor-based minicomputer has been used for the first time as the heart of a time-sharing system. The system, the 11V03 from Digital Equipment Corp. (Maynard, MA 01752. 617-481-7400), can handle up to four terminals and can be programmed in Basic at each terminal.

The operating system can also support a single terminal in Fortran IV or assembly language while operating the three other terminals in Basic. According to William G. Witmore, educational products group manager:

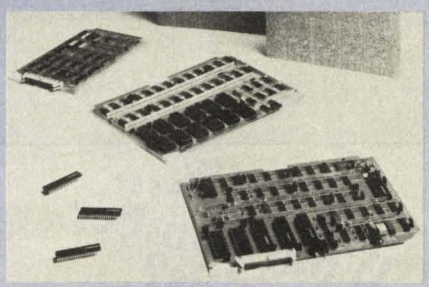
"The CPU in the system is the PDP-11/03 microcomputer. It contains 28-k words of main memory, with dual flexible discs adding more than one-half million bytes of mass storage. Purchasers can choose either the 24-line VT52 Video Terminal or the 30-CPS LA36 Decwriter II as the system's first terminal. Addition of a VT55 graphic display terminal provides interactive graphics capability."

One terminal is included in the $16,200 price. A four-terminal system can be had for $19,970 and up, depending upon the terminals selected.

"This is the first time that a four-terminal time-sharing system can be purchased for less than $5000 per terminal," Witmore says. "This is cheaper than the effective cost of renting four terminals on a larger time-sharing system. The only limitation is that the larger system provides storage for a larger data base. We see our first customers for this system as being in the educational market."

CIRCLE NO. 501

Three-chip set holds 16-bit microprocessor



Three silicon-gate NMOS chips comprise the basic components of the 16-bit microprocessor from Western Digital (3128 Red Hill Ave., Newport Beach, CA 92663. 714-557-3550).

The new MCP 1600 chip set employs the CP 1621B control chip to generate microinstruction addresses and control signals. The CP 1611B data chip performs arithmetic and logic functions, and it contains addressing and data-handling logic. Programs are stored in the third element, a microinstruction control ROM (MICROM), which has a 512 × 22-bit organization. Up to four MICROMs can be used, for a total of 2048 words of instruction storage.

Originally developed for Digital Equipment Corporation, the MCP 1600 is essentially the same as the chip set used in DEC's LSI-11 microcomputer. The MCP 1600 employs the same basic bidirectional bus structure.

While the MCP 1600 internally processes data words in 8-bit segments, it has been designed as a 16-bit machine. The three chips are interconnected by an 18-bit microinstruction bus. An additional data-access bus uses a 16-bit port for communicating with memory, I/O devices and other system components.

The CP 1611B data chip includes an ALU and 26 8-bit registers. Condition flags are provided on the data chip.

Address generation for fetching microinstructions and control signals for the data-access bus are supplied by the CP 1621B control chip. Four external and three internal interrupts

(continued on page 62)

(continued from page 61)

are provided on the CP 1621B along with seven system control lines. The programmable logic array on the control chip interprets interrupts, and it can be programmed by the user to provide data-driven program jumps.

Development aids include the following: a basic microcontroller board with a preprogrammed diagnostic MICROM; an interface board that provides the basic bus structure; a writable control storage board; and a PROM board. Users must furnish terminals and power supplies. Programs can be assembled and simulated by the use of Tymshare services or a DEC PDP-11 system equipped with Western Digital software packages. The basic MCP 1600 costs $159 in 100-to-999 quantities. Delivery is 6 weeks.

CIRCLE NO. 502

Wiring analyzer programs itself with aid of μP

Pressed by customers for a more flexible instrument that can interface to a variety of peripheral devices, Algorithm Technology (P.O. Box 1910, Prescott, AZ 86301. 602-445-8180) has come up with a new wiring analyzer that uses the Signetics 2650 microprocessor.

The analyzer is called the ATE 8000, and its internal 8-bit micro controls a switching array that can analyze up to 65,000 nodes in a circuit.

An unusual feature is that the analyzer is self-programming. According to Chuck Terry, design engineer for the unit, most other analyzers take several hours to program. But the ATE 8000 can be programmed in a few seconds, he says.

Explaining further, Terry notes that instead of manually programming in the details of the board to be tested, a known good board is inserted into a test fixture and analyzed by the machine. Once this is done, a digital display reads out a series of numbers that represent the interconnect pattern for that board. And when these numbers are dialed in on the unit's thumbwheel switches, the analyzer is set to test similar boards of unknown quality.

If a known good unit is not available but a magnetic tape with parameters is, the analyzer can be programmed from the tape.

Once the thumbwheel switch numbers are determined, the ATE 8000 takes only a few seconds to do a GO/NO GO test on an unknown board. If a printer is added to the basic tester, a listing of errors in the board under test can be produced. Prices for the basic system start at $4000.

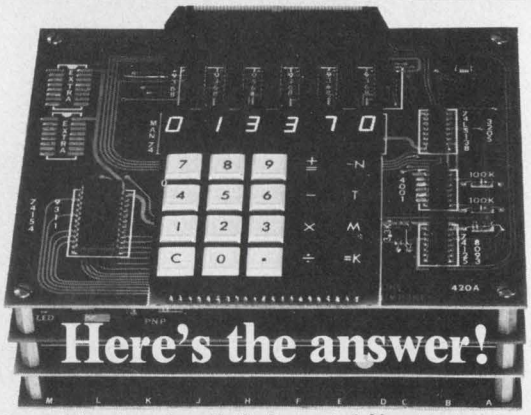
CIRCLE NO. 503

(continued on page 64)

QUICK... What number is this?

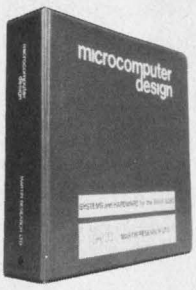
If you have to read your microcomputer the old-fashioned way – bit by bit, from rows of lights – the computer's making **you** do **its** work!

- Don't **toggle in** a program on a bank of switches – **key** it in.
- Don't read date and addresses **bit by bit** – read a series of **fully decoded digits** (octal or hex).
- Don't debug by **single-stepping** through a program – set **breakpoints.**



The **modular micros** from Martin Research. A 20-pad keyboard; six bright digits; and a Monitor program in a PROM make program entry easy. And, even the smallest system comes with enough RAM to get started! The **MIKE 2** system, with the 8008 and the 8080-based **MIKE 3** use the **same** bus structure. Accessories – like our 4K RAM – work with these and other 8-bit CPU's. And, systems start at under $400!

Still available from Martin Research – our innovative book, **Microcomputer Design.** An industry standard for the engineer designing with microprocessors.



With 8080, $150.
With 8008-1, $110.
With 8008, $100.
Alone, $75.

School and quantity discounts. Over 300 pages, dozens of schematics. Worth its weight in microprocessors!

MR

martin research

3336 Commercial Ave.
Northbrook, IL 60062 (312) 498-5060

INFORMATION RETRIEVAL NUMBER 40

The Right DMM Decision Means Five-Function Autoranging for only $225*

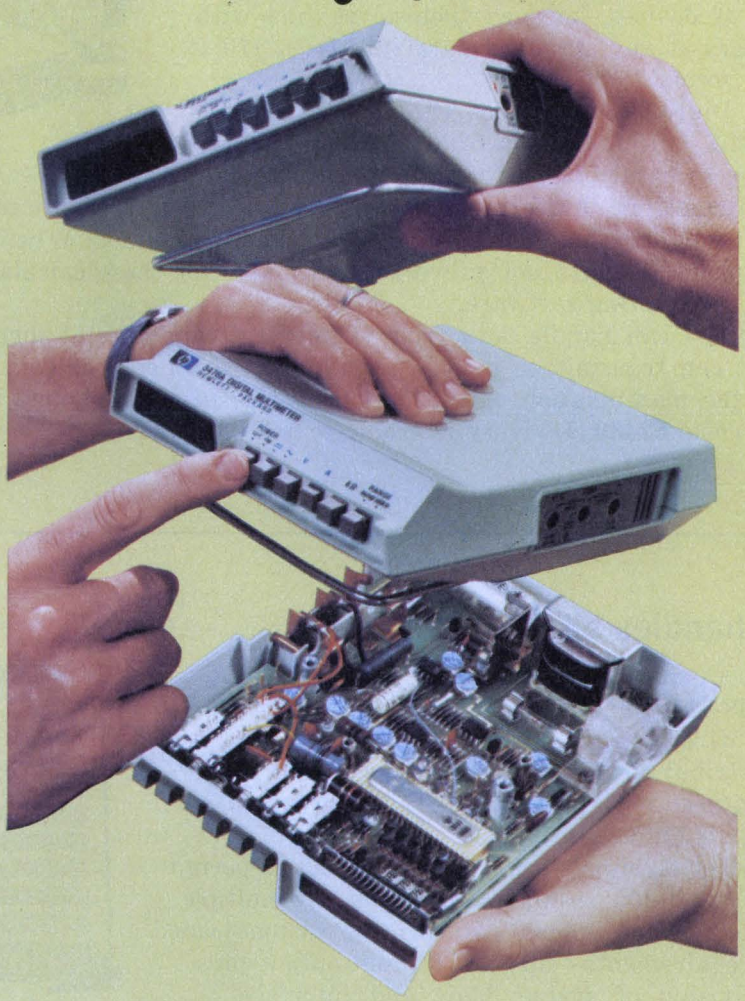
Introducing HP's 3476A DMM

The price is a big story in itself. But performance and reliability play a large part too. Take a look at the 3476A:

Autoranging—a big plus in a low cost DMM. It lets you concentrate on the point of measurement... minimizes reading errors... and speeds readings too. All readings are made directly in volts, kilohms, or amps-on an LED display. And there's a rangehold button to speed and simplify repetitive measurements.

Five functions—all the functions you want and need in a low cost DMM. Simply push the appropriate button to read AC volts, DC volts, AC or DC current, and ohms. There's no worry about polarity or zero... they're both automatic.

Advanced design—both circuit and packaging. And both contribute to high reliability. One circuit board contains all the electronics.



Tantalum nitride on sapphire processing allows replacement of all front end precision resistors by a single chip. That means greater reliability and better temperature stability. Of course it's input protected.

Convenient size—just right to hold in your hand... take with you in a brief case... or use on your bench. An optional carrying case and probe kit let you hang the instrument from a strap for "no-hands" operation. The "A" version ($225*) operates from the AC line for lab use. And for portable applications, the "B" version ($275*) has built-in batteries and recharging circuitry.

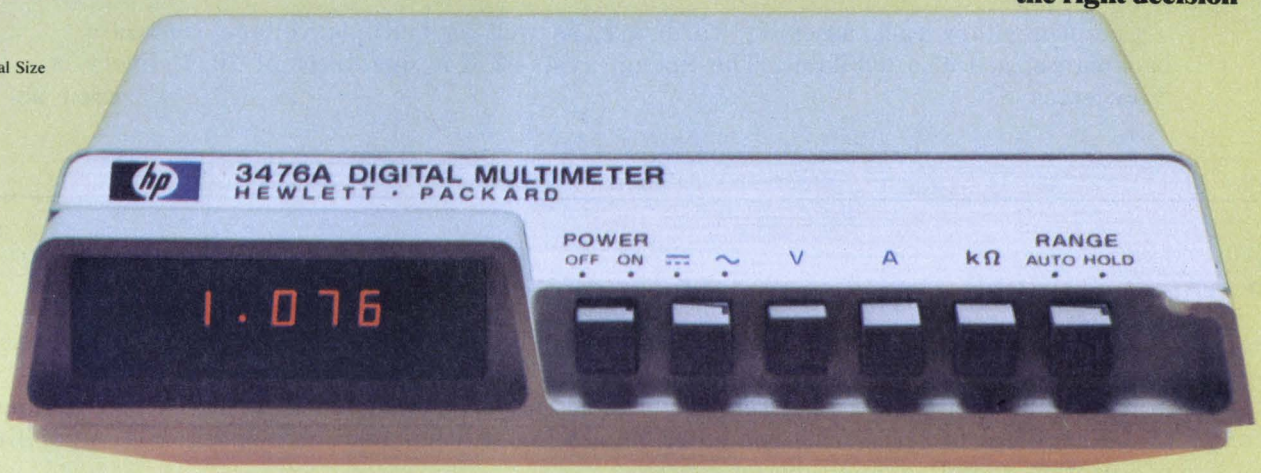
The 3476A is backed by HP's service organization ...another big plus for a low-cost DMM. With these prices and features, why not put your hands on the 3476A for your 3-1/2 digit measurements? Your local HP field engineer can tell you how.

*Domestic U.S.A. prices only.

HP DVM's— the right decision

Actual Size

095/52



HEWLETT hp PACKARD

Sales and service from 172 offices in 65 countries.
1501 Page Mill Road, Palo Alto, California 94304

INFORMATION RETRIEVAL NUMBER 41

(continued from page 62)

μC-based interface unit teams up with programmable calculator

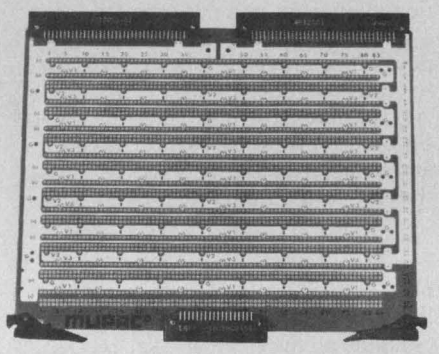
Thanks to a new μC-controlled interface unit, the WU-7, any of the estimated 25,000 existing Wang 600 and 700 programmable calculators can now communicate with a wide variety of devices, between themselves, and with other computers at any standard data rate from 110 to 9600 bits per second.

Offered by Digital Laboratories (377 Putnam Ave., Cambridge, MA 02139. 617-876-6220), the interface unit's μC is programmed to perform such functions as translation, formatting, buffering and serializing. Simple I/O procedures—one of the major features of programmable controllers—are still retained. When using communication-oriented peripherals—units not previously available for these calculators—the μC makes it possible to use existing software.

Also, the WU-7 can handle data from instruments and special-purpose apparatus. The interface unit can transmit or receive all 128 ASCII codes. The calculator can then be dedicated to the manipulation of the pertinent data just as if it had been keyboard entered.

The WU-7 costs $2450. Delivery is from stock to 30 days. CIRCLE NO. 504

Breadboard card handles all size packages



The Mupac Corp. (646 Summer St., Brockton, MA 02402. 617-588-6110) breadboard called the Sponge is a wrapped-wire panel that contains four voltage planes for power distribution. Microprocessors, random-access memories and read-only memories of all major vendors will plug directly into these panels.

Rows of socket terminals have been layed out to permit the mounting of all dual in-line packages on any multiple of 0.1-in. spacing. The Sponge may also be custom-loaded to customer requirements—up to 270 input-output pins provide subdivision of system logic and interface requirements.

Complementary rack assembly hardware, as well as multiple voltage connector backplanes, are also available. The Sponge costs $245 in quantities of 10. Delivery is from stock. CIRCLE NO. 505

μP cross assembler runs on most 16-bit minis

Mycro-Tek, Inc. (6631 E. Kellogg, Suite 214, Wichita, KS 67207. 316-686-3311) reports that software development time for 8080-based microcomputer systems can be significantly reduced with its cross assembler. The assembler is designed to give the programmer the advantages of large-scale computer processing, editing and high-speed I/O capabilities not usually found in micro-based systems.

Written in ANSI standard Fortran IV, Mycro-Tek's program will execute on any 16-bit word computer whose compiler supports this language. It can also run on machines with word lengths of greater than 16 bits. The program generates an assembled program

(continued on page 66)

There's a reason we make so many types of precision resistors.

You need them.

Established Reliability Metal Glaze. Per MIL-R-39017, 55182 and program specifications.

Precision Metal Glaze™. Rugged performance at low cost. An industry standard for semiprecision and precision film resistor applications.

Precision Metal Film. Excellent high stability performance in a wide variety of sizes and specs. S level MIL-R-55182.

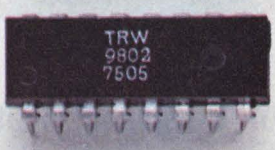
Precision Power Wirewound. Best available power-to-size ratio from ½-10W. Tolerances to 0.1%, TC < 20ppm.

Precision High Voltage, High Resistance Metal Film. Excellent high voltage load stability; 1.5-20KV, to 500 Megohms ±1%.

Ultra-Precision MAR™. Bulk property metal film. Rugged molded construction. Broad resistance range, high frequency response with TC's and tolerances to 2ppm and .01%.

Precision Power Metal Glaze. 3W rating in a molded RW69 size. Runs cooler than wirewound. Has excellent frequency characteristics.

Precision Power Metal Film. Excellent power-to-size ratio, 1-5W ratings. High frequency response. Tolerances and TC's to 0.1%, 25ppm.



Precision Film Resistor Networks. 7,8,10 and 12 bit R2R ladders replace up to 27 discretes. Other precision TaN-Film™ networks available.

Most types available from your local distributor. Or, for the broadest choice in resistors for all types of applications, write or call TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., 401 N. Broad St., Phila., Pa. 19108. Tel. 215-922-8900.

TRW® IRC RESISTORS

We give you a choice.

INFORMATION RETRIEVAL NUMBER 42

(continued from page 64)

listing and a hexadecimal object tape, compatible with Intel's MCS-80.

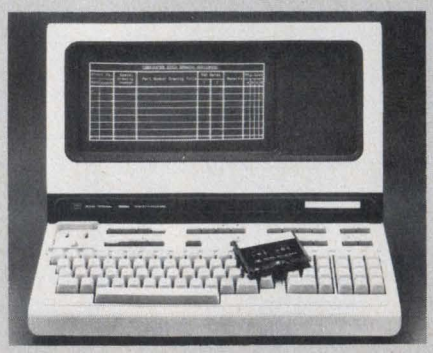
The assembler has these major features: No disc access is required; it will run on an 8-k machine; it accepts ANSI standard Fortran IV logical unit numbers for I/O devices; it does a two-pass assembly; and it comes with complete documentation. The assembler costs $300 and is available in 30 days. CIRCLE NO. 506

Industrial microcomputer system uses 8080 μP

The Electronic Products Div. of the Warner & Swasey Co. (30300 Solon Industrial Pkwy., Solon, OH 44139. 216-368-6200) has acquired the exclusive rights to market and manufacture the Micral microcomputer line from Realisations Etudes Electroniques in the United States and Canada.

The Micral μC is available with extended Basic, a disc operating system and a text editor. It is built around the Intel 8080 μP microprocessor chip and comes with two floppy-disc drives, desk enclosure and serial communications channel. The system costs $7995 in single quantities or can be leased on a five-year plan for $190 a month. CIRCLE NO. 507

CRT terminal has mass-data-storage capability



The μP-controlled Model 2644A CRT terminal has 220,000 bytes of built-in mass data storage. The Hewlett-Packard (1501 Page Mill Rd., Palo Alto, CA 94304. 415-493-1501) terminal can perform on a stand-alone basis many operations that would normally require connection to a computer.

Two tape transports, using the miniature version of the 3M data cartridge developed by HP, provide large amounts of data storage. Program preparation, editing, tape copying and tape-to-printer operations are all within the stand-alone capabilities of the 2644A. Single keys execute the most common tape-data transfer commands.

The architecture of the 2644A is generalized so data can be moved readily among any of the station's functional units. File records may vary in length from 1 to 256 bytes and can be stored in ASCII or binary format. The 2644 costs $4400 in quantities of six and is available from stock. CIRCLE NO. 508

One-pass assembler designed for 8080 μP systems

A one-pass assembler that runs in resident mode on an 8080 has been developed by Micro Systems Software (355 W. Olive, Sunnyvale, CA 94086. 408-735-1650). This program assembles a compatible sub-set of the Intel language and generates machine code directly

(continued on page 68)

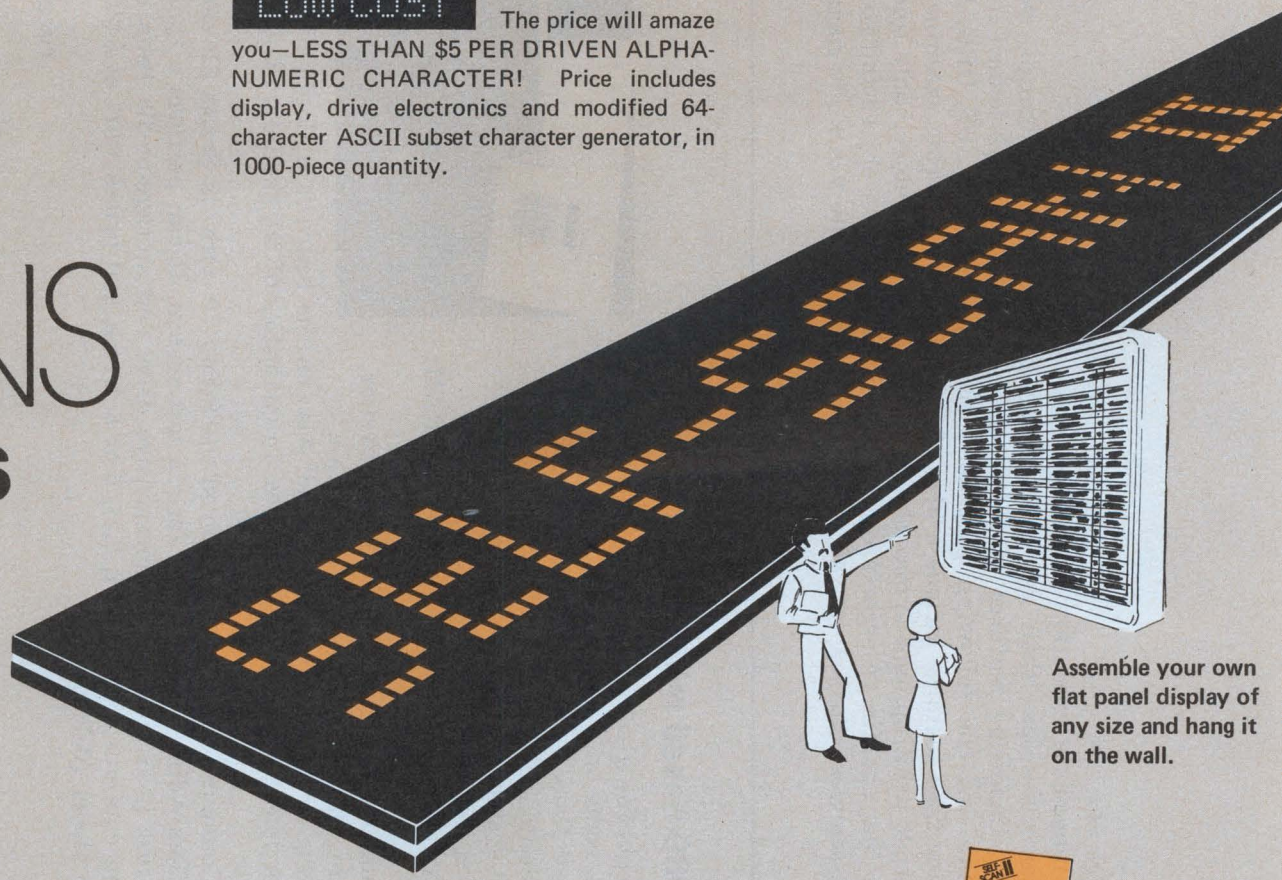
Burroughs SELF-SCAN®...II panel

NEW DIMENSIONS in electronic displays

Now, there's a whole new dimension in electronic readouts: Burroughs' new SELF-SCAN II display panels . . . the most advanced, most versatile display ever. There's nothing else like it in the world. SELF-SCAN II panels, with bright, large multi-digit alphanumeric characters, permit an entirely new display concept.

SELF-SCAN II panels can open up new applications for electronic displays. As single panels, they are ideal for point-of-sale displays, computer applications, moving message centers, and others; as modular building blocks, for attention-getting displays in airport terminals; for surface communication systems; for store window displays. Whatever the application, their high brightness and extra-wide viewing angle make them more cost effective, more visible and readable than other readouts.

LOW COST The price will amaze you—LESS THAN $5 PER DRIVEN ALPHANUMERIC CHARACTER! Price includes display, drive electronics and modified 64-character ASCII subset character generator, in 1000-piece quantity.



Assemble your own flat panel display of any size and hang it on the wall.

VERSATILE The modular design of the 20-character SELF-SCAN II panel means it can be butted horizontally, and stacked vertically to appear as one large display. You can assemble displays of almost unlimited size in various combinations without sacrificing performance.

READABLE The large, 0.7-inch high characters can be read easily at 50 feet in high ambient light. The viewing angle is extra wide: 165°. The gas plasma technology means that all characters are uniformly bright and sharp: no matching or alignment problems.

UNIQUE Combining the best of Burroughs' famous display products, SELF-SCAN and PANAPLEX® displays, the planar construction with screened electrodes of SELF-SCAN II means nothing moves . . . nothing wears. Only 18 external connections are required for 20 alphanumeric characters!

Burroughs' new SELF-SCAN panels are designed to interface with microprocessors. And they are available . . . NOW!!

To find out how you can build the information display you want with SELF-SCAN II panel displays, write or call Burroughs Corporation, Electronic Components Division, P. O. Box 1226, Plainfield, New Jersey 07061; or call our special sales/applications assistance number, (201) 757-3400, or (714) 835-7335 in California.

Write for:
"Self Scan II:
Important product information from Burroughs"

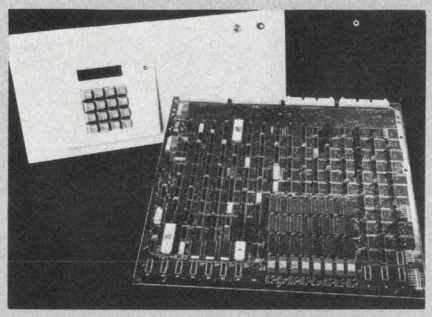
Burroughs

INFORMATION RETRIEVAL NUMBER 43

(continued from page 66)
into memory for immediate execution. if desired.

The assembler occupies less than 2-k bytes of memory and can economically be placed in PROM or ROM. Language features of the assembler include all Intel-defined instruction mnemonics and the following program pseudo-ops—DB, DW, DS, ORG, EQU and END. Execution-time features include a bias-address offset for storing machine code and three output print options—print object and source, print object only and no print. Instructions that contain an error are always printed with both object and source. The cost of the assembler starts at about $495, and delivery is one week. CIRCLE NO. 509

Single board holds 8080-based micro system



All the components for a complete microcomputer, based on the 8080, come on a single 15-1/2 × 15-in. board from Applied Data Communications (1509 E. McFadden Ave., Santa Ana, CA 92705. 714-547-6954). The new Series 70 system contains 4-k bytes of RAM and 1-k bytes of reprogrammable ROM. Sockets are provided for the expansion of ROM to 4-k bytes and RAM to 16-k bytes.

Terminal communication is provided for teletypewriter, CRT or modem through an asynchronous I/O with a selectable speed ranging from 110 to 9600 baud. Also on the board is a floppy-disc controller that can interface up to eight drives. In quantities of 50, the micro board sells for $949.

Applied Data Communications has combined the Series 70 with its Series 61 (an IBM-compatible floppy-disc system) to form a test system. It can perform a thorough floppy-disc drive test in 5 minutes. Comprehensive drive and storage-media tests require 15 minutes. System configurations test 1, 2, 4, 6 or 8 drives, and prices start at $4250 for the single-position Model 70-T200-1.

CIRCLE NO. 510

Compiler for PCL allows use of terminals

An upgraded compiler for Comstar's Process Control Language (PCL) allows data to be entered from a teletypewriter or similar terminal, including Texas Instruments' Silent 700 dual-cassette terminal. A high-level language, PCL simplifies the programming of PROMs and, thus, microcomputers.

The compiler from Comstar (30300 Solon Industrial Pkwy., Solon, OH 44139. 216-368-6200) handles the instruction set for the company's recently announced Model 4A and 4B microcomputers, built around the 4040 μP.

A terminal using the compiler can store, merge and edit data and also create programs on magnetic-tape cassettes. In addition eight new commands have been created for compilation from a data terminal. The commands permit such functions as the creation on tape of an entire PCL program or an adjustment of the delay following a carriage return.

The basic compiler—Model 9008-0920—costs $3595. Two other models—suffix 0921 and 0922—include 5.12 k bits of RAM and a serial communications interface. These models cost $4295. Delivery time is 30 days.

CIRCLE NO. 511

★ NATIONAL ANTHEM ★

ALL THE NEWS THAT FITS

A Review of New Products and Literature from National Semiconductor

National Rewrites the Book: LF 156 a New Standard of Comparison for Op Amps

National is very pleased to tell you about a new IC process that we've been working on. In fact—brushing modesty aside—we've come up with the industry's first major new linear process in a decade.

Put rather simply, we married the best that JFET technology offers to the best that bipolar technology offers. We call the union Bi-FET™ technology, and its first offspring are our LF155/156/157 op amps . . . so spectacular that they set completely-new standards for op amp performance.

The secret of Bi-FET performance is in the combination, on a single monolithic chip, of JFETS—well-matched via ion-implant techniques—with standard bipolar transistors. When reduced to practice—as in an op amp with JFET

(continued on page 3A)

Tri-share RAM puts 4096 bits in 18-Pin Package

We've entered the 4K RAM marketplace in a big way with our MM5270—a read/write memory that represents a major breakthrough in the design of MOS memories.

The MM5270 makes use of a unique design concept, which we've dubbed Tri-Share™. The Tri-Share concept lets a single port serve three functions —read/write, logical chip select, and VCC—saving three leads needed by all other RAMs.

And since our new RAM also features a Tri-State®, common input/output lead, we've managed to reduce the package lead count for 4096 bits of memory from 22 leads, which most of you have had to deal with 'til now, to only 18 leads on our MM5270. This allows a PCB memory density nearly *twice* as great as that possible with 22-lead, 4K RAMs, which translates directly into dollars saved. Thus, you can assemble 4K memory systems at a cost lower than previously possible.

And while you're saving money you're acquiring high-speed performance: the access time of the MM5270 is 200 ns min.; its cycle time is 400 ns max. So if you're looking for an unbeatable combination of system economy and performance, look into our MM5270; it's got it all.

NSC does SO Make FETS

Junction FETs . . . by the carload. We make virtually every type of JFET on the market today, including some with characteristics superior to anything else available.

Look at our brand-new PF5101-3 (molded TO-92) and NF5101-3 (metal TO-72), for example. Specially selected for ultra-low-noise audio and video applications, these JFETs feature a common-source spot noise figure at 10 Hz of only 1.5 dB maximum; and a typical e_n of only 5-7 nV/$\sqrt{Hz}$ at 10 Hz, 2-3 nV/$\sqrt{Hz}$ at 1 kHz . . . superb in preamps for hydrophones, vidicons, particle detectors, and high-quality audio/video equipment in general.

Remember too that we pride ourselves on being the most flexible and cost-effective JFET supplier you'll find anywhere. So when you think FETs, think National.

We're Big on Small-Signal Transistors

Singles, duals, quads . . . Metal can, molded, and ceramic packages . . . All popular commercial, industrial, and military types, and in volume . . . The best prices in town . . . And customer service unequaled in the industry.

We've just upped our capacity for both existing and new JAN/JTX/JTXV types, for example. Check out our 2N3498/99, 2N3500/3501, and 2N3700. Or our 2N2920, a dual for which we're one of the few active suppliers of its JAN/JTX/JTXV versions.

We support memory and peripheral houses too: witness our DH3467/3725/6376 quads in both epoxy and ceramic.

We second-source Motorola, Fairchild, TI, GE, and Sprague, which gives us a package/pinout versatility second to none. And this lineup now even includes the popular "Silect" types—our new Series TIS9X, 2N581X, etc.

We're the only supplier of all-copper-lead-frame, Epoxy B TO-92 types; a combination that gives you the most advanced product you can buy.

Small-signal transistors are a very big business with us. Just tell us your needs; we'll meet them.

In Support of RAMs

Imagine a diagram that shows a large block of random-access memory surrounded by an array of smaller blocks; each of the smaller blocks is an interface circuit necessary to the operation of the memory itself. If you imagine further that National part numbers fill all the interface blocks, then you can see the significance of our DS3640-49 and DS36147/149 families of RAM support circuits.

Regardless of function, these circuits share a number of features: they can drive highly-capacitive loads; they have DTL/TTL-compatible inputs; there is a damping resistor in series with each output. (Companion series DS3670-79 and DS36177/179 feature,

(continued on page 4A)

NATIONAL INTROS ACTIVE FILTER LINE

Whether you're after a Bessel, Butterworth, Cauer, or Tschebycheff function, our new AF100 active filter will do the job. You need only four external resistors to program it for any specific, second-order function; so if you wish to form, say, a sixth-order function, simply cascade three AF100s, embedding each in an appropriate resistive-programming network.

Lowpass, highpass, and bandpass functions are available simultaneously at separate outputs; notch and allpass functions are available by combining outputs in the unit's uncommitted summing amplifier.

Available to meet either commercial or military specs, and housed in both TO-8 metal-can and dual-inline packages, the AF100 operates from ±5 to ±18 V, and features independent frequency, gain, and Q adjustments, a Q range to 500, and operation to 10 kHz.

MD²™ Cuts System Display Costs

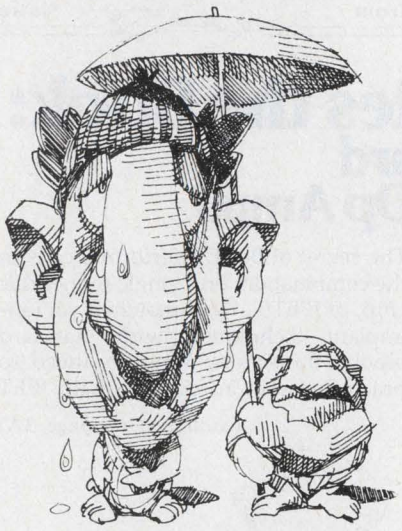
We've got a nifty item for any of you who have to display multiple digits. It's our MultiDigit Display family—MD²™ for short. Any member of this display family can significantly cut your display costs and, at the same time, improve the appearance of your LED readout because of MD²'s uniform segments, uniform digit-to-digit brightness, and good contrast.

Clocks, clock radios, appliance timers, instrumentation—you name it and MD² can handle it. Not only are dozens of display combinations possible, but MD² interfaces directly to MOS clock chips, MOS segment and digit drivers, DPM chips, even microprocessors and transducers.

MD² units are common-cathode displays (so far), with heights of either 0.3 inch or 0.5 inch. Both heights are end-stackable in multiples of five, for the 0.5-inch displays, or eight, for the 0.3-inch displays. And they're available in both multiplexed and direct-drive versions.

To find out more about the unique MD² concept, we suggest you call your local National sales office. Between our standard list and our custom options, we're pretty sure you'll find just what you're looking for.

Durawatt 92-Plus™... *A Surefire Way to Beat the Heat*



We bet you're one of many designers who've been playing the do-it-and-keep-your-fingers-crossed game. You know what we mean—trying to keep parts costs down by specifying TO-92 types and overstressing them "just a bit," because the next-higher-dissipation package costs maybe three-times more.

Sure, you win on short-term parts costs but . . . ZAP! You lose on long-term equipment reliability and service costs. Just when you thought you had it knocked.

That's been the story—either pay up or take a chance. Until now.

For our Durawatt 92-Plus™ types change the whole picture. A new line of general-purpose, complementary-symmetry power transistors, Durawatt 92-Plus devices take over where TO-92s fall short. They finally fill that long-empty slot—in dissipation *and* price—between TO-92s and the much-more-expensive, much-higher-dissipation packages.

With a 1200-mW dissipation capability, a built-in heat-dissipator tab, and 80-V/2-A maximum ratings, the Durawatt 92-Plus family is just what you've needed all this time.

No more "add on" dissipative components; no more compromises. Durawatt 92-Plus power types give you a solid dissipation capability at an affordable price, in an operating region where neither existed before. Remember the name—Durawatt 92-Plus. You can uncross your fingers now.

A Lamp for all Reasons

We call our new NSL4944 a *universal* lamp, for you can drive it with as little as 2 V or as much as 18 V, ac or dc. In response, our new lamp gives you uniform brightness (0.8 mcd, typ.) across that operating voltage range. Add a PIV of -18 V, and you've got a lamp unmatched in versatility by anything else in the marketplace.

The key to the NSL4944's wide-range operation is an IC current-regulator built into the two-lead T-1¾ package. As a result, the NSL4944 is the only lamp available that you can place directly across a TTL output and have it come on at TTL's guaranteed "1" state of 2.4 V. (The only other current-regulated lamp on the market comes on at 4.5 V, is usable to only 11, 12.5 or 16 V depending on the version, and its PIV is limited to 3 V.)

So no matter how you look at it—forwards or backwards—our NSL4944 universal lamp is unbeatable. Get a data sheet; or better yet—call your National salesman, ask for a sample, and see for yourself.

4-Digit Counters

We've recently introduced a family of 4-digit counters with some rather nice features that make them eminently suitable for clocks, DVMs, DPMs, and so on.

Each counter, for example, has an internal multiplexing circuit (which doesn't need an external clock) with four multiplexing outputs, NPN output sourcing-drivers for 7-segment displays, and an internal output latch. All of the counters operate from 3 V to 6 V, and source 80-mA (typ.) segment currents.

Let's start with the MM74C925—a basic 4-decade counter with Latch Enable, Clock, and Reset inputs. Next is the MM74C926: like the 925 except it adds a Display Select input, and a Carry-Out for cascade connection. (The Carry-Out goes high at 6000, low at 0000.)

The MM74C927 is like the 926, except that the second MSB divides by six, rather than by ten. This means that for a 10-Hz clock frequency the display reads tenths of seconds, seconds, and minutes.

Finally—the MM74C928: like the 926, except the MSB divides by two and the Carry-Out is an overflow indicator that is high at 2000, and goes back low only when the counter is reset. Thus, the MM74C928 is a 3½-digit counter.

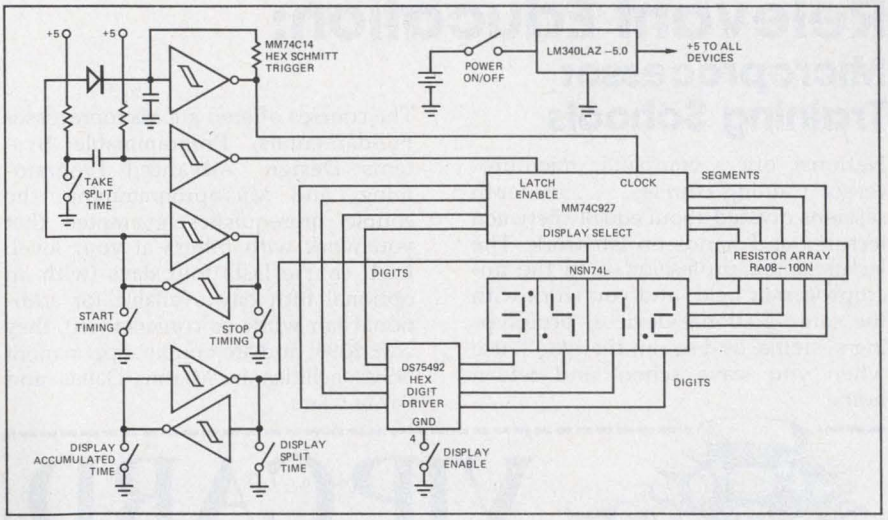
APPLICATIONS CORNER

Taking Time Apart... The Easy Way

Our MM74C925-928 family of 4-digit, multiplexed-output counters is well suited to a variety of instrumentation uses in which events must be counted and then displayed in a numeric format.

Consider the MM74C927, for example. In this part the second-MSB divides by six, which means that for a 10-Hz clock input the output display format is tenths of seconds, seconds, and minutes. This capability is exploited in the stopwatch design shown here, a very inexpensive circuit suitable for the timing of laboratory events, horses, swimmers, cars, soap-box racers, or whatever. The accompanying diagram shows the complete circuit.

A 10-Hz, RC, Schmitt-trigger oscillator provides the MM74C927's clock, which is started or stopped by a debouncer/latch formed by cross-coupled Schmitt triggers.



The Display Select debouncer/latch enables the contents of either the counter or the internal latch to the on-chip display drivers, which lets you read either accumulated time or split time (pulsing the Latch Enable line allows the taking of split time).

Grounding the emitter rail of the digit drivers enables the display; this technique yields a brighter display and longer battery life than would be otherwise obtainable. Uniform display brightness over the lifetime of the battery is assured by regulating the battery voltage to +5 V.

The voltage regulator, which also assures the stability of the RC clock oscillator, is our LM340LAZ-5.0, an inexpensive device housed in a TO-92 package. The switches, too, are inexpensive; with the exception of the main power-ON/OFF switch, all switches are Form-A contact, momentary-on types.

LF 156-Op Amps

(cont'd)

input, bipolar intermediate, and bipolar/JFET output stages—Bi-FET technology yields unbeatable performance. Witness these LF156A/LF356A specs, for example:

V_{OS}	2 mV max.
V_{OS} Drift	5 μV/°C max.
I_{OS}	10 pA max.
GBW	4 MHz min.
Slew Rate	10 V/μs min.
0.01% Settling	1.4 μs typ.
e_n	12 nV/$\sqrt{Hz}$, 1 KHz; 15 nV/$\sqrt{Hz}$, 100 Hz (typical)
i_n	0.01 pA/$\sqrt{Hz}$ typ., 1 kHz and 100 Hz
CMRR	80 dB min.
Power BW	200 kHz

These specs are for our prime version; but if you look over the 14-page data sheet, which presents the specs of all prime and standard types (including wideband and low-current-drain versions of the basic LF156), you'll find that *all* our Bi-FET op amps offer you performance superior to anything you've seen before, whether for military, industrial, or commercial usage.

Our UAR/T, Your FIFO Make Beautiful Music Together

Our MM5303 Universal Asynchronous Receiver/Transmitter, while often found snuggled cozily next to a FIFO, quite contentedly makes its home wherever data processing equipment interfaces to data transmission lines—as in modems, quite obviously. But remember, too, that even in more esoteric situations—data rate changers, for example—an LSI UAR/T such as our MM5303 still buys you more for your dollar than does any other approach.

So much for philosophy. Getting right down to it, our MM5303 replaces the TR1602A and COM2017 in many applications, as well as the TR1402A, COM2502, and TMS6011 in many other sockets.

The MM5303 is fully programmable for 5-, 6-, 7-, and 8-bit word lengths, and operates at full or half duplex, simultaneously receiving and transmitting at different baud rates (30K max.). Parity generation/checking may be even, odd, or inhibited. Stop bits, either one or two; and, in addition, our MM5303 is internally connected to generate one-and-a-half stop bits when programmed for a 5-bit code.

For Sale by Owner: Voltage Regulator Handbook

At last . . . A definitive, how-to book of contemporary power-supply design, which tells you everything you'll have to know to design local power sources using three-terminal and dual-tracking monolithic voltage regulators.

In its more than one hundred pages, our Voltage Regulator Handbook takes you from the raw basics of power-supply design, through heat flow and thermal resistance theory, and on to applications. Along the way, you're shown the inner workings of these regulators, and learn how to expand their capabilities beyond the expected.

Finally, our Handbook not only describes and specifies most of National's extensive line of three-terminal and dual-tracking regulators, but also provides you a cross-reference listing that puts major, competing types in perspective.

The Voltage Regulator Handbook is yours for four dollars; at three cents a page, it's a bargain.

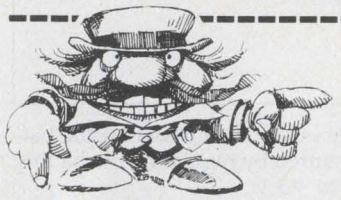
A Review of New Products and Literature from National Semiconductor

3A

Relevant Education:
Microprocessor Training Schools

National offers complete, microprocessor training courses . . . in-depth sessions divided about equally between lectures and hands-on lab work. The lecturers are professionals in the microprocessor field, and you work with the same National devices, prototyping systems, and so on, that you'll use when you leave school and return home.

The courses offered are Microprocessor Fundamentals, Programmable Systems Design, Advanced Programming, and Microprogramming; the course prerequisites guarantee that you work with others at your level. Each course lasts four days (with an optional fifth day available for additional lab work or consultation), they cost $395, and are taught at permanent NSC facilities in Miami, Dallas and Santa Clara.



VIP CARD

Complete card and mail to
NATIONAL SEMICONDUCTOR
2900 Semiconductor Drive, Santa Clara, CA 95051
Attn: Marketing Services

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Please send me the literature that I have circled:

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THINGS TO READ:
A Compendium of Recently-Issued Literature (e.g., stuff to file)

- ☐ **AN-125** LM377, LM378, and LM379 Dual 2-, 4-, and 6-W Power Amplifiers
- **AN-132** A new Interfacing Concept: the Monolithic Temperature Trans-
- ☐ **AN-139** MOS Encoder plus PROM Yield Quick-Turnaround Keyboard Systems
- ☐ **AN-142** Using a Microprocessor Beyond Apparent Speed
- ☐ **AN-144** Designing Memory Systems Using the MM5262
- ☐ **AN-147** Low-Cost IC Stereo Receiver
- ☐ **AN-151** Low-Noise JFET—the Problem Solver
- ☐ **LB-29** Low-Cost AM-Radio System Using the LM1820 and LM386
- ☐ **LB-30** Low-Cost LED Thermometer
- ☐ **μSpec 7** POWR I/O
- ☐ **μSpec 9** IMP-16 Assembler Programs
- ☐ **μSpec 13** Arithmetic CROM

WANTED:

QUESTIONS TO ANSWER

We would like to have a Question-and-Answer column as a regular feature of the National Anthem. We know that many of you, from time to time, have questions about our products . . . questions pertaining to their use, specs, or whatever. We will use the new column to answer as many of these as we can fit into a given issue.

The questions that we use in the Anthem will be those we feel to be of general interest to our readers. Nonetheless, all questions submitted will be answered, either in the Anthem or by direct correspondence.

Obviously, we need your help to make this idea work. We need your questions; and the sooner we receive them, the sooner we can answer them. To speed things along, we've allowed space on the VIP card for a question. Make use of it, and by helping us you'll help yourself.

Question: _____

_____ ED 1/6

Your End Product or Application: _____

Please print clearly. This will be used as a mailing list. Have Salesman Call ☐ **YES** ☐ **NO**

NAME _____ **TITLE** _____

COMPANY _____

ADDRESS _____

CITY _____ **STATE** _____ **ZIP** _____

In Support of RAMs
(cont'd)

instead of a damping resistor, direct, low-impedance outputs.) In addition, all of our RAM interface circuits make use of Schottky technology for good ac performance, and PNP input transistors to minimize loading.

The individual circuits that comprise our DS3640-49 and DS147/149 series of RAM support elements include Tri-Share™ port drivers, latch drivers (ours minimize propagation time and address skew because we use fall-through latches), refresh counters, address drivers, I/O registers, an enable demultiplexer, and clock drivers of all kinds (including the only available N-channel, single-supply device—our DS3642/72).

So if you're using a RAM (and who isn't?), remember who supports it. We've got the circuits that make it work.

6.95 V 'til Hell Freezes Over (and then some)

We've come up with the most stable Zener you've ever had the pleasure to work with . . . a Zener with an ultra-low TC (1 ppm maximum), in which both the Zener voltage (6.95 V ±2%) and the TC are insensitive to current over a 20:1 range (0.5 to 10 mA) . . .a Zener with an incredibly-low and stable dynamic impedance (typically, less than an ohm), very-low broadband noise (20 μVrms max.), and fantastic long-term stability (20 ppm typ.)!

We're talking about our LM199: a Zener combined with a temperature-stabilizer circuit on a single monolithic chip. From −55° to +85°C, the LM199 shows a 1-ppm max. TC (0.3 ppm typ.), which increases to only 15 ppm max. (5 ppm typ.) at +125°C. And it shows these TCs at currents from 500 μA to 10 mA. (Try this with any other so-called low-TC Zener and see what happens.) And if you need still better, we've got a prime version (suffix-A); this one even comes with 883 processing and/or certification of long-term stability.

Of course, if you don't need quite such a virtuoso performance, consider our LM299—0.3 ppm (typ.) to 1.0 ppm (max.) from −25° to +85°C; or our LM399—0.3 ppm (typ.) to 20 ppm (max.) from 0° to +70°C. Other than these differences in TCs, the LM199/299/399 are pretty much identical. So no matter what area you work in—military, industrial, or commercial—our super-low-TC Zeners stand ready to do a super job.

A Review of New Products and Literature from National Semiconductor

Dialight sees a need:

Need: A new computer-grade switch at a price you can afford.

LOW COST • COMPUTER GRADE QUALITY • DESIGN FLEXIBILITY • GOLD OR SILVER CONTACTS • CHOICE OF TERMINALS • MOMENTARY OR ALTERNATE SWITCHING ACTIONS • SPDT, DPDT • DESIGNED TO MEET UL SPECIFICATIONS • UNIFORM FRONT PANEL APPEARANCE AND REAR PROJECTION • MATCHING INDICATOR LIGHT • FRONT MOUNTING SNAP-IN BEZELS—4 SIZES/SHAPES TO CHOOSE FROM • REAR MOUNTING SWITCH WITH ANTI-ROTATION FEATURE • CHOICE OF OVER 200 CAP SHAPES, SIZES AND COLORS • CHOICE OF ENGRAVED, HOT STAMPED OR REPLACEABLE LEGENDS.

Dialight's low cost 554 series switches are available in a wide selection of rear panel and front bezel mounting types. Switches are available with silver or gold contacts for wide range of applications; operating life is 250,000 operations.

Fingertip grips permit easy cap removal . . . lamp replacement is from front of panel . . . no special tools needed.

Caps are available with or without underlying color filter in ⅝" and ¾" square, ⅝" x ¾" and ¾" x 1" rectangles. At Dialight it's your choice because we see your need.

DIALIGHT

Dialight, A North American Philips Company
203 Harrison Place, Brooklyn, N.Y. 11237
(212) 497-7600

INFORMATION RETRIEVAL NUMBER 45

HiNIL Interface

Prevent CMOS latch-ups and failures with a high noise immunity logic I/O.

CMOS systems are subject to latch-ups and failures in the field because of high voltage transients, static charge and improper field maintenance procedures. Moreover, due to their increased output impedance, CMOS is more susceptible to transient errors than corresponding bipolar logic.

A simple solution to these problems is to use Teledyne's bipolar High Noise Immunity Logic (HiNIL) as the system I/O interface. The I/O design approach shown in Figure 1 has solved these problems in applications such as business equipment, industrial controls and electronic games. The HiNIL interfaces protect the delicate CMOS inputs with a rugged bipolar "front end" not susceptible to CMOS failure modes. Also system noise immunity is maximized, and the HiNIL output devices provide direct, high current logic drive of relays, displays and long lines.

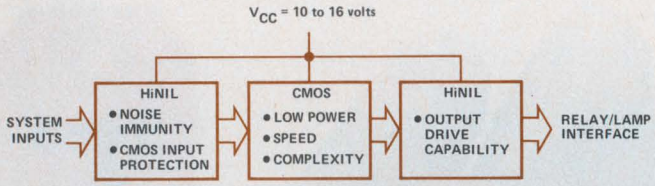

Figure 1. HiNIL input interface protects CMOS inputs while HiNIL outputs directly drive long lines and peripheral devices

The two families are directly compatible at the 10 to 16 volts V_{cc} range. The designer can take full advantage both of HiNIL's capabilities and of CMOS' low power dissipation, supply voltage flexibility and improved noise margin at higher supply voltages.

Parasitic SCR latch-up is an all too common CMOS malfunction. Large noise transients and DC input levels below ground or above V_{cc} could force CMOS input diodes into forward conduction, causing SCR action in the four-layer diodes formed by the diode and parasitic p-n substrate junctions. This condition leads to device latch-up, increased I_{cc} current and, when current is not limited, to gate destruction. Maximum protection can be obtained by using

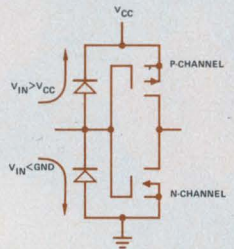

Figure 2A. CMOS latch-up causes

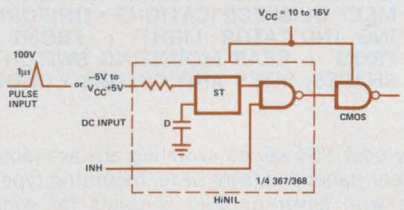

Figure 2B. HiNIL input protection

HiNIL Schmitt triggers. They prevent latch-up at DC input levels from −5 volts to V_{cc} +5 volts and suppress 100 volts transients as wide as 1μsec (Figure 2).

HiNIL inputs on plug-in cards will protect a CMOS system from problems associated with "on power" fault isolation, a widely used TTL system maintenance method. Plugging CMOS into powered connectors has led to latch-up failures because it allows inputs to see logic "1" signals before V_{cc} rises on the card. The failure is frequently catastrophic if input current is not limited.

HiNIL's lower output impedance and DC noise margin of 3.5 volts ignore large voltage noise transients that can cause CMOS logic errors. Also, static charges large enough to rupture CMOS oxide regions are often generated in dry environments by movement of materials and users. A HiNIL input gives more immunity to static and maximizes noise protection.

Examples of HiNIL Interface Devices

301 Dual 5-Input Power Gate 302 Quad Power NAND Gate (OC)	65mA relay or lamp driver
323 Quad NAND Gate (OC) 332 Hex Inverter (OC) 334 Strobed Hex Inverter (OC)	Input noise protection plus open-collector pullup to other logic levels
350 8-Bit Multiplexer 351 Dual 4-Bit Multiplexer	Drive longer lines than TTL with 10X noise immunity (I_{OH}=12mA)
361 Dual Input Interface 362 Dual Output Interface 363 Quad Output Interface	361 directly connects HiNIL to DTL/RTL/TTL 362 and 363 connect DTL/RTL/TTL to HiNIL
367 Quad Schmitt Trigger 368 Quad Schmitt Trigger (OC)	Suppress 100V/1μs spikes, protect CMOS, decode switches, etc.
380 BCD to Decade Decoder 381 BCD to Decade Decoder (OC) 382 BCD to Decade Decoder 383 BCD to 7-Segment Decoder	Provide decode/drive for lamps, LEDs, gas discharge displays, etc.
390 Interface Buffer Series	250mA HiNIL driver series will be available soon.

HiNIL reliability insurance costs little since the I/O circuits—unlike filters and shielding—generally replace other logic and drive circuits. So, don't wait until your new CMOS system runs into costly problems in the field. We'll show you how to build foolproof low-power systems. Call or write today for HiNIL application notes and specifications.

TELEDYNE SEMICONDUCTOR

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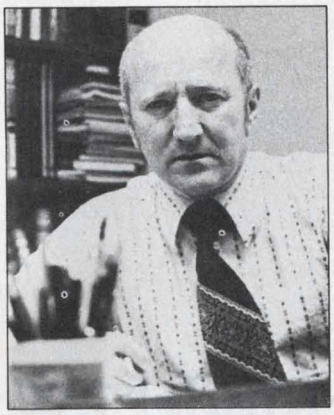
INFORMATION RETRIEVAL NUMBER 46

Editorial

The Czar's consultant

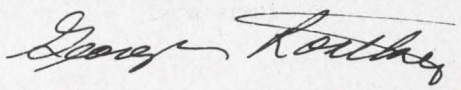


Before the first Russian Revolution of 1917, which changed his life-style, Czar Nicholas II was a very busy man. He had all sorts of parties, entertainments, hunts and other affairs of state to worry about. He was far too busy to spend a lot of time finding out what was going on in his vast empire.

So he did what many of us do when we lack information. He used a consultant, a monk named Rasputin, who had retired from his former career as peasant and horse-thief. Now Nick was wise enough not to depend exclusively on Rasputin for information and advice. He used another source, Mrs. Nick—Czarina Alexandra. This simplified matters because Alexandra's information and advice almost invariably confirmed what the Czar had learned from Rasputin. This should come as no surprise because the good lady got all her information from Rasputin, too. And, it was rumored, she got a good bit more.

Like any good consultant, Rasputin kept the Czar (and Czarina) informed of what was going on in the empire: Those ungrateful peasants were grumbling that they were starving just because their landlords wouldn't let them have enough to eat. Some ingrate peasants in an outlying district were protesting against the honor their pious landlord bestowed on their pre-teen daughters. Some patriotic landlords were requesting government aid to suppress unruly peasants who used the lame excuse of hunger to avoid working the landlord's property as hard as it should have been worked. In time, it turned out that some of those decisions may not have been the wisest. Rasputin, the Czar and his family were not given the opportunity to apologize.

It's pointless now to wonder if affairs in Russia might have taken a different turn had the Czar used a different consultant, or had he used more varied sources of information and advice. One can wonder, though, how many executives in the electronics industry place a bit too much confidence in the information and advice they receive from equally limited sources.



GEORGE ROSTKY
Editor-in-Chief

In the re

If your business involves measuring, and you're looking for precision instruments, you have to resolve some very real questions. What do I need? How much can I spend? Where can I get the most for my money?

Data Precision offers you a wide range of precision instruments that are the best values in the industry.

Instruments that are the result of innovative design and rigid testing.

When we developed and introduced Ratiohmic™ Resistance, Triphasic™ Conversion, and Isopolar™ Referencing we reduced the price of 5½ digit multimeters by 50% to 80%, breaking the $2000 price barrier. We also developed the world's most accurate 4½ digit multimeter; the first,

Model 134

3½ Digit DMM $189.00

Competitively priced with the best analog meters, the Model 134 provides digital accuracy and an easy-to-read ½ inch digital display. The Model 134 is an ideal, low cost lab or production test instrument.

The Model 134 measures DC volts, AC volts, DC current, AC current and resistance with a basic accuracy of ±.2% through a total of 22 range scales.

It features auto-decimal positioning, auto-polarity, 100% overranging, high voltage protection circuit, probes and a one year warranty.

The Model 134 is the logical alternative to analog instrumentation at a competitive price.

CIRCLE #291

Model 245

Portable, 4½ Digit DMM $295.00

Ideal for field use, the Model 245 is a rugged, truly miniature, lab-quality, 5-function instrument featuring a basic DC accuracy of ±0.05%, .005% resolution, 100% overranging, equipped with both rechargeable battery pack and battery recharger/line adapter.

Model 245 measures ACV (100μV to 500V RMS), DCV (100μV to 1000V), Resistance (100 milliohms to 20 Megohms), AC and DC current (1 microamp to 2 Amps). AC voltage/current response, 30 Hz to 50 kHz.

With over 25,000 in the field the Model 245 is still the only pocket-size portable 4½ digit DMM available.

CIRCLE #292

Model 1455

Bench/Portable 4½ DMM $355.00

Model 1455 — all the virtues of a laboratory bench instrument with the added benefits of complete portability.

A five function multimeter featuring ½" high display, 100% overranging, measures 100 μV to 1000 VDC, 100 μV to 500 VAC ; resistance 100 milliohms to 20 Megohms; AC and DC current 1 microamp to 2 amps. AC response, 30 Hz to 50 kHz.

Basic accuracy on DCV is ±0.02% reading ±0.01% f.s., ±1 digit for 6 months. Internal NiCd battery module and recharger.

Model 1450 4½ Digit DMM $325.00

The same specifications and features as the Model 1455, except batteries.

CIRCLE #293

al world.

nd still only, 4½ digit "pocket size" multimeter and the first 4½ digit ortable/bench multimeter; the first 7 digit, 100 MHz, Counter/Timer nder $300; and the first 5½ digit multimeter to break the $1000 price arrier.

And Data Precision isn't stopping there. We have just introduced ur Model 3400, the first complete 4½ digit systems multimeter under 1000. And the super-fast, super-programmable 5½ digit systems multi- ieter which will utilize our new circuit innovation, Quadraphasic Con- ersion, is on the way.

And when the competition keeps raising prices, Data Precision is eeping down your cost while giving you more.

Compare and save through innovative design.

Model 2440

½ Digit DMM $675.00

he world's most accurate 4½ digit)MM, the Model 2440 features a basic :curacy of ±0.007% of rdg. ±1 L.S.D.)r six months. 100 μV to 1000 VDC,)0 μVolts to 500 Volts AC, DC/DC ıtio, AC/DC ratio, 2-wire and 4-wire :sistance, 100 milliohms to 12 megohms. tandard features include autoranging, ıto-zero, remote ranging and remote iggering.

equency response for AC current and)ltage is 30 Hz to 100 kHz. Voltage ıtio and isolated BCD output are in- uded at no extra cost. Other Series 400 models are available from $580.00.

CIRCLE #294

Model 3500

5½ Digit DMM $995.00

The Model 3500 delivers more features for less money than any other 5½ digit DMM available. It is a full function, autoranging DMM with 6 months basic accuracy of ±0.007% of rdg. ±0.001% f.s. ±1 L.S.D. Remote ranging and trigger, 20% overrange and ½ inch planar displays.

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CIRCLE #296

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The PLA: a 'different kind' of ROM. Programmable logic arrays offer a cheaper and faster alternative to conventional ROMs, but they're not as easy to expand.

Mask-programmable logic arrays (PLAs) and their field-programmable cousins (FPLAs) can lower the cost and improve the performance of systems that now use discrete logic gates and certain ROM functions.

Actually PLAs can be thought of as "different kinds" of ROMs that can be replaced by conventional ROMs in almost every application. But in some cases the PLAs, though harder to expand, are a lot cheaper and faster.

For example, if the 8-k-bit ROM in Fig. 1 were changed to have 14, rather than 10, address inputs, the array would be enlarged from 1024 × 8-bits to 16,384 (or 2^{14}) × 8-bits. Since this is too large for one chip, sixteen 8-k ROMs would be needed in parallel to provide the same capacity. Now if the function being patterned in these ROMs requires far less than 2^{14} words, even though it has 14 inputs, it may be economical to use a special kind of ROM—one with 14 inputs, but far fewer than 2^{14} words, and programmable so that any input combination can reach any word. This essentially is a PLA.

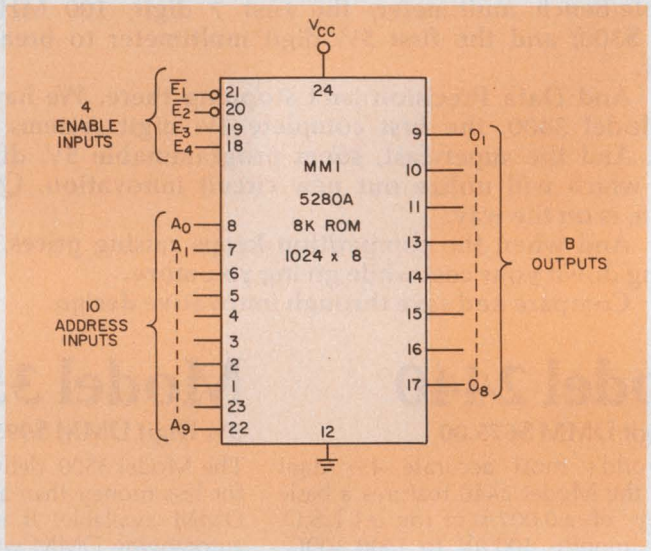
The internal logic of a commercially available PLA (Fig. 2) has 14 inputs, 96 words—or terms, as they are called in PLAs—and eight outputs. Each diode in the 28 × 96 input-AND array and 8 × 96 output-OR array may be programmed in or out.

The output-OR array resembles a 96 × 8-bit ROM. However, the PLA differs from a ROM in these five ways:

1. The 96 PLA terms, or words, are far less than the 2^{14} words that a ROM would have.

2. The address of each term in the input-AND array does not necessarily contain all 14 inputs (with each one true or inverted), as it would in a ROM. As many as 13 inputs may be left out of any term address.

3. A given PLA input combination may address more than one term simultaneously, whereas in an enabled ROM one, and only one, word is addressed at a time.



1. **Sixteen 8-k-bit ROMs would be needed** if the number of address inputs required were increased from 10 to 14. But if the function doesn't require all 2^{14} words, a single PLA chip could do the job.

4. A given PLA input combination may address no terms at all.

5. Each of the eight PLA output drivers is individually programmable as a buffer or inverter—T or C—whereas ROM output drivers are fixed.

The last feature may seem redundant. If all eight output drivers were T buffers, for example, a diode could be programmed into the output-OR array wherever a HIGH output is required or it could be left out for a LOW output. Then the output drivers would not have to be programmed at all.

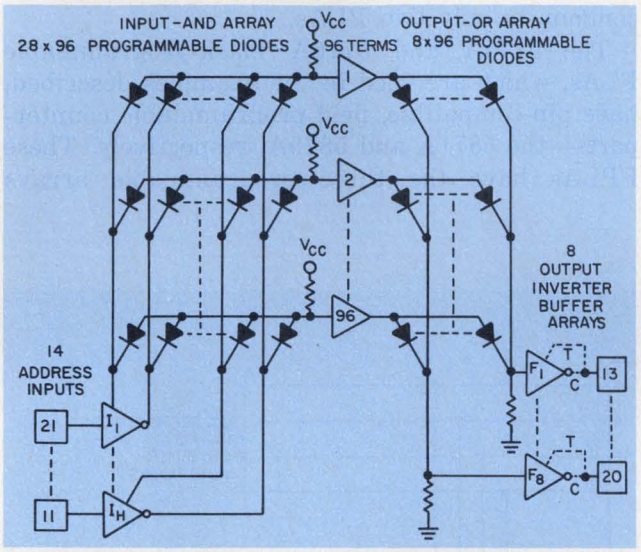
However, as we've seen, a PLA input combination may not address any terms—a situation not possible with enabled ROMs. Since there are 16,384 input combinations and only 96 words, this may happen quite often. When it does, the inputs to all used terms are pulled down in the input-AND array, the term outputs go LOW, and the diodes in the output-OR array have no control over the output polarities. The only way to set the unaddressed "off" condition polarities

Albert Hemel, Bipolar Design Engineer, Monolithic Memories, 1165 E. Arques Ave., Sunnyvale, CA 94086.

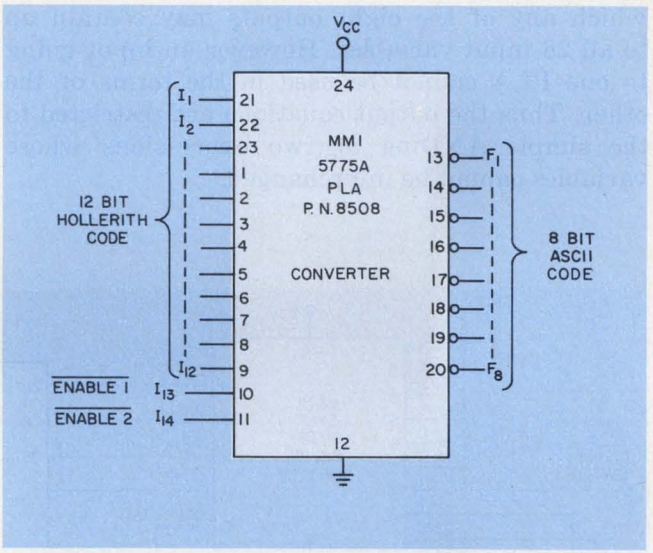
then is to program each output driver as a buffer for a LOW and an inverter for a HIGH.

Some PLA applications

The Hollerith-to-ASCII converter represents a natural application for PLAs (Fig. 3). Even though the Hollerith code has 12 variables, only 96 combinations are required. The input-AND array (shown in Fig. 2) contains the Hollerith code and the output-OR array contains the ASCII



2. **A PLA consists of three major sections:** input-AND array, output-OR array and output-inverter/buffer array. Monolithic Memories' 5775A has 14 inputs, 96 terms and eight outputs.



3. **A single PLA converts Hollerith code to ASCII.** Though the former has 12 variables, only 96 combinations are needed. The input-AND array contains the Hollerith code, while the output-OR array contains ASCII.

code. The eight output drivers are programmed as inverters, so that the outputs go HIGH if the chip is disabled (at pins 10 or 11) or an invalid Hollerith code is entered (and hence no terms are addressed).

In a counter-decoder circuit (Fig. 4), the time between 96 separate events may be selected from 2^{14} time intervals of the four-chip counter. The selection takes place in the input-AND array section of the PLA. The output-OR array divides into two parts: (1) Outputs F_8 to F_5 select one of six 54154 1-of-16 decoders, and (2) Outputs F_4 to F_1 address these six decoders in parallel, but only the selected decoder produces an event indication.

The F_8 to F_5 outputs are programmed as inverters. If the counter is not at any particular event time (no terms are addressed and the outputs are in the "off" state), all four outputs will go HIGH and disable all six decoders. The F_4 to F_1 outputs are programmed as buffers, so that the right half of the output-OR array can be programmed in straight binary sequence (Fig. 4b).

In some cases a single PLA is not enough to do the job. It may not have enough inputs, terms or outputs. Multiple PLAs can be paralleled to meet the requirements, but certain rules must be observed for each of three cases:

1. OUTPUT EXPANSION

Two FPLAs in Fig. 5 are combined to provide expanded outputs. The combination yields 14 inputs, 96 terms and 16 outputs instead of eight. At first glance, it may seem that there are 192 terms, but this is an illusion. If a term is to have 16 outputs, the input combination that addresses it must be duplicated in each chip. Therefore the input-AND arrays must be identical in both chips; so only 96 effective terms are available.

2. TERM EXPANSION

Expanded terms are obtained from the PLA combination in Fig. 6a. The two PLAs provide 14 inputs, 192 terms and eight outputs. Note that the PLAs with active-pullup outputs (used in Fig. 5) have been replaced with versions having passive-pullup outputs. This prevents excessive currents when a common output is HIGH in one chip and LOW in the other. Note also that the output drivers must be programmed as inverters. When the inputs address a term in one PLA, the other PLA will be in the unaddressed "off" state. The eight "off" outputs must be passive HIGH so as not to interfere with the addressed outputs of the programmable logic array.

The PLA in Fig. 6a has an internal pullup resistor for each passive output, so external pullup resistors are unnecessary unless faster rise times are desired. These internal resistors reduce the I_{OL} rating from 12 to 9.6 mA. They also limit the stack to a maximum of five PLAs, or 480 terms,

with each of the eight common outputs then rated at $I_{OL} = 2.4$ mA at 0.45 V.

If more than five PLAs are required, the outputs should not be shorted but rather gated, as shown in Fig. 6b. Note that here the active pull-up PLA can be used for faster rise times, but the output drivers are still programmed as inverters. Then the unaddressed "off" PLAs will have high outputs that do not affect the eight AND gates.

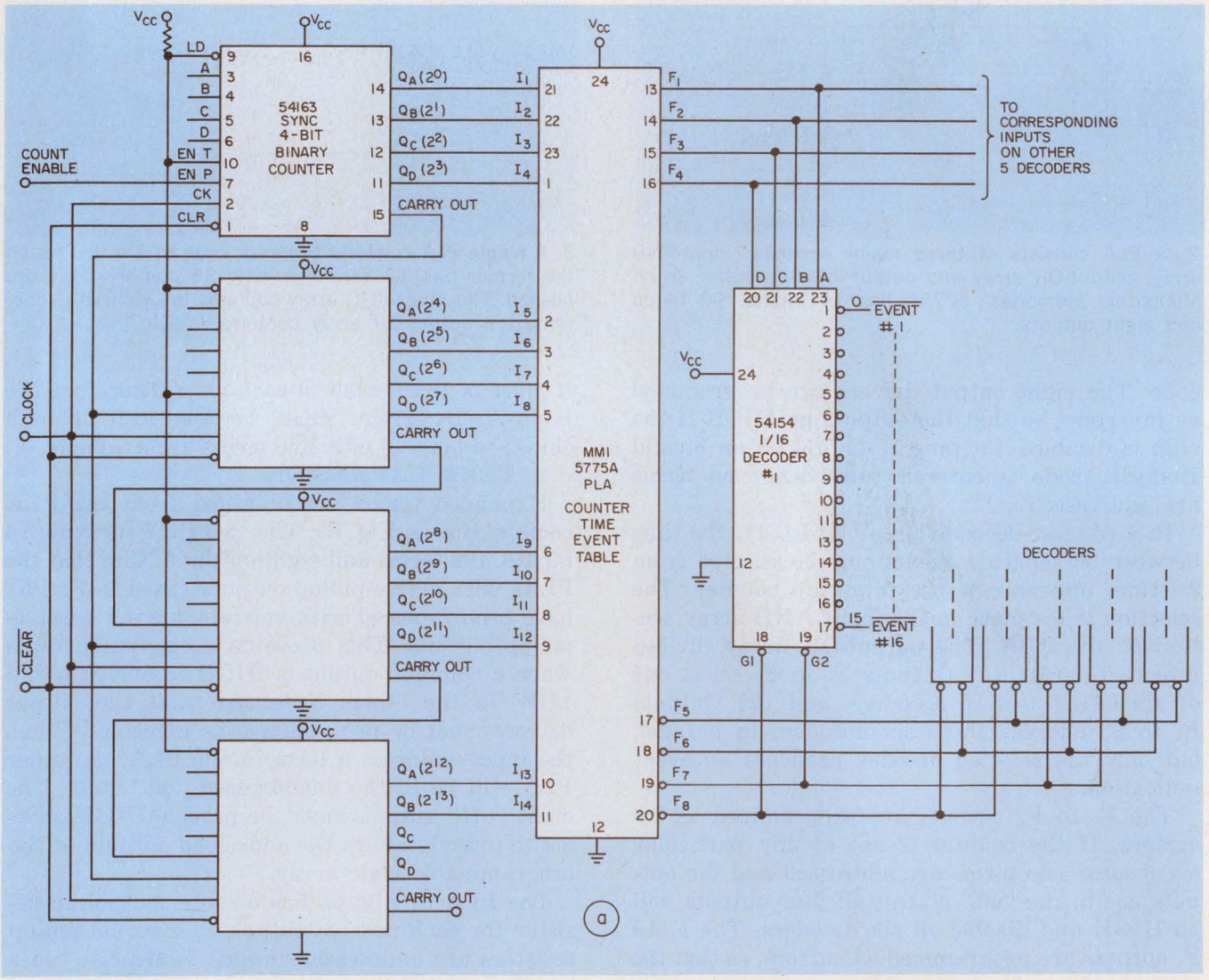
3. INPUT EXPANSION

While outputs and terms can be expanded as much as desired, input expansion is much more constrained. Fig. 7a shows a 28-input system in which any of the eight outputs may contain up to all 28 input variables. However an input going to one PLA cannot be used in the terms of the other. Thus the output equations are restricted to the simple ANDing of two expressions whose variables cannot be interchanged.

Fig. 7b shows a more modest expansion to 20 inputs, with eight common to both chips. The designer must select those input variables that go into the common group and determine how to split the other 12 so no term address will require inputs from both of these split groups.

If eight common inputs are not enough, a third PLA can increase this to 11 (Fig. 7c). Note that there are still only 20 total inputs but that the third PLA may overcome a programming problem of insufficient common variables. Programming flexibility can also be improved if the inputs are separated into seven groups instead of four and each of the additional three groups are common to only two PLAs.

The 5775A and 5776A mask-programmable PLAs, which are used in the examples described, have pin-compatible, field-programmable counterparts—the 5871A and 5870A, respectively. These FPLAs have the three programmable arrays



4. **A PLA keeps track of 96 separate intervals** out of a total of 16,384 (a). The PLA program table (b) shows the output-OR array to be divided between one part that selects decoders and another that employs a binary sequence to address them. The selection of time intervals occurs in the input-AND array.

Input-AND Array
H = Hi. Diode connected only to Input buffer output.
L = Lo. Diode connected only to Input inverter output.
X = Don't care. Diode not connected to buffer or inverter. (None here)

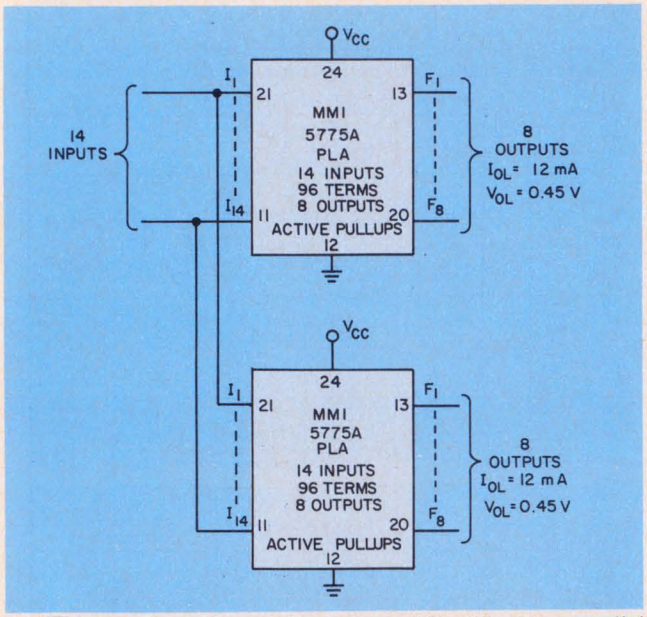
Output-OR Array
+ = Diode in = Hi input to Output Driver
Blank = Diode out = Lo input to Out. Dr.

Counter Output —Event Time	Term & Event No.	11	10	9	8	7	6	5	4	3	2	1	23	22	21	Decoder Selected				Decoder Binary Addr.				Decoder Selected	Dec. Bin. Addr.
		I_{14}	I_{13}	I_{12}	I_{11}	I_{10}	I_9	I_8	I_7	I_6	I_5	I_4	I_3	I_2	I_1	F_8	F_7	F_6	F_5	F_4	F_3	F_2	F_1		
170	1	L	L	L	L	L	L	H	L	H	L	H	L	H	L		+							1	0
365	2	L	L	L	L	L	H	L	H	H	L	H	H	L	H	+	+						+	1	1
512	3	L	L	L	L	H	L	L	L	L	L	L	L	L	L	+	+					+		1	2
2,560	15	L	L	H	L	H	L	L	L	L	L	L	L	L	L	+	+			+	+	+		1	14
2,728	16	L	L	H	L	H	L	H	L	H	L	H	L	L	L	+	+			+	+	+	+	1	15
2,820	17	L	L	H	L	H	H	L	L	L	L	L	H	L	L	+		+						2	0
2,884	18	L	L	H	L	H	H	L	H	H	L	H	H	L	L	+		+					+	2	1
5,440	32	L	H	L	H	L	H	L	H	L	L	L	L	L	L	+		+		+	+	+	+	2	15
5,473	33	L	H	L	H	L	H	L	H	H	L	L	L	L	H	+			+					3	0
5,489	34	L	H	L	H	L	H	L	H	H	H	L	L	L	H	+			+				+	3	1
8,118	48	L	H	H	H	H	H	H	L	H	H	L	H	H	L	+			+	+	+	+	+	3	15
8,300	49	H	L	L	L	L	L	L	H	H	L	H	H	L	L		+	+						4	0
8,428	50	H	L	L	L	L	L	H	H	H	L	H	H	L	L		+	+					+	4	1
10,801	64	H	L	H	L	H	L	L	L	H	H	L	L	L	H		+	+		+	+	+	+	4	15
10,811	65	H	L	H	L	H	L	L	L	H	H	H	L	H	H		+		+					5	0
10,939	66	H	L	H	L	H	L	H	L	H	H	H	L	H	H		+		+				+	5	1
13,631	80	H	H	L	H	L	H	L	L	H	H	H	H	H	H		+		+	+	+	+	+	5	15
13,831	81	H	H	L	H	H	L	L	L	L	L	L	H	H	H			+	+					6	0
13,895	82	H	H	L	H	H	L	L	H	L	L	L	H	H	H			+	+				+	6	1
16,383	96	H	H	H	H	H	H	H	H	H	H	H	H	H	H			+	+	+	+	+	+	6	15
Counter Output Binary Wt.		8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1	Decoder Addr. Wt.				8	4	2	1		

(b)

C = Complement
T = True

Output Inverter/ Buffer Array							
F_8	F_7	F_6	F_5	F_4	F_3	F_2	F_1
C	C	C	C	T	T	T	T



5. **PLA outputs expand from 8 to 16** with this parallel combination. However, the number of terms available remains at 96, the amount possible from a single PLA.

(shown in Fig. 2)—input-AND, output-OR and output-inverter/buffer. All three are programmed by blowing out fuses with high voltage in a manner similar to some PROMs. Note, however, that the 5871A and 5870A have only 48 terms instead of 96, because of the extra chip area required by the fuses and associated circuitry.

If the required function has 48 or fewer terms, the 5775A PLA and programmed 5871A FPLA are completely interchangeable, as are the 5776A and 5870A (Fig. 8). If 49 to 96 terms are needed, two FPLAs are required to replace one PLA (Fig. 9). Here the FPLAs must follow the same term expansion rules shown in Fig. 6a.

Thus, if a PLA with 49-to-96 used terms is to have an FPLA backup for future program changes, observe the following four rules: (1) Wire a spare socket "in parallel;" (2) Use a passive pullup PLA, since the FPLAs will have to be passive-pullup types and this will produce similar output rise times; (3) Program the PLA to have inverter outputs, and (4) Restrict the output loading to $I_{OL} = 9.6$ mA instead of 12 mA.

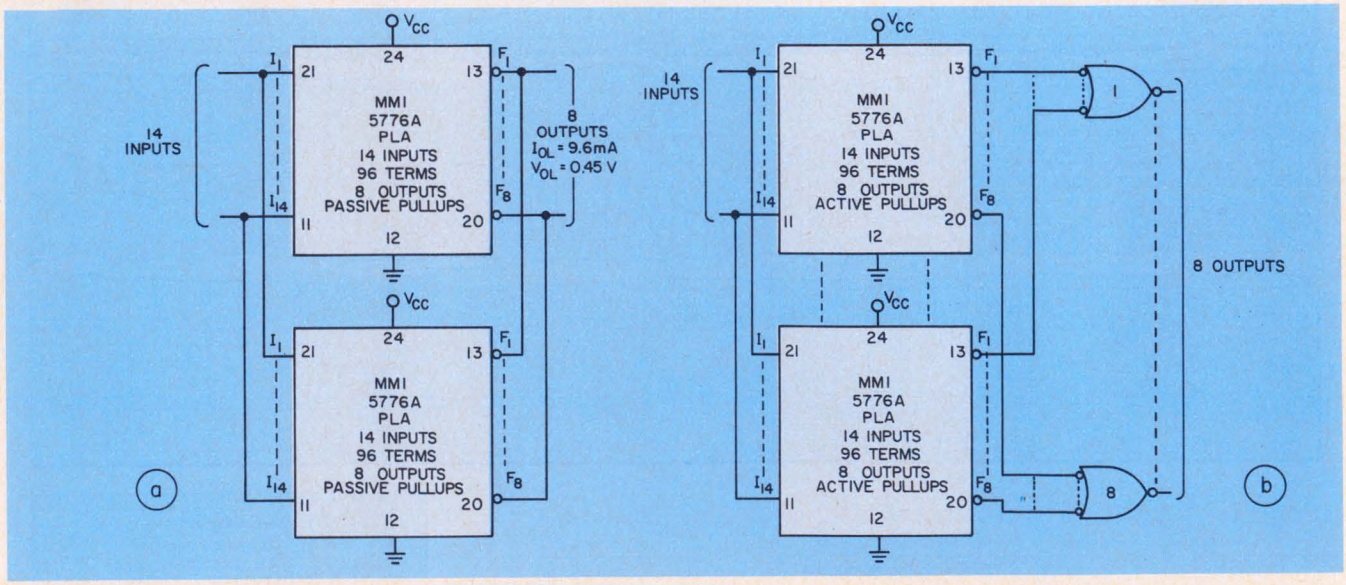
Variations on a theme

Some PLA features, not present in the units just discussed, would improve PLAs or facilitate their expansion. These features include an increased number of inputs, three-state outputs, programmable pullups and internal feedback loops. However, not all of these features can be implemented readily on the chip.

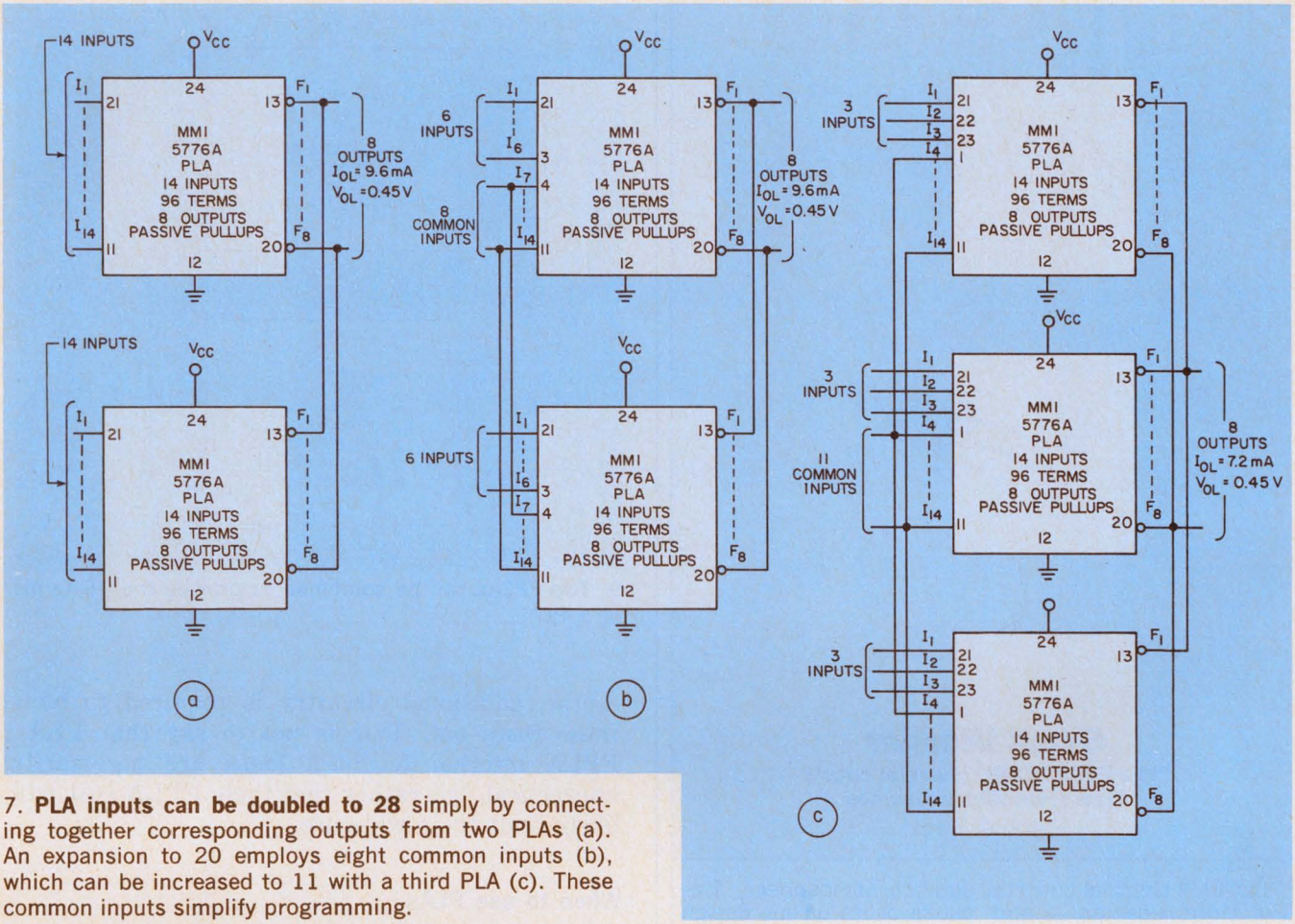
Common input groups (as shown in Figs. 7b and 7c) complicate PLA programming, and if too many are required, multiple PLA-input expansion will not be economical. It appears then that PLAs with considerably more than 14 inputs, even if with far fewer than 96 terms, can be expected in the future.

One PLA (in Fig. 3) is enabled with two address pins—a convenient use of leftover inputs. This is sufficient for active or passive-pullup PLAs. Three-state output PLAs can also be made, but these would require the addition of special chip-enable input pins.

You may wonder why the active pullup and passive pullup PLAs are not combined into one chip, with each output programmable as an active or passive pullup—just as it is programmable



6. **PLA terms can be expanded in two ways.** One method connects together corresponding inputs and outputs (a). If the number of terms required call for more than five PLAs, outputs should be gated (b).



7. **PLA inputs can be doubled to 28** simply by connecting together corresponding outputs from two PLAs (a). An expansion to 20 employs eight common inputs (b), which can be increased to 11 with a third PLA (c). These common inputs simplify programming.

as an inverter or buffer. This feature could be added with one programmable contact in each output.

However, it would also be necessary to combine the programmable feature into the pin-compatible FPLA counterparts. And the programmability of active or passive pullups is somewhat costly in FPLAs, even though it is practically free in PLAs.

This may seem surprising, since the FPLAs would require only one additional fuse per output. But the main cost is not in the eight fuses; it is in the circuitry required to blow them out. A high voltage, three-input, 1-of-8 decoder must be added to the FPLA to get at each fuse separately. And the decoder must not interfere with its three inputs when they are used in nomal operation. Since the FPLAs are already fairly large —which is why they have only 48 terms instead of 96—the feature would add an unacceptable increment to the cost.

Logically the PLA is a 96-wide AND-gate array fully connectable to eight OR/NOR gates in series. However, many, if not most, logic circuits require more than the single stage AND-OR or AND-NOR gates that the PLA provides. External feedback loops from outputs back to inputs are therefore quite common. Each such

PLAS				FPLAS			
14 INPUTS, 96 TERMS, 8 OUTPUTS				14 INPUTS, 48 TERMS, 8 OUTPUTS			
MIL		COMCL		MIL		COMCL	
ACTIVE PULLUPS	PASSIVE PULLUPS	ACTIVE PULLUPS	PASSIVE PULLUPS	ACTIVE PULLUPS	PASSIVE PULLUPS	ACTIVE PULLUPS	PASSIVE PULLUPS
5775A	5776A	6775A	6776A	5871A	5870A	6871A	6870A

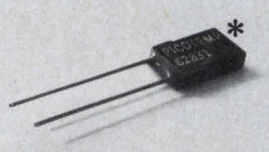
ARROWS INDICATE INTERCHANGEABLE PARTS EXCEPT FOR NUMBER OF TERMS

8. **Available chips allow direct interchange** of PLAs and programmed FPLAs.

loop, of course, costs an output and input pin as well as the circuitry to interface with the "outside world"—all of which can be avoided by use of internal feedback loops.

The output-OR array (in Fig. 2) has eight vertical lines for eight output drivers. If two more lines are added at the left, each connected to an internal inverter-buffer, the resulting four output leads can be incorporated into the AND array to make it 32 lines wide instead of 28. There would be programmable diodes at each new crosspoint in both arrays.

Here, again, it costs more to implement the feature in FPLAs than in PLAs. Fuses require more area than programmable contacts, and, of



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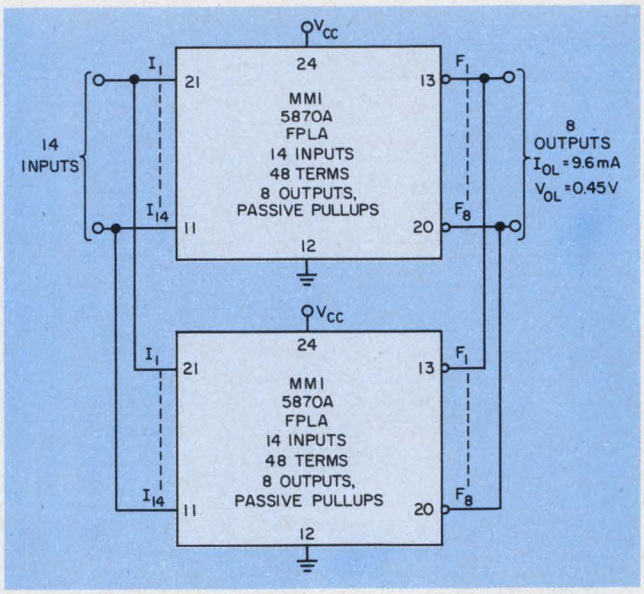

9. **Two FPLAs can be combined** to provide the 96 terms of a PLA.

course, additional circuitry is required to blow these fuses out. This is not to say that PLA/FPLA internal feedback loops are necessarily impractical, but rather that their FPLA cost will likely limit their wide use.

When to use PLAs

Standard-function PLAs, like the Hollerith-to-ASCII converter, tend to be the exception rather than the rule. Code converters, character generators, mathematical lookup tables and other such standard functions usually require too many words to make PLAs economical. The Hollerith code is the exception because it uses only 2-1/3% of the possible input combinations.

Based on some existing prices, here are some very rough rules for deciding between PLAs and ROMs:

- If less than 8% of the input combinations are used, PLAs are more economical.
- If more than 20% are used, ROMs win.
- If 8% to 20% are used, then the costs, including those for programming, should be compared.

Most standard functions use more than 20% of their input combination. So ROMs will probably continue to dominate these applications. PLAs appear better suited to custom programmed applications, like dedicated controllers and discrete logic circuits. These require a comparatively small portion of the total possible input combinations.

However these systems often require program changes, so that FPLA backups are needed. It appears then that PLA features and configurations will continue to be largely influenced by what is feasible in their FPLA counterparts. ■■

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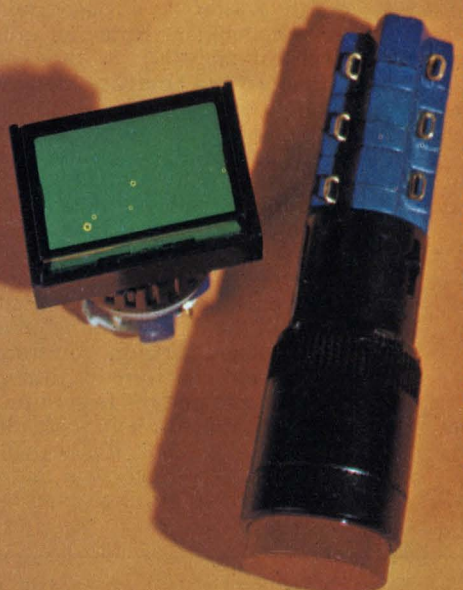

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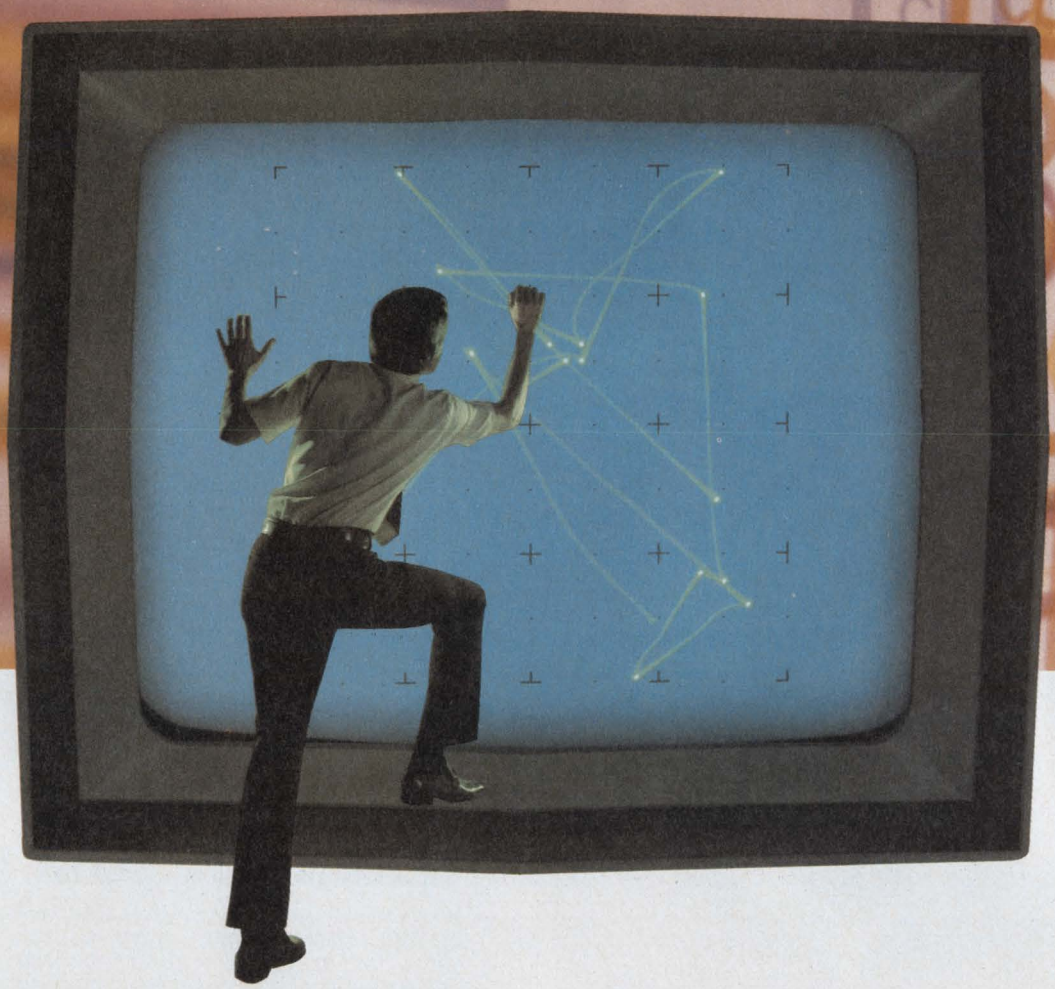

HP invites you to step inside your 16-bit parallel circuits for an overall view—and a detailed view—of logic-circuit operation. How? Just connect our new 1600A Logic State Analyzer to an operating circuit, and view actual logic states on the CRT—at clock rates to 20 MHz. Select the data you want to observe with pinpoint accuracy. And choose from two display methods for viewing the data words.

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In the mapping mode, the 1600A can display all possible combinations of its 16 data-channel inputs—over 65,000 in all. Each input combination or "word" appears as a discrete point whose location on screen identifies its address. Spot intensity shows relative frequency of occurrence, and the vectors show the sequential state locations.

This mode converts parallel data into a pattern that your eye can easily scan to quickly spot changing conditions or unusual events. You can even expand the view to zoom in on data of interest. And, with a cursor, locate the address of any spot. You can then use the address as a trigger point for a detailed look with the tabular display, or to trigger your scope for electrical analysis.

In store and compare mode, the 1600A triggers on any preset word up to 16 bits wide. The analyzer then displays the trigger word and 15 sequential words before, after, or surrounding the trigger word, so you can easily analyze logic states in detail. You can store one table of data and compare it with an active data display . . . have the analyzer compare the two tables and give you a display of logic differences on a bit-by-bit basis for easy comparison . . . or you can set the instrument to automatically halt when all the data in one table isn't identical to data in the second—freeing you from the tedious task of waiting and watching for infrequent sequences.

And that's just the beginning. The 1600A gives you qualifier inputs to help locate the specific data you want on a busy bus. It gives you a sequential trigger by providing a trigger arm that inhibits the word trigger until an arming signal is received. You can

hrough

logic designs: Mapping..... Store and compare.

delay the display up to 99,999 clock pulses from the trigger point, which lets you look virtually anywhere in your program flow.

The 1600A, priced at $4,000*, gives you new insight to operating logic circuits. With 16-bit word size, parallel operation, and 20 MHz speed, it's the ideal instrument for designers of minicomputers, peripherals, microcomputers, and microprocessor-based systems.

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FOR TECHNICAL INFORMATION CIRCLE # 271

FOR IMMEDIATE APPLICATIONS ASSISTANCE CIRCLE # 272

Base your IC tester on a μP, and you can carry the system into the field. Other benefits include data logging and low cost.

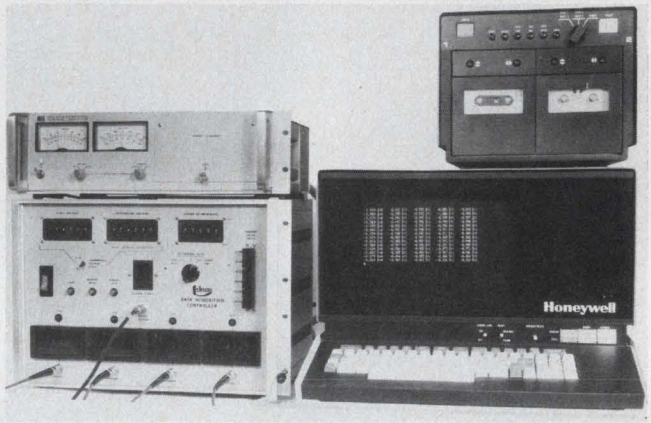
With a microprocessor, you can design for less than $14 k a portable IC test system with I/O capability, automatic operation and other benefits. In capability such a system falls somewhere between a fully automated, minicomputer-controlled tester and the bench-power-supply/VOM approach. The test system provides the following performance:

- One channel of programmable output voltage.
- Resolution of four digits, with a range from −100 V to +100 V.
- Four analog input channels that measure voltage response with 1% accuracy.
- Stand-alone operation as a voltage source and meter, with no data logging.
- Data storage on tape (in this case, the cassette unit of the Honeywell VIP 7700 video information system). The terminal is operated off-line from a systems computer, used to massage the data. Transfer of information from the screen of the VIP to the cassette is controlled by characters in the data stream. This allows a page of data to be stored in a formatted cassette file. Access to the terminal is made via a 2400-baud, synchronous RS-232C channel.

A look at the requisite control and communication capabilities reveals that a substantial amount of intelligence is needed. Since most of the data manipulation involves BCD digits, and the control and speed requirements are not excessive, a four-bit μP—such as the Intel 4004—is all that is necessary. However, a novel scheme lets you get eight bits of output-port information from the four-bit device.

Serving as the voltage source is an HP 6131C programmable supply with TTL, BCD I/O logic. The 6131C's range and resolution match the performance requirements, and the unit's BCD programmability fits nicely with a four-bit microcontroller.

The communications requirements are easily met by a programmable transmitter chip interfaced to the μP: The Western Digital PT1482B provides synchronous data transfer at the specified baud rate, generates a lateral parity bit and handles all serial communication.



A microprocessor controlled tester and data logger. Stimulus voltage is controlled with thumbwheel inputs and produced by a digital power supply. Four analog input channels are strobed, and reformatted data are sent on an RS232C channel to a display screen, then dumped to cassette tape. Error conditions and system status are displayed on a seven-segment display driven by the μP.

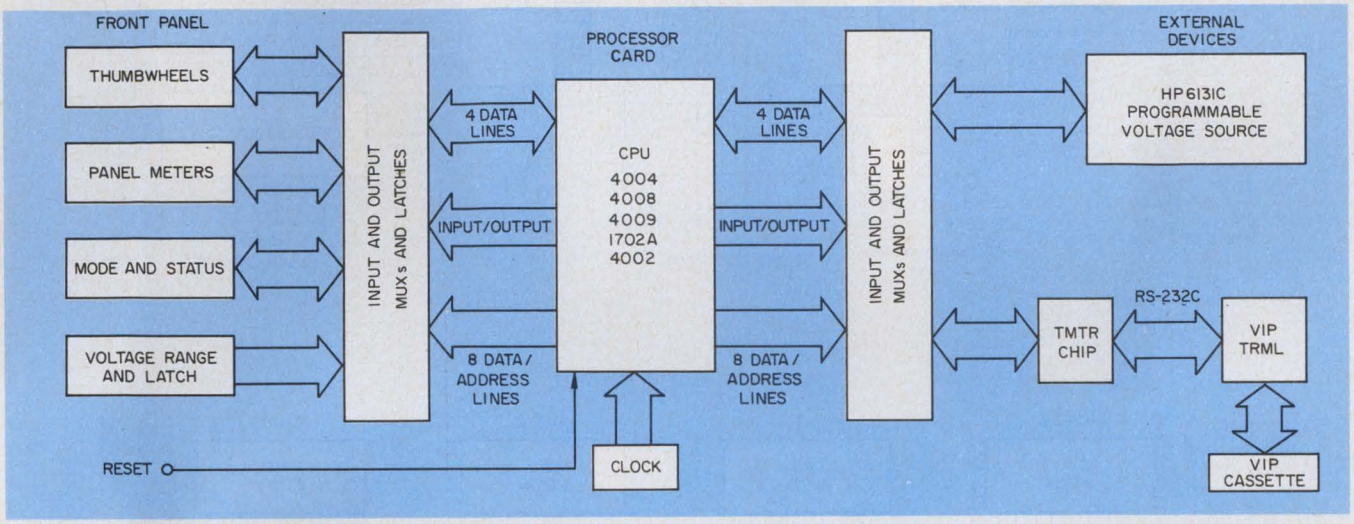
To speed design, buy, don't build

The interface itself consists of seven bits of parallel output data plus two control lines. With the flexibility of a programmable chip, the output channel can be readily modified anytime to interface with various communications channels.

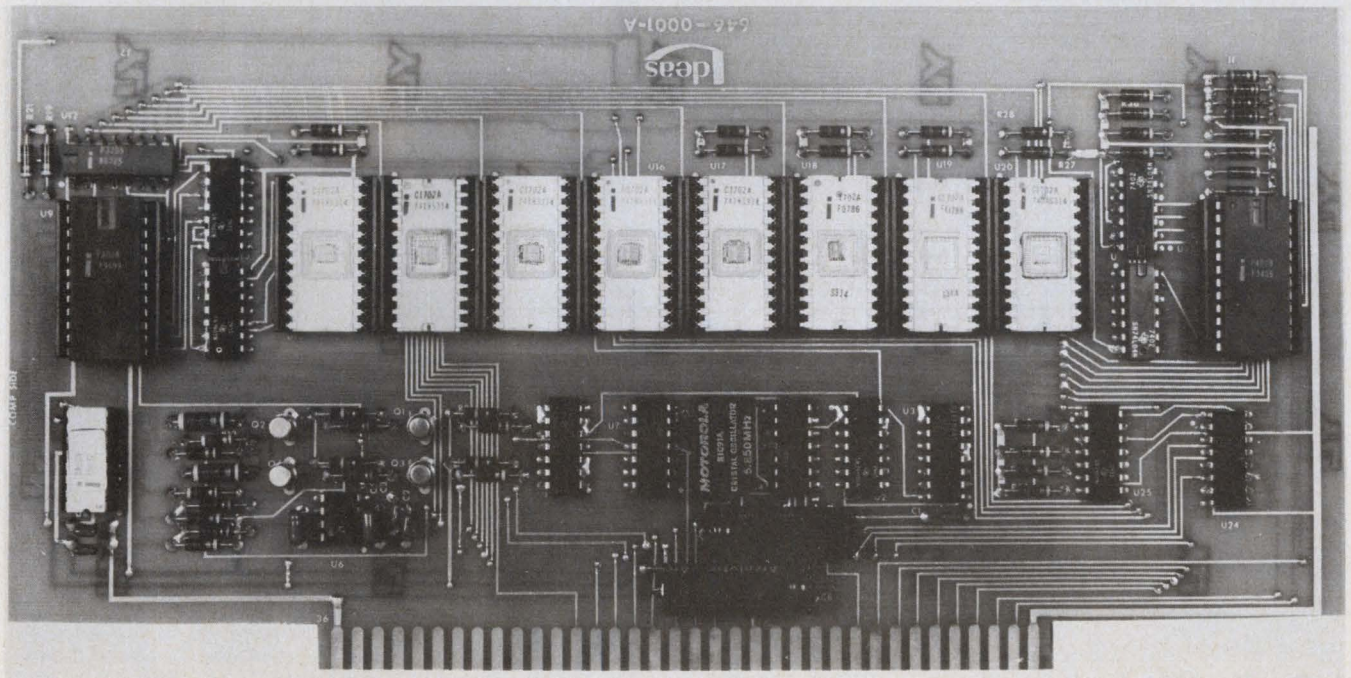
The four analog input channels present a design challenge. To operate as a stand-alone option, the channels must have display capability. With a digital panel meter, such as the Datel AR-2000 autoranger on each input, there's no need for analog design or separate display electronics. As an externally triggered unit, the AR-2000 can make 33 autoranged measurements per second—from a low scale of ±199.9 mV to a high scale of ±19.99 V.

In the tester, a sample consists of the output voltage value, the four input voltages, plus the

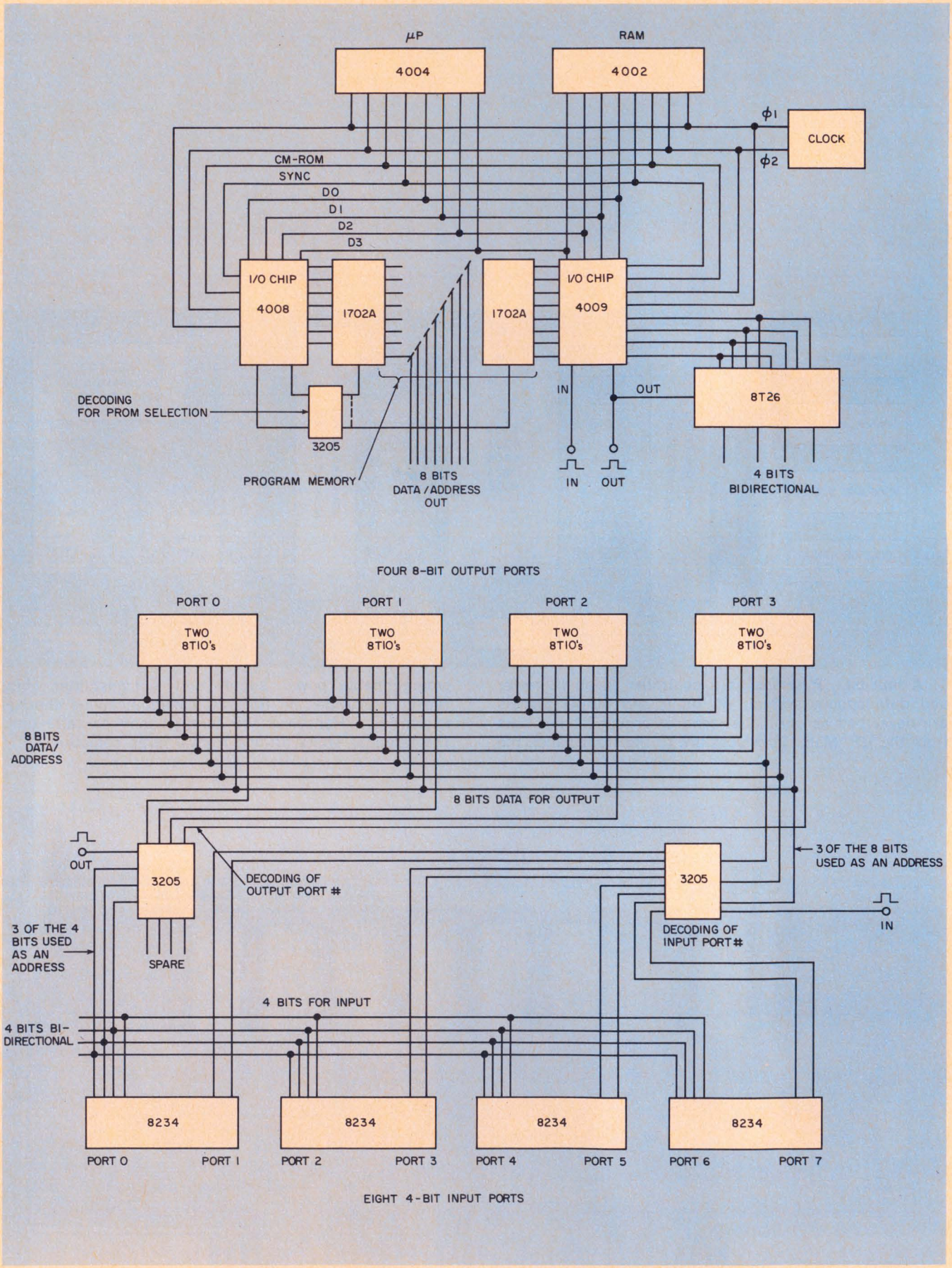
Jeffrey C. Rice, Project Engineer, Information Development & Applications, 10759 Tucker St., Beltsville, MD 20705.



1. **A four-bit μP serves as a controller** in an IC tester and data-logging system. All input and output signals are developed as ports that send or accept latched data from the μP. Major interfaces are to the front panel, the programmable power supply and a transmitter chip. The chip provides an RS232C communications channel to control a Honeywell VIP terminal and cassette unit. The terminal works off-line from a large computer.



2. **Microprocessor card layout:** At lower left is the 4004 chip. The lower part of the card contains the clock and power-up circuitry and the output-signal drivers. A total of 2048 bytes of program storage are included in PROMs. The 24-pin chips on either side of the PROMs are I/O interface chips, the Intel 4008 and 4009.



3. **How the 4004 can be developed** to accept four input bits, yet yield eight-bit output ports: A four-bit bidirectional bus carries the data input and also functions as an address for the output ports. Eight bits of data/address, developed by the Intel 4008, produce eight bits of data output. These lines also form the address for the input ports. Two strobes activate decoders, which enable one of eight input or output ports.

control characters necessary to access the VIP terminal—67 characters in all. At 2400 baud, less than five samples per second are transmitted. Therefore the speed of the panel meter is not a problem.

To obtain the range of ±100 V, any channel in which the voltage magnitude might exceed 20 V —the DPM's highest scale—must have a ÷ 10 probe in its path. A toggle switch for each panel meter illuminates a ×10 LED and signals both the μP and the operator that the voltage reading of the meter is actually 1/10 the measured value.

Output voltage values are varied much as in a BASIC FOR-NEXT loop, with front-panel thumbwheels setting the initial value and the number and size of the voltage increments. A separate set of pushbuttons programs the latch value of the voltage supply, as well as the range. All voltage levels are reformatted within the micro and sent along the communication link in floating decimal-point form.

The μP as a traffic cop

In its central role as a data communications handler, the Intel 4004 communicates with the outside world through input and output ports controlled by I/O interface chips, the 4008 and 4009 (Fig. 1). The interface chips allow program storage in reprogrammable ROMs, rather than masked devices, and facilitate data transfer to and from the CPU. Note that all developmental, and most low-volume, μP-based systems use such storage. Fig. 2 shows the microprocessor card, with the CPU, clock, power-up circuitry and program storage in 1702A PROMs.

Systems design with any μP is a tradeoff between hardware and software (firmware) tasks. Once you integrate the processor into the system, it is better to implement as many functions as practical in firmware rather than hardware. Use external hardware only where the task is highly real-time oriented and is either too fast for the processor or will occupy the CPU unnecessarily. An example of such a tradeoff is the use of a transmitter chip for parallel-to-serial conversion and for clocking on an RS-232C communications line.

Given a basic chip set, there are many ways to accomplish I/O operations with the 4004. Using the 4008 and 4009, you can generate four bidirectional data lines, two control strobes for I/O latches and eight output lines for data or address. The output can be either four bits of data with eight bits of addressing or eight bits of data with four address bits.

Fig. 3 depicts the 4004 connected to the I/O interface chips and to typical input and output ports. Signals produced by the 4008 and 4009 yield latched input and output data.

To read into the accumulator the four bits presented on an input port, the following program steps are executed. In the program, "X" represents the eight-bit device address:

```
0    FIM OP X
1
2    SRC OP
3    RDR
```

The first statement, which uses two locations, loads an eight-bit register pair with a binary number from 0 to 255. Statement 2 causes that eight-bit value to form the output during a specific clock cycle of each successive instruction. Statement 3 causes an input strobe to be generated during the same clock cycle in which the eight output bits of register pair 0 are formed. The four bits of input data from the addressed device are thus loaded into the accumulator.

Output is illustrated here as an eight-bit transfer. The following program steps cause eight bits of data labeled "Y," to be delivered to device address "X":

```
0    FIM OP Y
1
2    SRC OP
3    LDM X
4    WRR
```

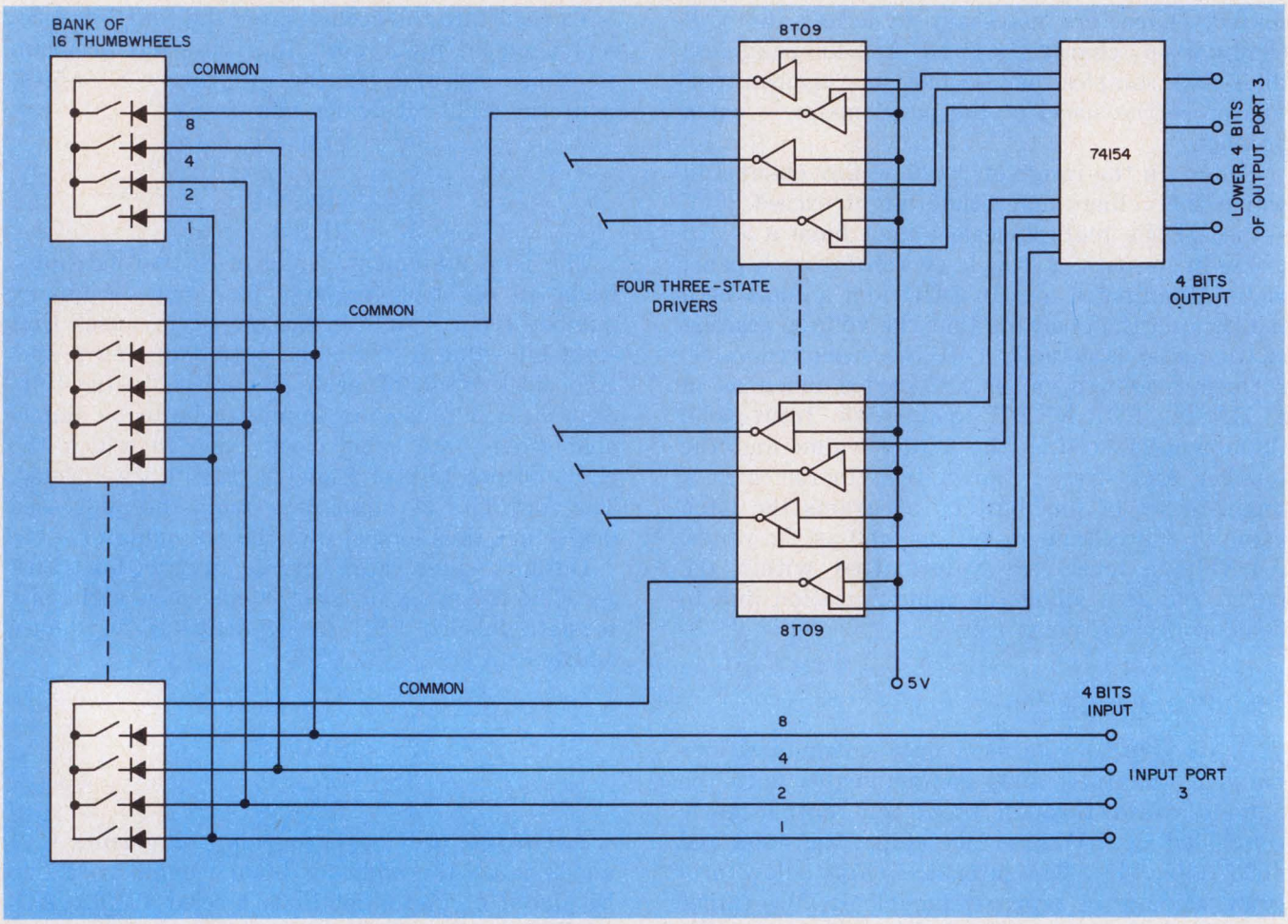
As in the previous program, statements 0, 1 and 2 cause the eight-bit binary number "Y" to be placed on the eight lines labeled DATA/ADDRESS in Fig. 3. Statement 3 loads a four-bit number, "X," into the accumulator of the 4004. Statement 4 generates an output strobe during the interval in which the value "X" appears on the bidirectional bus. Here the data lines of the bus operate as an address for the delivery of eight bits to one of 16 output devices.

Solving the interface problem

With the general scheme of input/output operations outlined, you can use five chips to design a typical interface to a bank of 16 thumbwheel switches (Fig. 4). The chips are external to the overhead ICs used in the input/output ports. This interface method is not necessarily the most effective, but it illustrates how data flow in and out of a four-bit μP.

The thumbwheels use series diodes to produce BCD outputs. To read a thumbwheel's output, the processor sends out a four-bit address on the lower portion of an eight-bit output port. The four-bit value of the thumbwheel is read into the accumulator and stored in a RAM. This arrangement requires only 20 lines between the card rack and the front panel.

The four address bits feed through a 74154 four-to-sixteen-line demultiplexer, which sets one of sixteen lines to ground. The 16 lines, in turn, control the three-state output of driver chips.



4. **In the interface** between the 16 thumbwheel switches and the 4004, the lower four bits of an eight-bit output port feed a demultiplexer, which controls the three-state inputs of 8T09 drivers. Thus one of the 16 "common" inputs of the switches is grounded, with the 15 other lines remaining in a high-impedance state.

The inputs of the drivers are set to produce a grounded output when activated. The result is one line of 16 in a grounded state, with the remaining 15 in a high-impedance state.

These 16 lines connect to the "common" inputs of the thumbwheel switches. The four output bits of each thumbwheel can now be connected in a common four-bit bus and read into the μP accumulator through one 4-bit input port. The program to accomplish this appears as follows:

```
0  READ  FIM OP 0    /Start with first thumb-
                      wheel.
1
2        SRC OP       /OP selects which "com-
                      mon" to activate.
3        LDM 3        /3 is the number of the
                      four-bit output port.
4        WRR          /Value of OP is sent to
                      address 3.
5        FIM 1P 3     /3 is the address of the
                      input port.
6
7        SRC 1P
8        RDR          /Read value of thumb-
                      wheel.
9        SRC OP       /Point to location in
                      RAM.
10       WRM          /Store value in RAM.
11       ISZ 1 2      /Increment register 1, If
                      ≠ 0, go to line 2.
12
```

The lower four bits of output port 3 set one of the thumbwheel common inputs to ground, and the four bits of BCD data are read in from input port 3. As each value is read into the accumulator, it is stored in a RAM. The RAM used here is the Intel 4002, part of the chip set of the 4004.

Register pairs are composed of two 4-bit registers. Statement 11 causes the lower four bits of register pair 0 to be incremented by 1. The program loops 16 times through statements 2 through 11. This causes the 16 common inputs to be placed in a ground state, allowing the value of that switch to control the four-bit bus. The four-bit register overflows to a 0 on reaching 16, and succeeding program steps are executed.

Thus with the μP as a controller, a system performance level is achieved that is not possible with random logic within a moderate price range. ■■

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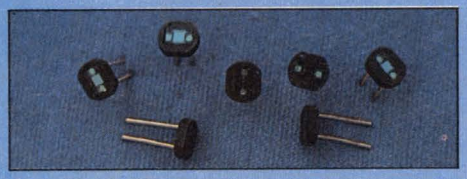

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INFORMATION RETRIEVAL NUMBER 51

UNRETOUCHED

MICROPHOTOS

Your IC lead frames look like this at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

Arrows indicate scars and abrasions made by rough edge of lead frame.

THEIRS

An ordinary edge-bearing socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame.* Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.

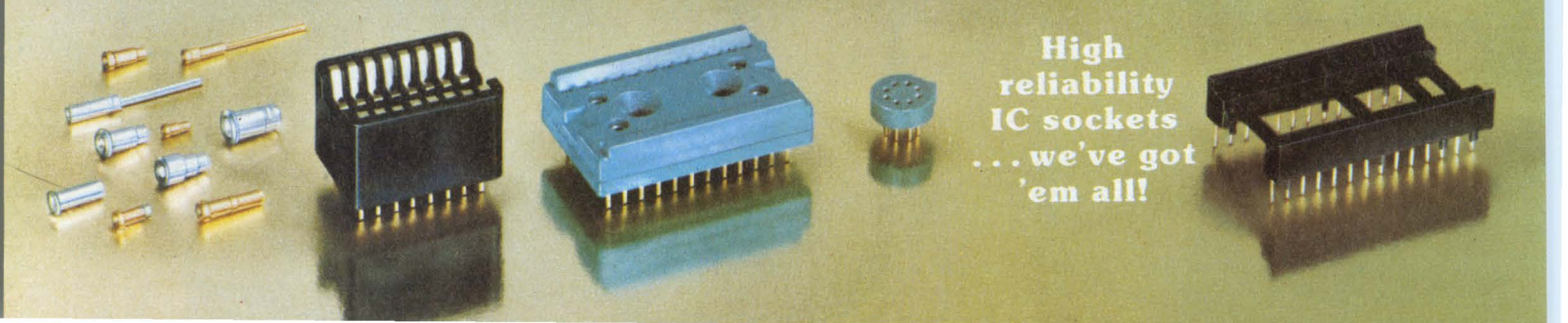
Lead frame in place in an ordinary edge-bearing contact.

Arrows indicate contact surface still smooth, clean, free from abrasions.

OURS

ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.

Lead frame in place in RN "side-wipe" contact.



expose 'junk' socket problems

Secret of RN high reliability 'side-wipe' DIP sockets revealed by microphotos

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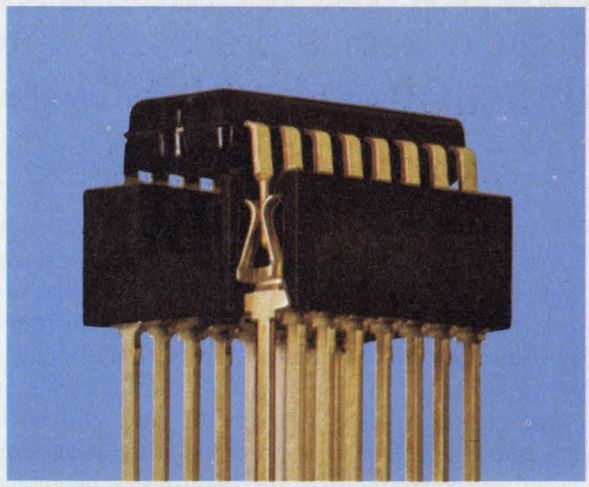

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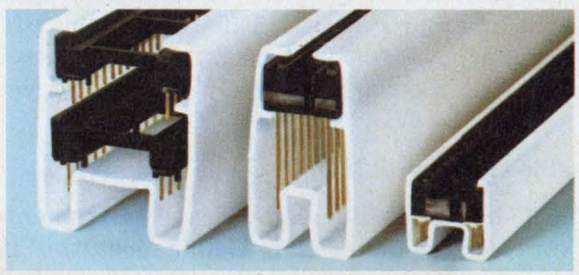

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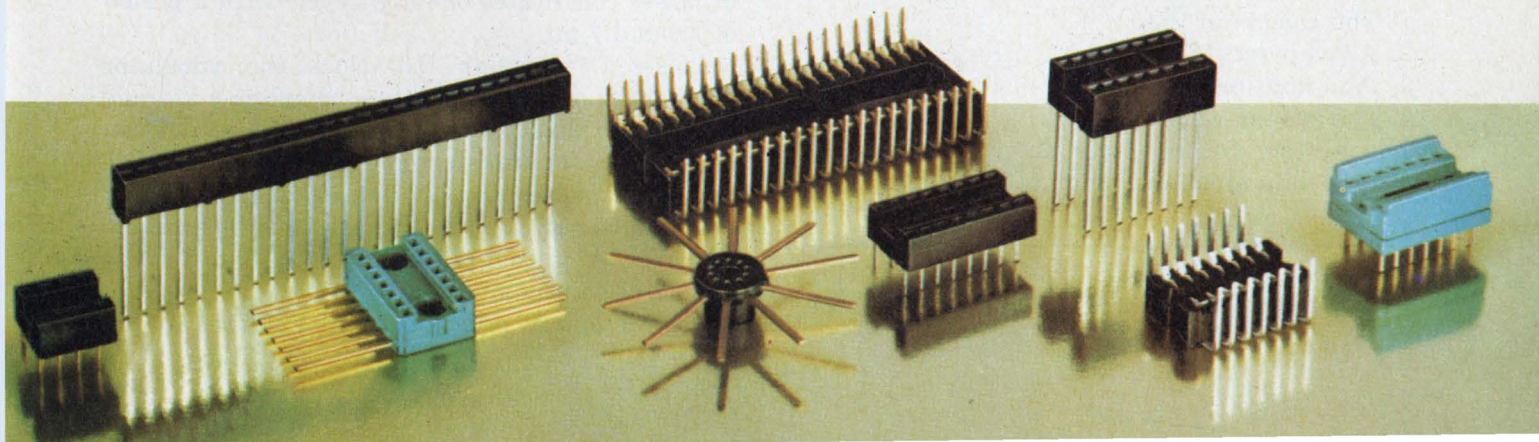


Incorporate a calculator chip,

instead of a microprocessor, into your number-processing data system, and avoid software for math functions.

For number-crunching applications, a calculator-based system is a good alternative to a microprocessor, if processing speed is not a major constraint. Logic designers must overcome the urge to use microprocessors everywhere merely because they happen to be in vogue. A microprocessor system can result in design overkill. And the software needed for a microprocessor may cost considerably more than the logic designer is prepared to invest.

A typical calculator chip is merely a microprocessor that has a built-in microprogram to solve arithmetic functions. So, for simple numerical calculations, why seek trouble with more versatile microprocessors? Take advantage of a calculator's powerful arithmetic internal instruction set. The software is already written for you.

Versatile chip with BCD I/O

The TMS 0117NC, made by Texas Instruments, is a versatile calculator chip. Unlike most, this 10-digit processor handles all data I/O in a BCD format. And it generates status signals that discriminate between Busy (output data invalid, no data can be entered) and Ready (output data valid, data can be entered). The chip provides the four arithmetic functions in a fixed-point mode, and some additional functions as described in Table 1. Table 2 shows the approximate times needed to complete these functions.

Fig. 1 is a block diagram of a calculator-based digital-instrumentation data-acquisition system that can be programmed to sample data from 16 inputs and mathematically evaluate the data. The system consists of four major sections:

1. The calculator chip.
2. A temporary output storage resistor.
3. Data multiplexing and serializing networks.
4. The system control logic.

The system control logic determines the sequence of data input and computation and consists of the following elements:

- Program memory.
- Program counter.
- Program sequence logic.

The program memory capacity is 32 words × 16 bits, and the memory can be implemented with two 256-bit PROMs. In some applications additional PROMs may be used to extend the program beyond 32 instructions.

The 16-bit words stored in the memory are partitioned into three bit fields (Table 3). The first five bits, A1 to A5, define the instruction field. These bits enter the calculator data input, KQ, serially via the input-data serializer, 3c, shown in Fig. 5. A detailed circuit of the serializer is shown in Fig. 2. Note that bit A5 divides the instruction field into two parts—numerical information and instruction codes.

The second data field, Data-select, provides 4 bits to select 1 of 16 data input channels (Fig. 3). The last group provides a Data-disable signal to interrupt data flow from the input-data multiplexer. At the same time this signal allows numerical or instruction data to enter the calculator chip. Also, additional control signals such as Wait, Reset and Display Data are included in the last group.

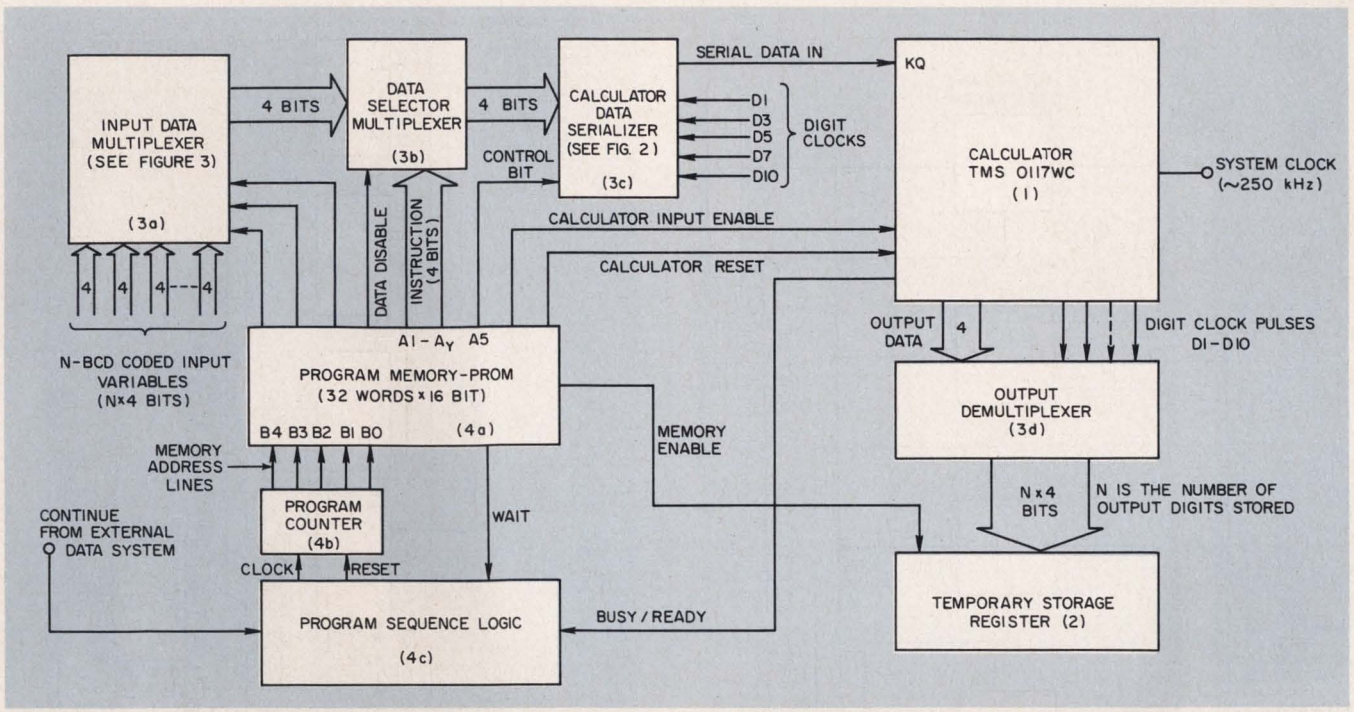
Calculator chip provides timing pulses

An external clock at a nominal frequency of 250 kHz provides timing for the calculator system. The calculator generates 11 pulses, which appear sequentially at 11 output terminals. This sequence of pulses, numbered D1 through D11, is generated when output data are ready. One set of pulses constitutes one digit cycle with a period of about 1.7 ms.

Pulses D1 through D10 clock the calculator chip's BCD output data into a temporary storage register, so that the complete 10-digit output can be displayed, or transferred elsewhere, as a single word. And pulses D1, D3, D5, D7 and D10 clock the serializer (Fig. 2) to convert the 5-bit instruction code, A1 through A5, into serial data for the calculator-chip input.

A 5-bit binary program counter addresses the

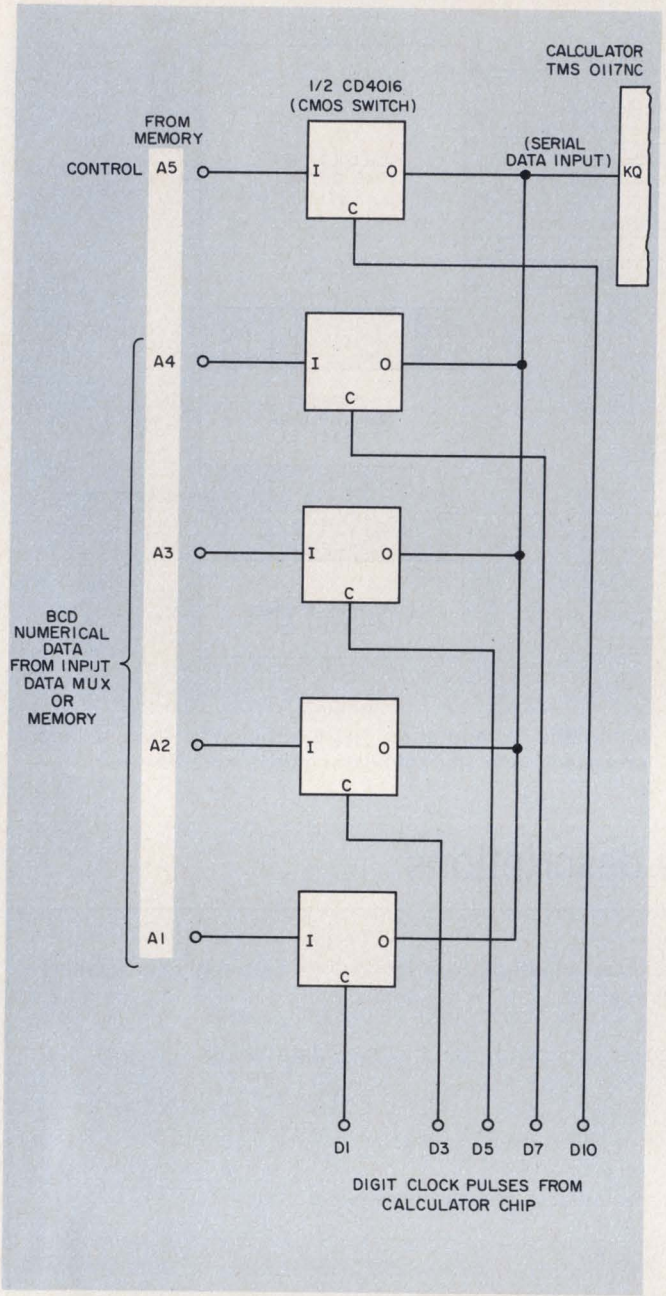
Kurt Skytte, Electronic Engineer, Rucker Control Systems Div., 4700 San Pablo Ave., Oakland, CA 94608.



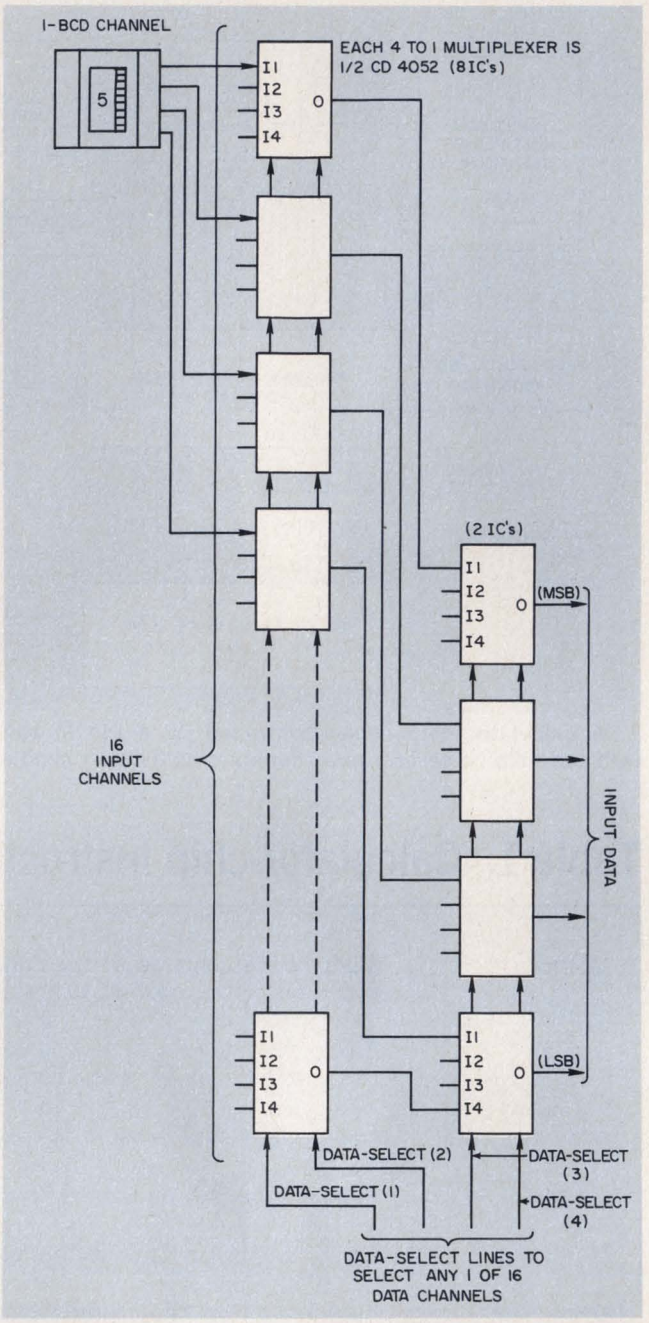
1. **A calculator chip,** when controlled by a PROM and with the help of several mux/demux circuits, can handle arithmetic computation more efficiently than a microprocessor, and the calculator needs no software.

Table 1. Calculator-chip instruction descriptions

Multiply	Multiply the contents of the output register (multiplicand) by the last data entry (multiplier) and transfer the product to the output register.
Divide	Divide the contents of the output register (dividend) by the last data entry (divisor) and transfer the quotient to the output register.
Add	Add the last data entry to the contents of the output register.
Subtract	Subtract the last data entry from the contents of the output register.
Increment	Add 1 to the contents of the output register.
Decrement	Subtract 1 from the contents of the output register.
Add to Overflow	Continuously increment at the rate of 1 per digit cycle the contents of the output register until overflow is reached.
Subtract to Overflow	Continuously subtract 1 at the rate of 1 per digit cycle from the contents of the output register until zero is reached.
Equal	Execute instruction. Causes the processor to carry out the last stored instruction.
Right Shift	Move the contents of the output register one place toward the least significant digit.
Left Shift	Move the contents of the output register one place toward the most significant digit.
Exchange Operands	Interchange the last pair of numeric entries, e.g. a + b becomes b + a.
Clear	Clear all stored instructions and data registers.
Reset	Reset is a master clear and will operate under all conditions.



2. **Parallel BCD numbers from the input-data multiplexer** or the memory are converted to serial form when they are clocked with digit pulses from the calculator chip.



3. **Input data are selected from 16 BCD input channels** by data-select codes derived from the program memory.

Table 2. Typical computation times

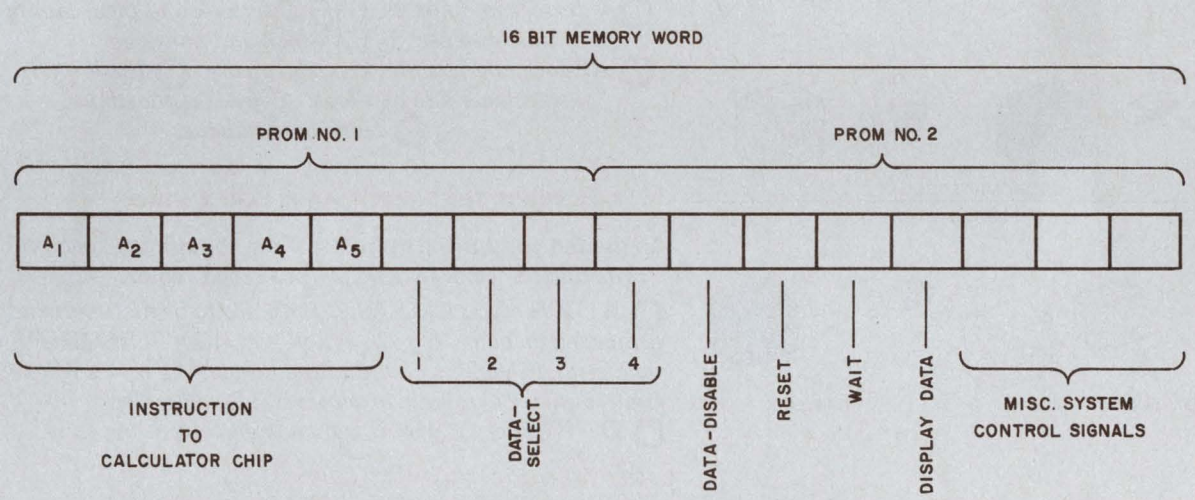
Function	Time
Numeric Entry	5.2 ms (maximum)
Operation Instruction Entry	6.9 ms (maximum)
Shift Left or Right	1.72 ms
Increment or Decrement	3.4 ms
Exchange Operands	5.2 ms
Add, Subtract	8.6 ms
Multiplication	70 ms (maximum)
Division	80 ms (maximum)

program memory. When the calculator accepts new data and instructions, it generates a Busy signal, while carrying out the instructions. The Busy signal increments the program counter to address the next program word in the memory, and new data and instructions automatically enter the calculator when the Ready condition occurs. The final memory instruction is a Reset signal that clears the calculator and resets the program counter. A wait state, which momentarily suspends program flow, may be necessary to provide time to check that input data are valid before entry into the calculator.

Input data to the multiplexer network may

Table 3. Calculator-chip program input

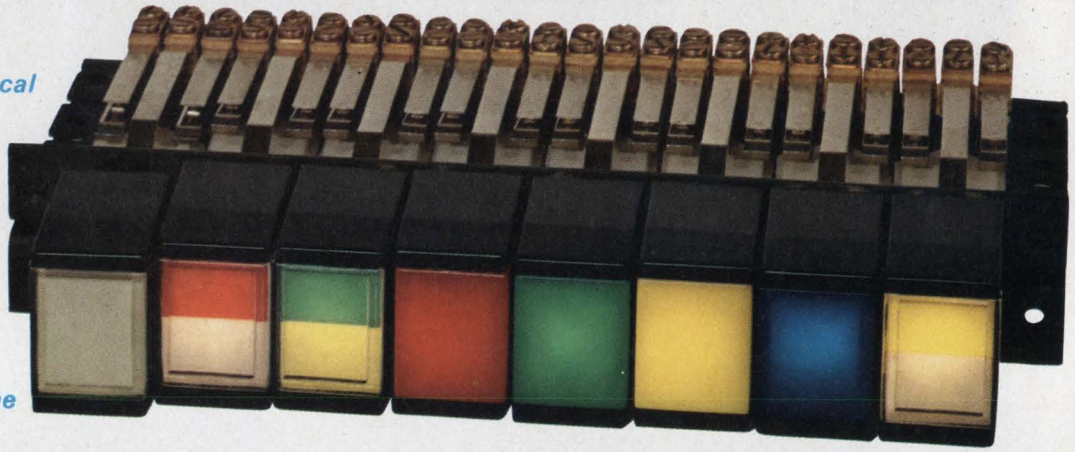
A5	A4	A3	A2	A1	Instruction	
0	0	0	0	0	0	
0	0	0	0	1	1	
0	0	0	1	0	2	
0	0	0	1	1	3	
0	0	1	0	0	4	Numeric Data
0	0	1	0	1	5	
0	0	1	1	0	6	
0	0	1	1	1	7	
0	1	0	0	0	8	
0	1	0	0	1	9	
1	0	0	0	0	Clear	
1	0	0	0	1	Equals	
1	0	0	1	0	Multiply	
1	0	0	1	1	Divide	
1	0	1	0	0	Add	
1	0	1	0	1	Add 1	
1	0	1	1	0	Subtract	Instruction Code
1	0	1	1	1	Subtract 1	
1	1	0	0	0	Add 1 to overflow	
1	1	0	0	1	Subtract 1 to zero	
1	1	0	1	0	Shift right	
1	1	0	1	1	Shift left	
1	1	1	0	0	Exchange operands	
1	1	1	0	1	No operation	
1	1	1	1	0	No operation	Not Used
1	1	1	1	1	No operation	



originate from digital thumbwheel switches that provide BCD output codes or from analog-to-digital converters. A/d outputs may be held in a temporary register to ensure stable information during data entry to the calculator. If a/d conversion time is slow, it may be necessary to use the wait state until the data conversion is completed. A continue signal from the converter could then end the wait state.

A practical digital instrumentation system based upon a calculator chip can be built with roughly 50 ICs for about $100. A system program for 30 instructions has a cycle time of about 250 ms. Different programs loaded into several PROMs that easily plug into the circuit allow quick change of the system's operation. ■■

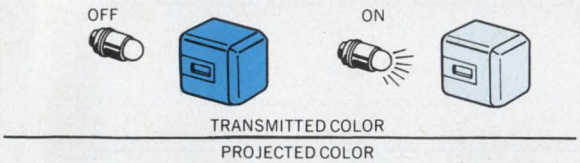
Try the great pushbutton



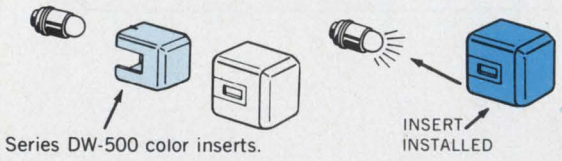
Multiple station mechanical pushbutton switches probably aren't the most important thing in your life—until you have to specify one within tight performance or cost specifications. Then they can get a little complicated.

That's why this little game might be helpful. And interesting. Take three or four minutes and see if your "pushbutton switch I.Q." is up to par.

Be careful. Some of the questions are tricky.



2. OFF



1. YOU CAN'T HAVE EVERYTHING. OR CAN YOU?

Which of the following pushbutton switch functions CAN be intermixed on a single frame of a multiple station switch?

○ *Interlock and non-lock* ○ *Interlock and push-lock/push-release* ○ *All-lock and non-lock* ○ *All-lock and push-lock/push-release* ○ *Push-lock/push-release and non-lock* ○ *All of the above* ○ *None of the above*

2. SOME TRIVIA THAT MIGHT MAKE YOU A HERO

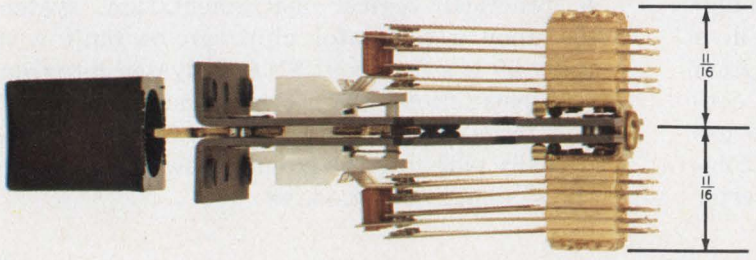
In lighted pushbutton switches, when should you specify "transmitted" color instead of "projected" color?

○ *A) When you REQUIRE the color to be distinguishable in an unlighted display.* ○ *B) When you DON'T REQUIRE color to be distinguishable in an unlighted display.* ○ *C) When you have limited power available to achieve lighted display.* ○ *D) None of the above, transmitted color is obsolete.*

3. GET DOWN TO THE NITTY-GRITTY

You're working with low-level signals and are specifying dry circuits—circuits with voltages and currents too low to break down contact surface films or corrosion. What kind of contacts should you specify in your pushbutton switches?

○ *Silver* ○ *Cadmium oxide* ○ *Gold* ○ *None of these*

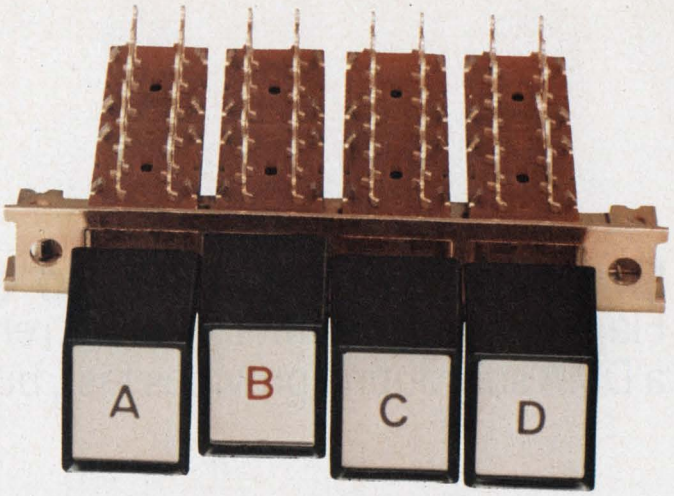


4. A POWERFUL PROBLEM

Pushbuttons switches with leaf-type switching give you extremely long life and lots of circuit flexibility in limited space—but they're limited to relatively low-current applications.

○ *True* ○ *False*

switch quiz.

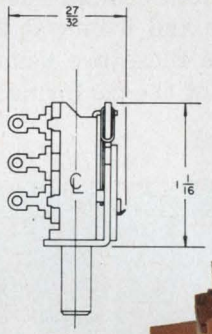


5. WATCH OUT FOR THIS ONE

"Push-lock/push-release" and "alternate action" are identical functions—with one important difference. Which is it?

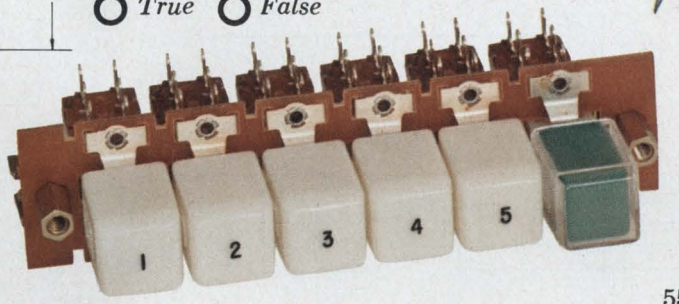
○ *A) Pushbutton is depressed once to actuate switch.* ○ *B) Pushbutton falls back only slightly from the "in" position.* ○ *C) Pushbutton is depressed again to return switching circuits to normal.* ○ *D) Pushbutton is depressed twice to return switching to normal position.*

6. THE BEST OF BOTH WORLDS



Mechanical multiple-station pushbutton switches give you the flexibility you need, but they're too bulky for your miniaturized design. Your best bet is to design a custom switch from a basic series.

○ *True* ○ *False*



7. YOU CAN LOOK AT THIS TWO WAYS

What is the mechanical function whereby the actuated switch station stays in the "in" position when operated and releases ONLY when the "release station" pushbutton is depressed or a release solenoid is operated?

○ *A) Lock-out* ○ *B) All-Lock*
○ *C) Accumulative Lock* ○ *D) Interlock*

A LITTLE "YANKEE INGENUITY" GOES A LONG WAY

Switchcraft makes more ways to solve your problems with pushbuttons and mechanical pushbutton switches than anybody else. And what you consider custom might just be a standard item. In any case, we provide you with complete and easy-to-use technical literature to help you sort through the possibilities. Contact your local Switchcraft representative for your free dictionary of switching and contact terminology. Or send the coupon for your basic engineering specification file and your free dictionary. See what a little yankee ingenuity can do to help boost your "pushbutton switch I.Q." Switchcraft Inc., 5555 N. Elston Ave., Chicago, Illinois 60630.

ANSWERS:

1. ALL can be intermixed. Switchcraft's DW Multi-Switch® switches lets you mix functions of switching stations anywhere on the frame on all fourteen different types of series.
2. A is correct. And Switchcraft has both types. With single or twin lamp display. Plus filters and silicone boots for greater color flexibility.
3. GOLD is what you want. Silver oxidizes at the surface; Cadmium Oxide is designed for higher voltages. Of course, we have all of these.
4. FALSE. Switchcraft's standard welded cross-bar palladium contacts handle up to 2 amps, 200 watts max., A.C. non-inductive load. Fine Silver goes up to 3 amps; silver cadmium oxide goes up to 5 amps.
5. B is the difference. The switching function is identical, but the push-lock/push-release gives you a clear visible indication that the switch is actuated. Alternate action switches don't. We have both types.
6. FALSE. Switchcraft's little "Multi-Switch" switches give you up to six pole, double throw per station in .6 square inch panel space—with no sacrifice in features or functions. The DW Multi-Switch switch gives double pole, double throw circuitry with only 1¼" depth behind panel.
7. B AND C are both right. They're the same.

If some of these questions threw you a little, send for Switchcraft's glossary of technical terms.

Switchcraft Inc.
5555 N. Elston Ave., Chicago, Illinois 60630.

SWITCHCRAFT

Please send me your engineering file plus your glossary of technical terms.

☐ Pushbutton switches (illuminated and non-illuminated single-station pushbutton and cord pendant switches).

☐ Multi-Switch® switches (illuminated and non-illuminated multiple station pushbutton switches).

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Software links a/d's to computers.

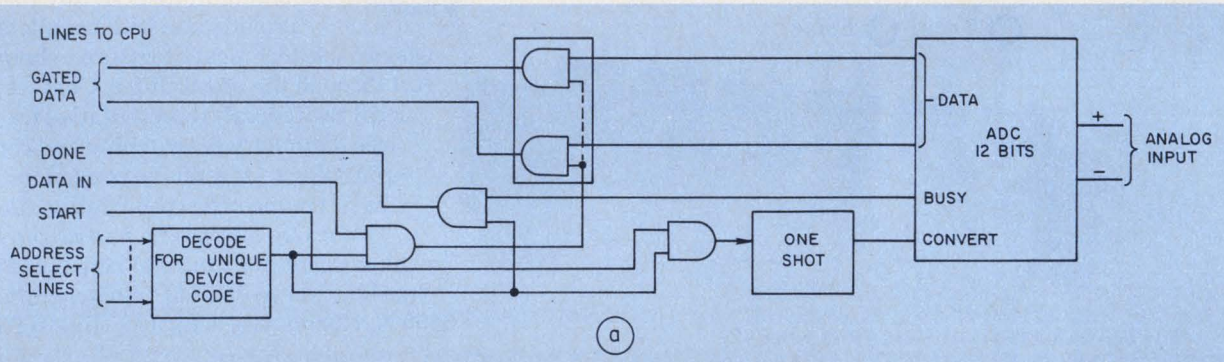
Flag checking permits slow but reliable operation, while a DMA subroutine provides fast, but noise-sensitive, data flow.

Whether you use a minicomputer or a microprocessor to control an analog data collection system, interfacing the analog-to-digital converter to a processor needn't be difficult. Two basic types of interfaces can be used with almost any a/d converter: a low-speed flag check or a high-speed data channel interface (sometimes called direct memory access—DMA).

Flag checking is limited in speed by the program cycle time while DMA inputs are usually limited by converter speed, except when super-high-speed converters are used (250-MHz conversion rate). When high speeds are needed, converters are usually operated in a burst-mode and the data fed into a high speed buffer memory, and then fed into the main memory. This method of data handling is usually called double-buffering. It gives the computer extra time to handle bursts of data.

A/d's are available in a wide range of speeds, accuracies and costs. Typical limits might be 14 bits at 100 kHz, 16 at 20 kHz and 6 bits at 250 MHz. Prices for top units like these are usually over $10,000. At the lower end of the performance

Ralph D. Taylor, Senior Project Engineer, Brooks Research & Manufacturing Inc., 5612 Brighton Terrace, Kansas City, MO 64130.



(a)

NOVA 1200

```
        LDA 2, BUF          ; INITIALIZE POINTER

Next:   NIOS ADC            ; START ADC
        SKPBZ ADC           ; BUSY?
        JMP .-1             ; YES, LOOP
        DIA ϕ, ADC          ; NO, READ ADC

        STA ϕ,ϕ,2           ; STORE IN CORE
        INC 2,2             ; INCREMENT CORE
        DSZ CTR             ; LAST READING?
        JMP NEXT            ; NO
        HALT                ; YES, STOP

        ;
        CTR: 50.            ; TAKE 50 READINGS
        BUF: DBUF           ; POINTER TO BUFFER
        DBUF: .BLK 50       ; INPUT BUFFER FOR ADC
```

(b)

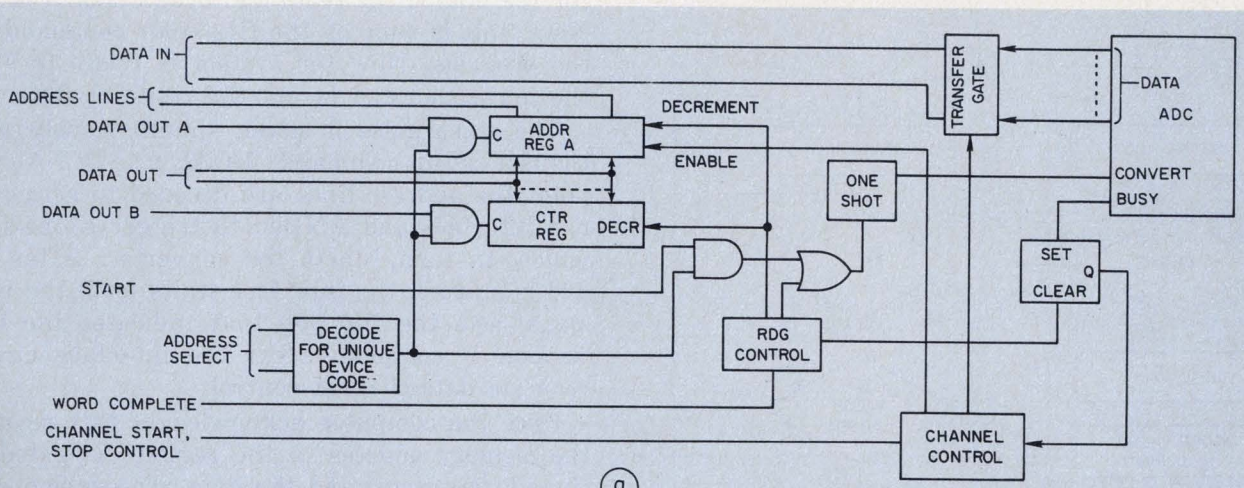
PDP 11

```
Assumes: bit 1 is convert line
         bit 2 is busy flag

         LDA R2, #BUF
Next   : MOV #1, ADC         ; START ADC
         TST #2, ADC         ; BUSY = 0
         BR .-1              ; NO, LOOP
         MOV ADC, (R2)+      ; YES, READ AND
                               INCREMENT
         DEC CTR             ; LAST READING
         BNE NEXT            ; NO, ANOTHER
         HALT                ; YES, STOP
         ;
         CTR: 50             ; TAKE 50 READ-
                               INGS
         BUF: .+50           ; BUFFER
```

(c)

1. **A few gates and a one-shot** are all that are needed for a flag-check converter-to-computer interface (a). To talk with a converter, the software for a Nova 1200 (b) or a PDP-11 computer (c) requires only a few lines.



(a)

NOVA 1200		PDP 11/20	
LDA 1, CTR	; # of Readings	Assumes: ADC is status reg ADC +2 contains word counter ADC +4 contains buffer start	
DOB 1, ADC	; Send # of Reading to ADC	MOV #50, ADC +2	; Set for 50 readings
LDA 2, BUF	; Core start for buffer	MOV #BUF, ADC +4	; Set buffer address
DOAS 2, ADC	; Start ADC transfer	MOV #1, ADC	; Start ADC
.		.	
.		.	
.		.	
.		.	
.		.	
BUF: DBUF	; Pointer to Buffer		
DBUF: BLK50.	; 50 Readings	BUF: .+50.	; ADC Buffer

(b)

2. **The DMA interface** between a computer and a converter (a) requires many more control lines than the flag-check scheme. The programs needed to control the interfaces let data move at 3.3 Mwords/s rates (b).

range are 8, 10 and 12-bit modules that have 5 or 10-kHz conversion rates and cost under $100.

Combining the module and computer can be done easily. The mini or micro is used to start conversion or accept data when conversions are complete. The flag-checking method uses teletypewriter and low-speed card-reader interface procedures. The processor constantly checks a particular line until the signal on the line disappears, at which time it interrupts the program it is processing and accepts the data from the a/d.

Interface the a/d with software

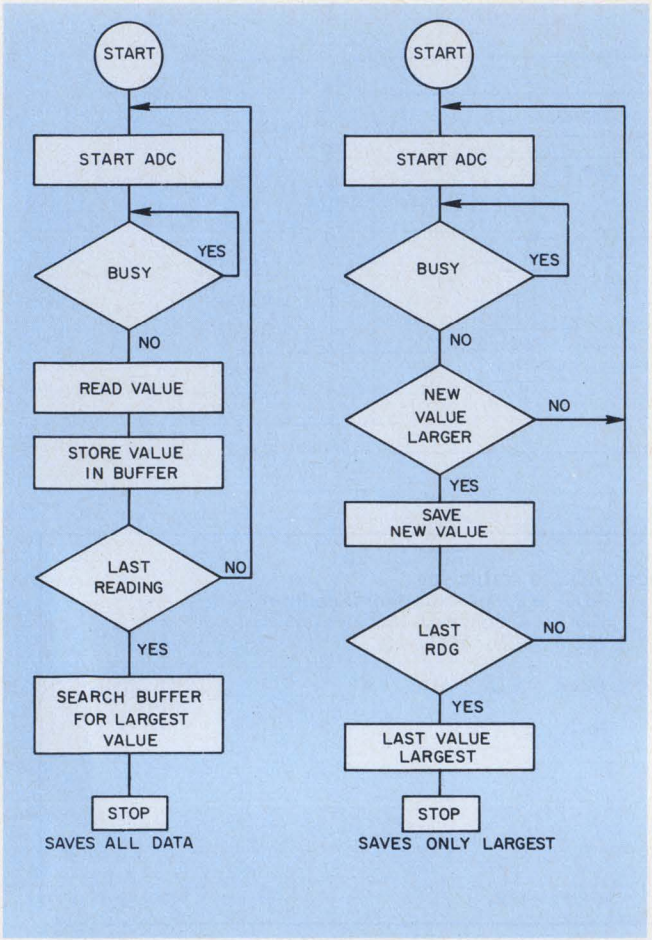
Two common minicomputers used throughout industry are the Data General Nova 1200 and the Digital Equipment PDP-11. Let's see how an a/d converter can be interfaced to these two machines with flag-checking programs (Fig. 1).

The circuit needed to interface an a/d with either machine is shown in Fig. 1a. To check for a flag, a monitoring program, like that shown in Fig. 1b, must be used. The computer starts the converter by using the NIOS ADC statement to send a pulse on the start line. This statement contains the device code for the converter, which is decoded by some selection logic and then ANDed with a one-shot, which, in turn, starts the a/d converter.

Once the converter is triggered, the program enters a loop, waiting for the converter to set a "done" flag when conversion is complete. The SKPBZ ADC does this by checking the peripheral address for a flag. If no flag is found, the program loops by using the JMP. −1 command which tells the processor to do the previous command (SKPBZ ADC).

When the flag is sensed, the program breaks out of the loop and goes to the DIA ∅, ADC statement, which tells the processor to read the data from the converter into accumulator ∅. The process described so far can be repeated to get as many readings from the a/d as needed. The program shown takes 50 readings. Of course, after data are sent into accumulator ∅, they must be stored in memory or they will be lost when more data enter the accumulator.

Depending upon the actual a/d converter selected, you may have to invert the busy signal or other lines for the signal levels needed by the processor. There are three signals of particular interest: a start signal, a monitoring signal



3. **These two simple flow charts** let the computer determine the maximum value of a waveform. The chart on the left saves all input data, while the one on the right saves only the highest value.

(busy) to indicate when conversion is complete, and a signal to gate data into the computer.

Similarly the program shown in Fig. 1c interfaces the PDP-11 to a converter. Execution times for these programs are typically 20 μs for the Nova and 15 μs for the PDP-11. These times do not include the actual conversion time of the a/d and are thus the limiting factors that determine the input data rate. The data rate using the flag check is thus limited to about 50 kHz.

Try DMA for fast interfacing

If a data rate of 50 kHz is too slow for your needs, you can make the converter feed its output directly into memory. To use a DMA interface, the computer must generate or make use of signals either needed or sent out by the a/d. Fig. 2a shows a simplified schematic of a DMA control circuit. The software programs to bring the data in are listed in Fig. 2b.

The programs must first initialize two counter-registers before any data transfer takes place. One register must be loaded with the core address for the first data word; the other register is set for the number of readings to be taken. For the Nova, this is done by the first four commands of the program. Now the system is ready to start the conversion and accept the resulting data.

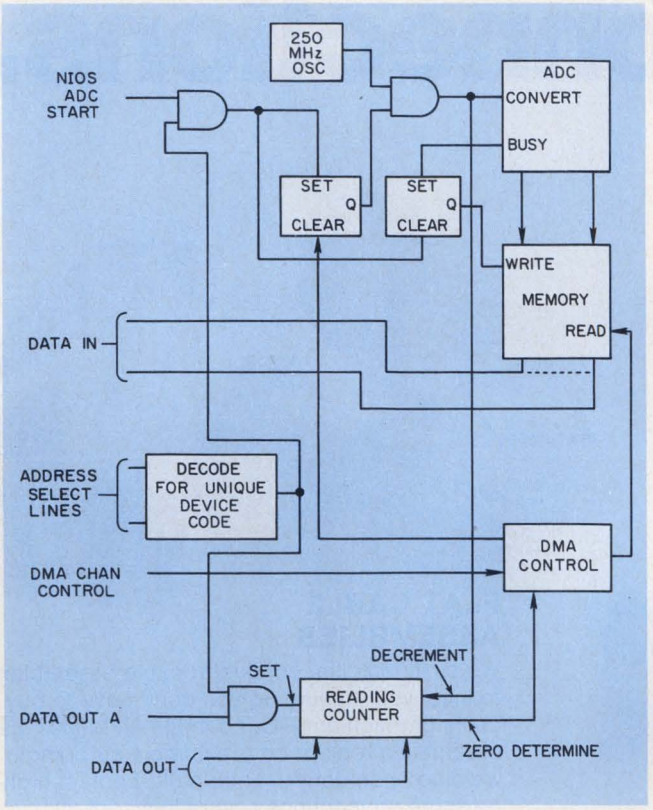
The start pulse is given simultaneously with the last set-up command: DOAS 2, ADC. At this point the address lines are decoded to select the a/d interface and ANDed to trigger a one-shot, which, in turn, starts the converter. After the a/d is started, the interface waits until the busy signal sets the flip-flop that indicates the conversion is complete. Next the interface circuit requests data-channel control.

Once the computer acknowledges this request, the memory address in the register is gated on the address lines, and the data are enabled onto the data bus. The required control signals are different for each computer type but must be generated to load the data word into memory. When the word is loaded, the processor signals back to indicate data are in memory. After the interface circuit receives this signal, it resets the control flip-flop, changes the core address counter, changes the reading counter and issues another convert command. This process continues until the word counter reaches zero when control goes back to the main program. Similarly the PDP-11 program offers an almost identical operating procedure.

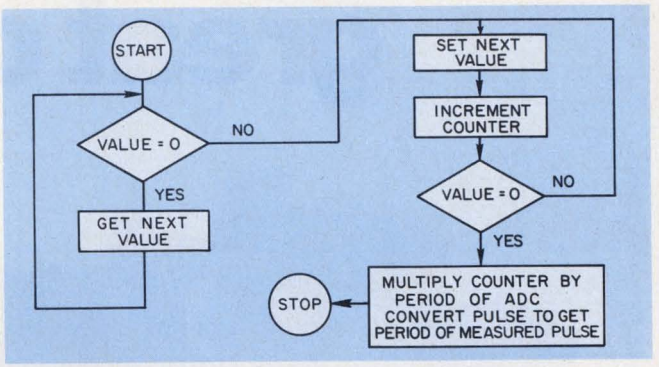
The hardware needed for a DMA interface is much more complex than for the flag-checking method. The important signals for the DMA interface are: data out, start and channel control. Since this interface operates faster and needs accurate timing, it is more sensitive to noise and other interference. Typical data rates depend upon the machines, but they range from 0.8 to 3.3 M words/s. If you have a lot of data to transfer, consider double-buffering the a/d and using a mass storage system, like a disc. This permits you to fill a buffer of a fixed size and then start putting converter data into a second buffer, while the data in the first buffer are being transferred to the disc.

Before you go to double-buffering, though, check these examples:

- Use of a 5440 disc drive (made by Pertec, Wangco and others) and a data transfer of maximum rate with a buffer size equal to one cylinder (one complete revolution of the disc without any head movement). This is about 6000 readings (depending upon sector size, word size, etc.) and represents the data that can be stored in one revolution of the disc—about 17 ms. Thus, if your data rate is so fast that the buffer will fill in less than 17 ms, the system won't keep up.
- Use of a 5440 disc drive, a buffer of 256 words (sector buffer) and an a/d conversion rate of 1 kHz. This system would take 256 ms to fill



4. **A very-high-speed** interface for a 250-MHz a/d converter contains its own ECL buffer memory and high-speed clock.



5. **To use an a/d converter** to take time or time-interval measurements, you can use this program to count the number of conversions and multiply them by the period of the converter.

the first buffer, and while the second buffer is being filled, you can transfer data from the first buffer onto a disc.

However, if only a small quantity of data are needed (enough to fit in core) at a high data rate a core buffer can also be used. Thus, with operation at a maximum data channel rate, data rates of up to 750 kHz are common.

Try out the low-speed interface

Let's consider some typical circuit applications of these interfaces. For the low-speed interface, let's try to monitor a 1-kHz signal and measure the high and low values. To do this, the first step is to select an a/d and a sample/hold, if they are not already built into the a/d. According to Shannon's Sampling Theorem, a sampling rate of at least 2 kHz must be used. This provides a sample interval of 500 μs, and thus any signal or spike with a width of less than 500 μs could pass undetected. So, just to be on the safe side, let's use a conversion speed of 4 kHz.

To determine how fast a sampling rate you need, these formulas might prove helpful:

$$S_I = 1/P \text{ (for digital signals) or,}$$

$$S_I = N/P \text{ (for analog signals),}$$

where S_I is the sample interval, P is the narrowest pulse interval to be detected and N the number of readings per pulse interval.

Once the converter and sampler are selected, the software must be written. Fig. 3 shows two possible flow charts for programs. The chart of Fig. 3a stores all readings and searches for the highest value. In Fig. 3b, the chart compares each reading and stores only the highest value. Similarly a flow chart can be devised to store the lowest value. The high and low charts can then be combined, and the min and max values stored in memory for further calculation.

Pulse measurements are often very tricky. Let's try to digitize a pulse that occurs only once and lasts for only 50 μs. From the digitized result, we would like to find the energy of the pulse and how much energy was dissipated in the first x microseconds. Also, let's assume we have a 1-MHz a/d with sufficient aperture time to track the signal. With speeds this high, flag checking is ruled out, and a DMA interface must be used.

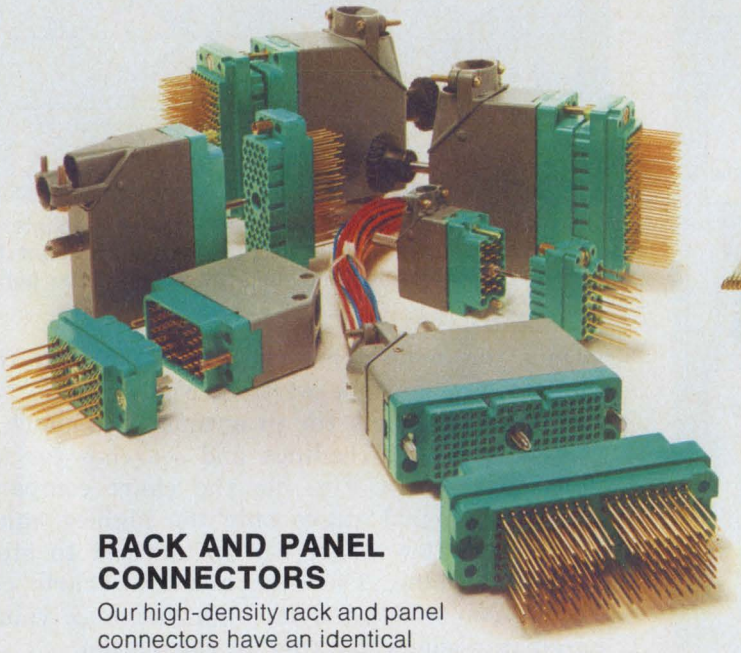
After the data are in core, the processor can access the memory and make the calculations for total energy and dissipated energy.

To record very-high-speed events, converters that can do 250 million conversions per second can be used. However, they are limited to very short-term events, since 25 M words are available in 1 second. Typical memories, such as core or MOS, can't handle data at such a high speed, so special high-speed buffers, built with ECL (emitter-coupled logic), must be used. To interface the high-speed converter with the ECL, a complex circuit is needed (Fig. 4).

The circuit is similar to that used in Fig. 2a; however, a separate 250-MHz clock must be used, and the buffer memory must be large enough to hold the samples. Once data are in the buffer memory, they can be transferred to the main memory and then be processed at a slower rate.

An a/d can also be used to measure the width of pulses or the time between them. If an a/d is combined with a stable clock, it can monitor a pulse train. By counting the conversions, you can then determine how long the pulses are. The flow chart for this is in Fig. 5. ■■

great connections...



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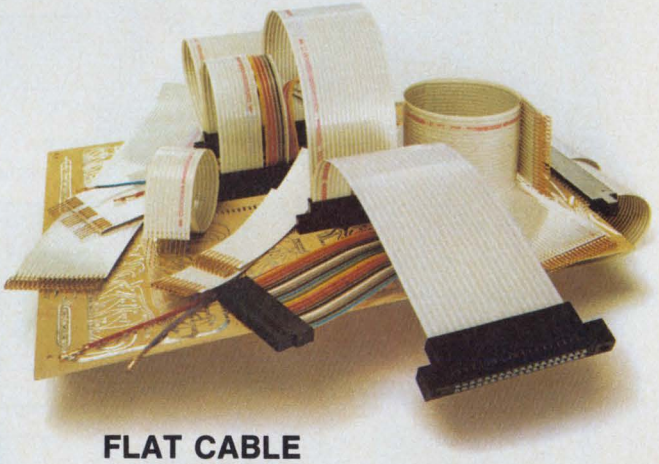

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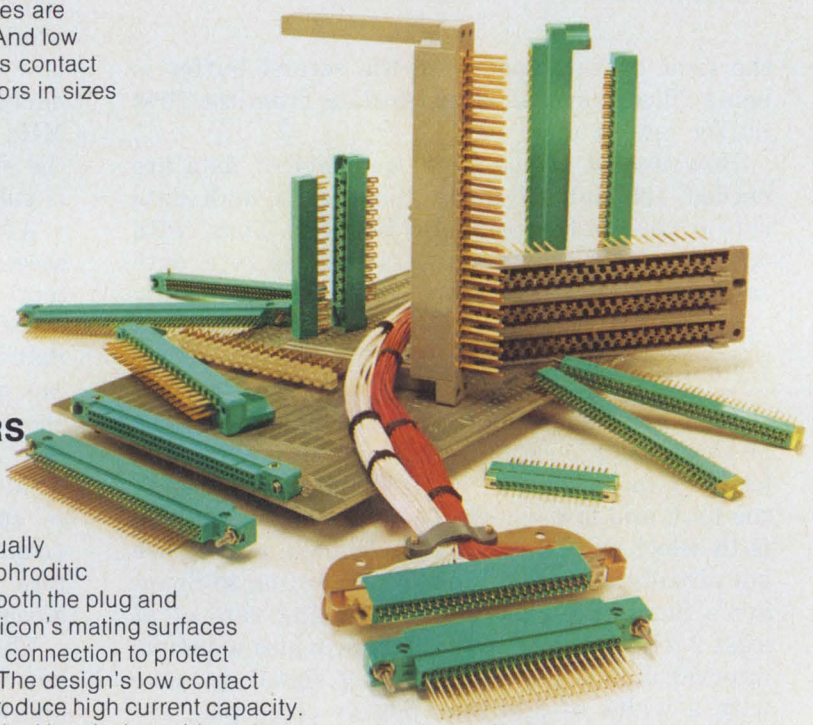

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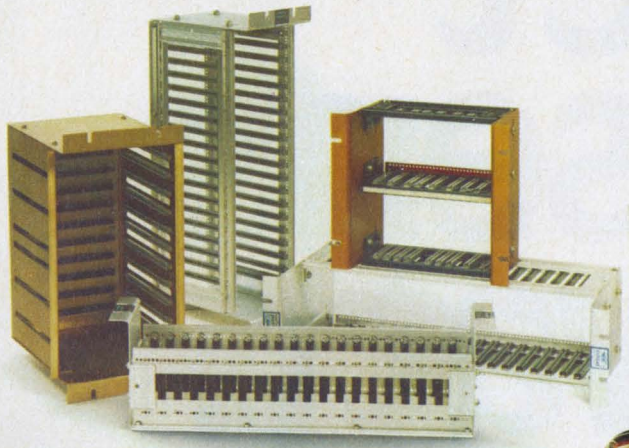

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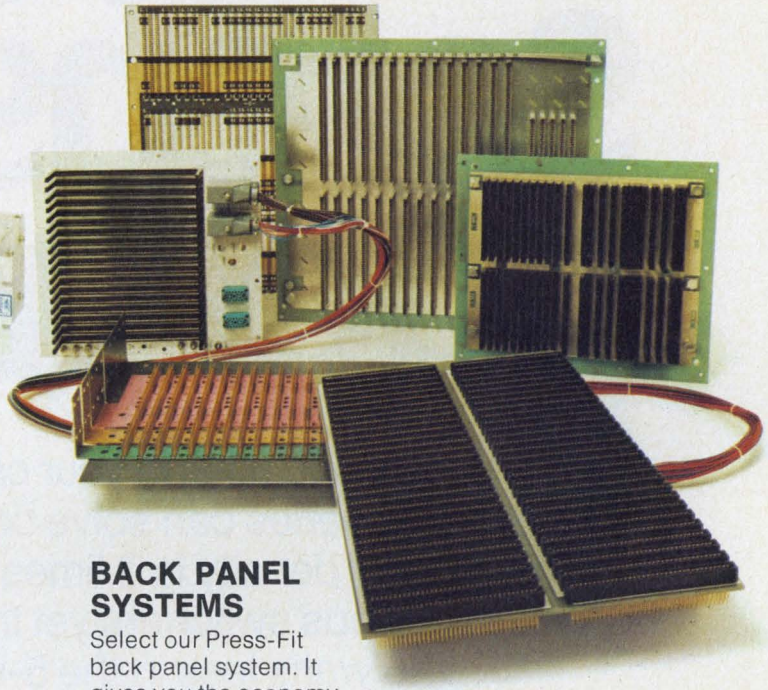

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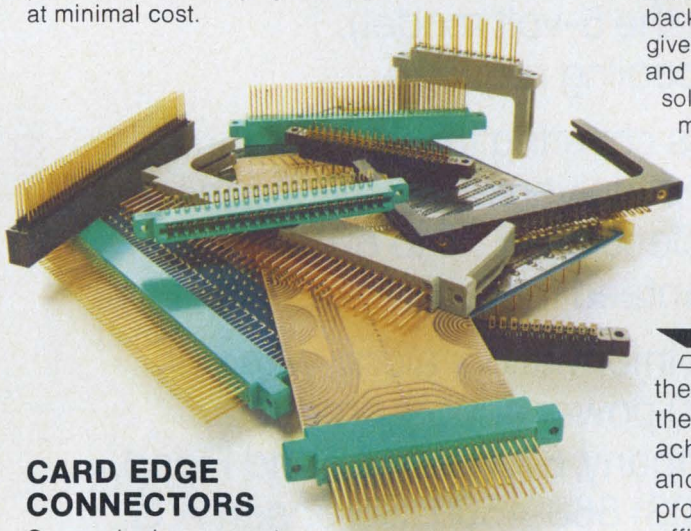

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Shozo Yokogawa of Yokogawa Electric Speaks On Interfacing Engineers with Others

When our engineers designed a product years ago, it was certain to sell well. Everything sold well. The economy was booming. All our products enjoyed great success. In addition, before he retired three years ago, our former president Dr. Miyaji Tomota was a great leader of engineers, so everybody followed him eagerly because people thought he never made a mistake.

So there was a widespread impression throughout our company, and certainly throughout our engineering departments, that our engineers were a bit like gods. It was only natural that engineers should dominate the company and, therefore, that the head of engineering should determine the products our company should make.

It's different today. In today's economy, even if Dr. Tomota were here to provide the kind of

leadership he provided in the past, it would be difficult for a company to depend on one person. It's difficult for any product to sell well because the economy is slow today and all companies face severe competition.

Our economy has left its period of rapid growth and entered a period of relatively slow growth. So today we must evaluate the instruments we plan to develop in terms of the economy. We must now be much more careful about how we spend our development funds.

When I assumed the presidency of this company I noted one vital element that we lacked. It was a serious weakness that appears not only in this company, but in many Japanese companies as well. We lacked a marketing function.

I really shouldn't say that. We did have a marketing function, but it was included within the Research and Development function or, a bit, as part of the sales function. At any rate, the marketing function was taken care of by other people on a side-job or spare-time basis. But basically, the problem of serving the market was left to engineering. You can well imagine what happened.

Engineering would develop a product and turn it over to the sales department. If the product didn't sell well then, of course, the engineers chided the sales people for not being good salesmen. "This should sell well," they would say, "what's wrong with you?"

The obvious solution to this problem is simple, you might say. Start a marketing department.

Starting a separate marketing department is not as simple as it seems. You have to realize that our company had a tradition of almost 60 years in which the engineer dominated everything. So he had great importance, not only in his own eyes, but in the eyes of everyone else. If we were to start a separate marketing department, the engineer would lose some of his power and influence.

We certainly couldn't make such a change abruptly. So we started a series of coordination conferences. I attend these conferences along with leaders of engineering, sales, production and a newly formed marketing department whose initial role would be advisory.

Now, aside from the obvious value of these conferences—developing designable, manufacturable products that we're able to sell—there's a subtle benefit. Our engineers become more conscious of the needs of the marketplace. They begin to think of what the market requires rather than what they would like to design. So these conferences don't merely help us structure our company better; they also help us educate our engineers.

There's still another benefit of such meetings. They develop close cooperation between engineering and marketing. Obviously, the object is to get engineers to think in terms of the needs of the market. And it's marketing's job to learn those needs. But marketing doesn't really know what engineering can do. And the customers don't either.

But as you develop a close relationship between the two groups, they try to help each other. Marketing, for example, might say, "Let's build a digital voltmeter that can do such and such." Then engineering might say, "We can do better than that, using microprocessors. How would you like this?" And that might be nice because marketing might never have heard of a microprocessor.

So we've solved the problem of interfacing engineering with marketing. Can we relax now? No.

Engineers have always regarded themselves as being of central importance in an engineering company. And they're right. But that's part of the problem. You have to recognize that engineers in Japan and, I'm sure, all over the world, feel that what they've done is best. In that sense they may be like anybody else. So it becomes necessary to guide them so that they don't all run off in their own "best" directions.

You have the same "what we've done is best" attitude in other parts of an organization, too. Traditionally, for example, the production people have always felt that once they manufactured a product, and naturally they've manufactured it well, their job was done.

But I feel that our job has just begun when a product is sold to a customer. In a complex product we must be sure the product can be serviced. Serviceability in a measuring instrument is extremely important.

So we must coordinate the efforts of the design engineers, not only with those of the sales and marketing people, but also with the work of the production engineers and the service people. This is an area where I devote a great deal of attention because that coordination is critical.

The coordination between the design and production engineers helps us develop products that are easier and less expensive to manufacture, as well as higher in performance.

A production engineer, for example, might say, "I'd like to move the transformer over here." Then, if you've established a good relationship, the design engineer might say, "No, that won't do because it will induce hum in the input cir-

Who is Shozo Yokogawa?

A year and a day before Yokogawa Electric Works was founded in 1915 by Dr. Tamisuke Yokogawa, his son Shozo was born. Shozo joined his father's company in 1947 after he earned his bachelor's degree from Keio University, not in engineering, but in economics. Starting in the Advanced Planning Department, he moved up to the position of president in 1974, replacing Toshinori Matsui, who became Chairman of the Board.

Today, what started as a small laboratory for developing and manufacturing electrical indicating and measuring instruments has some 3500 employees, including about 600 engineers. In its fiscal year ending September 1974, the Tokyo-based company enjoyed a sales volume of about 53.7 billion yen, roughly $180 million. And the company now produces a wide range of instruments and computer-control systems, mainly for process-control applications.

When he's not guiding the destiny of Yokogawa Electric, Shozo Yokogawa likes to spend time gardening. He's also extremely fond of 35-mm color photography so he shoots hundreds of pictures of places he visits around the world.

He used to play a lot of golf, he reports, but he quit when he realized that his game was ruining the countryside.

cuit. But if it will help, we could move the transformer over *there* instead."

Without such exchanges, one engineer is unaware of the problems of the other, and he might make decisions that are easy for him but difficult for others. Without the coordination of design and production, design engineering could design a marvelous product that takes forever to manufacture.

We need interface, too, between the design engineer and the service personnel. Otherwise, the design engineer might never think in terms of the difficulties in servicing a piece of equipment in a hostile field environment.

I have a special technique for bringing this lesson home to my engineers. When an engineer brings me a prototype of a new instrument, I ask him to climb a ladder and try to make some adjustments or repairs when the instrument is on top of a cabinet. That's not so far-fetched. After all, that instrument might be used in a process-control application and it might not be located in a convenient place.

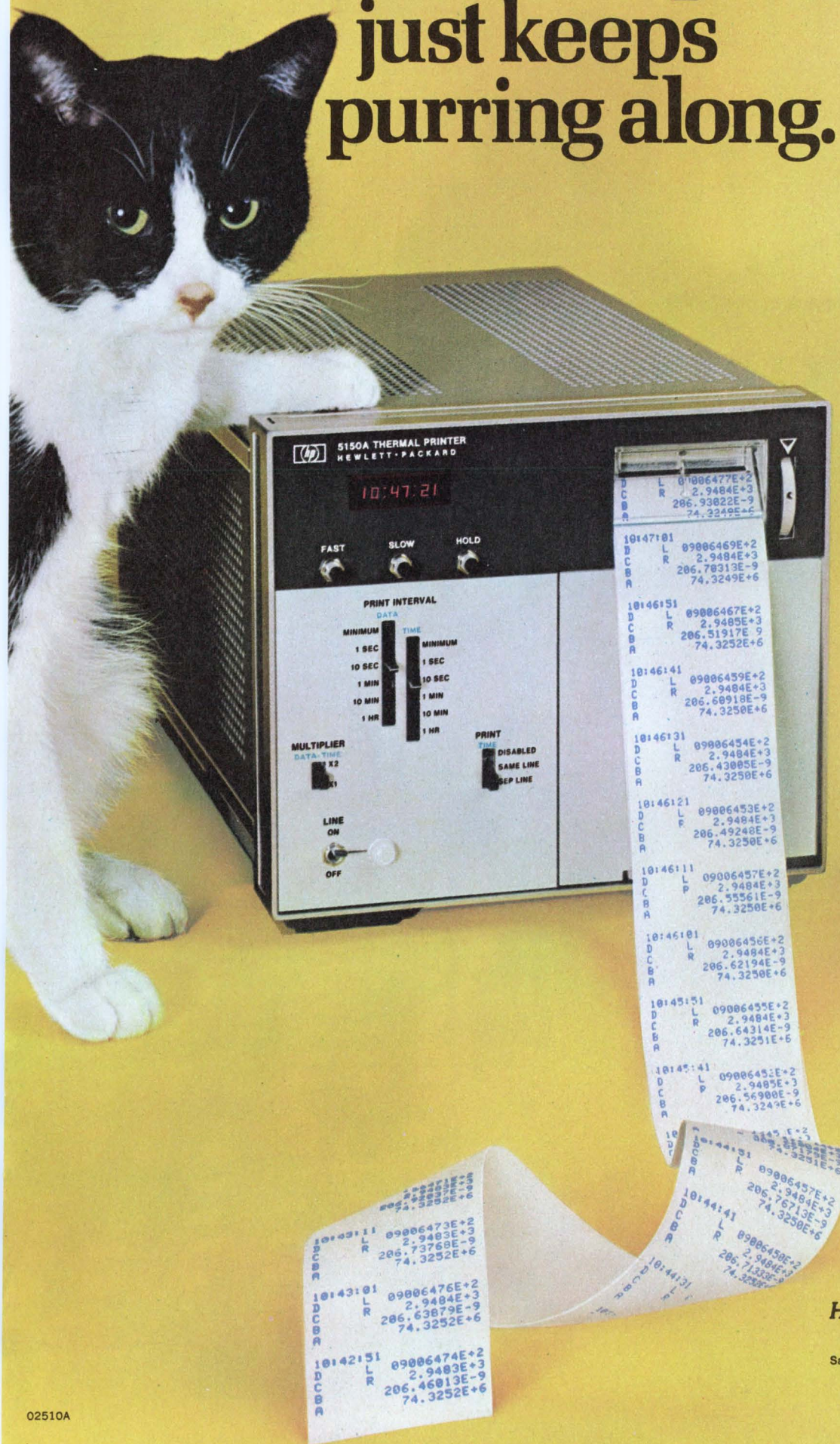
Further, since time is extremely costly in such an application, we want to be able to service the instrument quickly without having to tear everything down and without having to take it to a service shop where everything is convenient.

You can be sure that when I challenge an engineer this way a couple of times, he pays a great deal of attention to serviceability in his next design. He's made further conscious of such problems when he speaks to the people in our service department.

So, you see, our design and development engineer must interface with many different groups. He must work with the marketing people so that he'll know what products are needed in the marketplace. He must interface with our manufacturing people so that he'll design products that are relatively easy to manufacture. He must interface with our service organization so that he'll design instruments that are relatively easy to service in the field.

Obviously we can't have coordination meetings all the time or we'd have no time to do anything but meet. So we try to instill in our engineers the feeling that all of these factors must be constant, day-to-day considerations. Of course, meetings help. But the important thing is get your engineers to think beyond their traditional boundaries. ■■

HP's new thermal printer just keeps purring along.



Say goodby to the clank and rattle of mechanical printers and say hello to quiet, reliable operation. With its thermal printing technique, the new HP 5150A Thermal Printer needs only two moving parts — those that transport the tape.

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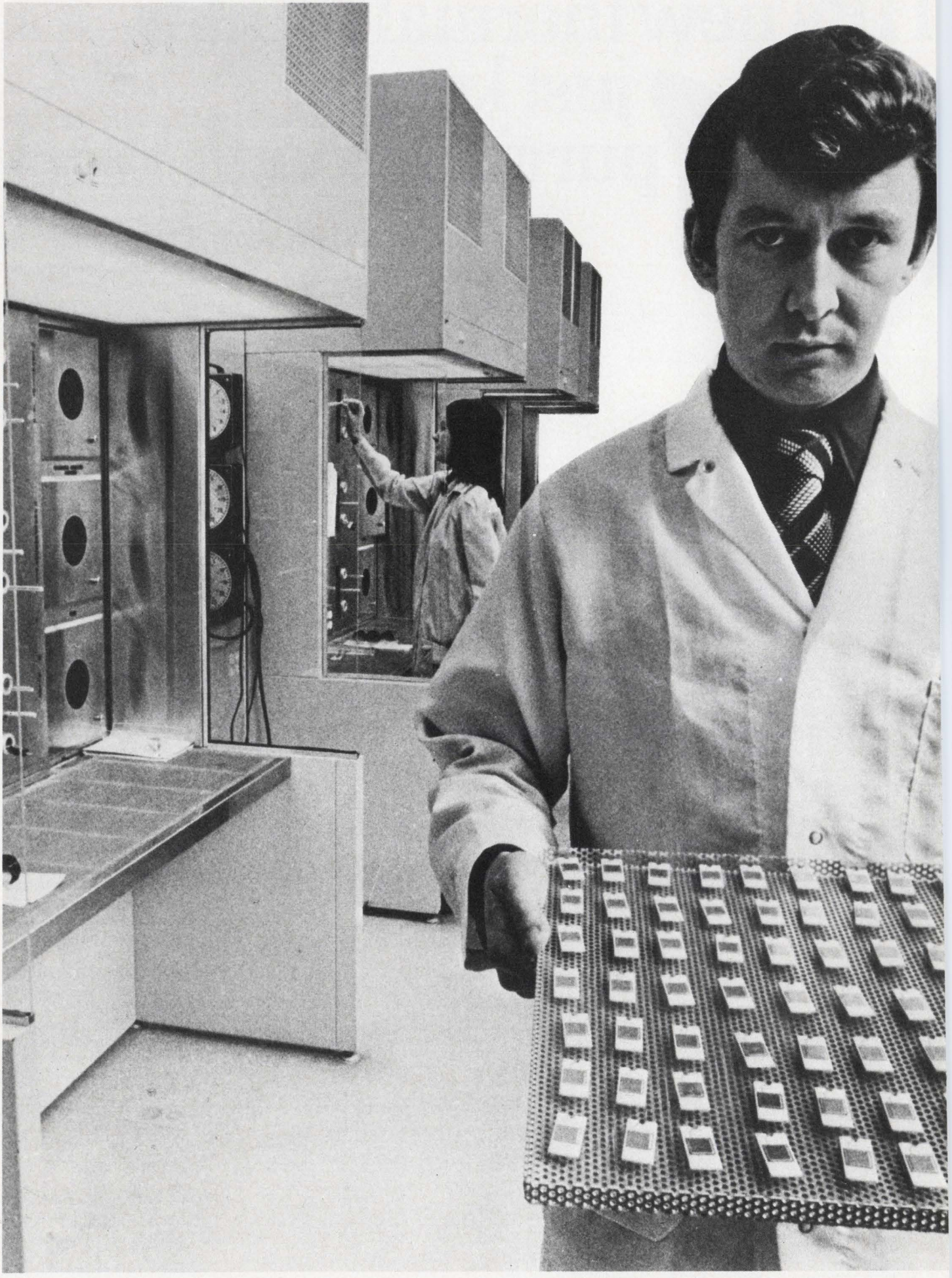

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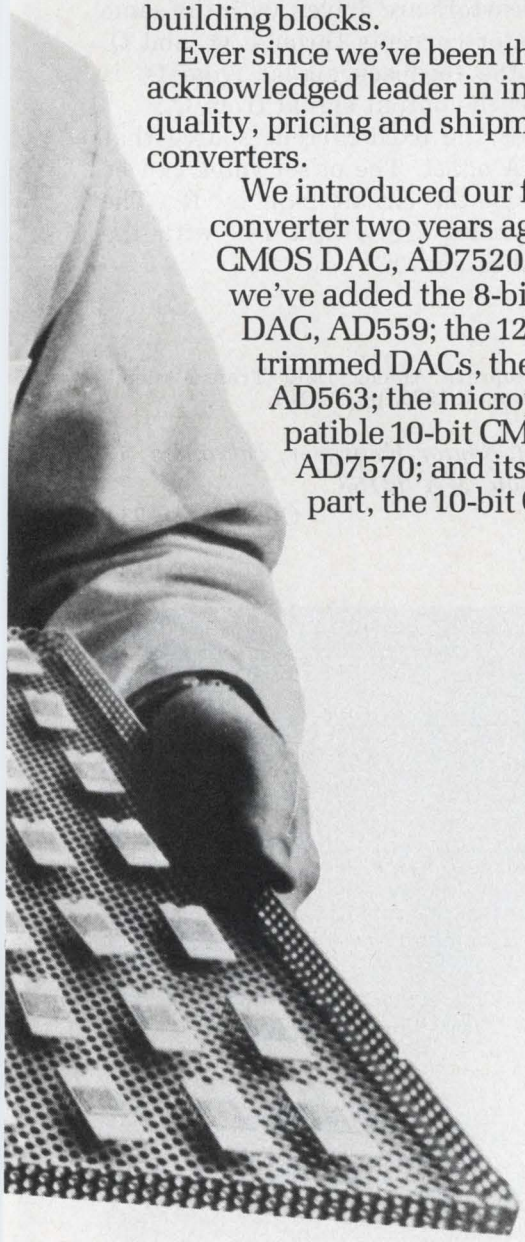

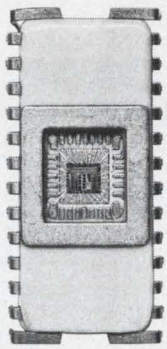

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10 bits (CMOS)	±0.05%	AD7520L
10 bits (CMOS)	±0.05%	AD7522L
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12 bits	±0.0125%	AD562
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ANALOG DEVICES

INFORMATION RETRIEVAL NUMBER 57

Circuit converts voltages to 4-20 mA for industrial current-control loops

A simple, low-cost circuit can convert voltage signals from most standard analog function modules into a 4-to-20-mA output with linearity of 0.1%.

Current loops over the 4-to-20-mA range have become a standard way to carry analog information in industrial environments. The 4-mA level corresponds to a zero signal and 20 mA is full scale. When the current loop is carried in a twisted-wire pair the common-mode characteristics of a differential receiver amplifier will reject electrostatic and electromagnetic interference. The 4-mA zero signal can be used to sense a broken line. And a current loop overcomes the attenuation effects of line and connection resistances.[1]

The circuit's output impedance is greater than 100 kΩ for output signals to +10 V. Thus external shunt resistors can easily be used to alter the output's zero and full-span current values.

The circuit consists of two voltage-controlled current sources, Q_2 and Q_3, and a fixed current source, Q_4. The circuit of Q_2 supplies feedback signals to the analog module, A_1, and Q_3, supplies the output. Normal voltage outputs from the module are coupled to Q_2 and Q_3 via Q_1.

The bases of Q_2 and Q_3 are tied together, and because both transistors are driven with the same signals, the collector currents through Q_2 and Q_3 are equal. Thus the feedback signal from Q_2 is about the same as the output signal from Q_3.

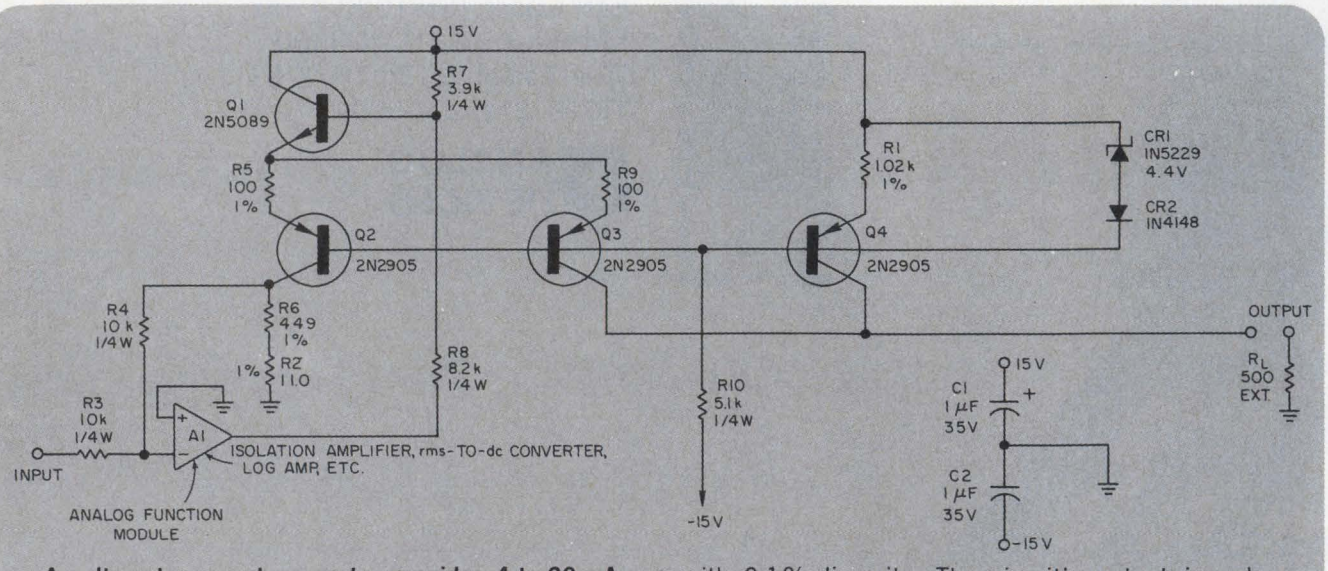
Transistor Q_4 is the fixed-current source that provides the 4-mA offset. The offset value can be adjusted by R_1 and the circuit gain by R_2. The offset and gain values are within 1% with the fixed resistor values shown.

Reference

1. Graeme, J., "Improve Analog Data Transmission," *Electronic Design*, Jan. 4, 1975, pp. 94-101.

Bucky Crowley, Senior Engineer, Intronics, 57 Chapel St., Newton, MA 02158.

CIRCLE NO. 311



A voltage-to-current converter provides 4-to-20-mA output to drive an analog-information current loop with 0.1% linearity. The circuit's output impedance is greater than 100 kΩ.

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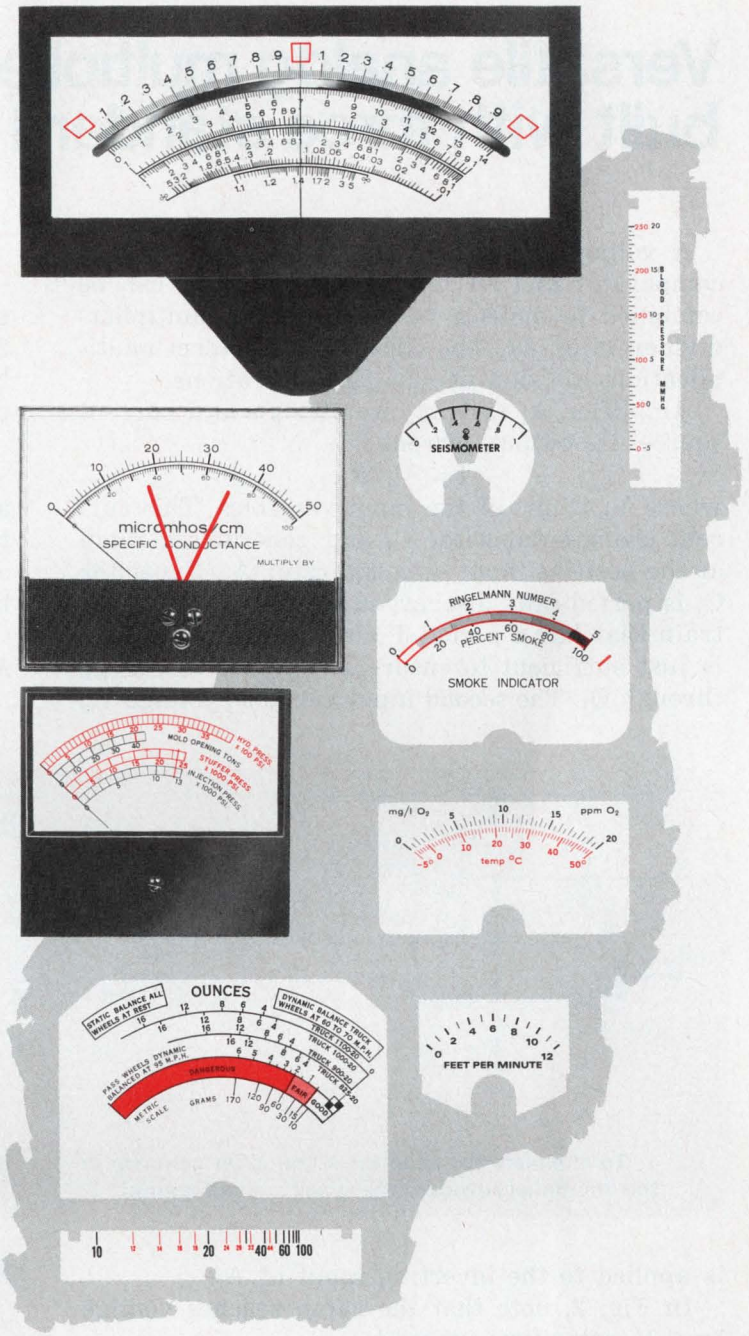

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INFORMATION RETRIEVAL NUMBER 58

Versatile analog multiplier/divider built with three standard ICs

A voltage-controlled current source, a voltage comparator and an active low-pass filter can be combined to make a versatile analog multiplier-divider (Fig. 1). The circuit can perform multiplication, division or squaring operations.

Amplifier A_1 and its circuitry form a current source. Its output current is

$$I = V_1/R_1,$$

where V_1 is one of the input variables. This current charges capacitor C_1 and generates a ramp at the positive input of comparator A_2. Capacitor C_1 is periodically discharged by an external pulse train that has a period T and a pulse width that is just sufficient to ensure a complete discharge through Q_1. The second input variable, voltage V_2, is applied to the inverting input of A_2.

In Fig. 2, note that the ramp reaches voltage level V_2 after time interval

$$t_A = V_2R_1C_1/V_1,$$

and that the output from A_2 has the following duty cycle:

$$t_A/T = V_2R_1C_1/(V_1T).$$

This controlled duty-cycle signal modulates the third input variable, V_3, via the chopping action of Q_2. Amplifier A_3 averages this signal to yield a final output:

$$V_o = -R_1C_1V_2V_3/(V_1T).$$

If the time constant R_1C_1 is made to equal T, then

$$V_o = -V_2V_3/V_1.$$

The component values in Fig. 1 make $T = R_1C_1 = 10^{-4}$ s. The low-pass filter made with amplifier A_3 has a double pole at 45 Hz.

Keep V_2 constant, and the circuit operates as a divider. Fix V_1, and the result is a multiplier. Connect V_2 and V_3 to a common input, and the result is a squaring operation:

$$V_o = -V_2^2/V_1.$$

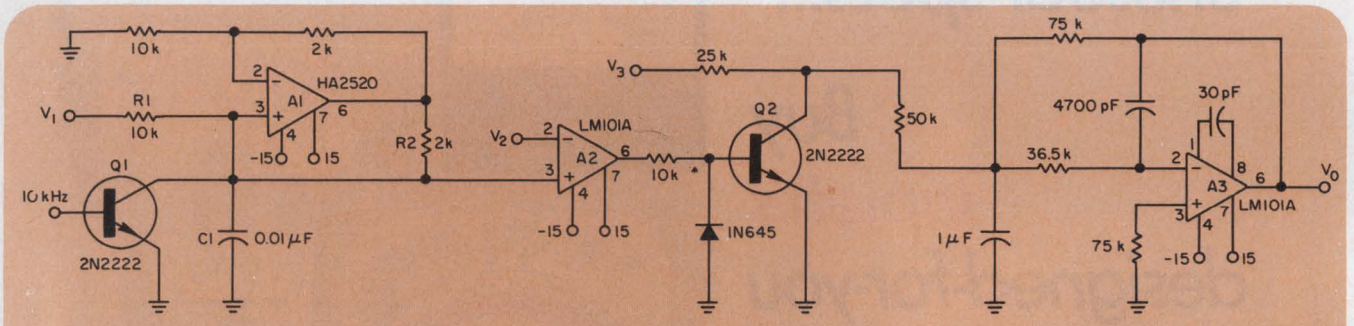
All three input voltages must be positive. However, if a FET or chopper transistor, such as a 2N2945 or 2N2432, is substituted for Q_2, V_3 can be negative or positive. Also A_1 can be operated differentially so that

$$I = (V_1^+ - V_1^-)/R_1.$$

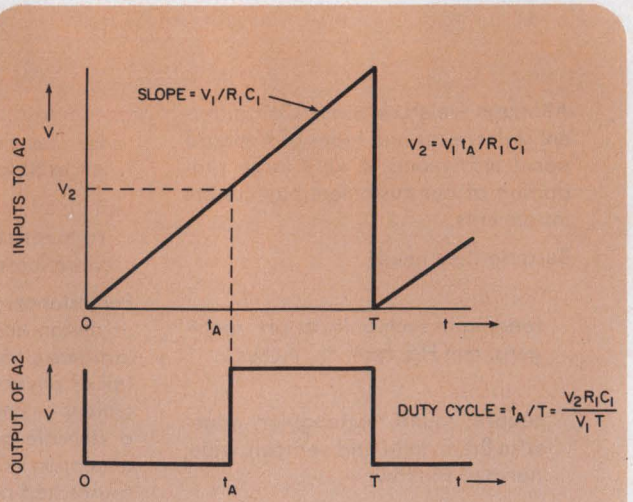
Low-drift components should be used for R_1, R_2 and C_1 for stable operation in varying temperatures. The variable input voltages, V_1, V_2 and V_3, are limited to about +10 V, and V_2 must always be somewhat less than V_1.

Ronald R. Clark, Senior Engineer, Martin Marietta Corp., Orlando, FL 32805.

CIRCLE NO. 312



1. **To eliminate the need for a multiplier constant in the multiplier/divider,** the clock's input period, T, is set equal to R_1C_1. Then the output is $V_o = -V_2V_3/V_1$.



2. **The voltage across C_1 rises until it equals V_2,** where it causes the output of the comparator to go HIGH. The rate of charge of C_1, which is proportional to input voltage V_1, controls the duty cycle of the output of the comparator.

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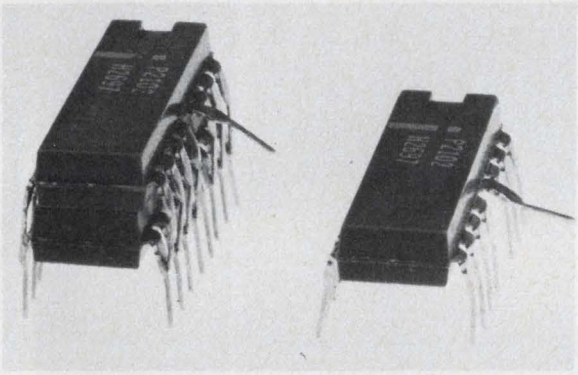
Merely solder a second identical chip in piggyback fashion upon the original IC. In Fig. 1, only the chip-select terminals, CS, of a memory chip are left unconnected. When mounted on a PC board, connect all the CS terminals of the piggybacked chips together and wire them to the proper address-decoder control signal. Your memory capacity is now twice as large.

Fig. 2 is a memory board that has been doubled in capacity, with the original interboard spacing retained. Of course, you must take care of the increased power dissipation and be sure that you have adequate drive capability. Also, the technique uses some kluge wiring, which must be carefully done to avoid shorts and noise problems.

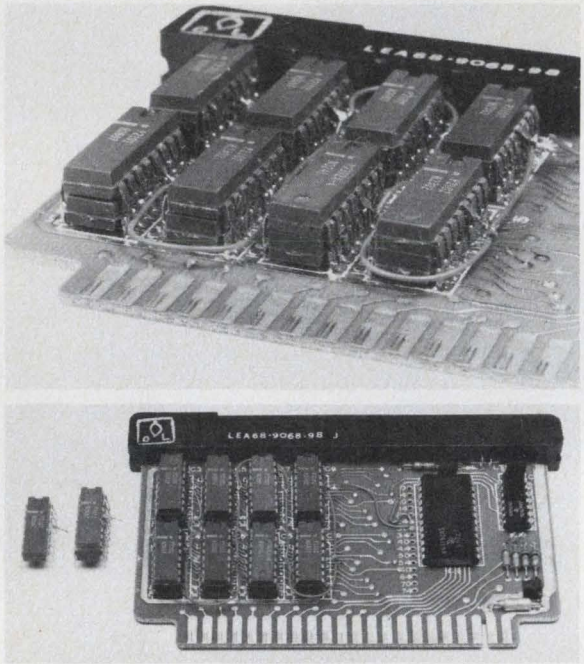
But for a low-cost fix to a design, this solution is hard to beat.

E. R. Fisher, Electronics Engineering Dept., Lawrence Livermore Laboratory, University of California, P.O. Box 808, Livermore, CA 94550.

CIRCLE NO. 313



1. **Piggyback mounting of IC chips** can be used to increase the capacity of microcomputer's memory without the need for mounting hardware.



2. **The chip-select terminals of the piggyback unit are kluge-wired** together (top) and connected to the proper address-decoder control signal. Without increase in board size, a board (bottom) has twice its original memory capacity.

IFD Winner of September 1, 1975

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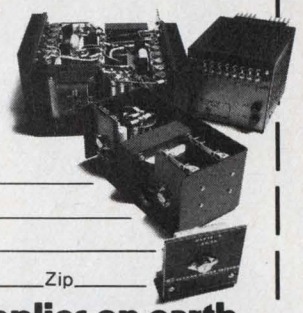
City_____State_____Zip_____



Elexon: the ugliest dc supplies on earth.
Get UGLY at Cramer, Newark, MIL-COMM or QPL. Or call 714/979-4440. ED

GET MUGGED BY MAIL.

Why do more than half the people in the world who buy solid state relays choose Crydom?

Maybe it's because Crydom pioneered, perfected and patented electro-optical isolation and zero-voltage switching. Or because we use efficient back-to-back SCR's. Possibly it's because we offer more standard models. Could be our encapsulation process, our broad distribution, our extensive applications experience, or the fact that you can specify a Crydom relay in the U.S. and order the same part number anywhere in the world.

Back-to-back SCR's are superior to triacs in many applications.

Technically Speaking . . .

All Crydom Solid State Relays use inverse parallel SCR's which are superior to triacs in many applications. Back-to-back SCR's have much higher critical dv/dt ratings and greatly improved performance with inductive loads . . . minimal need for "snubbers" or softening devices.

Crydom was the first to use transfer-mold encapsulation, applied under pressure, to fully protect circuitry from humidity, shock & vibration. Many merely "pour fill"—a process that can leave troublesome voids or bubbles within the relay.

Two more firsts. Crydom's patented photo-isolation & zero-voltage switching! The optical isolator, which never wears out, provides complete input isolation without transformers or reed relays. The zero-voltage switching feature minimizes current surges & RFI noise caused by arcing contacts.

Every Crydom relay is 100% solid state. There are no moving parts to malfunction or wear out. This means infinite life, silent operation & no maintenance. Also, Crydom's SSR's are digital logic IC compatible. UL & CSA approved too.

Cutaway photo shows complete encapsulation of components.

A Single Minded Company . . .

Crydom produces *only one* product. Our total resources, including the manufacture of many internal components, are dedicated toward refining and improving this product. This is why we've become the pace setters in the SSR technology. And why the name Crydom means ultimate quality in the field of solid state relays.

World-wide Distribution . . .

Crydom has a network of distributors throughout the world, with manufacturing facilities in Holland & Japan. Over 60 distributors service the U.S. alone. Each is fully stocked to provide immediate delivery on Crydom standard models.

Crydom has over 50 standard models from 1 to 200 amperes.

More Models Than Anyone . . .

Crydom has over 50 standard catalog models (including a complete line of 400 Hz relays) with current ratings from 1 to 200 amperes. We also react fast to the toughest OEM custom designs.

So contact Crydom today. Or send for our SSR catalog and list of authorized distributors.

To receive Crydom catalog promptly, attach coupon to letter head and mail to:

Crydom
1521 Grand Ave.
El Segundo, Ca. 90245

Name

INTERNATIONAL RECTIFIER

I2R CRYDOM DIVISION

1521 Grand Avenue, El Segundo, California 90245
(213) 322-4987

INFORMATION RETRIEVAL NUMBER 61

International Technology

Phosphor displays called mass-producible

Dc electroluminescent display panels that are said to be well-suited to mass production and cost-competitive with competing technologies are being produced by G.E.C.'s Hirst Research Centre in London.

The displays are based on a zinc-sulfide phosphor, but, unlike earlier ac displays, the phosphor particles have a low bulk concentration of copper and are not separated from each other by an insulating matrix. In the basic display the phosphor particles are sandwiched between a transparent conducting film on a glass substrate and a back electrode. Panels up to 18 × 12 inches have been constructed.

When a dc potential is first applied, no light is observed, as the devices must go through a "forming" stage in which a barrier is created at the interface between the front electrode and the phosphor. The barrier continues to form until the initial operating voltage, from 80 to 100 V, is reached. Light is then produced.

It is possible, if the doping of the zinc-sulfide phosphor is altered, to produce a range of colors, but manganese-doped phosphors have been found to be the most efficient to date. A golden-yellow light is produced, centered at 580 nm and with sufficient bandwidth to allow red and green light to be obtained by filtering. The emission comes principally from the first layer of phosphorus, resulting in a viewing angle approaching 180°. A brightness of over 100 ft L can be achieved, and displays with an initial luminance of 50 ft L were found to last over 5000 hours before the luminance decreased to 25 ft L.

Microprocessor made for washing machines

A microprocessor developed by ITT Semiconductor in Footscray, England, is aimed at manufacturers of washing machines and other domestic appliances. Such manufacturers have traditionally used electromechanical techniques and have so far been reluctant to commit themselves to electronics.

These reservations should be overcome with the introduction of the Model F150 mark-programmed microprocessor, says Malcom Penn, marketing manager for MOS and custom ICs.

The device, says Penn, was designed for a leading British washing-machine manufacturer to replace the electromechanical timer/controller. The chip produces the signals to cycle through any of nine standard washing programs approved by the International Standards Organization.

Safety features prevent wash action and heating from occurring if insufficient water is present, and there is also a door interlock and a "child-proof" program lockout to prevent interference with the program.

The microprocessor can be adapted for use with sewing machines, dishwashers and other appliances.

Storage oscilloscope uses digital memory

A dual-channel storage oscilloscope introduced by Gould-Advance Ltd. in Britain uses semiconductor memories to eliminate a special storage tube. The instrument, designated 0S4000, serves as a 10-MHz scope or as a digital store handling input signals up to 200 kHz.

Eight 1-k RAMs replace the storage tube, and Don Beckman, marketing manager of Gould-Advance's Instrument Div., lists several advantages of this technique: Besides eliminating the storage tube, and consequently the expense of this component, the new approach provides pre-triggered viewing of waveforms and comparison of stored and real-time signals.

TV system adjusts to any light condition

A new development for AEG-Telefunken's Hamburg Laboratories is an automatic TV system that can be used in almost any ambient light—from bright daylight to a moonless night.

A high-speed objective lens is used to produce an image that is fed, via a fiber-optic disc, to an image intensifier tube. The image intensifier is connected to one of AEG-Telefunken's Ebsicon TV pickup tubes, which provides further amplification of the light pulses. The electrons produced in this tube are directed onto a silicon disc, 16 mm in diameter, which contains about one million diodes. An electron beam scans the disc to generate a normal TV signal.

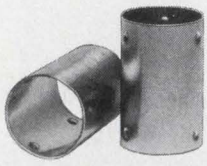
The PB35 camera incorporates a sensitive feedback system that adjusts both the lens aperture and the image intensification factor according to the amplitude of the TV signal produced.

MAGNETIC SHIELDS—ANY SIZE OR SHAPE

AD-MU AD-VANCE MAGNETICS SHIELDING

From Ad-Vance Magnetics, Inc., The Problem Solving Magnetic Shielding Specialists

Pictured are typical examples of magnetic shielding problems solved by Ad-Vance Magnetics. Tell us your problem. Be assured our Engineering Department will design the optimum magnetic shield to your exact requirement.


Small Transformer Shields

Storage Tube Shield

Motor Shields

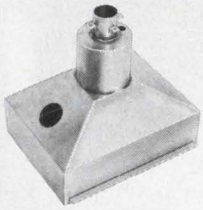
Radar Display Tube Shield

CRT Shield

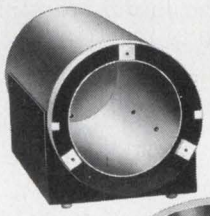
Small Transformer Shield

CRT Deflection Yoke & Neck Shield ("L" locking)

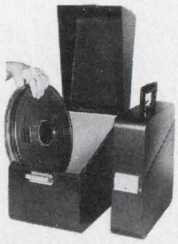
Scan Converter Shield


Specialized CRT Shield

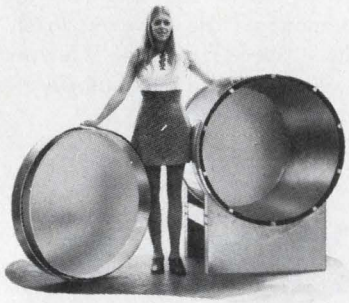
Hydroformed CRT Shield

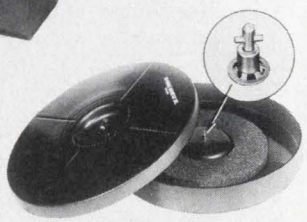

Magnetic Isolation Chamber

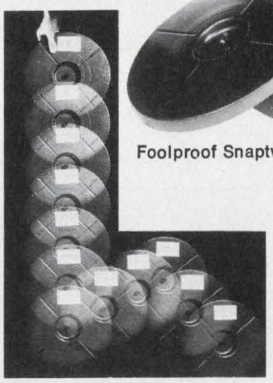
Geo-Magnetic Investigation Chamber

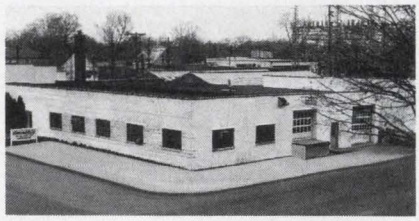

Presidential Model Tape Data Protector

Hydroformed Storage Tube Shield

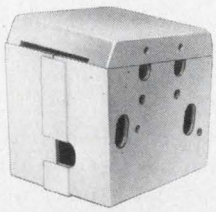

Movable Multi-Layer Controlled Magnetic Environment Chamber


Foolproof Snaptwist Fastener Lock


Loaded Single Reel Tape Data Protector Drops 4 Feet to Concrete Surface Without Tape Damage



Our 2 factories only manufacture magnetic shields. Complete in-house facilities.


Video Recorder Head Assembly Shield

Special 5-Layer PM Shield

Typical DC Magnetic Properties For AD-MU Shielding Alloys

	MATERIAL	INITIAL PERMEABILITY at 40 gauss	PERMEABILITY at 100-200 gauss	MAXIMUM PERMEABILITY	SATURATION INDUCTION gauss	COERCIVE FORCE oersteds
High Permeability	AD-MU-80	35,000	45,000	350,000	8,200	0.015
	AD-MU-78	20,000	30,000	300,000	7,500	0.015
Med. Permeability	AD-MU-48	11,000	27,000	100,000	15,200	0.03
Low Permeability	AD-MU-00	300	500	3,000	22,000	1.0

Let our Problem-Solving Engineering Department help solve your shielding problem.

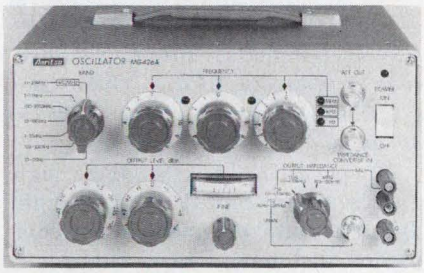
Our 3rd Decade of Magnetic Shielding Leadership

AD-VANCE MAGNETICS, INC., 226 SEVENTH STREET / ROCHESTER, IND. 46975 / (219) 223-3158 / TWX 810-290-0294

INFORMATION RETRIEVAL NUMBER 62

New Products

Compact oscillator weighs just 13 lb



Tau-Tron, 11 Esquire Rd., North Billerica, MA 01862. (617) 667-3874. $1440; 4-6 wks.

MG426A is a compact oscillator aimed at adjustment of audio, video and carrier transmission lines. It is useful for gain and loss measurements, impedance measurements, crosstalk and distortion measurements. The unit covers 10 Hz to 20 MHz in seven bands. Frequency stability is ±0.5% with output level adjustable from −50 to +15 dBm. Other features: Single-band, three-dial selection, flat output and variable output impedance (75, 150, 600 Ω).

CIRCLE NO. 302

Memory tester fits on bench

Alma Div. of Develco, 530 Logue Ave., Mountain View, CA 94043. (415) 968-3903. $24,900; 60 days.

Diagnostic and high-volume parametric/functional test capabilities are combined in the 760, a new modular memory test system. Limit boards and adaptors are used to completely test MOS, TTL and ECL RAMs. Test capability is extended to shift registers via optional microprogram boards and to ROMs with an optional "self-learning" subsystem. Performance advantages include the ability to generate a wide variety of patterns without dummy cycles. A 48-bit wide by 64-address deep microprogrammer produces barber pole, checkerboard and walking columns as well as many other complex patterns.

CIRCLE NO. 303

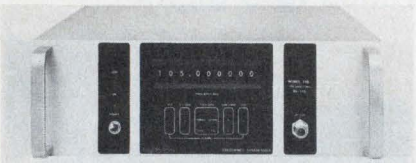
50-MHz freq counter weighs just 3-1/2 lb

Nucleonics and Telecommunications Pty. Ltd., The Boulevarde & Woodfield Boulevarde, Caringbah, New South Wales, Australia, 2229.

This pocket-sized automatic frequency counter weighs only 3-1/2 lb with its power cord. The NET-C500 is constructed with extruded aluminum framework and has a range from dc to 53 MHz, with automatic ranging and 7-digit resolution. The frequency range is covered by two channels. The manual mode also provides direct measurement of the average frequency of an input signal. The gate time is 1 s, which increases resolution to eight digits. Standard minimum long-term accuracy of the time base frequency is ±1 part in 10 million.

CIRCLE NO. 304

Indirect synthesizers fill frequency slots

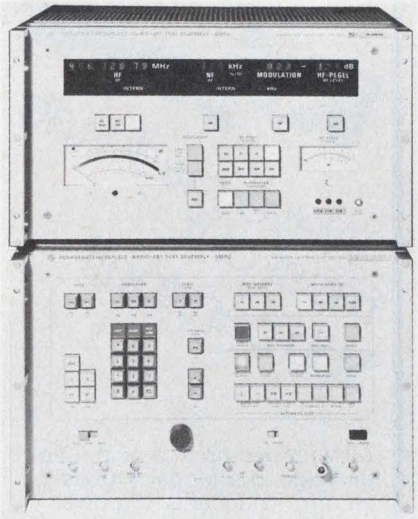


Logimetrics, Inc., 121-03 Dupont St., Plainview, NY 11803. (516) 681-4700. Start at $2800; stock-60 days.

The 4000 and 5000 series are designed for systems and use indirect synthesis rather than direct or hybrid methods. Size is 5-1/4 × 19 × 19 in. and is said to take 1/3 less rack space than conventional models. Resolutions of up to 1 Hz are available. Frequency selection is with front-panel thumbwheels or external BCD access. Harmonics are 30-dB down, and the rf output is leveled at +13 dBm, ±1 dB, with SWR at 1.5:1. 4000-Series models come in frequency ranges of 40 to 65 MHz; 65 to 100 MHz; 100 to 160 MHz. The 500 Series offers these plus 95 to 115 MHz and 125 to 160 MHz.

CIRCLE NO. 305

Unit automatically tests radio sets



Rohde & Schwarz, 14 Gloria Lane, Fairfield, NJ 07006. (201) 575-0750. $42,800.

Model SMPU uses an internal microcomputer to automatically measure radio-set parameters. The unit measures and digitally displays bandwidth, sensitivity, squelch response and s/n ratio. The push of a button initiates an entire measurement. Or, since the SMPU is programmable in ASCII, a card reader can take control. Simultaneous manual and programmed operation is also possible. All settings are entered by pushbuttons. By use of the IEC data bus, the SMPU can be connected to a minicomputer or desktop calculator for fully automatic production testing and data logging.

CIRCLE NO. 306

Skinny DPM measures ac V, ac I and watts

Nationwide Electronic Systems, 1536 Brandy Pkwy., Streamwood, IL 60103. (312) 289-8820. $580 to $585; stock-3 wks.

The company's Slimline series has added another new member—the Power-Lyzer. This unit measures ac volts, amps and true watts. Accuracy is 0.5% and wattage readout automatically compensates for power factor. The Power-Lyzer is only 5/8-in. thick, has a 0.55-in. LED display and provides full-parallel BCD outputs (TTL/DTL compatible).

CIRCLE NO. 307

RF power

We've made the most of it... You can, too!!

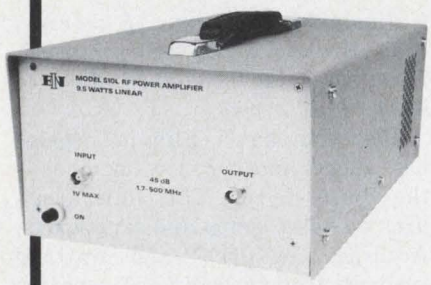
All wrapped up in a neat little package, our Model 510L is an ultra-wideband RF power amplifier whose wide range of frequency coverage and power output provide the user with the ultimate in flexibility and versatility in a laboratory instrument. Easily mated with any signal generator, this completely solid state unit amplifies AM, FM, SSB, TV, pulse and other complex modulations with a minimum of distortion.

Constant forward power is continuously available regardless of the output load impedance match making the 510L ideal for driving highly reactive loads.

Unconditional stability and instantaneous fail-safe provisions in the unit provide absolute protection from damage due to transients and overloads.

This outstanding unit covers the frequency range of 1.7 to 500 MHz with a linear power output of more than 9.5 watts and there is no tuning.

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



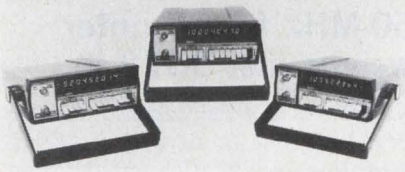
ENI

SEE Electronic Design's GOLD BOOK FOR COMPLETE PURCHASING INFORMATION

The world's leader in solid state power amplifiers

INFORMATION RETRIEVAL NUMBER 63

Three counters head to the field



John Fluke, P.O. Box 43210, Mountlake Terrace, WA 98043. (800) 426-0361. $860, $1055 and $1155, respectively; 30 days.

Three portable frequency counters measure 520, 1000 and 1250 MHz. They are, respectively, the Models 1920A, 1920A-13 and 1920A-14. The units feature a rechargeable, optional built-in battery pack, 9-digit LED display, burst or cw measurements, and sensitivity to 15 mV with agc standard. Another option coherently multiplies audio tone signals by 1000 to provide a resolution of 0.001 Hz in one second. A "free running" rapid-access gate feature eliminates measurement delays.

CIRCLE NO. 308

Panel meter measures ratios to 5 digits

California Instruments, 5150 Convoy St., San Diego, CA 92111. (714) 279-8620. $695; 30 days.

Cimron DRM 51 5-digit digital-panel ratiometer (dc/dc) measures from 0.00000:1 to 0.99999:1 with a signal input of from 0 to +11 V and a reference input of from +1 to +11 V. The unit provides automatic zero correction plus a fully guarded, three-wire differential input with an NMR of 60 dB at 10 Hz (and multiples of 10 Hz). The unit's CMR, with 1-kΩ imbalance, is greater than 140 dB at dc and 120 dB at 60 Hz and above. The 90-day accuracy (at 20 to 30 C) is ±0.0055% of reading + (0.02% ÷ reference voltage).

CIRCLE NO. 309

Unit analyzes digital data streams

BP Instruments, 10601 S. Saratoga/Sunnyvale Rd., Cupertino, CA 95014. (408) 446-4322. $2375; 60 days.

Model 20D LOGISCOPE logic analyzer can capture up to eight different data channels. As a companion instrument to virtually any scope, the unit allows the precise setting of triggers, thresholds, latches and sweep modes for the recording of digital data streams. LOGISCOPE provides a pretrigger record mode, up to 256 sample bits before trigger, as well as a delay mode, up to 9990 samples after trigger. Operating from an internal or external clock up to 20 MHz, LOGISCOPE accepts bit streams through threshold detectors whose outputs are stored in an 8 × 256-bit memory. Thresholds are adjustable through the range of ±10 V.

CIRCLE NO. 310

DMM measures rms, counts to 6000

Data Technology, 2700 S. Fairview St., Santa Ana, CA 92704. (714) 546-7160. $395; stock.

Model 31 DMM incorporates a true-rms ac detector for nonsinusoidal ac voltage and current measurements. The unit also measures dc volts, dc current and resistance to 6000 counts, three times the range of the conventional 3-1/2-digit (2000 count), instrument. As a true-rms unit, Model 31 measures ac volts from 100 μV to 1000 V with a maximum crest factor of up to 5. As a dc voltmeter, the unit handles 100 μV to 1000 V with a basic accuracy of ±0.04% of reading +1 count. Five full-scale ranges are offered. Resistance ranges from 600 mΩ to 60 MΩ in six ranges and current from 100 nA to 5 A, dc or true rms. Model 31 works from batteries or line power.

CIRCLE NO. 320

INFORMATION RETRIEVAL NUMBER 64 ►

Gates introduces the future in energy cells.

There's now a new energy source that's a superb alternative: Rechargeable, sealed lead-acid batteries from Gates.

We call these batteries the future in energy cells. And for good reason.

They have all the product advantages you need plus economic advantages that may well give a new dimension to your product pricing.

Advantages: Gates Energy Cells are as compact as nickel cadmium or gelled type cells. And they are completely sealed, so that no acid vapor can leak out (they also include a self-sealing vent for extra safety). Gates Energy Cells provide low internal impedance for high discharge rates (more than 100 amps from the D cell and 200 amps from our X cell for short periods of time). And can be operated or stored in any position.

Gates Energy Cells offer great packaging flexibility. In fact, our individual cell availability allows you to choose your own specific voltage (in 2-volt increments) and current, as well as configuration.

Just as important as what Gates Energy Cells have to offer is what they don't have to offer. Like outgassing problems. Or cell reversal. Or "memory" problems.

Because Gates Energy Cells are made from low-cost materials that are readily available, they're very high in watt-hr. per dollar value. Which means that if you specify them, you'll probably save your company more than a few dollars. And make yourself into something of a hero in the bargain.

To find out more about the future in energy cells, circle our reader service number or write us. We'll send you *free* literature containing features, application information, ratings and specifications. George Sahl, Gates Energy Products, Inc., 1050 S. Broadway, Denver, CO 80217.

Gates®
Energy Products

Where the energy future is now

Some open talk about open frame

Q SERIES

power supplies

We're so open about our **Q Series** Open Frame Power Supplies because we want you to know everything about them. Like our one year warranty. And stock delivery. About our thermal design, the best around, making our heat sensitive parts run cooler and operate longer. And we're the **only** maker of Open Frame Power Supplies where **all** components operate well within mfrs. specs.

That's why Deltron "Open Frames" save you money three ways: When you buy them. By avoiding costly downtime. And by lasting longer.

Choose from these models:

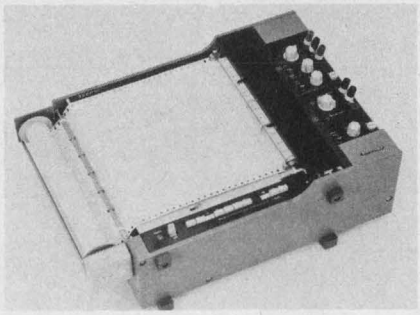
Size A Model No.	Size B Model No.	Size C Model No.	Size D Model No.	Size F Model No.
volts — amps	volts — amps	volts — amps	volts — amps	volts — amps
Q 5 — 3.0	Q 5 — 6.0	Q 5 — 9.0	Q 5 — 12.0	Q 5 — 18.0
Q 6 — 3.0	Q 6 — 6.0	Q 6 — 9.0	Q 6 — 12.0	Q 6 — 18.0
Q 12 — 1.7	Q 12 — 3.4	Q 12 — 5.7	Q 12 — 7.0	Q 12 — 10.8
Q 15 — 1.5	Q 15 — 3.0	Q 15 — 4.8	Q 15 — 6.3	Q 15 — 9.5
Q 18 — 1.3	Q 18 — 2.6	Q 18 — 4.0	Q 18 — 5.2	Q 18 — 7.8
Q 20 — 1.3	Q 20 — 2.6	Q 20 — 4.0	Q 20 — 5.2	Q 20 — 7.8
Q 24 — 1.2	Q 24 — 2.4	Q 24 — 3.3	Q 24 — 4.8	Q 24 — 7.2
Q 28 — 1.0	Q 28 — 2.0	Q 28 — 3.1	Q 28 — 4.2	Q 28 — 6.0
Dimensions: 4⅞ x 4 x 1⅝	Dimensions: 5⅝ x 4⅞ x 2½	Dimensions: 7 x 4⅞ x 2¾	Dimensions: 9 x 4⅞ x 2¾	Dimensions: 14 x 4⅞ x 2¾
Price: 1 — $32.00 100 — $26.00 250 — $24.00	Price: 1 — $54.00 100 — $44.00 250 — $41.00	Price: 1 — $67.00 100 — $54.00 250 — $51.00	Price: 1 — $87.00 100 — $70.00 250 — $66.00	Price: 1 — $113.00 100 — $ 91.00 250 — $ 85.00

For some more open talk about Deltron Q Series and a copy of our Comparative Engineering Reports, write or call collect to Deltron, Inc., Wissahickon Avenue, North Wales, Pa. 19454, Telephone: 215-699-9261, TWX 510-661-8061.

Deltron inc.

INFORMATION RETRIEVAL NUMBER 65

Flatbed recorders offer ink or electric writing



Yokogawa Electric Works, Ltd., 2-9 Nakacho Musashino-shi, Tokyo 180, Japan. Yokogawa Corp. of America, 5 Westchester Plaza, Elmsford, NY 10523. (914) 592-6767.

Types 3051 and 3052 flatbed recorders are ac-servo-system single and dual-pen recorders with an accuracy of ±0.3% and maximum sensitivity of 5 μV/cm. Electric writing (using electrosensitive paper) is available in addition to the ink writing system (using self-folding strip chart or roll chart). Input ranges and functions can be changed by selection from seven plug-in units: dc voltage units (single, 13, 17 and 19-range), ac voltage unit and offset unit. Chart drive speeds are selectable.

CIRCLE NO. 321

FET multimeter measures capacitance

Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44108. (216) 541-8060. $175; stock.

Model 370 FET multimeter is a solid-state bench instrument with full volts, current and ohms measurement capability plus six ranges of capacitance from 500 pF to 10,000 μF. Input impedance on ac and dc voltage measurements is 10 MΩ on all ranges. Pushbutton selection of ranges and functions in the Model 370 speeds measurements and avoids switching through unwanted steps. True autopolarity with indication eliminates lead reversing or switching on dc voltage measurements and requires no zero-centered scale. All functions and ranges are protected against overload. Frequency response is 20 Hz to 50 kHz.

CIRCLE NO. 322

Ultraviolet recorder conditions inputs

SE Labs (EMI) Ltd., North Feltham Trading Estate, Feltham, Middlesex, England.

Built-in signal conditioning is the salient feature of a new 12-channel ultraviolet recorder, the SE 6150. Thus the user can record and display voltage parameters directly on any of six channels. A special amplifier circuit adjusts the input voltage—between 500 mV and 500 V—to suit the sensitivity of the galvanometers. Other features include full-scale deflection of up to 2 kHz, a direct scaling of volts/cm, and power consumption of 100 VA.

CIRCLE NO. 323

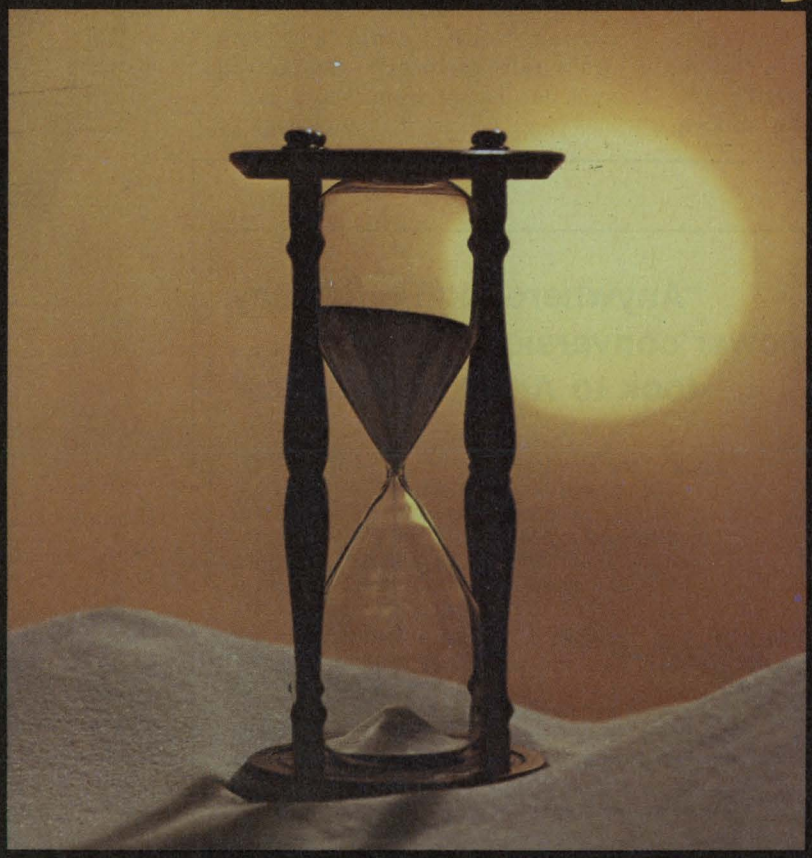
10-MHz counter fits into hand

Logic Technology Inc., 1950 Colony St., Mountain View, CA 94043. (415) 967-1007. $189; 30 days.

Pocket Counter II is a hand-held, battery-operated frequency counter. The unit provides a seven-segment LED digit readout plus overrange indication and has a measurement range of 1 Hz to 10 MHz. Sensitivity is 250 mV rms, 0 to 40 C, and accuracy is 0.01% ±1 count. Input impedance is 100 kΩ shunted by less than 51 pF, with a maximum input of 200 V rms at 10 kHz, derated to 10 V rms at 10 MHz. Pocket Counter II is powered by four size AA rechargeable NiCd batteries (which are supplied) and will operate for more than 8 h at 30% duty cycle when fully charged. Size is 7.825 in. high by 4.050 in. wide by 1.7 in. deep and weight is 22 ounces.

CIRCLE NO. 324

Just as you can count on 24 hours in a day,



you can count on Synchron® motors.

We custom-make every Synchron motor. Every one. Because it's almost impossible to stock ready-made synchronous motors exactly right for your needs.

Perhaps the motor you need for your product calls for a little more speed than the motor that's letter perfect for someone else. Or you need a little less torque. Or a threaded output shaft instead of a knurled one.

If we say we'll ship in 5 weeks, we'll do it. At a fair price.

And if we've approved your application we'll stand behind our motor 100%.

Stated simply: You can rely on Synchron motors to be designed and built right, to do the job right. That's the only way we do business.

Call or write for our specification sheets and the name and location of our representative in your area.

Choose from five principal styles of Synchron motors—60 or 50 Hz—from one revolution per week to 900 rpm—from 8 thru 98 oz-in torque at 1 rpm—from hundreds of different outputs.

MALLORY

HANSEN MANUFACTURING CO.
a division of P. R. MALLORY & CO. INC.
Princeton, Indiana 47670

We make every Synchron motor as if our name were on your product

CMOS clock chip has 10-ns edge speed

Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $2.40 (100-999).

The ICM7209 CMOS clock generator can be used with microprocessors such as Intersil's IM-6100 CMOS μP or in other applications requiring accurate external frequencies. With a fanout of five TTL gates, the clock circuit's typical rise or fall time is 10 ns. Operation is guaranteed to a maximum oscillator output frequency of 10 MHz. At this frequency, the device requires only 50 mW of power. At 1 MHz, typical supply current drops to 3 mA, and power drain falls to 15 mW. Supply voltages can range from 2 to 6 V.

CIRCLE NO. 325

Anywhere high efficiency power conversion is needed . . . look to Arnold Magnetics!

Look at the performance: AC (115-230 VAC, 47-500 Hz) and DC (12, 28, 48, 115, and 150 VDC) inputs . . . 1 to 6 isolated and regulated DC outputs from 4.2 to 300 VDC . . . line and load regulation to 0.1% . . . efficiencies to 85% . . . 3.9 watts delivered per cubic inch . . . short circuit and transient protected.

Look at the design: Over 1200 input/output configurations are available using off-the-shelf sub-modules. You specify to your needs using our exclusive "Design-As-You-Order" specification form that eliminates engineering cost, lost design time and long delivery schedules.

Look at the package: Compact, lightweight . . . your complete Power Conversion System is provided in a tested and encapsulated miniaturized, conduction cooled package.

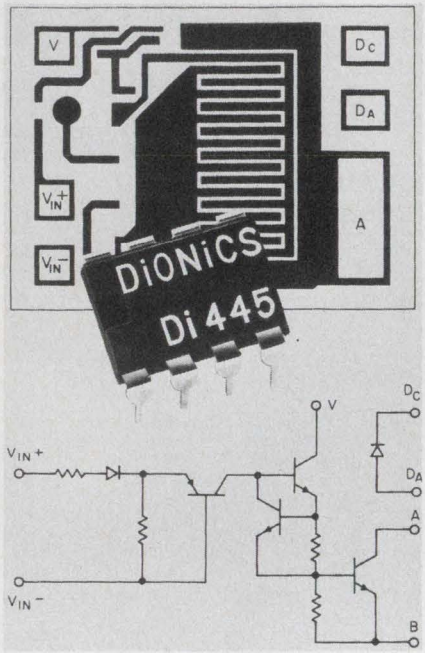
Looking for high efficiency power conversion?
Look to Arnold Magnetics . . . today!

ARNOLD MAGNETICS

ARNOLD MAGNETICS CORPORATION
11520 W. Jefferson Blvd.
Culver City, CA 90230
(213) 870-7014

INFORMATION RETRIEVAL NUMBER 67

Power driver outputs 80 V



Dionics, 65 Rushmore St., Westbury, NY 11590. (516) 997-7474. $1.20 (10,000); stock.

The DI-445, a high-voltage, high-current driver device, provides convenient interfacing between low-power logic and higher-power system elements such as relays, lamps or actuators. Either positive-true or negative-true inputs may be used. The new circuit comes in an 8-pin DIP. It has minimum voltage ratings of 80 V and handles up to 125-mA continuous, 200-mA peak. Supply current is less than 10 mA.

CIRCLE NO. 326

See the Microprocessor Design section for microprocessors and related products.

Quad digit drivers simplify LED watches

Qualco, 1 First St., Los Altos, CA 94022. (415) 964-7666. 50¢ to 70¢ (5000).

A quad digit-driver chip, the Q1776, can be used for LED displays on electronic watches. The 40 × 41-mil chip features backside isolation (Suffix I version), and it interfaces directly with CMOS watch circuits. Three common-emitter bonding pads are provided on each die.

CIRCLE NO. 327

WHICH ADS *DO YOU THINK* WILL BE BEST READ IN THIS ISSUE?

TEST YOUR SKILL

WIN...

- **$1,000 CASH**
- **A WINDJAMMER CRUISE (FOR TWO)**
- **PASSAGE-PAID AIR TRANSPORTATION**
- **FREE AD RERUN FOR YOUR COMPANY**

100 PRIZES IN ALL!

COLOR TV SET • DIGITAL WATCHES • TECHNICAL BOOKS

Electronic Design's

1976 TOP TEN CONTEST

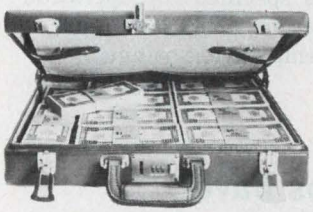
SEE NEXT TWO PAGES FOR DETAILS...

THIS YEAR...

LET ELECTRONIC DESIGN PAY FOR YOUR VACATION

ENTER OUR JAN. 5, 1976

TOP TEN CONTEST



WIN THE POPULAR CARIBBEAN WINDJAMMER CRUISE FOR TWO

Once again, by reader demand, a week's Windjammer Cruise for two in the fabulous blue Caribbean is waiting for the lucky winner of *Electronic Design's* annual TOP TEN CONTEST. Think of it . . . a complete vacation absolutely FREE! Spend easy carefree days sailing among the Bahama Out Islands, the U.S. and British Virgin Islands, or the exotic Windwards and Leewards. Shop in the free ports, sun, swim, snorkel, help sail the ship or just relax by the rail. It's truly the cruise of a lifetime.

PLUS A COOL $1,000 CASH AND PRE-PAID AIR TRANSPORTATION FOR TWO

In addition to the cruise, the first prize winner gets $1,000 cash, plus air transportation for two to and from the cruise ship's point of departure.

PLUS FREE AD RERUNS FOR YOUR COMPANY

If your company has an ad in *Electronic Design's* Jan. 5, 1976 issue, and you are one of the top three reader or advertiser winners, you earn a free ad rerun* that can be worth up to several thousand dollars for your firm.

100 PRIZES IN ALL

READER PRIZES

1st Prize: Caribbean Windjammer Cruise for two, $1,000 cash, air transportation for two, free ad rerun*.

2nd Prize: Portable color TV set, free ad rerun*.

3rd, 4th, & 5th Prizes: Digital wristwatch, free ad rerun* (3rd prize only).

6th through 100th Prizes: Technical books.

SEPARATE CONTEST FOR ADVERTISERS AND THEIR AGENCIES

Advertisers, marketing men, and advertising agencies can enter too. Duplicate awards are given to the top three winners (cruise, cash, air transportation, free ad rerun*, color TV and digital watch). Remind your advertising people it's the issue of the year to build business for your company *and* win valuable prizes at the same time.

HERE'S ALL YOU HAVE TO DO TO ENTER

Examine the January 5, 1976 issue of *Electronic Design* with extra care. *Read the Rules.* Then:

(1) Select the ten ads you think will be best seen and read.

(2) List the ten ads by company name and inquiry number on the contest entry card.

(3) Fill in your name and address and mail before midnight Feb. 15, 1976.

*The top ten ads will also receive free reruns. Only one free rerun per company. The first three prize winners in the reader contest and the first three prize winners in the advertiser contest awarded reruns only if their companies have an ad in the Jan. 5, 1976 issue.

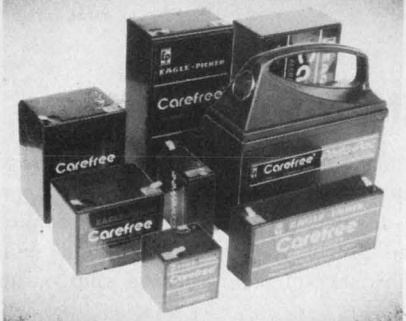
RULES AND ENTRY BLANKS ON PAGE 192 OF THIS ISSUE

EAGLE
SINCE EP 1843
PICHER

Carefree®
RECHARGEABLES

LEAD-ACID
BATTERIES

- SEALED • RUGGED
- NO MAINTENANCE
- SAFE • SPILL-PROOF
- WIDE TEMPERATURE OPERATING RANGE
- LONG LIFE



RELIABLE ECONOMICAL RECHARGEABLE POWER for

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- Telephone Carrier Equipment
- Portable Television
- Communication Equipment
- Portable Instrumentation
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Commercial Products Dept. ED
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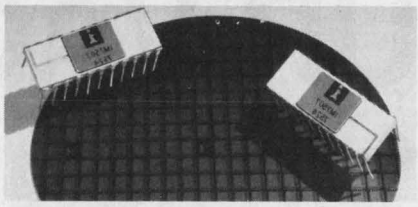
Telephone (417) 776-2258

INFORMATION RETRIEVAL NUMBER 68

INTEGRATED CIRCUITS

4-k dynamic RAM chooses 22-pin DIP

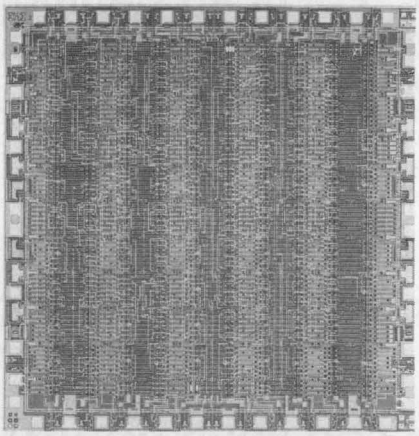


Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $24.25 to $29.25 (100-999).

A 4096 × 1-bit dynamic NMOS RAM is a direct, pin-for-pin replacement for the TI 4060, the Intel 2107A and the Intel 2107B, all of which come in 22-pin DIPs. The new RAM is available in three speed options. The IM7507 provides 300-ns maximum access time; the IM7507-1, 250 ns; and the 7507-2, 200-ns maximum access. All inputs for the IM7507 except for chip enable are TTL-compatible and require no pull-up resistors.

CIRCLE NO. 328

CMOS chip speeds custom designs



International Microcircuits, 3000 Lawrence Expwy., Santa Clara, CA 95051. (408) 735-9370. $8 to $14 (production qty.).

A large-scale master-slice CMOS chip, called MasterMOS L, contains over 500 CMOS transistor pairs along with 44 buffers and interface pins ready to be interconnected for each custom application. The new chip reportedly doubles the circuitry that can be integrated into a single master-slice chip and increases I/O capability by 50%.

CIRCLE NO. 329

Sense amp enhances operating margin

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $3.00 to $3.40 (100).

An improved version of the DS-7520 core sense amplifier—denoted by a suffix A—decreases threshold range to ±2 mV over the rated temperature range. Several models are offered with the enhanced operating margin. The basic circuit employs a common reference input, which allows adjustment of the input threshold level in both amplifiers. All models have identical preamp configurations, while individual logic connections are provided to suit specific applications.

CIRCLE NO. 330

Bus transceiver specs 20-ns delay

Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086. (408) 732-2400. $3.90 to $9.10 (100); stock.

A Schottky-TTL interface circuit—the Am8T26—consists of four bus driver and receiver pairs all with three-state outputs. Each driver output and receiver input pair is connected to form the bus. Worst-case delays through the driver and through the receiver are specified at better than 20 ns. The unit is specified for operation over commercial (N8T26) and MIL (S8T26) temperature ranges.

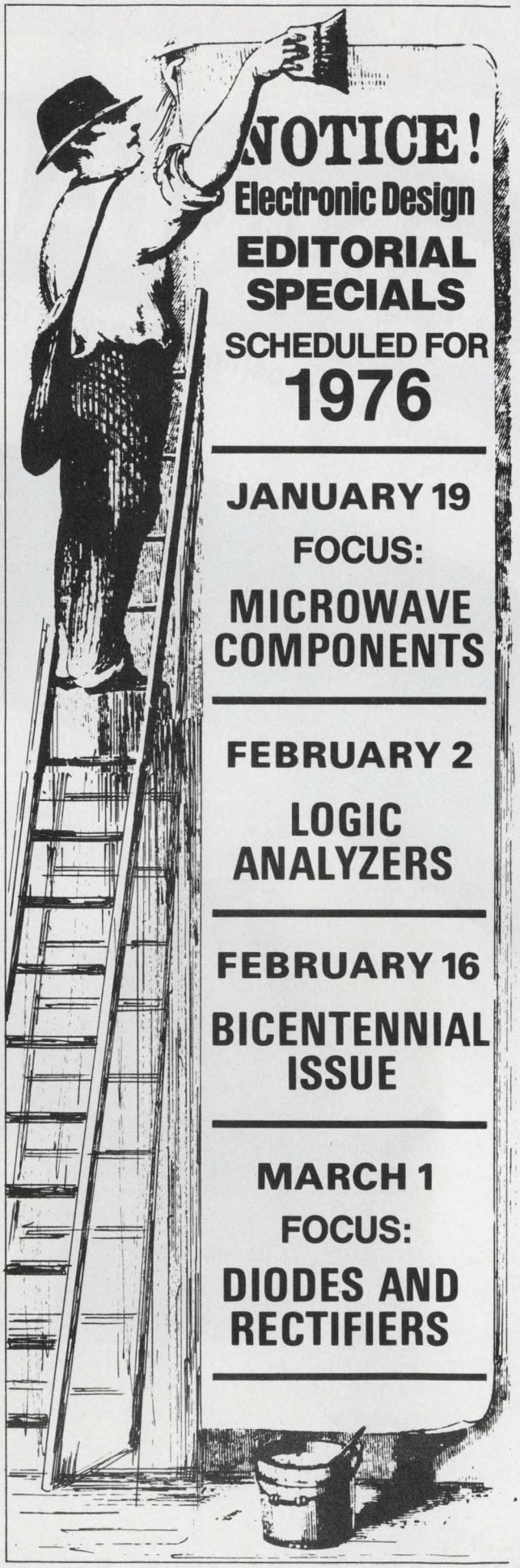
CIRCLE NO. 331

Op amps have 32-V output swings

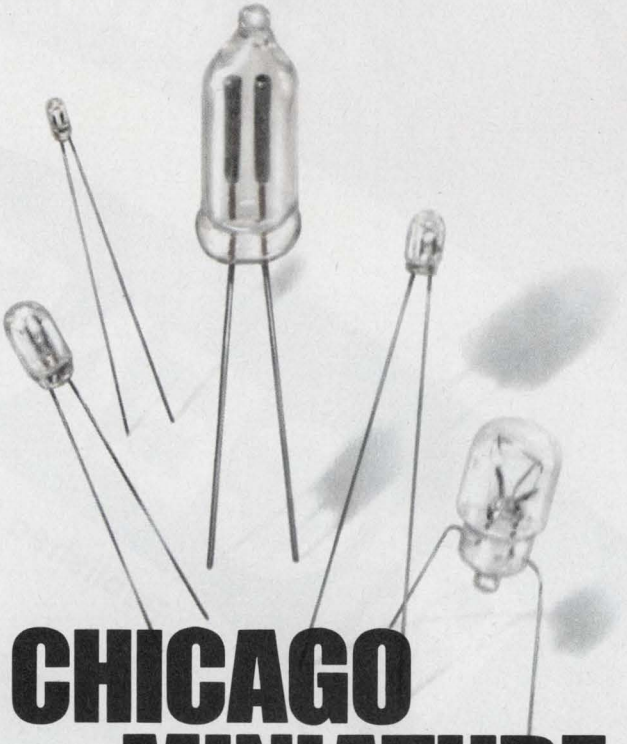
Silicon General, 7382 Bolsa Ave., Westminster, CA 92683. (714) 892-5531. $2.60 to $27; stock.

A series of monolithic op amps, operating with supply voltages from ±5 to ±40 V, provides an output swing as wide as ±32 V. Input bias current is typically 30 nA over the rated temperature range, with typical differential input impedance of 10 MΩ. Other characteristics include common-mode voltage range of up to ±25 V and typical large-signal voltage gains of 500 kV/V.

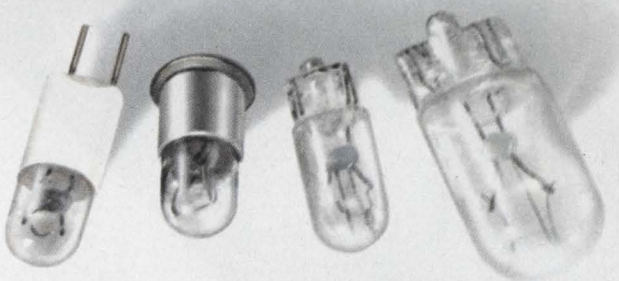
CIRCLE NO. 332



asking about LAMPS?



CHICAGO MINIATURE HAS THE ANSWER!



Our answers come in incandescent and neon . . . miniature to microminiature sizes . . . all base configurations or wire terminal . . . standard products and specials . . . all colors . . . whatever you need with high quality at competitive prices. Backed by more than 65 years experience in lamp and lighting technology. For off-the-shelf delivery on most items check your local distributor. For more information or expert design help with your applications, contact us at 4433 N. Ravenswood Avenue, Chicago, Illinois 60640. Phone (312) 784-1020.

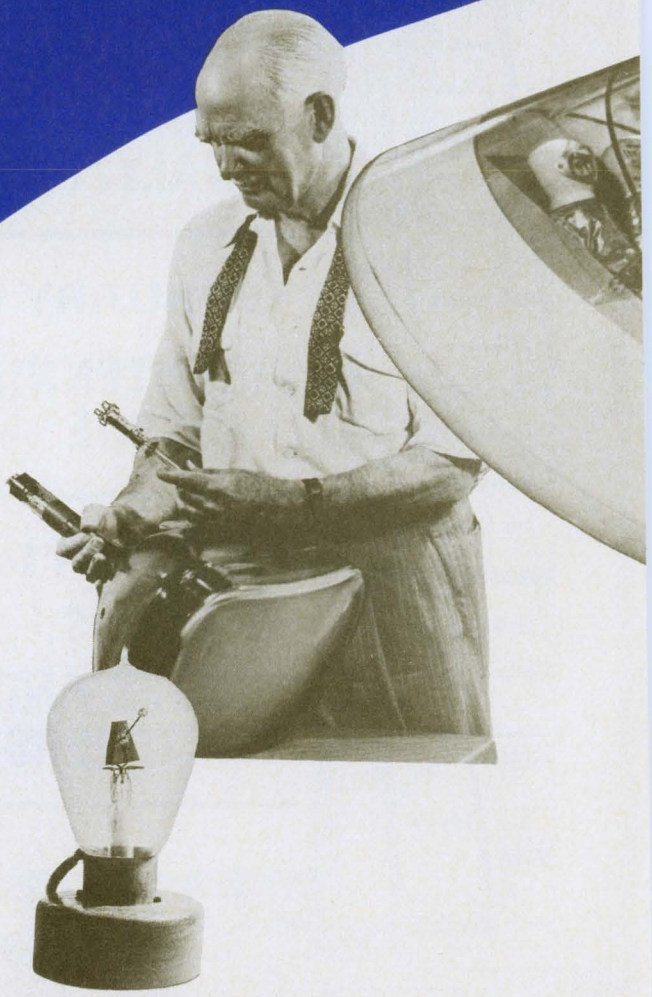
CHICAGO MINIATURE LAMP

SUBSIDIARY OF GENERAL INSTRUMENT CORPORATION

INFORMATION RETRIEVAL NUMBER 69

Electronic Design's BICENTENNIAL

Published February 16, 1976 — Closing January 9, 1976



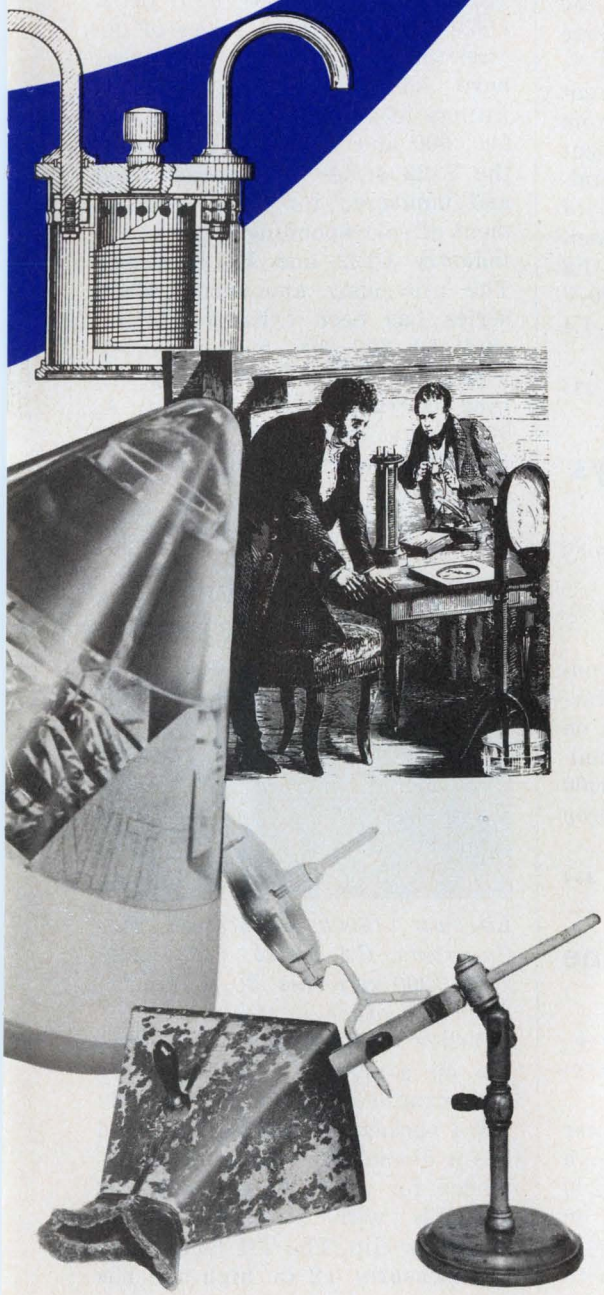
AN HISTORIC PUBLISHING EVENT

YOU'LL NEVER SEE ANOTHER ISSUE LIKE THIS ONE FOR 200 YEARS!

SSUE

Electronic Design 4

200 YEARS OF PROGRESS



NO PUBLICATION HAS EVER ATTEMPTED THIS BEFORE IN OUR INDUSTRY!

A UNIQUE PUBLISHING "FIRST"

On February 16, 1976, *Electronic Design's* editors are presenting a special BICENTENNIAL ISSUE — a salute to the 200 years of technological progress that has led to the electronics industry as we know it today. This material will be *in addition to* all of the regularly-scheduled technical articles and features.

Is history or nostalgia a worthwhile topic for a technical magazine? Our 20th Anniversary issue proved that it is. Electronics engineers are proud of their profession and proud of their industry. They're deeply involved. They care about its past, present and future. Our anniversary issue brought tremendous reader response. Readers dug into their own pockets to buy extra copies. Letters and phone calls to the editors broke all records. And almost 70,000 inquiries from this single issue clearly showed that information about the past can produce business in the *present*.

Now our editors are going to do it again — only more so — with the issue for this century...for a lifetime.

The February 16 BICENTENNIAL ISSUE traces the electronics industry from experiments in the Colonial period to today's large-scale integrated circuits; shows how it's been shaped and re-shaped, not only by technological breakthroughs, but by the socio-economic, political and even artistic climate of the times. It's a technical review that engineers will read, reread and treasure as the industry continues its march upward to new heights; new achievements.

ALMOST EVERY TYPE OF PRODUCT IS INVOLVED

There isn't a component or system manufacturer that hasn't been affected by this technological revolution — from capacitor and resistor suppliers to communications and computer system companies.

America, the melting pot of peoples, is also the melting pot of technology. And this is especially evident in electronics. America has become the focus for electronics engineers from all nations. Each has contributed to the growth and progress of our $40 billion industry.

When Benjamin Franklin demonstrated the electrical nature of lightning a little more than two centuries ago, he not only advanced man's knowledge, he created an industry as well. Lightning rods spread quickly throughout the U.S., to England, and the Continent.

The story is the same today. Each major development is almost always dependent on work that had preceded it. The tube from Lee DeForest, from J. A. Fleming, from J. J. Thompson, from Thomas Edison. The transistor, in part, from Julius Lilienfeld. And so on.

But the timing, the rate of development, is bound to the human condition: to population, to climate, to wars, to the industrial revolution, to automation, to education, to art, to *people*.

AN ISSUE THAT WILL BE READ, REREAD, KEPT AND TREASURED

Electronic Design's BICENTENNIAL ISSUE is possibly the most valuable issue for readers and advertisers that we've ever published.

It presents a perspective, a design overview of an industry that is probably poised for its greatest growth period of all time.

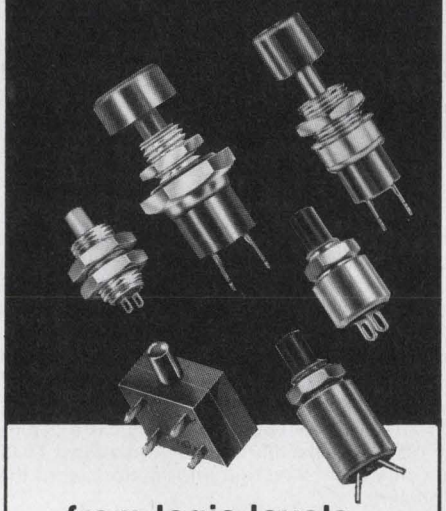
The way this growth will take place, and the speed with which it evolves is bound to the imaginations of all of us, scientist and citizen alike. As the U.S. approaches its BICENTENNIAL year, we hope to draw lessons from the past that can and will help to shape a more positive electronic future for all nations.

Electronic Design

A HAYDEN PUBLICATION

50 ESSEX STREET, ROCHELLE PARK, NEW JERSEY 07662

tiny
but tough
...Grayhill
push-button
switches



from logic levels
to UL-listed
power switching

- As small as .250" diameter, .675" over-all length
- Wiping or butt contacts; momentary or alternate action; SPST, SPDT, DPDT
- Bezel, bushing, or sub-panel mounting, variety of button colors and shapes

There's a wide range of options in the Grayhill miniature push-button switch line, but all offer high reliability over a long life span. Off-the-shelf availability of standard types is augmented by a superior custom design capability for unusual circuitry, environmental, usage, or size requirements. For details, consult EEM or write for free literature.

Grayhill INC.®

561 Hillgrove Ave., La Grange, Illinois 60525
(312) 354-1040

INFORMATION RETRIEVAL NUMBER 70

Hyperabrupt diodes have 1.5% linearity

Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801. (617) 935-5150. From $24.50 (1-9); 10 days.

The DKV6550 Series of microwave hyperabrupt tuning diodes provides ±1.5% linearity with a 1.7:1 tuning ratio from 0 to 10 V without a compensation network. General characteristics of the diodes include: minimum reverse voltage (I_r = 10 μA) of 22 V, maximum reverse leakage current (V_R = 20 V) of 50 nA, maximum capacitance temperature coefficient (V_R = 4 V) of 400 ppm/°C, minimum Q (−4 V, f = 50 MHz) of 500 and typical junction capacitances for the DKV6550A of 1.2 pF at −4 V and 0.4 pF at −20-V bias and for the DKV6550B of 1.4 pF and 0.5 pF, respectively.

CIRCLE NO. 333

Green numeric displays have 0.6-in. height

Energy Electronic Products, 6060 Manchester Ave., Los Angeles, CA 90045. (213) 670-7880. $3.50 (100-up).

The EP 62 G seven-segment numeric display has a 0.6-in. character height. It emits green light on a 560-nanometer wavelength. Luminous intensity per segment is 2000 μcd at 20 mA and the voltage drop is only 2 V.

CIRCLE NO. 334

Npn transistors combine high V and high beta

Semicoa, 333 McCormick Ave., Costa Mesa, CA 92626. (714) 979-1900. $6 to $14 (100-up).

A group of npn medium-power transistors, the 2N5660 through 2N5667, has V_{CEO} ratings from 200 to 300 V, with typical betas of 60 at 1 A. The transistors are useful at frequencies up to 30 MHz, with switching times of 1.5 μs max. Maximum collector current is either 3 or 5 A, with units available in a TO-5 package for dissipation up to 15 W, or a TO-66 package good for up to 35 W.

CIRCLE NO. 335

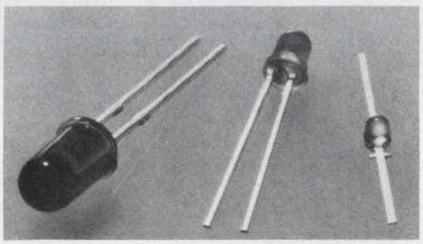
Medium current SCRs offer wide choice

RCA, Route 202, Somerville, NJ 08876. (201) 722-3200. From $0.82 (100-up); stock.

Four series of medium-current SCRs in the company's Versawatt molded-plastic package include 27 new types and three existing types that have upgraded current ratings. These devices have rms on-state current ratings of 8 A (S122 series), 10 A (S2800 series), 12 A (S6000 series) and 16 A (S6100 series). Each series of devices consists of eight types that have off-state voltage (V_{DROM}) ratings of 50, 100, 200, 300, 400, 500, 600 and 700 V. The types in the S122 series are characterized and numbered for direct replacement of corresponding types in the industry C122 and IR122 series. The previously announced S2800 series has been expanded to include 50, 300, 500, 600 and 700-V types, and the current rating has been upgraded from 8 to 10 A. The S6000 and S6100 series feature 60-Hz surge-current ratings of 125 and 135 A, respectively.

CIRCLE NO. 336

LEDs in 3 case styles come in yellow & green



Litronix, 19000 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. 1000-up prices: $0.49 (axial); $0.59 (all others); stock.

Yellow and green LED lamps are all available in T-1, T-1-3/4 and axial-lead packages. The T-1-3/4 package is 0.34 in. high and has a diameter of 0.2 in. It is intended for panel mounting and is available with a plastic panel-mounting clip. The T-1 lamp package measures 0.2 in. high and has a diameter of 0.125 in. The axial-lead lamp is designed for mounting on a PC board. Its width of 90 mils permits it to be inserted in standard PC board spacing of 100 mils.

CIRCLE NO. 337

JOIN OUR BME-KAP™ SAVINGS PLAN

SAVE 30% TO 50% ON THE COST OF MONOLITHIC CERAMIC CAPACITORS

This major cost saving is the result of our new BME™ capacitor technology. We've eliminated precious metals entirely from the electrodes and terminations of our BME™ capacitors. No precious metals means lower cost. So now we offer you our complete line of monolithic ceramic capacitors – BME Chips™, BME Radials™ and BME Axials™ – at a genuine savings of 30% to 50%.

This significant reduction is not based on a momentary drop in precious metal prices. This is a long-term solution due to the replacement of precious metals by non-noble metals which are not subject to the same dramatic cost spirals.

SAVE WITH RELIABILITY

Our BME™ capacitors have not sacrificed the inherent electrical and mechanical Ceramolithic® quality. Their reliability can be demonstrated by the extensive test procedures to which they have been subjected. Write to our Applications Engineering Department for complete test reports.

SAVE WITH DESIGN FLEXIBILITY

Now you can seriously consider monolithics to replace micas and tantalums. Our BME™ capacitors feature non-polarity, a wide range of capacitance value, low leakage, high volumetric efficiency, availability in chip, radial and axial packages at prices competitive with mica below 1000pF and tantalum up to 2.2μF.

TYPICAL SELLING PRICES PER UNIT QUANTITIES OF 5000 OR MORE

BME™ "J" DIELECTRIC (COG)	BME-Chip™	BME-Axial™	BME-Radial™
1 thru 100 pF, 5%, 50WVDC	5.1¢	6.8¢	7.5¢
1000 pF, 5%, 50WVDC	12¢	16¢	16¢
BME™ "S" DIELECTRIC (X7R)	**BME-Chip™**	**BME-Axial™**	**BME-Radial™**
.01 μF, 20%, 50WVDC	3.5¢	5.8¢	5.8¢
.1 μF, 20%, 25WVDC	9¢	16¢	14¢
1.0 μF, 20%, 25WVDC	52¢	—	73¢
BME™ "R" DIELECTRIC (Z5U)	**BME-Chip™**	**BME-Axial™**	**BME-Radial™**
.1 μF, +80 −20%, 25WVDC	5.7¢	8.8¢	8.8¢
.47 μF, +80 −20%, 25WVDC	13¢	16.5¢	16.5¢
1.0 μF, +80 −20%, 25WVDC	19¢	27¢	25¢
2.2 μF, +80 −20%, 25WVDC	35¢	—	49¢

JOIN THE USCC/CENTRALAB BME™ CAPACITOR SAVINGS PLAN

Get all the details today. Write on your company letterhead for your concise Savings Plan Price list – your pass book to the lowest monolithic ceramic capacitor prices available. Compare it with anyone else's price list and see.

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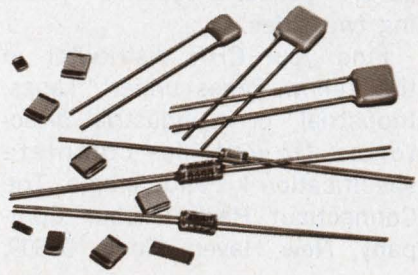

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INFORMATION RTRIEVAL NUMBER 71

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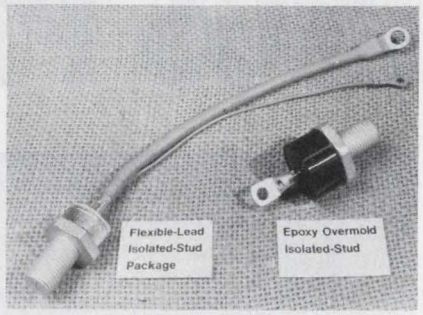
INFORMATION RETRIEVAL NUMBER 72

Plastic overmold keeps thyristor failures down



RCA, Route 202, Somerville, NJ 08876. (201) 722-3200.

An epoxy "overmold" prevents failures in the glass-to-metal seals of hermetic thyristor packages when the high-current-carrying terminals are stressed during installation. The first devices offered with the overmold include 12 thyristor series and there is no increase in costs. Eight are SCRs, four of which are rated at 75 A (TAS8612, TAS8613, TAS8622 and TAS8623) and four at 100 A (TAS8610, TAS8611, TAS8620 and TAS8621). The units at each rating are available in stud (TAS-8610, TAS8611, TAS8612, TAS-8613) and isolated-stud (TAS-8620, TAS8621, TAS8622, TAS-8623) versions. The other four series of triacs, the T8411 and T8421 series of 60-A units and the T8410 and T8420 series of 80-A devices, are available in stud and isolated-stud packages.

CIRCLE NO. 338

LED indicators designed to snap into holes

Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 371-8800. From $0.33 (1000-up); stock.

The 559 series of snap-in LED indicators is designed for quick positive insertion in panels from 0.031 to 0.062 in. The indicators fit in a 0.25-in. clearance hole, and can mount on 0.3-in. centers. They are available with red, green, or yellow LEDs, with or without integral current limiting resistors. The 559 series comes with rigid terminals suitable for wrapped-wiring and/or soldering, or with 6-in. wire leads.

CIRCLE NO. 339

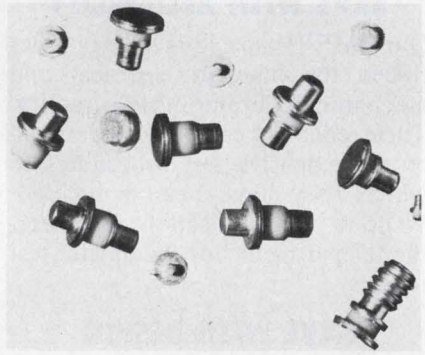
DIP-housed optocouplers available in 10 models

Sensor Technology, 21012 Lassen St., Chatsworth, CA 91311. (213) 882-4100. From $2.50; 30 day.

The STOC series of opto-couplers/isolators has 10 models. They are electronically and mechanically interchangeable with the Monsanto MCT-2 series. The couplers are housed in 6-pin plastic DIPs that measure only 0.3 × 0.35 × 0.125 in. Typical current-transfer ratio for Models STOC 1500, 1510, 1520 and 1600 is 150% (minimum 100%). Typical rise time for each is 8 μs and typical collector-emitter saturation voltage is 0.4 V. Typical CTR for Models STOC 1700, 1710, 1720, 1800 and 1900 is 80% (minimum 30%). Rise time for each unit is only 2 μs and $V_{CE(sat)}$ equals 0.4 V for the STOC 1700 and 1710. For the other three units $V_{CE(sat)}$ equals 0.6 V. Model STOC 2000 has a typical CTR of 30 (minimum 10%), rise time of 20 μs, and a $V_{CE(sat)}$ of 0.6 V.

CIRCLE NO. 340

Varactors have gain bandwidths to 35 GHz

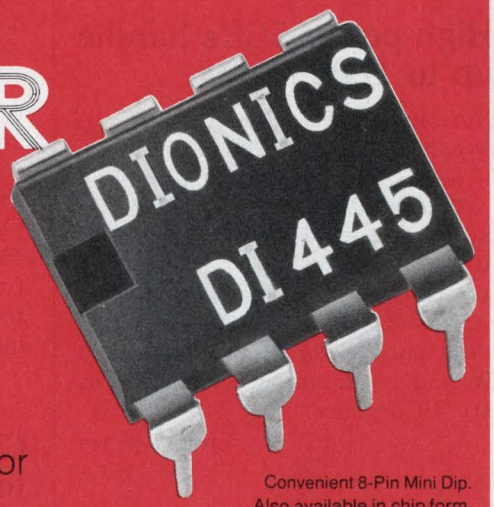


Microwave Associates, South Ave., Burlington, MA 01803. (617) 272-3000. From $79 (1 to 9); 2 to 6 wk.

The MA-48500 series of GaAs varactors is specifically designed for use in both room temperature and cryogenically cooled parametric amplifiers. High gain-bandwidth products can be achieved using these diodes over 1 to 35 GHz with pump frequencies as high as 90 GHz. All varactors are available in a choice of 17 different case assemblies and in chip form. The cathode is the heat sink end of the package. The diodes can operate at temperatures from 4 to 352 K.

CIRCLE NO. 341

"UNIVERSAL" POWER DRIVER



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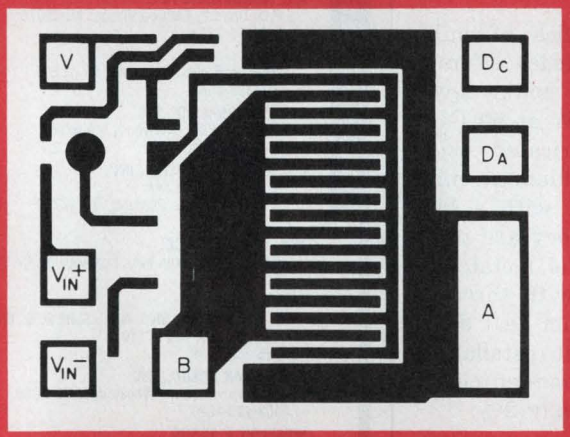

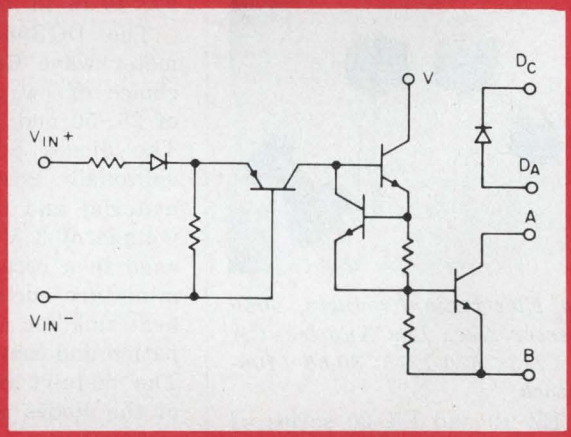

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INFORMATION RETRIEVAL NUMBER 73

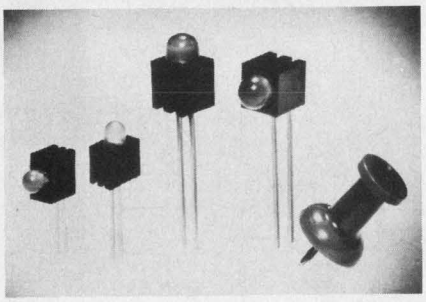
High power SCRs handle up to 1200 A rms

National Electronics, Geneva, IL 60134. (312) 232-4300. For a 100-V unit: $165.25 (100-up); stock.

The NL-F609 Theta-gate firing SCR can handle 1200 A rms and a 10,000-A surge. The diodes are available with repetitive peak off-state voltages from 100 to 1300 V. Peak gate power dissipation is 200 W and commutated turn-off times are 40 μs max.

CIRCLE NO. 342

LED fault indicators are TTL compatible



Energy Electronic Products, 6060 Manchester Ave., Los Angeles, CA 90045. (213) 670-1275. $0.66 (100-up); stock.

The EZ 19 and EZ 20 series of logic state/fault indicators use high-efficiency GaP LEDs. The devices are designed for high density packaging and can be easily mounted on printed-circuit boards. They are TTL-compatible, vibration resistant and are available in three different colors (red, green and yellow).

CIRCLE NO. 343

Germanium transistors handle up to 15-A loads

Germanium Power Devices, P.O. Box 65, Shawsheen Village Station, Andover, MA 01810. (617) 475-5982. $2 to $6; 4 to 6 wk.

A series of pnp power transistors in TO-36 metal packages has current capabilities of 15 A. The 2N278 to 2N2492 series also have collector voltage ratings of up to 100 V.

CIRCLE NO. 344

8-A power transistors designed for switchers

RCA, Route 202, Somerville, NJ 08876. (201) 722-3200. From $3.50 (100-up); stock.

Three 8-A npn power transistors, types 2N6306, 2N6307 and 2N6308, are intended for off-line switching regulator type power supplies. These transistors have voltage [$V_{CER(sus)}$] ratings of 350, 400, and 450 V, respectively, typical turn-on times of 500 ns, fall times of 200 ns at 3 A and power handling capabilities of 125 W.

CIRCLE NO. 345

Gunn diodes deliver up to 100 mW at 50 GHz

Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801. (617) 935-5150. 100-mW model: $295 (1 to 9); 10 to 15 day.

The DGB6848 series of millimeter wave Gunn diodes offers a choice of cw output power levels of 25, 50 and 100 mW at 50 GHz. The diodes are fabricated using epitaxially grown gallium-arsenide material and operate with a bias voltage of 3 V dc. They are packaged in a ceramic and metal subminiature enclosure with threaded heat sink for maximum heat dissipation and easy circuit installation. The dc-to-rf conversion efficiency of the diodes is typically 2%.

CIRCLE NO. 346

Switching transistors have 300-ns fall times

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 678-6281. Typical 100-up; $3 (2N6306), $4.50 (6308); stock.

A family of power transistors with sub-microsecond fall times and low leakage and switching losses is suited for chopper circuits or inverters. Typical fall time under high I_{B2} conditions at 10 A is 300 ns. In contrast, the JEDEC specification is 1 μs at 8 A. In addition, the units are capable of maintaining collector-emitter sustaining voltages above 375 V. The fast switching transistors are in three series—2N6249-51 are 30-A, 175-W units; the 2N6306-08 are 16-A, 125-W; and the 2N6542-45 are 8-A, 125-W.

CIRCLE NO. 347

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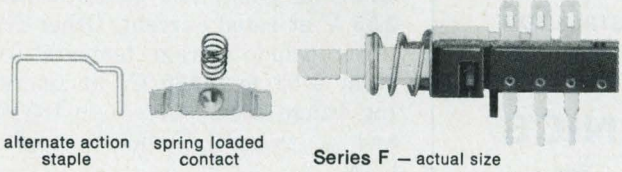

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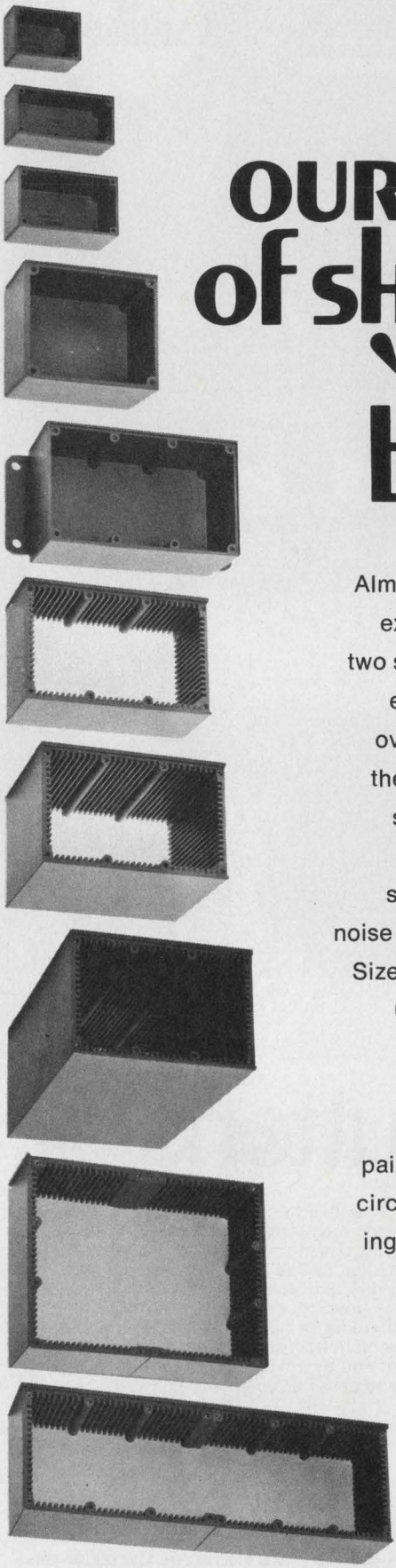

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INFORMATION RETRIEVAL NUMBER 76

LED lamps available in red, yel, orange & green

IEE, 7740 Lemona Ave., Van Nuys, CA 91405. (213) 787-0311. From $0.34 (100-up); stock.

The Hercules Electra Series 225/226/227 of red, yellow, orange and green GaP indicators fit either T-1 (225) outlines or T-1-3/4 (226, 227) outlines. The Series 225 indicators have a viewing angle of 75° while the 226 and 227 have a viewing angle of 80°. All three series are socket-interchangeable with matching performance and no change of power requirements. Typical luminous intensity is 1.5 mcd at 1.9 V dc with a 10-mA forward current.

CIRCLE NO. 348

Npn and pnp transistors have low saturation R's

Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. (617) 491-1670. $5.30 (100-up); stock.

The 2N6566 and 2N6567 npn and pnp switching transistors have a maximum r_{EC} (sat) of 2 Ω. They are designed for digital and switching applications. The devices have a low C_{eb} and 30-V collector-to-base and emitter-to-base breakdowns.

CIRCLE NO. 349

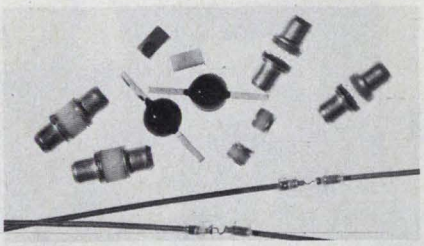
Power Schottky diodes handle 8 A continuous

Solitron, 1177 Blue Heron Blvd., Riviera Beach, FL 33404. (305) 848-4311. From $2 (100-up); 4 wk.

A series of 8-A Schottky barrier diodes has rated breakdown voltages of 10 to 60 V. These Schottky diodes are packaged in DO-4 (JEDEC) cases and are identified as the SSP-810, 20, 30, 40, 50 and 60 series. Their peak surge capability is greater than 450 A for an 8.3-ms pulse. The V_F is less than 0.55 V at rated current. Other features include storage temperatures from −55 to +165 C; an operating range from −55 to +135 C; and a thermal impedance of 2 C/W.

CIRCLE NO. 350

Schottky diodes operate at zero bias at Ku band

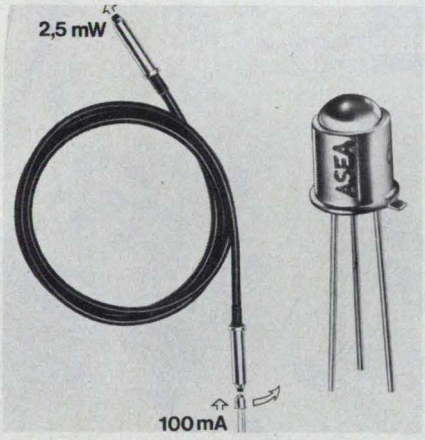


Microwave Associates, South Ave., Burlington, MA 01803. (617) 272-3000. $25 (1 to 9); 2 to 3 wk.

The MA-40230 series of zero bias Schottky diodes offers a tangential sensitivity of −55 dBm min. They have a voltage sensitivity of 8000 mV/mW at X-band with zero bias current. The devices are designed for Ku and Ka-band operation. All diodes are available in hermetically sealed packages and as chips for MIC applications.

CIRCLE NO. 351

Infrared LEDs made for fiber-optic cables

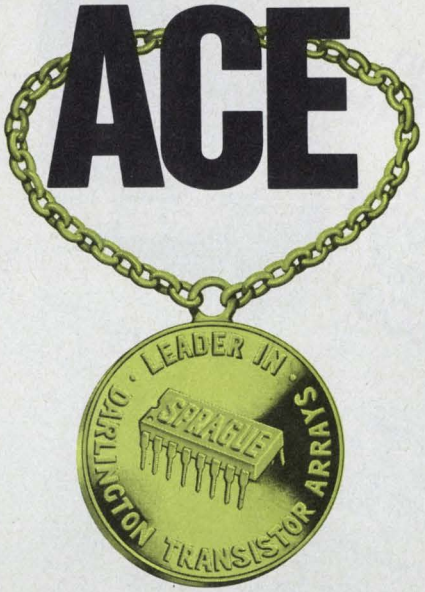


ASEA-HAFO AB, S-162-10 Vällingby 1, Sweden.

The 1A83 infrared emitting diode is specially designed for efficient coupling to 2-mm diameter optical fiber bundles. The diode is housed in a TO-18 case with a lens cap. At 100 mA, the total emitted radiant flux is at least 7 mW and typically 10 mW. The radiant flux output from an ordinary fiber bundle having a 2-mm diameter and a length of 1.8 m is typically more than 25% of the input flux. The wavelength is 940 nm and diode switching times are 0.6 μs at 100 mA and 0.3 μs at 1 A.

CIRCLE NO. 352

INTERFACE ACE



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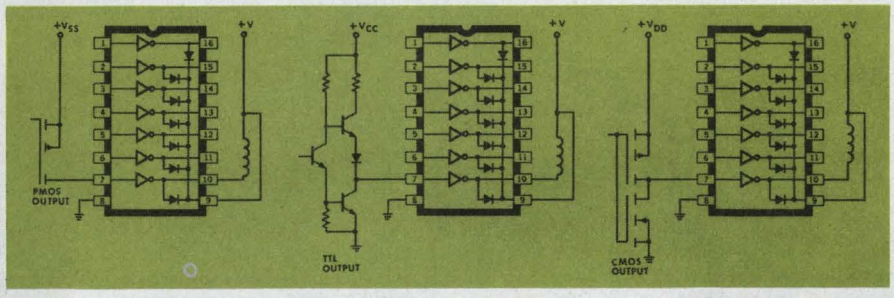

A new exclusive Sprague development, Series 2000 Transistor Arrays are high-voltage, high-current integrated circuits comprised of seven silicon NPN Darlington pairs on a common monolithic substrate. They feature open collector outputs and integral suppression diodes for inductive loads.

Supplied in 16-pin dual in-line plastic, these devices greatly reduce the number of discrete components used to interface between digital logic and high-voltage and/or high-current loads. In some applications, all discrete components can be replaced by a single DIP, resulting in substantial space and cost reduction.

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Type ULN-2001A is a general-purpose array, pinned with inputs opposite outputs to facilitate circuit board layout. Type ULN-2002A is designed for use with 14 to 25 V PMOS inputs. Type ULN-2003A interfaces with TTL or CMOS operating at a 5 V supply voltage.

For more information, write or call Chuck Scott, Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Tel. 617/853-5000.

For Engineering Bulletin 29304, write to Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

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INFORMATION RETRIEVAL NUMBER 77

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The Tektronix TM 500 High Speed Logic Instrumentation plus the Tektronix 485 Oscilloscope (350 MHz) or 475 Oscilloscope (200 MHz) provide all the instrumentation you need for TTL or ECL or to 250 MHz. The four plug-ins of the TM 500 High Speed Logic system are a PG 502 Pulse Generator ($1395) with 1 ns and 0 levels . . . a DC 505A Digital Counter ($1395) with 10 ns single shot resolution and averaging to variable logic 1 and 0 levels . . . a DC 505A Digital Counter 100 ps . . . A DM 501 Digital Multimeter ($575) with temperature measurement capability added to all its conventional functions so you can verify operating temperatures of logic IC's and detect hot spots in tightly packed circuitry) . . . and the PS 505 Power Supply ($196) with the 3.0 to 5.5 V dc high-current (4 A) output essential for breadboarding or testing TTL and ECL devices. Also . . .

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The TM 500 Product Line is a growing, compatible family of 29 plug-in modular instruments, accessories, and one, three, four, and six-compartment mainframes providing the common power supply. The modular Rollabout Configuration can accommodate two TM 503, 3-compartment mainframes. Select the plug-ins from 11 signal sources, 5 counters, 2 digital multimeters, 5 power supplies, 3 signal processors, 1 oscilloscope, and an X-Y monitor. There's also a blank plug-in kit to make it more convenient for you to assemble the specialized circuits you require. A TM 500 modular Rollabout Configuration lets you take the instrumentation you need where you need it.

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- and more

The TEKTRONIX modular Audio Frequency instrumentation group provides the test and measurement instruments you most frequently need . . . for only $1970.* These compact light weight instruments work together as a system or independently within a TM 504 power module/mainframe.

The above TM 500 configuration features a dB reading DM 502 Digital Multimeter with 3½ digit display and optional (S125)* temperature measurement capability (a function that has proven valuable in identifying active solid-state device circuit problems); the SG 502 Audio Oscillator provides 5 Hz to 500 kHz sine and square waves, 5000 output, and low distortion (0.05% from 20 Hz to 50 kHz); the DC 504 Digital Counter offers 8-digit LED display of frequency to 80 MHz and period resolution to 1 μs; and the SC 501 Oscilloscope is a single-channel, dc-to-5 MHz modular instrument with triggered sweep and vertical sensitivity to 10 mV/division.

All TM 500 plug-ins are readily interchangeable within the entire TM 500 line. Plus there's a blank plug-in kit, which allows you to add your own special circuits to a TM 500 system. The plug-ins can work together through the common interface circuit board of the power module/mainframe. So you can tailor a system of instrumentation exactly to your needs . . . a system that's only 6" x 11" x 20" and weighs less than 30 lbs. . . . and a system that offers you benefits difficult to duplicate with "monolithic" instruments.

TM 500 is a growing, compatible family of 29 plug-in modular instruments, accessories, and one, three, four, and six-compartment power module/mainframes. Package configurations can be selected for work in high-speed logic circuitry, medical instrumentation, instrumentation calibration, industrial equipment, and more. All may be hand carried, all go on the bench, and there are rack-mounting and SCOPE-MOBILE® configurations as well. You can select from general-purpose instruments, such as the DM 501 Digital Multimeter, or highly specialized instruments, such as the AF 501 Tunable Bandpass Filter or AM 502 high-gain amplifier with calibrated gain to 160 dB and switch-selectable high and low-pass filters. If your work requires the measurement of electrical phenomena in the audio frequency range, Tektronix TM 500 offers substantial benefits to you.

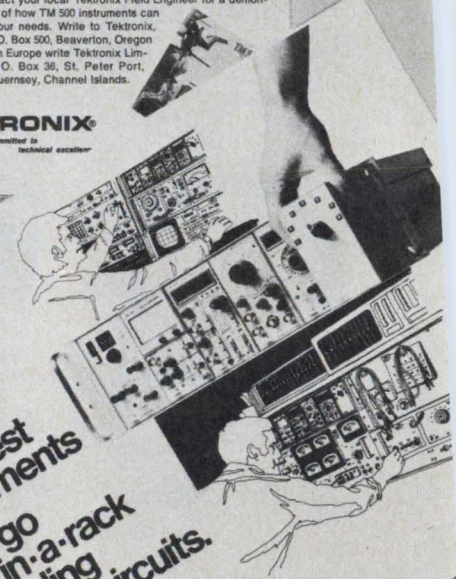
Find out what TM 500 can do for you. Get the TM 500 Catalog A-3072 with full specifications and applications information. Or contact your local Tektronix Field Engineer for a demonstration of how TM 500 offers a better solution to your needs. Write to Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

TEKTRONIX®
committed to technical excellence

*U.S. Sales Prices FOB Beaverton, Oregon

Tektronix TM 500

a line of 29 test instruments that go six-in-a-rack including custom circuits.



- digital multimeters
- counters
- generators
- amplifiers
- power supplies
- oscilloscopes
- a blank plug-in for your own circuitry
- and more

TEKTRONIX modular instrumentation offers your QC, production test, or built-in test equipment a highly compact, extensive line of test instruments . . . TM 500. They are designed to work totally independently or as a system with each other. Blank plug-in kits make it easier for you to build in your own testing circuits compatible with TM 500. The RTM 506 rackmounting power module/mainframe (only 5¼" high) provides as compartments to accommodate TM 500 plug-in modular instruments and the plug-in kits. It is available for benchtop or portable use (TM 506), as well as for rackmounting (RTM 506).

A common interface circuit board within the mainframe permits the intercommunication of inputs, output, and various parameters among the plug-ins. Tektronix will supply you with data on voltages, currents, and pin connection diagrams so you can determine the feasibility of assembling your special circuits in blank TM 500 plug-in kits.

The TM 500 family of instruments is designed to fulfill your test and system needs in such widely divergent areas as high-speed logic; dc, power and time frequency; audio, and rf to 550 MHz; oscilloscope and other instrumentation calibration; and even medical instrumentation. They represent Tektronix standards of quality in design, performance, and ease of operation. Included are pulse ge
independent pulse top
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Counter/Timer featur
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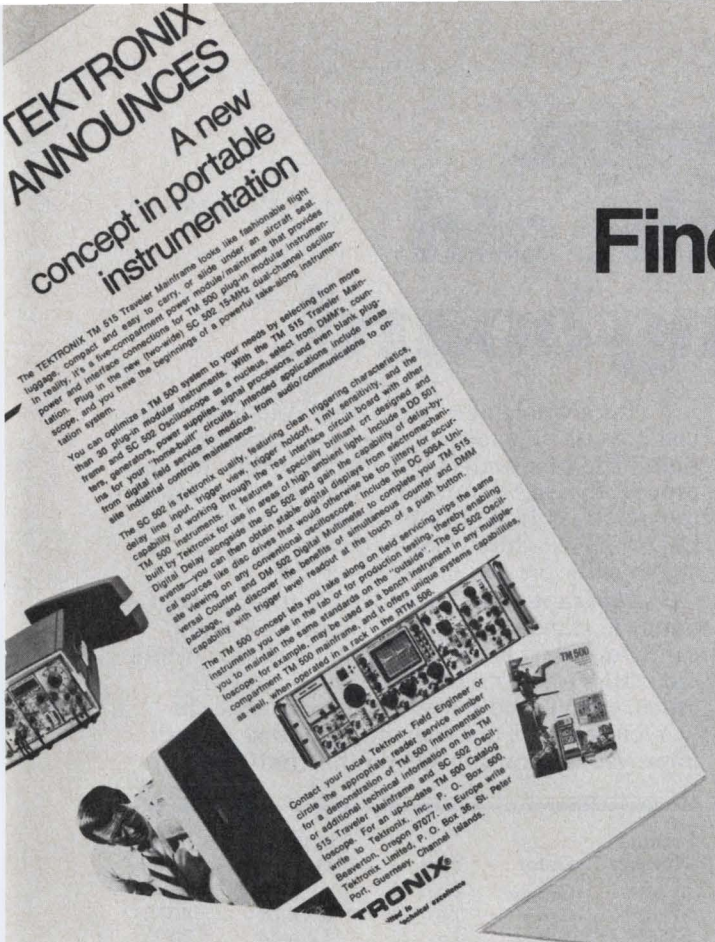


Find out what TM 500 can do for you.

While any TM 500 plug-in modular instrument can be operated as an independent unit purely on the basis of its performance, the systems capability of the TM 500 Product Line is what makes this instrumentation especially valuable to you. TM 500 instruments plug into mainframes providing a common power supply and an interface circuit board allowing them to "talk" to each other and work together.

Often a TM 500 system allows you to optimize your instrumentation far beyond the capabilities of a collection of monolithic instruments. Some systems applications merely call upon three or four independent units working side by side to fill a basic need like oscilloscope calibration. Others, such as production testing setups, can be accomplished best by several instruments working into one another through the common interface circuit board of their power-module/mainframe. Openendedness is achieved through two sizes of blank plug-ins, into which you might assemble control devices or circuits for your own special needs. Tektronix provides Instruction Manuals, Applications and Construction Notes, and technical consultation to whatever level of sophistication you require.

TEKTRONIX TM 500 is an extensive family of instrumentation that includes six power-module/mainframes, more than 30 plug-in modular instruments, and numerous accessories. Some instruments are intended for broad versatility, some for state-of-the-art performance, some for special purposes. They include multimeters, counters, oscilloscopes, power supplies, amplifiers, a variety of generators, a logic analyzer, and the blank plug-ins. Use the TM 500 Catalog to get full specs, articles offering insight into applications techniques, and a form to put your name on the Tektronix mailing list for Applications and Construction Notes.

For further information on what TM 500 Instrumentation can do for you, ask for a demonstration; a Tektronix Field Engineer will contact you. Ask for literature, and you'll get the comprehensive TM 500 Catalog shown below.

To 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.

U.S. Sales Prices FOB Beaverton, Oregon.

TEKTRONIX®
committed to technical excellence

FOR TECHNICAL DATA CIRCLE #285
FOR DEMONSTRATION CIRCLE #286

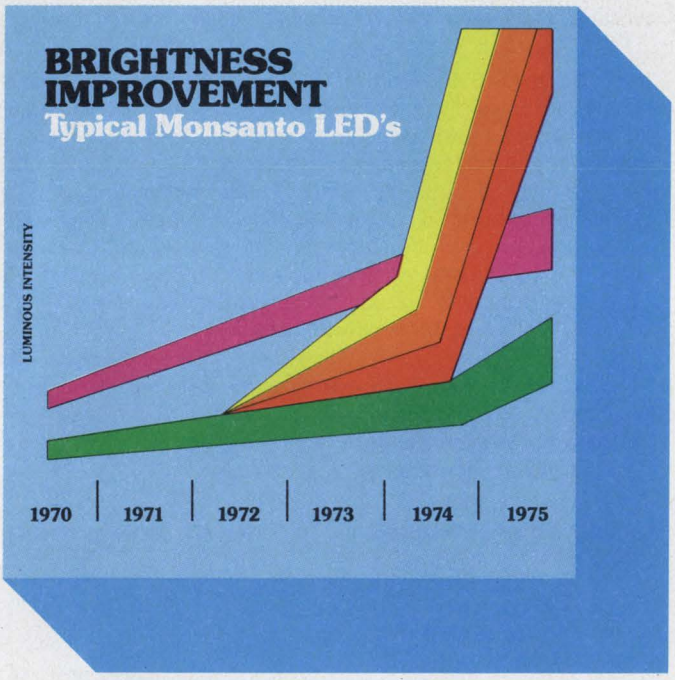
O.K., you guys, back to the old drawing board.

It's a whole new ball game. And just when you'd made all your panel lamp decisions, right? But Monsanto's patented nitrogen doping process for GaAsP on GaP substrates has improved the light-emitting efficiencies of our LED lamps so dramatically that every good designer will want to take another look.

Monsanto has T-1 and T-1¾ replacement lamps in standard red color (improved significantly over last year's red LEDs) and new bright red which is *unbelievably* bright. Red. Plus green, yellow, and a dazzling new orange. In two lens choices and two lead lengths. And all improved, as you can see on the chart.

Model Number	Color	Size	Luminous Intensity	Viewing Angle
5174B*	Orange	T-1	5.0 mcd	90°
5274B*	Green	T-1	1.0 mcd	90°
5374B*	Yellow	T-1	4.0 mcd	90°
5774B*	Red	T-1	5.0 mcd	90°
5152**	Orange	T-1¾	40.0 mcd	28°
5252**	Green	T-1¾	15.0 mcd	28°
5352**	Yellow	T-1¾	45.0 mcd	28°
5752**	Red	T-1¾	40.0 mcd	28°

*Also available with 1" lead lengths, low profile (.138" high) lens, and 180° viewing angle.
**Also available with 24° and 65° viewing angles.



Last year there were some sockets that demanded filament lamps, despite their inherent failure-and-replacement problems. *Bright* was needed, and damn the torpedos.

This year you just might find the bright you need in a shake-rattle-and-roll-proof LED lamp. Come and see.

If you can take the time, you just might be able to add a lot of T to your MTBF.

So it's reset to zero, folks, if you want the best indicator lamps (and widest choice of functional differentiation colors) in your gear.

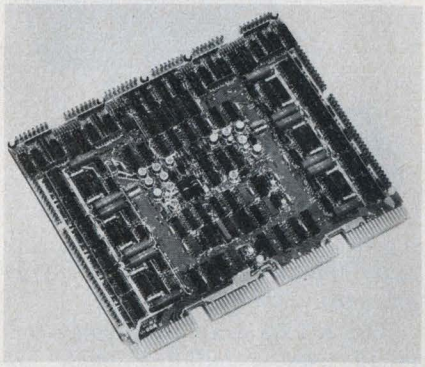
For product information, circle the service number or call your local Monsanto man. Or write Monsanto Electronics Division, 3400 Hillview Avenue, Palo Alto, CA 94304.

Putting innovation to work.

Monsanto: the science company.

INFORMATION RETRIEVAL NUMBER 80

Core memories fit PDP-8 minis



Dataram Corp., Princeton-Hightstown Rd., Cranbury, NJ 08512. (609) 799-0071. $2045: 16 k × 12, $1860: 8 k × 12; 30 days.

Dataram's DR-118 and DR-118/A single-board, 16-k core memory is specially designed for use with DEC's PDP-8 series of minicomputers. The memories are Omnibus compatible and can be inserted directly into the backboard of the host minicomputer. The DR 118 is compatible with the PDP-8/E, F and M, and the DR-118/A is compatible with the PDP-8/A-400 and the PDP-8/A-500. Both systems are available in either 16-k × 12 or 8-k × 12 configurations.

CIRCLE NO. 357

Photo-scanner xceiver sends TV via phone line

Robot Research Inc., 7591 Convoy Court, San Diego, CA 92111. (714) 279-9430. $995 (unit qty).

The Model 300 scan-converter transceiver makes possible transmission of closed-circuit quality TV pictures via telephone. Pictures are 256-line resolution, and an entire image can be transmitted full frame in 34 s, or half frame in 17 s. The unit can be used in conjunction with any black-and-white monitor or commercial TV set and closed-circuit TV camera.

CIRCLE NO. 358

Acoustic coupler uses LSI circuitry

Omnitec Corp., 2405 S. 20th St., Phoenix, AZ 85034. (602) 258-8244. $341 (unit qty); stock.

With a proprietary LSI circuit, the Model 701R acoustic coupler has fewer than half the number of components of earlier models. This fifth-generation coupler is fully compatible with the latest conversational terminals that operate at data rates in excess of 450 baud. It can also be supplied to operate at data rates in excess of 600 baud. Additional features include TTY and RS-232 interfacing, acoustic or hardwire coupling, half or full-duplex operation and ultra-high sensitivity.

CIRCLE NO. 359

Dish it out. They can take it beautifully.

When your customer takes your equipment into the field, be prepared for the worst to happen.

Don't take chances. You've spent a lot of time and money designing your equipment. Your customer has invested in the results you promised him. And the extra strength, quality and reliability of a Zero Centurion™ aluminum carrying case can mean the difference between equipment success or failure.

With the distinctive good looks of a Zero Centurion case going for you, most people just naturally seem to treat your equipment better. But for those that don't, Zero Centurion cases will take all the abuse they can dish out.

The anodized silver "Elite" line and the textured blue "Valuline" are available in 59 standard sizes for two week delivery A.R.O.

Send for your free catalog today.

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FOR PRODUCT DEMONSTRATION CIRCLE #163
FOR LITERATURE CIRCLE #164

Controller/driver kit for floppy-disc storage

Shugart Associates, 435 Indio Way, Sunnyvale, CA 94086. (408) 733-0100. From $1110 (50 up).

For OEMs who want to include a floppy-disc storage in minicomputer or microprocessor systems, the new SA8800 Streaker kit consists of a single 12.5 × 17.5-in. PCB disc controller and from one-to-three disc drives in optional single or double density. Users can add their own cabinet, standard power supply and interface. Or they can purchase a standard Shugart SA3800 Diskette storage subsystem and add additional drives in increments of one, two or three in a single cabinet.

CIRCLE NO. 360

See the Microprocessor Design section for microprocessors and related products.

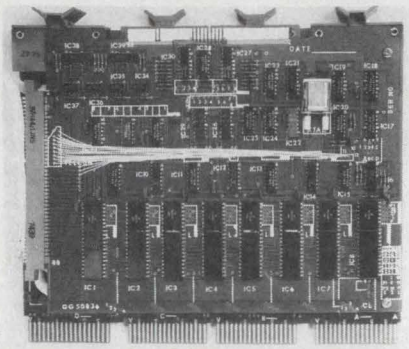
Memory emulates ROM to test new systems

Data I/O Corp., P.O. Box 308, 1297 N.W. Mall, Issaquah, WA 98027. (206) 455-3990.

The Data I/O Romulator allows a ROM program to be emulated in the user's developmental system before committing to a PROM. The unit provides data entry for binary, hex or octal codes and the display allows a program to be edited. Both data and address locations are conveniently displayed. The Romulator can be interfaced with Data I/O programmers, Models I, II, III and V and the new Model PD (portable-duplicator). The unit operates on its own battery pack or ac power.

CIRCLE NO. 361

Multiplexer provides 8-channel FIFO to PDP-8



Telcon Industries, Inc., 1437 S.W. 1st Ave., Fort Lauderdale, FL 33315. (305) 527-5004. $1950 (unit qty).

A communication multiplexer contains eight full duplex asynchronous communication channels, which are fully compatible with the PDP-8, A, E, F or M Omnibus. Each multiplexer contains a First In-First Out (FIFO) memory to buffer input data and minimize input processing overhead. The data input/outputs are either RS-232C or TTL levels.

CIRCLE NO. 362

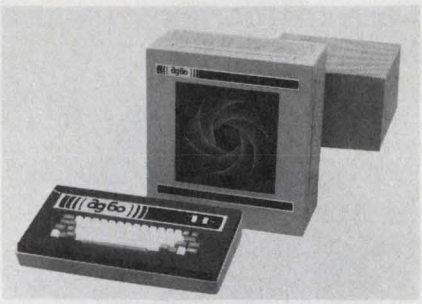
Tape recorder accepts asynchronous data

Kennedy Co., 540 W. Woodbury Rd., Altadena, CA 91001. (213) 798-0953. $5100 to $6600; 60 days.

A new asynchronous magnetic tape recorder, the Kennedy Series 9832, uses dual RAMs to record time-independent data with no loss of data during gap insertion. Unlike competitive units, the transports are truly asynchronous—data can be both written or read at any rate up to 250,000 characters per second on 8.5-in. reel tapes. Buffers and format electronics are contained within the transport chassis, thereby eliminating interconnecting cables.

CIRCLE NO. 363

Graphic display terminal uses plasma panel



Applications Group Inc., P.O. Box 444, Maumee, OH 43537. (419) 874-3051. $5000 (unit qty).

The AG 60 graphics display terminal uses a building block approach to terminal design. The terminal uses a 512 × 512-line plasma display panel with a resolution of 60 lines/in., which has excellent contrast and readability and a complete lack of distortion, flicker or jitter, according to the manufacturer. In addition to the usual character and line generators, the AG 60 also includes: a second, independent character generator to display two sizes of characters on the same display; a programmable matrix generator, which defines up to 64 independent 8 × 16 dot matrices and displays them at any location on the panel; and an unrestricted matrix format to allow the display of alphanumeric characters at any locations on the panel, with subscripting and superscripting easily accomplished. Any portion of the display may be erased without affecting the contents of the remainder of the display.

CIRCLE NO. 364

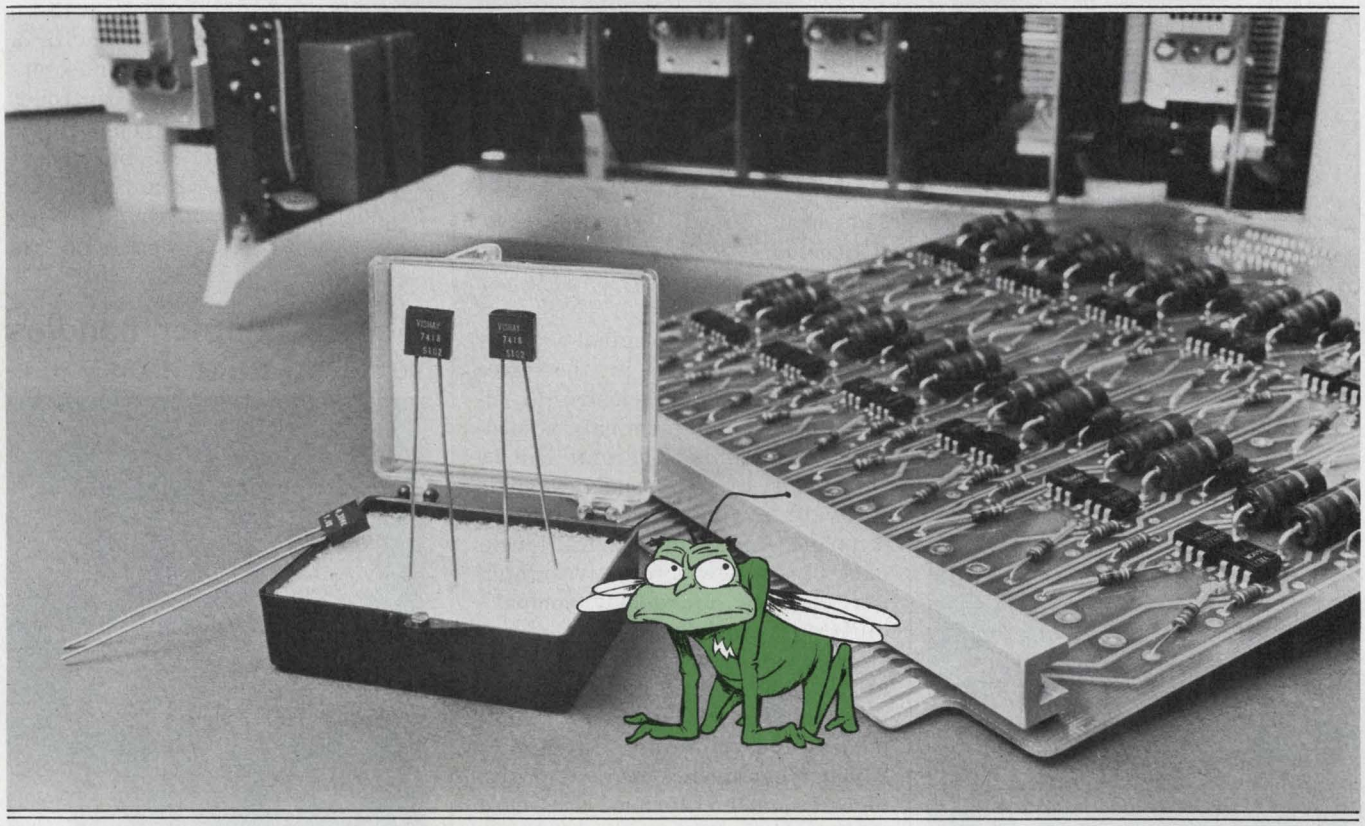
Translucent tablet helps digitize data

Summagraphics Corp., 35 Brentwood Ave., Box 781, Fairfield, CT 06430. (203) 384-1344. See text.

A new translucent, data, tablet digitizer is designed for back-lighting and rear-projection applications, such as when digitizing X-ray and other films and Mylar drawings. The tablet may be placed on a light box or table, or images may be projected from behind. The prices for an 11 × 11-in. and 14 × 14-in. tablets are $2650 and $3000, respectively. Resolutions of 100 to 200 lines/in. are available.

CIRCLE NO. 365

THAT BUG IN YOUR EQUIPMENT: YOU MAY NEED VISHAY RESISTORS.



Here is some news that may shock you:

Many manufacturers and users of precision electronic equipment suffer unnecessarily with unexplained instabilities and drifts. They resign themselves to the need for constant adjustments and troubleshooting which could, in fact, be avoided.

Often, the instability is traceable to a few "fixed" resistors which aren't fixed at all. If these resistors would only retain their original values, there would be no need for costly controls and other compensating circuitry.

The answer? A *real* precision resistor.

Some precision resistors offer you tight tolerance at the expense of high inductance. Others offer low inductance and fast rise time at the expense of loose tolerance. But only Vishay Bulk Metal® resistors offer you the complete set of top performance characteristics, including 0±1 ppm TCR, that will most often get that frustrating bug out of your equipment. Only Vishay offers you the consistent matching and tracking so necessary in A/D conversion networks and bridge circuits.

And now Vishay offers you the chance to *make your own* custom Bulk Metal resistors for breadboard and prototype use. Call or write for information on our popular one-day training seminar in calibrating and encapsulating Vishay resistors in your own plant. Vishay Resistive Systems Group, 63 Lincoln Highway, Malvern, PA 19355; phone (215) 644-1300; TWX 510-688-8944.

VISHAY RESISTIVE SYSTEMS GROUP

Only Vishay resistors give you all six top performance specs.

TCR to 0±1ppm/°C

TOLERANCE to .001%

As low as 1-ns RISE TIME– NO INDUCTANCE

TRACKING to ½ ppm/°C

STABILITY to 5 ppm/yr

NO NOISE

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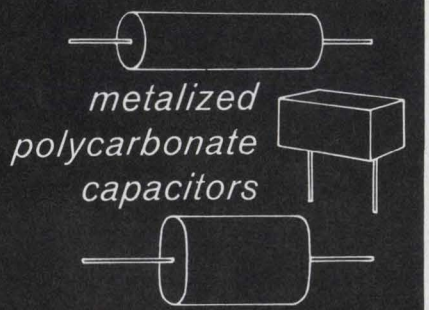
6463

INFORMATION RETRIEVAL NUMBER 83

If you can't stand the heat

stay out of the kitchen!

Here are components that stand the heat . . . and the cold (—55°C to +125°C) without voltage derating. The dissipation curve is as flat as a pancake . . . and the other specs are out of this world. Maybe your recipe calls for



Try Standard's PC2-E (Rectangular Epoxy) and PC2-W (Wrap and Fill).

Send for Catalog and complete details.

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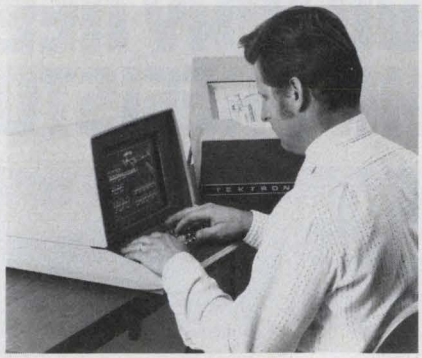
INFORMATION RETRIEVAL NUMBER 84

DATA PROCESSING

Graphic data terminal at cost of alphanumeric



Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. (503) 644-0161. $2995 (unit qty) or $150 per month on 2-yr. lease.

The 4006-1 terminal places graphics capability in the price range previously exclusive to alphanumeric CRT terminals, according to Tektronix. The unit will be supported by the same graphic software available for Tektronix' complete family of graphic terminals, plus a new interactive graphing package. Hard-copy compatibility is included and off-line storage can be provided. Data rates up to 4800 b/s are available. The terminal has 1024 × 780 viewable points, and its screen capacity of 2590 alphanumeric characters provides as much information as most CRTs that are merely alphanumeric.

CIRCLE NO. 366

Calculator chip forms basis of controller

Elcom Industries Inc., Civilian Terminal, Hanscom Field, Bedford, MA 01730. (617) 274-6656. $629 (unit qty); stock to 45 days.

A programmable calculator/controller, the Procal 4/u, is a mini/micro data system that fills the gap between microprocessors and hard-wired controllers. It uses a calculator chip plus program storage, I/O data registers, panel function-programming switches and an eight-digit display. Standard program storage accommodates up to 10 instructions, with optional expansion to 256 steps. Instructions include add, subtract, multiply and divide. Programming is similar to using a calculator.

CIRCLE NO. 367

Line-printer controller mates many printers

MDB System Inc., 981 N. Main St., Orange, CA 92667. (714) 639-7238. $750 (unit qty).

A low-cost line-printer controller, completely software compatible and transparent to the host computer, is a single PC half-board that fits into any Interdata 15-in. chassis. The board comes with a ribbon cable and mating connectors to the line printer. The controller module handles many popular line printers including all models of Centronics, Data Printer, Data Products, ODEC and Printec.

CIRCLE NO. 368

Modem adapter handles voice on data lines

Intertel, 6 Vine Brook Park, Burlington, MA 01803. (617) 273-0950. Under $375.

A new voice adapter, the VCA-700, for voice communication on four-wire data lines, is compatible with Intertel's 1200-baud, 2400-bps, 4800-bps, and 9600-bps modems. It has a molded plastic handset and base similar to the Princess telephone used by the Bell System. The adapter connects to an Intertel modem through a self-contained cable. No connections to the telephone lines are necessary. The modem and voice adapter take care of all switching, ringing, interrupts and signal summing. A small speaker produces audible ringing signals. And, for areas where a ringing signal cannot be heard, a LED indicator lights to show that a ringing signal is present.

CIRCLE NO. 369

Hit Switcher

For the highest efficiency in your power switching circuits the fast switching 2N6340 series of STC Power Transistors features a max. fall time of 250 ns. at 10 Amps. with VCEO sus. up to 150 Volts.

Power Supplier

For your high voltage switching circuits the 2N6251 series of STC Power Transistors features VCEO sus. to 350 Volts with 10 Amp. continuous current ratings.

Dearest Darlington

For space, and weight saving designs the high gain 2N6282 thru 87 series of STC monolithic NPN and complimentary PNP Darlington Power Transistors feature a gain of 100 at 20 Amps, and VCEO sus. up to 100 Volts.

WHATEVER YOUR POWER TRANSISTOR NEEDS, YOU CAN GET THE *RIGHT* ONE

FROM STC

THE POWER SOURCE

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Get complete data on these and other STC Power Transistors.

INFORMATION RETRIEVAL NUMBER 85

Be selective turn to SERVO-TEK

for superior quality products produced by efficient, modern manufacturing techniques. These products — Bi-Mode Servos, Control Meter Relay Systems, Adjustable-Speed Drives, Permanent-Magnet Servomotors, Speed Indicating Systems and Tachometer Generators — are products of proven design versatility and reliability. Turn to us for advice on your design problems and information on standard unit modifications too! Be selective.

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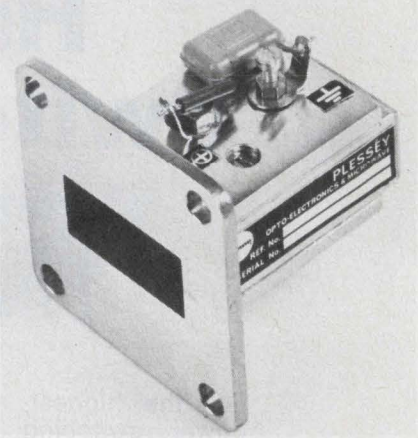
SERVO-TEK

INFORMATION RETRIEVAL NUMBER 82

Voltage tuned Gunns cover X to Ka bands



Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. $40 (1000); stock to 12 wks.

Electronically tuned Gunn oscillators come in 17 standard models covering X, Ku and Ka bands. X-band units have either ±25-MHz or ±250-MHz tuning ranges, and preset frequencies from 9 to 11 GHz. Output power ranges from 10 to 100 mW. Ku-band oscillators deliver from 10 to 50 mW, tuning through a range from ±20 to ±300 MHz, with a preset frequency from 12 to 17 GHz. Ka-band units output either 20 or 50 mW, and are electronically tunable through either ±100 MHz to ±200 MHz, with a preset frequency from 26 to 40 GHz. Typical tuning voltage range is from 2 to 20 V. Typical signal-to-noise ratio for a ±25-MHz, 100-mW X-band unit is 90 dB with FM carrier-to-sideband offset of 10 kHz.

CIRCLE NO. 450

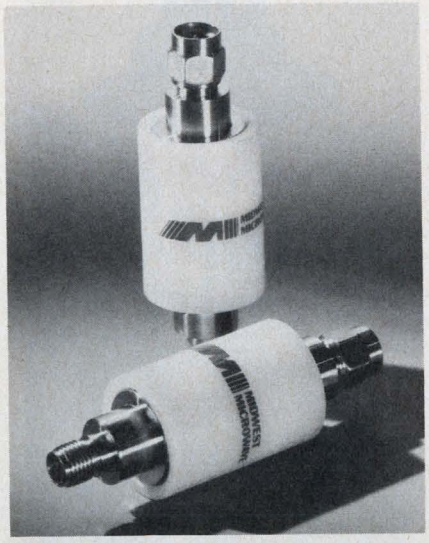
Schottky mixer diodes reduce forward drop

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $5.95 to $62.40; stock.

Low forward-voltage Schottky-mixer diodes feature forward drops of 200 to 300 mV. Typical noise figure is less than 6 dB at 9 GHz for power levels ranging from −5 dBm to +5 dBm. The 5082-series diodes are available as chips and in beam lead and quad configurations.

CIRCLE NO. 451

Suppress noise up to 18 GHz



Midwest Microwave, 3800 Packard Rd., Ann Arbor, MI 48104. (313) 971-1992. $65 to $70; 20 days.

Broadband noise suppressors with stainless steel SMA connectors operate over the frequency range of 100 MHz to 12.4 GHz (Model 2537) and 100 MHz to 18.0 GHz (Model 2538). The maximum insertion loss is 0.54 dB from 100 MHz to 18.0 GHz and the maximum VSWR ranges from 1.20 to 1.35. The units have both an inner and outer block and they specify a dc working voltage of 200 V. Units measure 2.3-in. in length and they have 0.75-in. diameter.

CIRCLE NO. 370

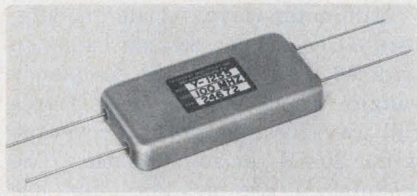
Amplifiers offer flat responses

B & H Electronics Co., Box 490, Chester, NY 10918. (914) 783-4988. $499 to $1099 (100); 2-6 wks for small qty.

A series of low-noise linear amplifiers—the DC-3002 and AC-25XX and 30XX—offers virtually flat frequency response from 2 kHz to over 3 GHz. Voltage gain is typically 21 dB for the DC-3002 and AC-30XX and 10.5 dB for the AC-25XX. And the gains are flat to within a mere 0.6 dB maximum. Units have a typical noise figure of 2.5 dB, rise and fall times of 130 ps and ±1.0-V input offset range.

CIRCLE NO. 371

Compact osc can be used with strip line



Greenray Industries, Inc., 840 W. Church Rd., Mechanicsburg, PA 17055. (717) 766-0223. $149 to $198 (1 to 3); 4 to 5 wks.

Small enough for mounting to a strip-line substrate, the Model Y-1255 oscillator outputs any customer-specified frequency in the range of 10 to 150 MHz. The compact unit measures 2 × 1 × 0.26 in. The internal crystal provides ±0.003% stability with an output power of +5 dBm.

CIRCLE NO. 372

This is a rack-full of counter capability.

HP's new 75 MHz Timer/Counter is easily held in your hands. Take a look at the front panel: Never before has there been so much counting capability in such a small package at such a small price. Seven other modules snap on to convert to other instruments — including a DMM — or to connect to the HP Interface Bus.

Features include: 1 nsec time interval averaging • autoranging of frequency, frequency ratio, period average, time interval average • full complement of triggering controls, monitor LEDs • preset ECL and TTL thresholds • an astonishingly low price of only $910* total for 5308A module with 5300B mainframe. *Domestic USA price only.

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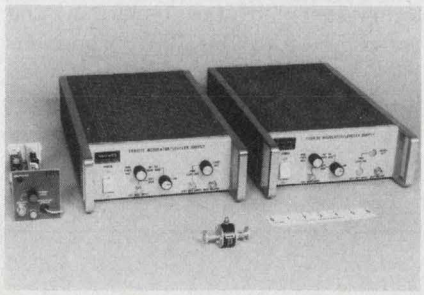
1501 Page Mill Road, Palo Alto, California 94304

02503

INFORMATION RETRIEVAL NUMBER 87

Mm-wave modulators span 26.5 to 110 GHz



Hughes, 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121. $1075; 60 to 90 days.

Millimeter-wave ferrite modulators cover six waveguide bands in the 26.5-to-110-GHz frequency range. Each modulator features full waveguide-bandwidth coverage with 20-dB on-to-off ratio. The modulators are designed for use with Hughes' modulator/leveler power supply (Model 44711H) or plug-in (Model 44425H), but they can be used with customer supplies.

CIRCLE NO. 373

180° phase shifter has 30-to-76-MHz band

Merrimac Industries, 41 Fairfield Pl., West Caldwell, NJ 07006. (201) 228-3890. $225; 4 to 6 wks.

A continuously variable phase shifter covers the 30-to-76-MHz band with a phase range of 0 to 180 degrees. The Model PS-3-53 has a VSWR of 1.8:1 at an impedance of 50 Ω, 1.5-dB insertion loss, and 25-W power-handling capability. The unit comes with BNC connectors and an uncalibrated dial.

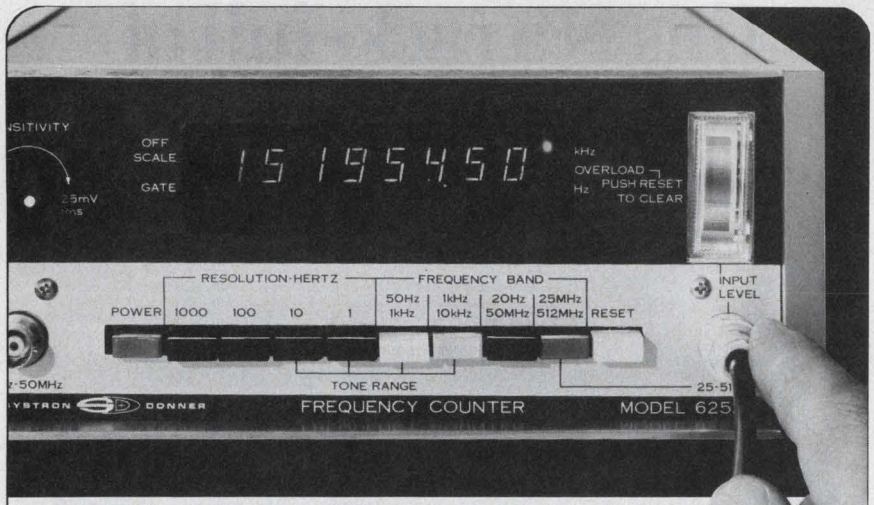
CIRCLE NO. 374

8-18-GHz Gunn osc outputs 10 mW

Solid State Technology, 3650 Charles St., Santa Clara, CA 95050. (408) 247-8620. $1200 to $2500; 60 to 90 days.

The SSV-0100 series of voltage-tuned Gunn oscillators provides 10 mW minimum over the −54-to-85-C temperature range and covers the 8-to-18-GHz frequency range in two bands. Militarized units include integrated voltage regulators, isolators, proportional controlled dc or ac ovens, and linearizers. Units are linear to ±1% over the combined effects of temperature and 3.0:1 load VSWR. Post-tuning drift is within 1 MHz of final frequency.

CIRCLE NO. 375



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- **Tone Measurement:** Example: measure 1020.001 Hz automatically in 1 sec.
- **Price:** All of the above standard features on Model 6252 for only $895
- **Options:** Tailor your counter with two **TCXO's** or three **oven oscillators,** internal **battery** pack, external **DC operation, carry case,** etc.

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5 MHz Frequency Counter	$430
50 MHz Frequency Counter	$595
50 MHz Universal Counter	$695
180 MHz Frequency Counter	$795
512 MHz Frequency Counter	$895

For more details, contact Scientific Devices or Systron-Donner at 10 Systron Drive, Concord, California 94518. Phone (415) 676-5000.

SYSTRON DONNER

INFORMATION RETRIEVAL NUMBER 88

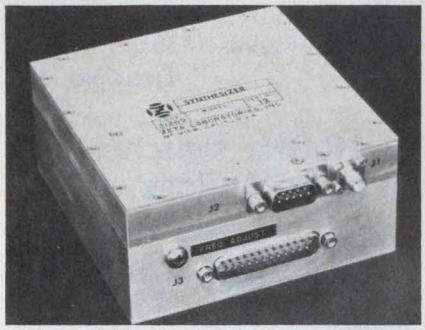
Active isolator offers 3-dB gain

Locus, Inc., Box 740, 1517 Science St., State College, PA 16801. (814) 237-0301. $700; 30-60 days.

Model RF458C active isolator provides 15-dB isolation over its 500-MHz-to-2-GHz bandpass, and it comes in a package measuring 0.94 × 1.5 × 2.13 in. The unit has +3-dB gain and operates with an output power of +25-dBm at 1-dB gain compression. Second-order harmonics are more than 25-dB down at +25-dBm output power.

CIRCLE NO. 376

Synthesizer covers Tacan band



Zeta Laboratories, 616 National Ave., Mountain View, CA 94043. $4500; 60 days.

Model 6595 frequency synthesizer, for use in the 962-to-1213-MHz Tacan band, provides a minimum output of 10 mW. It is tunable in 1-MHz steps with 250-μs switching time (20-μs switching is also available) from a TTL or MIL-STD-291 input. Spurious outputs are at least 80 dB below the carrier. The 6595 occupies 40 cubic inches.

CIRCLE NO. 377

SPDT switch/driver comes in flatpack

LRC, 1001 Digital Dr., Hudson, NH 03051. (603) 883-9351. $132 (1-9); stock to 4 wks.

A 3/8-in. flatpack holds a single-pole double-throw p-i-n diode switch and driver. The ISD 23702-FSA operates over the 50-to-400-MHz frequency range and has a switching speed of less than 5 μs. All rf lines have dc-signal blocks, and the driver input features TTL compatibility. Maximum VSWR is 1.3.

CIRCLE NO. 378

Optical guides limit loss to 20 dB/km

Fiber Communications, 391 Lakeside Ave., Orange, NJ 07050. (201) 678-8143. $2.25 per meter (500 to 1000-meter lengths); stock to 3 wks.

Optical fiber waveguide—called Fiberguide—has less than 20-dB-per-kilometer transmission loss at a wavelength of 0.8 μ. A multimode glass fiber, it's available in continuous lengths from 100 to 1000 m, and with a jacketing of EVA or PFA Teflon. Other features of the S20 series Fiberguide include step index profile, 0.16 numerical aperture and 1.45 core index of refraction. Outside fiber diameter is 90 μ.

CIRCLE NO. 379

100-mW osc comes in small package

TRAK Microwave Corp., 4726 Eisenhower Blvd., Tampa, FL 33614. (813) 884-1411. $370; 90 days.

The 1036/1037 series of 100-mW crystal-controlled oscillators provides frequency coverage from 60 to 1200 MHz. Designed for either PC board (1036 series) or base-plate mounting (1037 series), the oscillators have an accuracy at room temperature of ±0.0025% with stability rated at ±0.0025%. The oscillators measure as small as 0.69 × 0.67 × 0.49 in.

CIRCLE NO. 380

18-GHz sweeper outputs 25 mW

Weinschel Engineering, 1 Weinschel Lane, Gaithersburg, MD 20760. (301) 948-3434. Start at $17,500; 60 days.

The Model 4310A/K-P sweeper system delivers 25 mW with a ±1-dB maximum variation over the entire 10 MHz-to-18-GHz frequency range. The solid-state rack-mountable sweeper consists of a mainframe, series of rf oscillator plug-ins, plug-in interface unit and a multiband control unit. The system may be swept across the entire band at 0.83 GHz/ms. Frequency accuracy is ±1% at all sweep speeds.

CIRCLE NO. 381

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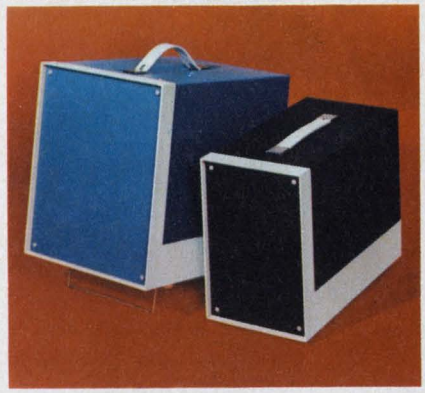

Bud Radio, Inc., 4605 E. 355 St., Willoughby, O. 44094, (216) 946-3200. Now in stock.

ShowCase — available at your Bud Distributor. Use as a desktop instrument case, in systems, racks or as a portable enclosure. Front, rear panels and bail included. Lightweight. Sturdy. Side gussets give additional strength. Recessed handles secured firmly into top for safe handling. Top, sides and bottom .060 aluminum; front panel, .090; rear panel, .050. Five accessory chassis. Two color combinations. For further information, phone —

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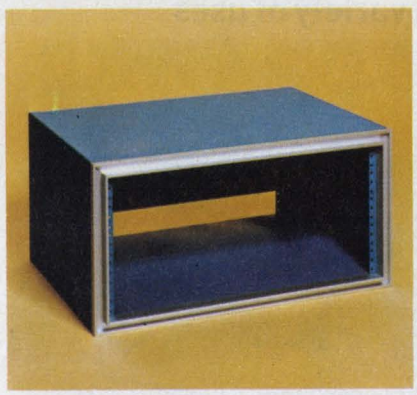

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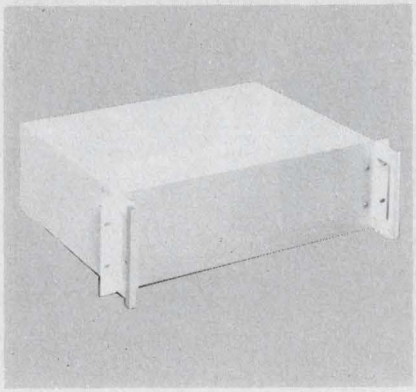

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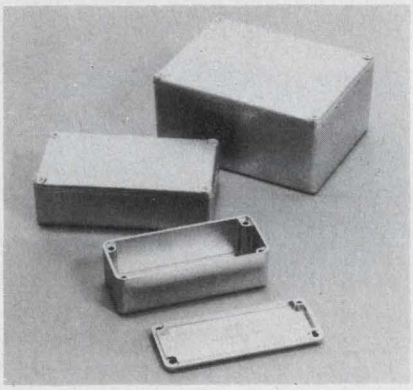

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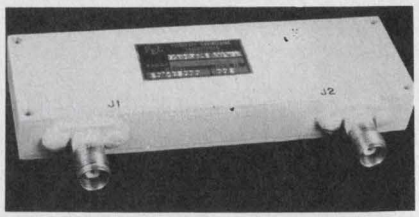


Frequency Engineering Laboratories, Farmingdale, NJ 07727. (201) 938-9221. $280 (5); 6-7 wks.

A series of broadband, fixed-tuned, bandpass filters handles high peak and average powers. Using a nine-stage combline structure and operating in L-band with SMA connectors, units can withstand more than 13 kW peak and 260 W average power. Typical specs for the SF20I-183 are a bandwidth of 1200 to 1400 MHz, insertion loss of 0.5 dB maximum. and rejection ratio of −40 dB minimum at both 1030 and 1090 MHz. VSWR is 1.3:1 maximum. The unit measure 5.25 × 1.63 × 0.72 in.

CIRCLE NO. 382

Low-power meter has 70-dB range

Boonton Electronics, Route 287 at Smith, Parsippany, NJ 07054. (201) 887-5110. $1210 to $1600; 12 wks.

The 42C series of rf microwattmeters can measure powers from 10 nW (−50 dBm) up to 100 mW —a 70-dB dynamic range. And units have 2-W overload tolerance. Three power detector heads are available, all with a lower frequency limit of 200 kHz and an upper one as high as 18 GHz. VSWR is less than 1.12 to 4 GHz, 1.18 to 12.4 GHz, and 1.28 to 18 GHz.

CIRCLE NO. 383

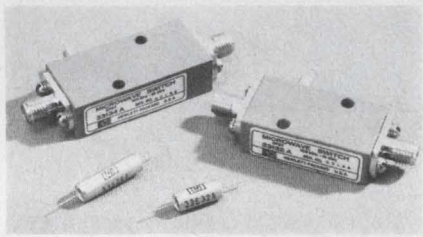
1-GHz linear amp delivers 4 W

Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121. $1695 to $2195; 90 days.

Two solid-state class A amplifiers are designed for instrumentation applications in the 0.5-to-1.0-GHz frequency range. Model 1404H provides a minimum gain of 28 dB with 2-W minimum linear power output and 3-W saturated power output. Model 1406H provides 30-dB minimum gain, 4-W minimum linear power and 6-W saturated power. Each unit contains an integral ac-to-dc regulated power supply, measures 10.1 × 14.5 × 3.9 in. and weighs 13 lbs.

CIRCLE NO. 384

0.1-18-GHz switches cut insertion loss



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $57.75 to $173.25 (25-99); stock.

Two SPST microwave switches reduce insertion loss in X-Band and Ku-Band by 20% over currently available types. Model 33132A is a complete two-diode switch with insertion loss of 1.8 dB maximum from 12.0 to 18.0 GHz. Model 33134A is a complete 4-diode switch with insertion loss of 2.3 dB maximum over the same frequency range. Coaxial switch module Models 33632A and 33634A are also sold separately. These SPST switches use p-i-n diodes in shunt across a 50-Ω transmission line. Although negative bias (−10 V) is required for lowest insertion loss, they may be operated at 0 V with somewhat higher loss. Control current for specified isolation for the 33132A and 33632A is 30 mA; control current for specified isolation for the 33134A and 33634A is 200 mA.

CIRCLE NO. 385

We'll never forget Janice.

Such a nice, quiet English girl.

Lover of Jane Austen, good music, country walks, big sloppy dogs and, of course, Jermyn customers.

For whom she slaved early and late to send off data, answer inquiries and put nice packages of DIP sockets and other Jermyn goodies on the UPS truck the same day she got the order.

Fact is, her tour of duty, as they say in the best British regiments, has come to an end.

Here's what we've done about it.

We've moved all the stock, all the data and all the famous Jermyn service over to the east coast.

And the guy to talk to is Steve Scorza.

No, of course he doesn't look like Janice.

He's more your rugged type, and he has a fantastic personality to rely on.

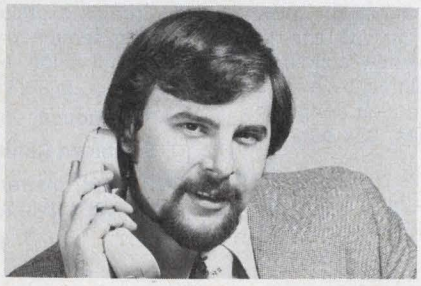
Plus a fantastic new Jermyn ultra low-profile socket, with six advantages of which no other brand has more than three.

If you're happy with your TI, Augat or Robinson Nugent low-profiles we're happy too, but you ought to see the Jermyn.

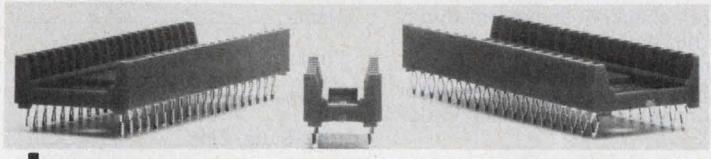
PS. Yes, we do have Janice's address, but not for publication. If you have an urgent message we'll happily pass it on, especially if it comes with an order.

INFORMATION RETRIEVAL NUMBER 91

This is Steve



And this is the new socket.
Call Steve on toll-free 800 431 1072 for details.



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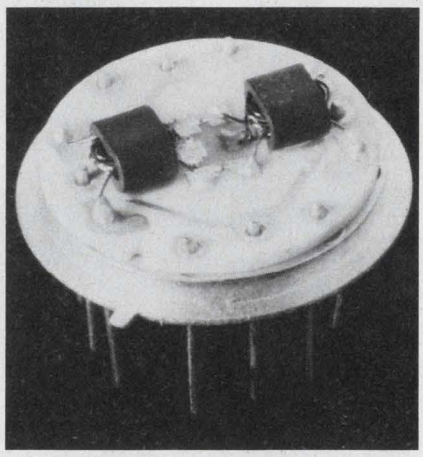
If/rf building blocks now in hybrid form

Raytheon Co., Quincy, MA 02169. (617) 899-8400. P&A: See text.

A family of i-f/rf broadband hybrid modules is available in either TO-8 cans or flatpacks (5/8 × 5/8 or 3/8 × 1/2 in.). These Hypak circuits are high reliability building blocks that can simplify and improve the design of i-f/rf systems.

Eventually the Hypak family will include most blocks required to build a high-performance receiver. Presently available units include: two-way power divider, double-balanced mixers, rf switches, three-way power dividers, modulators/mixers, 180° hybrid junctions, couplers, 90° quad hybrids and rf amplifiers. All of these hybrid circuits span a general frequency range of 5 to 1000 MHz with some



circuits up to 2000 MHz.

The use of thick-film hybrid circuits has resulted in an over-all (tested) reliability improvement from 10 to 20 to 1. Environmental tests include shock, vibration, centrifuge, moisture resistance, high-temperature storage and operating life, all in accordance with such documents as MIL-STD-202, 810, 750 and 883.

The same construction can be used for commercial grade circuits, but without the environmental screening and results in a 30% max, cost savings. The MTBF (mean-time-between-failures) for a typical Hypak is about 1×10^6 h and is 2×10^5 h for a functionally equivalent module.

Prices for Hypak modules, with full military screening, generally range from $30 to $100 per module, in lots of 1000. All modules are available "off-the-shelf," with deliveries ranging from 2 to 7 weeks.

CIRCLE NO. 301

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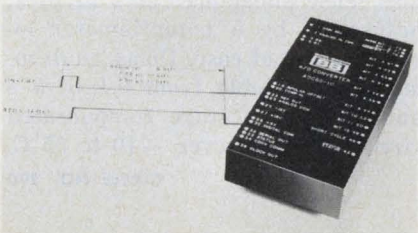
S/d module claims an MTBF of 250,000 hr

North Atlantic Industries, Terminal Dr., Plainview, NY 11803. (516) 681-8600. Under $500.

The LSI/85 synchro-to-digital converter module uses a custom LSI circuit that permits a 250,000 hr. MTBF rating for ground use. Resolution is 14 bits for the 400-Hz model and accuracy is 3 min. ±0.9 LSB. A 60-Hz version is also available, but an external transformer is needed. Accuracy for either model remains constant with velocity inputs as high as 1440°/s. The module requires supplies of ±15 V and +5 V and an external reference that can range from 26 to 115 V.

CIRCLE NO. 386

Fast a/d's available in 8, 10 & 12 bit models



Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. 1 to 9 prices: from $330 (8-bit); 2 wk.

The ADC60 series of modular a/d converters provides 1-to-3.5-μs conversion speeds for 8 to 12-bit resolution. Models are available for 8, 10 and 12-bit resolution and have a ±1/2-LSB maximum nonlinearity, no missing codes at 25 C and a guaranteed monotonicity over 0 to +70 C. Total accuracy drift for the 8 and 10-bit models is ±20 ppm/°C and ±15 ppm/°C for the 12-bit unit. Maximum conversion speeds and corresponding maximum linearity errors are 0.88 μs and ±0.2% for the 8-bit model, 1.88 μs and ±0.05% for the 10-bit, and 3.5 μs and ±0.025% for the 12-bit unit. All converters are complete with internal clock, reference and user selectable analog input ranges of ±2.5, ±5, ±10, 0 to +5, 0 to +10, and 0 to +20 V. The ADC60s are housed in 2 × 4 × 0.75-in. modules and require only ±15 and +5 V supplies.

CIRCLE NO. 387

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Exterior close-up of evaluation model. U.S. Navy photo.

INFORMATION RETRIEVAL NUMBER 102

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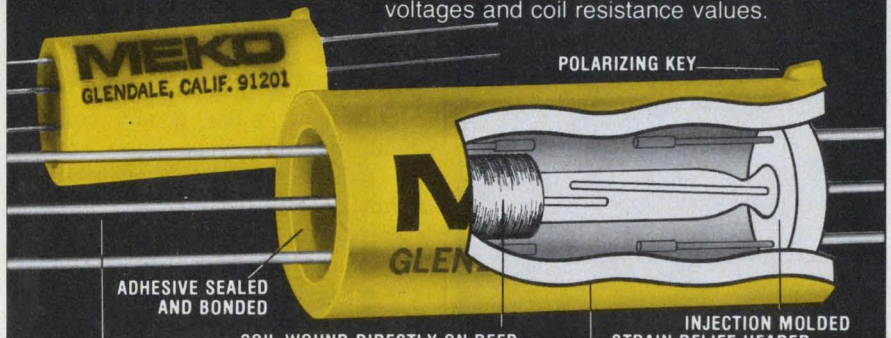

Available in DIP and encapsulated packages

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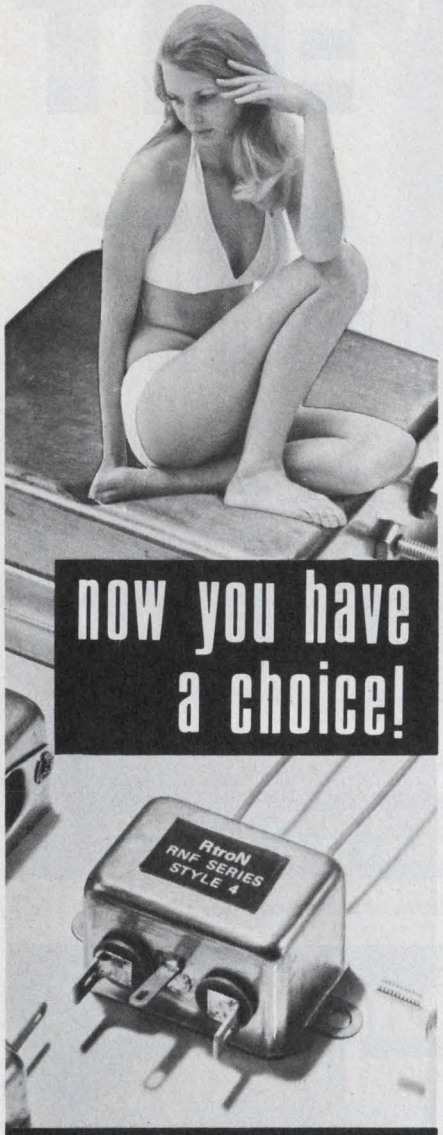

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(312) 679-7180

INFORMATION RETRIEVAL NUMBER 104

MODULES & SUBASSEMBLIES

Frequency synthesizer outputs 0.1 Hz to 16 MHz

Syntest, 169 Millham St., Marlboro, MA 01752. (617) 481-7827. $345.

The SM-102 frequency synthesizer module resolves to 5-1/2 digits. It has an output frequency range of 0.1 Hz to 16 MHz. This unit has a resolution of 100 Hz at its top end and frequency stability of ±10 ppm over 0 to 50 C. The BCD programming uses parallel TTL levels for frequency and range. On-board monolithic power regulation provides high isolation from external variables. The output signal is a TTL level set for a 50-Ω load. Power requirements are less than 5 W total. Size of the synthesizer is 6.5 × 4.5 × 0.75 in. and the PC connector is a 22-pin double-sided contact on 0.156 in. centers.

CIRCLE NO. 388

BCD-controlled one-shot offers variable delays

Technitrol, Inc., 1952 E. Allegheny Ave., Philadelphia, PA 19134. (215) 426-9105. Under $2000; stock to 4 wk.

The Model 2141 TTL/ECL-compatible one-shot system is a digitally programmable pulse module. It provides output pulses within 1 ns of selected time in a range of 20 to 1020 ns after a TTL or ECL trigger is applied. The new system also provides variable pulse widths from 15 to 1000 ns. Delay and pulse width are each controlled by three decades of remotely generated BCD inputs. Output pulses from the Model 2141 include: six ECL outputs that are pulse 1 and complement, pulse 2 and complement and difference pulse (pulse-2 — pulse-1) and complement; four Schottky TTL outputs are pulse 1 (low to high), pulse 2 (low to high) and difference pulse (pulse-2 — pulse-1) and complement. External trigger rate is 0 to greater than 15 MHz. Input impedance is 50 Ω and the insertion delay is less than 20 ns (including uncertainty of ±500 ps). Programming time is less than 100 ns and the worst-case jitter between leading and trailing edge pulse is ±200 ps.

CIRCLE NO. 389

Phase unbalance sensor protects motors

Diversified Electronics, P.O. Box 6231, Station B, Evansville, IN 47712. (812) 426-2806. $275 (ALMA), $300 (ALMR); 4 to 6 wk.

The SLB series of phase unbalance monitors detects phase unbalance, phase loss and phase reversal. If the phase unbalance exceeds a preset delay on drop-out, the output relay will de-energize. Model SLB-200-ALMA will reset automatically. On Model SLB-200-ALMR, a manual pushbutton will reset the monitor after conditions return to normal. On both models, an indicator lamp lights when the monitor has been tripped. The unit protects motors against "single phasing" and phase unbalance sensing as low as 2%. Sensing of very small (2%) unbalance eliminates problems caused by large motor back-EMF. The unit can also sense unbalances of 2 to 15%, adjustable by a potentiometer located on top of case. Delay on drop-out is adjustable from 0.1 to 5 s and the temperature compensated circuit is stable over —10 to 65 C.

CIRCLE NO. 390

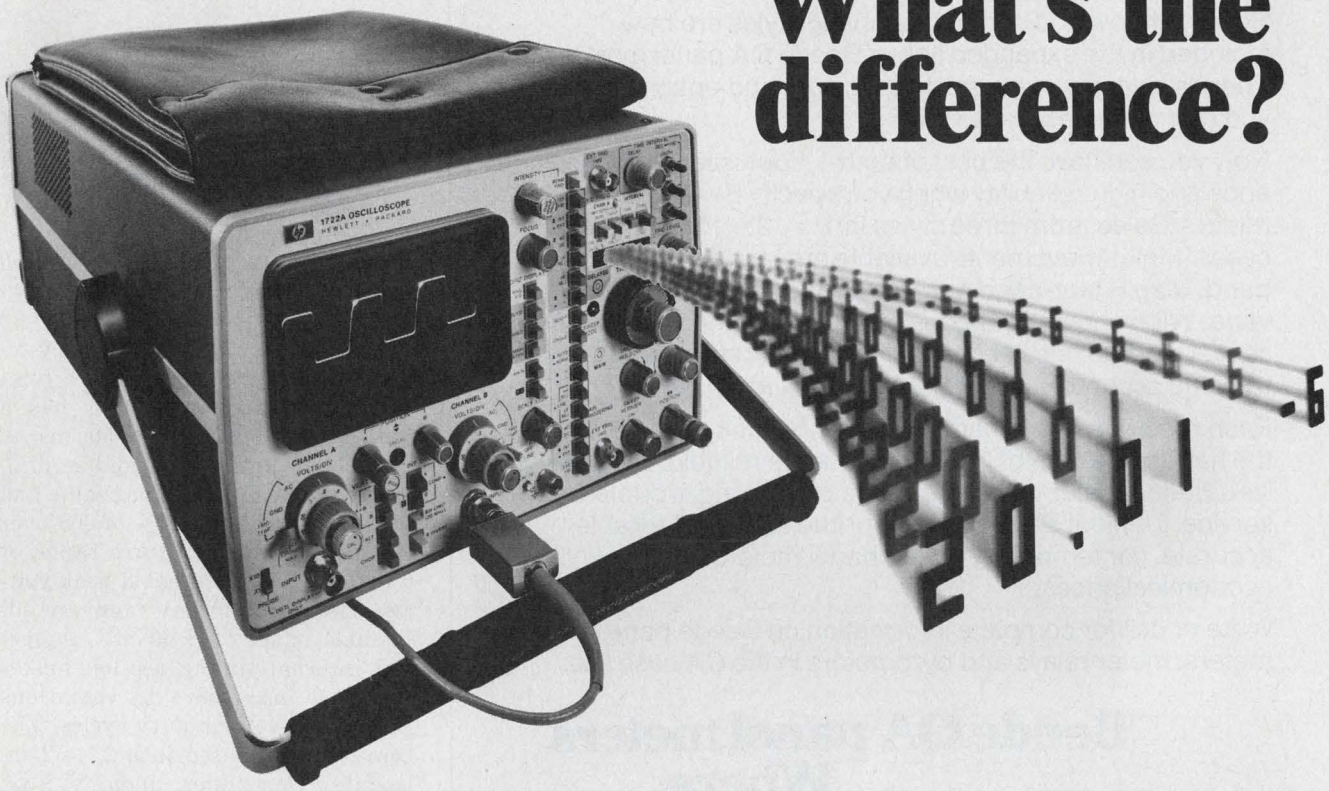
Variable speed controls have stepless operation

Minarik Electric Co., Krystal Controls Dept., 303 S. Wall St., Los Angeles, CA 90013. (213) 624-3161. From $12.40 (unit qty.); stock.

The Krystal Controls provide stepless speed variation for 90-V-dc permanent magnet motors as well as series wound motors. One group of units has an output of 0 to 90 V dc, 3 A and is designed for use with series-wound or permanent-magnet motors. Features include line voltage compensation and feedback, minimum and maximum speed adjustments and regulation adjustment. A second group runs series-wound ac/dc motors and has an output of 0 to 55 V dc, 115 V ac, 3 A. These units provide feedback at low speeds and minimum speed adjustment. A third group, for series-wound ac motors, delivers 0 to 105 V ac, 3 A, and features minimum speed adjustment.

CIRCLE NO. 391

Dual Delay...Single Delay What's the difference?

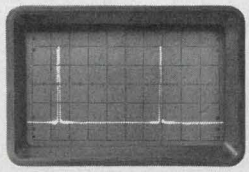


Only HP offers Dual-Delayed Sweep.

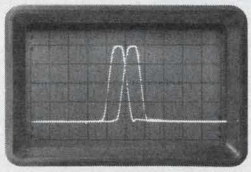
And with Dual-Delayed Sweep, the difference is... the end of graticule counting... the end of mental calculations... the end of remembering the time reference line... and the beginning of faster, more accurate scope measurements.

A scope with single delay just can't compete in terms of speed, accuracy, and repeatability. Here's why: 1) Dual-Delayed Sweep cancels amplifier and CRT nonlinearities for greater accuracy. 2) There's no time reference line to adjust to. You simply set two intensified markers or overlap two traces and read the value directly on the LED display. 3) You can preset the time interval on the LED display and adjust your system to meet specs by aligning traces with the intensified markers... saving time in production.

Are you making single trace measurements such as rise-times, pulse durations, periods? Simply adjust the two intensified markers to coincide with the points you want to measure between. Your time-interval measurement (in seconds) is displayed instantly on the LED readout.



Suppose you're making dual trace measurements such as propagation delays, dual-clock phasing, transmission line matching, and cable length measurements. Then you simply overlap the two traces. Again, your time interval measurement is displayed instantly on the LED readout.



There's only one Dual-Delayed Sweep. It's from HP. And you'll find it on this new 1722A scope with a built-in microprocessor and on our lowest cost 1712A with voltage scaling output for direct reading on an external DVM.

The 275 MHz 1722A is priced at $4,750* and gives you Dual-Delayed Sweep plus easier, more accurate measurements of frequency, instantaneous and dc voltage levels and relative amplitude. In all of these measurements, you get direct readout in the units of seconds, Hertz, volts, and percent. The microprocessor automatically keeps track of dial settings and position-control rotation.

You can even convert the 1722A (option 101) to do Logic State Analysis. Simply couple the 1722A to an HP 1607A Logic State Analyzer, and you're ready to tackle problems in the data domain.

The 1722A simply outperforms many scopes costing twice as much. It offers unmatched capabilities.

Let your local HP field engineer give you all the details. Call him today or write for our informative eight-page brochure and our six-page App-Note #186.

*Domestic U.S.A. price only.

HEWLETT hp PACKARD

086/1

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INFORMATION RETRIEVAL NUMBER 105

New case styles!

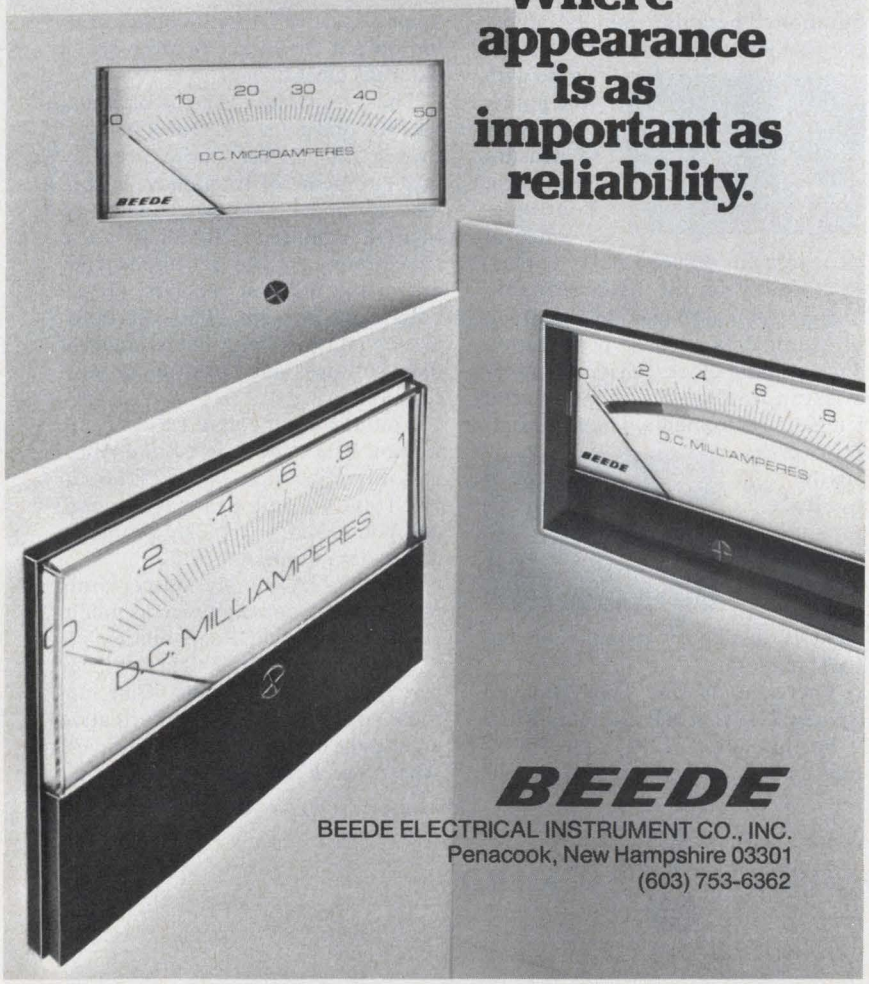
Bezel, window and surface mounting styles are now included in the expanded line of Beede QA panel meters. There's a variety of meter styles, colors and options to give you complete design flexibility.

Now you can have the best of both... sophisticated appearance *and* high reliability when you specify Beede panel meters. Select from three styles in 1½", 2½", 3½" and 4½" cases. Meter movements available are shielded bar taut-band, Mag B taut-band or pivot-and-jewel, and AC iron vane. Wide choice of options including multi-colored scales, special resistances, different calibration points, tracking accuracies to ±½% and many more.

Each meter has the smart, clean design look. And behind the handsome face of the QA case is the reliable, rugged-ized Beede meter you can depend on for long, trouble-free service. Think of Beede as your prime source of reliable, accurate, contemporary-styled panel meters at economical prices.

Write or call for complete information on Beede panel meters, meter relays and pyrometers in the QA case line.

Beede QA panel meters. Where appearance is as important as reliability.



BEEDE

BEEDE ELECTRICAL INSTRUMENT CO., INC.
Penacook, New Hampshire 03301
(603) 753-6362

INFORMATION RETRIEVAL NUMBER 106

F/v converter series has choice of tempcos

Dynamic Measurements, 2 Lowell Ave., Winchester, MA 01890. (617) 729-7870. See text; 2 to 4 wk.

The Model 9200 frequency-to-voltage converter series has a 0-to-1-kHz frequency range. It has a unit step response of 150 ms to ±0.1% of final value and nonlinearity of ±0.01% of final value and nonlinearity of ±0.01% of FS over its operating temperature range of 0 to 70 C. The 9200 has a peak voltage ripple of 20 mV and an adjustable offset of ±50 mV. A special internal timing section makes the 9200 insensitive to variations in input waveform duty cycles. The converter is housed in a 2 × 2 in. module. Depending upon V_{fs} vs. temp, the 9200 (±150 ppm/°C) costs $51, the 9201 (±30 ppm/°C) $59 and the 9202 (±10 ppm/°C) $67.

CIRCLE NO. 394

Telephone-tone circuits cover all needs

Beckman Instruments, Helipot Div., 2500 Harbor Blvd., Fullerton, CA 92634. (714) 871-4848. Under $150 (100-sets); stock to 8 wk.

The Series 883 hybrid circuits are designed for central office tone receiver applications. The circuits meet Bell System performance requirements. Circuits in the series include a dial tone reject filter, a high-band filter, a low-band filter, a dual limiter, eight tone filters and quad detectors. Each filter circuit is functionally laser trimmed to meet stringent performance requirements for twist, wide-input-amplitude range and proper tone decoding in the presence of speech, noise or dial tone. Each model is available on a stand-alone basis, on a tone-receiver set basis, or in a complete PC-board mounted configuration.

CIRCLE NO. 395

INFORMATION RETRIEVAL NUMBER 107 ►

HIGH VOLTAGE — 10 sizes, up to 17.5 KV, up to 1000M, as low as 100 PPM/°C.

FLATSO — 4 sizes up to 20 KV, up to 300M, ½, ¼, 1 and 2W. Tolerances, 1, 2, 5 and 10%.

NETWORKS — Discrete resistors matched in Temperature Coefficient, Tolerance and/or Ratio.

CHIPS — 7 sizes with values ranging from 10 ohms to 2 M.

CUSTOM NETWORKS — Sure, the Pyrofilm Thick Film Resistor Line is broad . . . but there are times when you have a unique set of requirements. That, too, is the time to talk to Pyrofilm. For descriptive literature, write to: Pyrofilm, 60 South Jefferson Road, Whippany, N.J. 07981 or call (201) 887-8100.

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PYROFILM

THICK FILM RESISTORS COME IN MANY SHAPES

Proximity sensor works with all metals

Micro Switch, 11 W. Spring St., Freeport, IL 61032. (815) 232-1122. $6 large qty.; stock.

The XK self-contained solid-state sensor uses the eddy current principle to respond to ferrous and nonferrous metal-foil targets. The unit is sealed and measures just over an inch long. It can handle up to 1000 operations/s and can deliver 6 to 16 V dc to logic level loads. The XK operates over a −40 to +125 C (−40 to 257 F) range and switches consistently at a 0.06-in. distance throughout that range. Push-on or lead-wire termination is available and slots along the sides will accept #4 mounting screws and permit 0.14-in. position adjustment.

CIRCLE NO. 396

Open board timer has 0.5-to-480-s delays

Omnetics Inc., P.O. Box 113, Syracuse, NY 13211. (315) 699-5262. From $6.56; 10 day to 2 wk.

The series MOR, UL recognized, open board time-delay relay features factory-fixed or adjustable time delays from 0.5 to 480 s. The units can operate from ac and dc, voltages from 24 to 240 V and have normally closed or normally open configurations. Contacts are rated at 5 A, or 1/6 horsepower at 120 V ac. Repeat accuracy is ±2% and the expected mechanical life of the device is said to be over 1,000,000 operations. Full-load life is rated at 500,000 operations.

CIRCLE NO. 397

Module converts digital angles into voltages

C & A Products, 37-12 58 St., Woodside, NY 11377. (212) 779-4303. $750; stock to 4 wk.

The DT320 module is a miniature converter that changes digital angle data into a pair of dc voltages that are proportional to the sine and cosine of the digital angle input. The module is designed for applications that require polar to rectangular conversion or digitally generated radar PPI displays. Inputs of 13-bits binary, or four-decade BCD (359.9°) can be handled by the module while the outputs represent 10 sin θ and 10 cos θ V dc.

CIRCLE NO. 398

Miniature amplifiers have 5 to 400 MHz bw

Aydin Vector, P.O. Box 328, Newtown, PA 08940. (215) 968-4271. Under $30.

Two miniature-sized, TO-12 packaged transistor amplifiers, the Models GA1 and GA2, have a frequency response from 5 to 400 MHz. Their gain is insensitive to input voltage variations of from 10 to 15 V. The operating temperature range of the amplifiers spans a −55 to +100 C range. Other specifications include: gain, 13 dB min.; flatness, 1 dB; noise figure, 4.5 dB (GA1), 6 dB (GA2); VSWR (50 Ω), 2 in and out; and input power, 15 V at 10 mA (GA1), 15 V at 24 mA (GA2). Either unit weighs 1 gram.

CIRCLE NO. 399

Modular power driver delivers up to 5 A, peak

Electronics Research Group, 22 Mill St., Arlington, MA 02174. (617) 646-9760. $29.95 (10-up); 2 wk.

The 303D is a high-power transconductance operational driver. The unit operates with supplies of up to ±50 V and can deliver 5-A peak output current. It dissipates 20 W at 25 C, still-air ambient. The 303D is essentially a high-power version of the smaller, monolithic power drivers such as the Signetics SE540 and the Motorola MC1438. The unit connects with a standard, 10-finger PC edge connector. It is mounted to its own heat sink, and measures 1-13/16 × 5-1/8 in.

CIRCLE NO. 400

Voltage comparators deliver up to 100 mA

Calex Mfg., 3305 Vincent Rd., Pleasant Hill, CA 94523. (415) 932-3911. $12 (100-up); stock to 2 wk.

The Model 540 Voltsensor is a voltage comparator designed for rough industrial environments. It has a fully protected input and output, 100-mA output rating, and is housed in a rugged 1.4 × 0.6 × 0.5-in. case. The comparator plugs into any 16-pin DIP socket, hysteresis and latching can be externally programmed by pin connections, and requires power from a dual supply of ±5 to ±16 V, or from a single 5-to-32-V supply.

CIRCLE NO. 401

Ise introduces five new ways to make the competition turn green.

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.

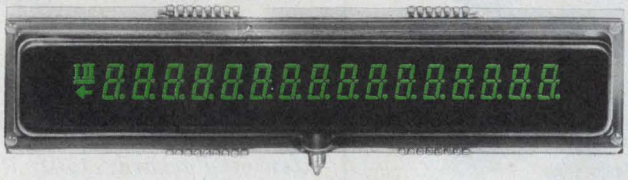
itron®

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

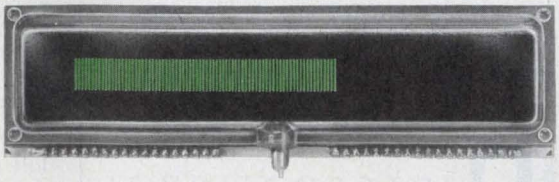
ef = 5.5V
ec = eb = 35Vp-p
ic = 8mAp-p
ib = 6.5mAp-p
Wd. 140mm
Lg. 59mm
Segment 25mm

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 = 55V
ec = eb = 35Vp-p
ic = 4mAp-p
ib = 0.2mAp-p
Wd. 140mm
Lg. 40mm
Segment 8mm

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INFORMATION RETRIEVAL NUMBER 109

DC/DC CONVERTERS

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Actual Size

Not your usual DC/DC converters...

the lowest noise DC/DC converters–

Quiet Q Series

Ideally suited for powering DACs, ADCs, and linear circuits. These low profile modules, with outputs to 3 watts, incorporate a high performance π input filter as well as SCI's unique converter design and regulation techniques . . . The result is a guaranteed output ripple of <5mV p-p.

Model 30C5-15D100Q — $5V_{in}$, ±15V @ 100mA out — $74.95 (1-9).

Other input and output ratings are also available. For full information, contact Ron Garmon at 617-373-9104.

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INFORMATION RETRIEVAL NUMBER 110

Built to work no matter how you use it.

The Crown 800 ¼" mag tape transport is rugged[1], computerized[2], professional[3] and adaptable[4]. It's designed, built and one-by-one tested by people who are good at their jobs. It will work exactly the way you expect. No glitches.

Good design and careful fabrication are the reasons why the 800 transport works in many different systems. Audio record/playback systems. Data recording. Program origination.

If your latest project includes ¼" mag tape capabilities, ask Crown to explain the 800 transport.

crown INTERNATIONAL

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1. ¾" thick aluminum front plate. Anodized or plated metal parts. Only 10 moving parts. All subassemblies are plug-in.

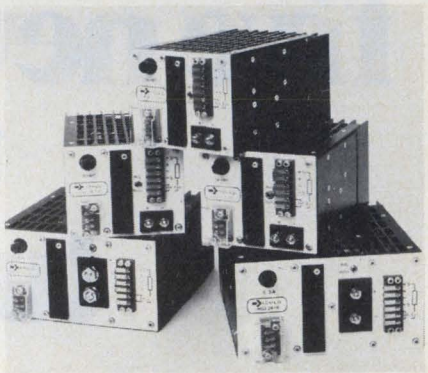
2. Logic circuit automatically sequences transport, regardless of command sequence, to prevent tape spill or breakage. Remotable.

3. Three motor drive. DC braking. Automatic end-of-tape braking. 19" rack mount. Wow and flutter 0.09% @ 7½ ips guaranteed maximum.

4. Heads independently mounted — can be easily changed. 4ch, 2ch or mono. Build your own electronics or order from Crown. Crown will customize. Variable speed drive available.

INFORMATION RETRIEVAL NUMBER 111

Switching supplies work above 30 kHz



Allied Control Div., Gould Inc., 100 Relay Rd., Plantsville, CT 06479. (203) 628-9654. Prices range between $250 and $400; stock-4 wks.

A new line of switching-regulator power supplies, MG Series, is available in ratings of 5 to 24 V dc at 10, 20, 40 and 60 A. MGT triple-output model is available at 5 V dc with 20-A main output and either ±12 or ±15-V auxiliary outputs. Switching frequency is greater than 30 kHz. Other specs include: regulation of 0.1% max for 100% load change and ±10% line change, ripple of 10 mV rms, 50-mV pk-pk max; and a tempco of ±0.01%/°C. Various protection is offered.

CIRCLE NO. 402

Switching supply offers brownout protection

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $375; 6 wks.

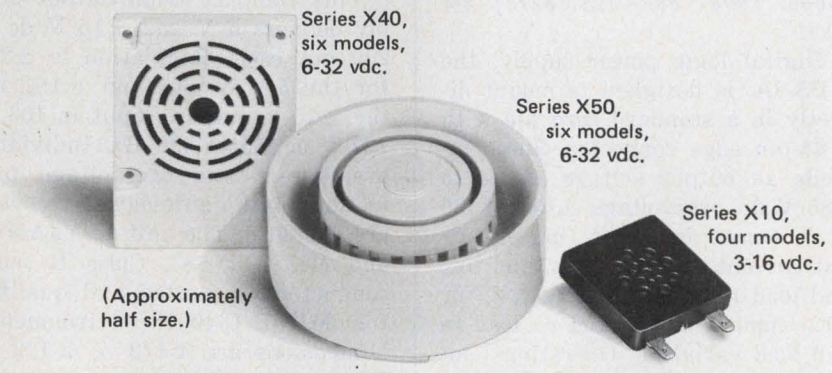
Model 63005C switching-regulated modular supply is designed to power OEM data processing equipment and features brownout protection with input voltages ranging from 87 to 127 V ac or 180 to 250 V ac. The unit is regulated to 0.1% with ripple and noise of 5 mV rms, 40 mV pk-pk (20 Hz to 20 MHz). It will supply 22 A at 5-V continuous output from 0 to 40 C. Linear derating is 0.37 A/°C from 40 to 70 C. Output can be shut down by a TTL control signal or a contact closure. Another feature is the delay (20 ms) in loss of dc output voltage following ac power failure or transients.

CIRCLE NO. 403

WE'RE WARNING YOU...

. . . loud and clear. You'll get more attention with these exceptional new piezo crystal solid state audio indicators. Many models to choose from. Series X10 (continuous tone) or Series X11 (pulsing) with pins, wires, or fastons, for computer terminals, remote control fault detection devices . . . Series X40 for panel-type home or factory warning and alarm systems . . . Series X50 for all types of fire, security and backup alarms. Some models rated to 85 dBA at ten feet.

Write for complete specifications and application data.



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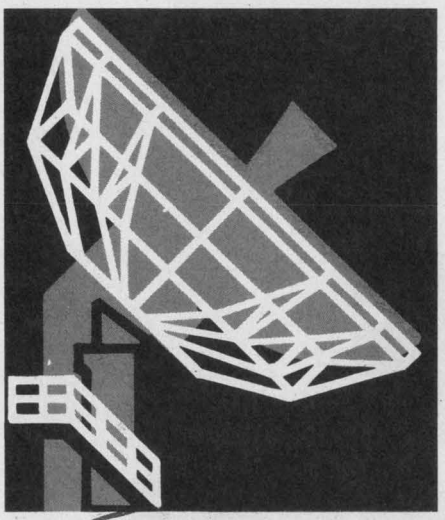
INFORMATION RETRIEVAL NUMBER 112



We go to great lengths and give you unbeatable SWR

Our SWR specs are the best in the business— now less than 1.07 from 200 kHz to 1 GHz, 1.18 to 12.4 GHz, and 1.28 to 18 GHz. With virtually no limitation on detector cable length, the programmable Series 42C microwattmeters are as accurate at 3,000 ft. as at 3. Measure from −50 to +20 dBm with negligible drift—and at a price you can afford. Choose from our analog Model 42C, digital Model 42CD or, for field use, the analog-battery Model 42CB. Analog models have power and dBm scales; digital offers 3½ digit LED display for power plus optional autoranging and 4-digit dBm display with 0.01 dB resolution. For full details or a demonstration, contact: Boonton Electronics Corp., Rt. 287 at Smith Rd., Parsippany, N.J. 07054; (201) 887-5110.

BOONTON

INFORMATION RETRIEVAL NUMBER 113

POWER SOURCES

Lithium battery offers 25 A-h at 1 A

Power Conversion Inc., 70 MacQuesten Pkwy. South, Mount Vernon, NY 10550. (914) 699-7333. Less than $6.00 (OEM quantities); stock-2 wks.

Model 660-5 lithium primary cell can provide 25 A-h at 1-A drain for an energy density of 135 Whr/lb. The unit is the latest addition to the company's line of Eternacell lithium batteries characterized by a shelf life greater than five years; low temperature performance to −65 F; highest energy per unit weight and volume of any type battery; 2.8-V nominal operating voltage (double that of ordinary batteries); and a high-rate discharge performance. This new battery is 1.64 in. in diameter, 4.5 in. high and weighs 7.8 oz.

CIRCLE NO. 404

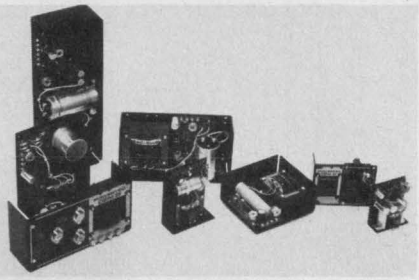
Logic supply mounts in standard card file

Wyle Computer Products, 3200 Magruder Blvd., Hampton, VA 23666. (804) 838-0122. $115; 2-4 wks.

Digital logic power supply, the MPS-2A, is designed to mount directly in a standard card file with a 44-pin edge connector. Specs include an output voltage of 4.4 to 5.85 V dc, overvoltage cutoff of 6.6 V dc (max) in 11 μs (max), output current of 2.5 A max, and line and load regulation of ± 2 μV, for 10% input changes and no load to full load variation. Operating temperature range is 0 to 70 C.

CIRCLE NO. 405

Open-frame units offer wide choice of models

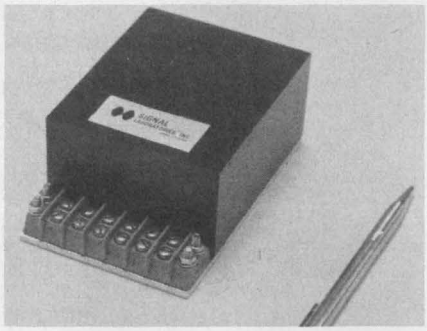


Powertec, Inc., 9168 De Soto Ave., Chatsworth, CA 91311. (213) 882-0004. Start at $24.95; stock.

Designated OEM II, these open-frame dc sources offer new case sizes and models and are redesigns that provide even higher efficiency and lower primary power consumption than the original series. OEM II offers 30 single-output models with 70 different outputs to choose from, plus 24 multiple-output models, including both duals and triples. In all, 16 case sizes are offered. Model 2A is said to be the smallest open-frame dc supply in the industry (1.28 × 2.15 × 3.78 in.).

CIRCLE NO. 406

Compact source provides 3 outputs

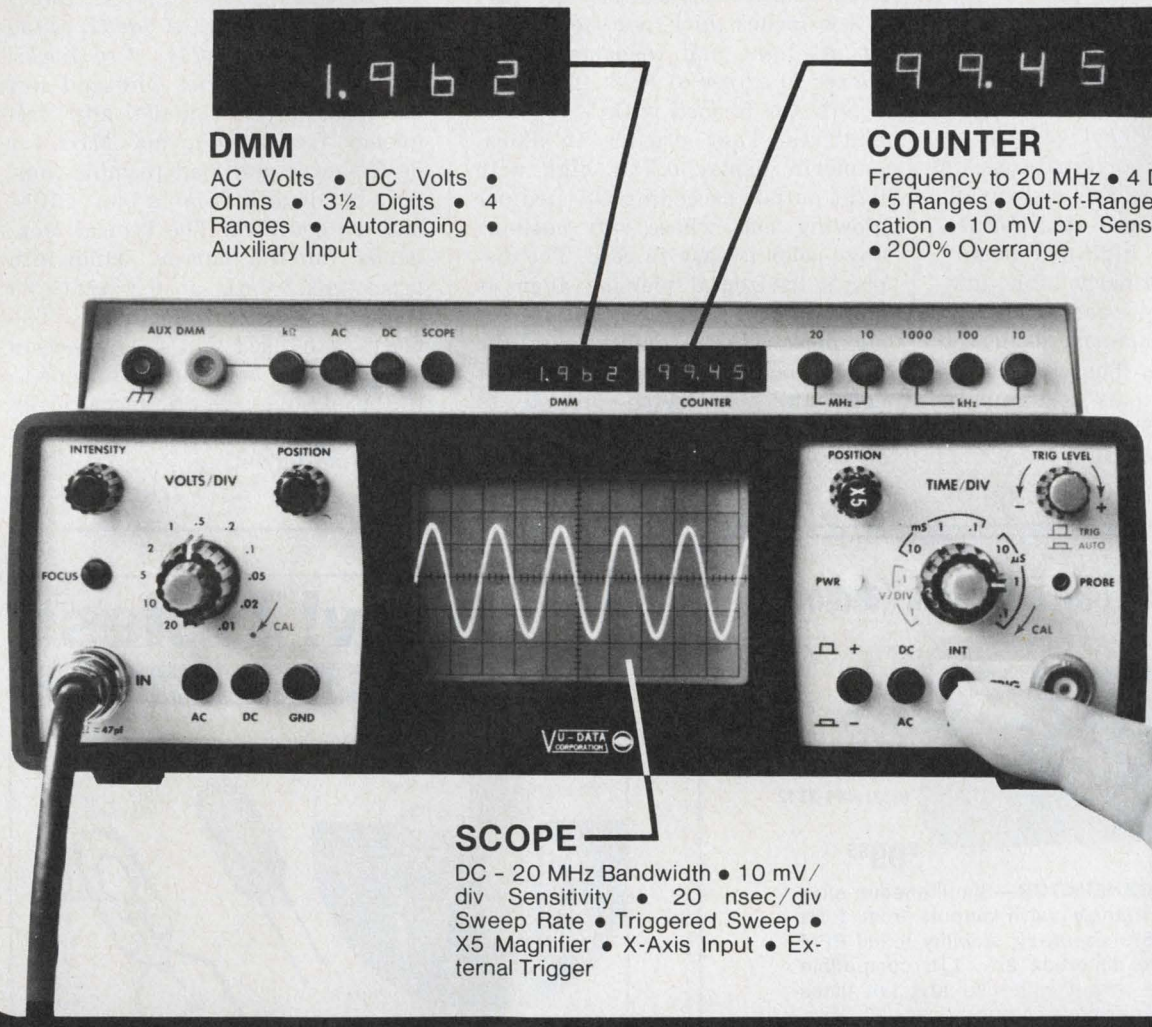


Signal Laboratories, 202 N. State College Blvd., Orange, CA 92668. (714) 634-1533. $495.

This compact triple-output supply delivers 5 V and ±15 V dc at 200 mA each. Regulation is ±2% for the 5-V output and ±1% for the ±15-V output. Input is 103 to 127 V ac, 55 to 420 Hz. Individual overcurrent and overvoltage protection with automatic recovery are standard. The unit uses JANTZ and MIL-STD-883, Class B semiconductors, is potted and qualifies for MIL-E-16400F environments. Dimensions are 4-1/2 × 2-1/2 × 2 in.

CIRCLE NO. 407

This mini-scope measures up . . .



DMM

AC Volts • DC Volts • Ohms • 3½ Digits • 4 Ranges • Autoranging • Auxiliary Input

COUNTER

Frequency to 20 MHz • 4 Digits • 5 Ranges • Out-of-Range Indication • 10 mV p-p Sensitivity • 200% Overrange

SCOPE

DC - 20 MHz Bandwidth • 10 mV/div Sensitivity • 20 nsec/div Sweep Rate • Triggered Sweep • X5 Magnifier • X-Axis Input • External Trigger

CONVENIENCE . . . is the key to efficient operation in today's mobile test environment. Never before has the coordinated measurement capability provided by Model PS915/975 DMM - Counter - Mini-scope been offered in a single instrument. These three functions comprise the industry's basic measurement tools, and they can be employed simultaneously as complements to one another using but a single probe. Also, they can be operated independently with separate inputs. And each measurement function has its own dedicated display.

In addition, it is AC, DC or battery operable, weighs only 10 lbs., and fits in a tool kit or briefcase Excellent reliability and serviceability are backed by a TWO YEAR parts warranty.

• Interested in this "visual trouble shooting tool" ? Call Hal Wardein at (714) 279-6572, or write to us at 7170 Convoy Court, San Diego, California 92111.

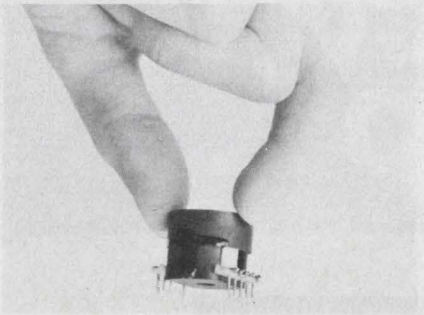
From a Leader in Mini-Portable Oscilloscopes

V U-DATA CORPORATION

Model PS915/975 DMM - Counter - Mini-scope $1250*
Model PS915 Mini-scope $825*
*U.S. Sales Price, F.O.B. San Diego, California

INFORMATION RETRIEVAL NUMBER 114

Pot cores handle 50 W, provide 10 terminals



Ferroxcube Corp., 5083 King's Highway, Saugerties, NY 12477. (914) 246-2811.

"Touch Tone" pot cores, so named for their original use in telephone systems, are now available in a manganese-zinc ferrite, 3C8 material for high-flux-density applications. Formerly for low-power use, the new cores can now be used for transformers in the 10-to-50-W range. The cores come with 10-pin terminals in a square-format bobbin that needs less space than standard units.

CIRCLE NO. 410

Alphanumeric displays deliver moving messages

Burroughs Corp., P.O. Box 1226, Plainfield, NJ 07061. (201) 757-3400. $85 (1000 up).

Self-Scan II panel displays can be configured with 20 to more than 1920 characters, yet they are only a few inches thick, are viewable in bright light and readable at distances in excess of 50 ft. The characters are formed with 5 × 7 dot matrices. They provide an alphanumeric display 0.7-in. high with light output exceeding 300 μcd per glowing dot, whose soft neon-orange color is easy to read. The display's horizontal viewing angle is more than 150 degrees. Suitable for moving-message applications, the panels have been designed to abut horizontally and stack vertically to enable 24 lines of 80 characters to be mounted in a 4-by-5-ft frame.

CIRCLE NO. 411

Bandpass filters handle 100 to 500 MHz

TT Electronics Inc., 2214 S. Barry Ave., Los Angeles, CA 90064. (213) 478-8224. Typical $59; 2 to 3 wks.

The new T series vhf and uhf bandpass filters handle any frequency from 100 to 500 MHz for 50-Ω source and load terminations. Any bandwidth from ±1 to ±10% may be specified. The typical stopbands for the narrow bandwidth types are 30 dB at 0.8 and 1.35 times the center frequency. The filters are used for the rejection of harmonics and noise adjacent to the passband. Their hermetically sealed steel cases are designed for PC board mounting.

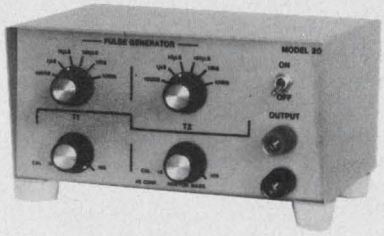
CIRCLE NO. 412

TWO FOR THE PRICE OF ONE (almost)!

A. E. CORP.
P.O., Box 63
Newton, MA 02161
(617) 449-3142

$89.95

FUNCTION GENERATOR—Simultaneous sine, square and triangle wave outputs from 1 Hz to 1 MHz ±5% accuracy, stability ±200 PPM and sinewave distortion 2%. TTL compatible square wave output with rise and fall times 100 nsec. Adjustable output 0 to 20 Vpp. 105-125 VAC 5 Watts.



$79.95

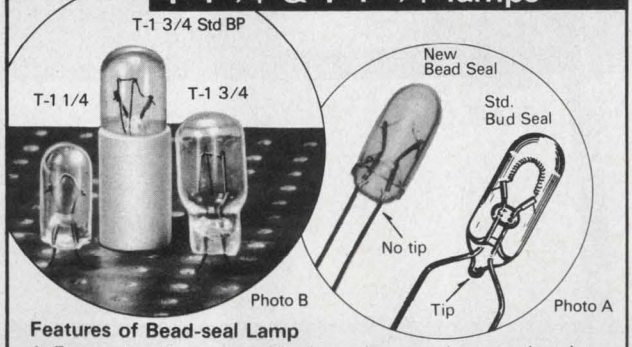
PULSE GENERATOR—Pulse width continously adjustable from .1 sec to 100 nsec. (5 Hz to 5 MHz Frequency Range) with 20 nsec rise and fall times, 0 to + 5 volts output (10 TTL fanouts). Input power 105-125 VAC 60 Hz at 5 watts. Size 6" x 4" x 3" and weight 1 lb.

15 DAY FREE TRIAL PERIOD

INFORMATION RETRIEVAL NUMBER 115

New! Tipless

T-1 1/4 & T-1 3/4 lamps



Features of Bead-seal Lamp

1. Easy to handle ..... No sharp tips anywhere on the glass bulb help prevent breaking of seal (Photo A).
2. Saves lamp space ..... Maximum overall length shorter than other similar lamps provide a high degree of design freedom.
3. Saves PC board costs... Can be mounted directly to PCB, the same as Bi-Pin lamps (Photo B).
4. Increased reliability..... Stronger seal, Higher vacuum level, Tighter filament mounting.
5. Abundant types ..... Up to 60V lamps in the same size bulb are available, even for T-1 1/4 size.

SUBMINIATURE LAMP SPECIALISTS

• Ask informations to:

WAMCO Technical Sales, Inc.
705 W. 16th Street, Costa Mesa, California 92627 TEL: (714) 833-9361 TELEX: 678459

OSHINO ELECTRIC LAMP WORKS, LTD. TOKYO, JAPAN

INFORMATION RETRIEVAL NUMBER 116

Chances are, we already have the packaging you want. That's the beauty of our single-chip design and packaging concept: freedom of choice. Because our ultra-low $V_{CE\ (SAT)}$ modules are pre-rated, pre-tested and inventoried, we can put them in any package to meet any need...help you optimize size, weight and performance *without* long lead times for custom packaging. Whether you need 5 or 500 pieces, we'll welcome the opportunity to discuss your special needs. For application notes and further information, call Sales Engineering, PowerTech, Inc., 9 Baker Court, Clifton, N. J. 07011; (201) 478-6205.

TYPICAL PACKAGE SELECTIONS		
I_C	P_D	TYPE
1200A	2100W	PPS 1200
500A	625W	PP 500
250A	325W	PPS 250
150A	325W	TO-114
90A	325W	TO-63

Copper grid distributes current most efficiently for lowest V_{ce} (sat).

Two choices: 570 mil diam. or 820 mil diam. single chips!

Void-free bonding techniques eliminates hot spots.

Integral solid copper leads and heat sink make pre-bond chip tests and inventory possible.

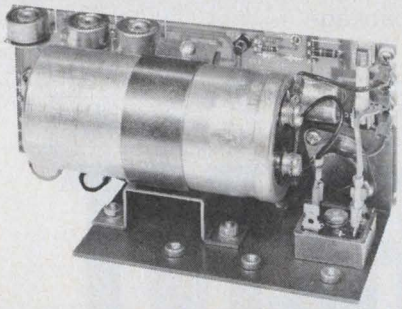
All packages are solid copper.

HIGH CURRENT TRANSISTOR PACKAGING UNLIMITED

PowerTech, Inc.
"BIG IDEAS IN BIG POWER"

INFORMATION RETRIEVAL NUMBER 117

Customized power supplies at unaccustomed prices.



Power/Mate presents the sub-modular MS Series.

Power Mate created a breakthrough by breaking the power supply into sub-modular elements. Then they standardized the whole system for easy adaptability and speedy design which makes the MS series more economical than anything before it.

The system consists of 48 different models in 8 package sizes, to create an unlimited number of either single or multiple power configurations.

All feature built-in over-voltage protection, current limiting overload protection, adjustable controls for voltage and protective functions, and the electronics necessary for filtering, regulating and rectifying.

In addition, these tough little units are UL recognized.

The Cost? Prices start at a mere $25.00. So you get a customized power system at a very unaccustomed price.

For more information call or write:

PMC

Send for catalog describing 32,500 other models.

POWER/MATE CORP.

World's largest manufacturer of quality power supplies.

514 South River Street/Hackensack, N.J. 07601/Phone (201) 343-6294 TWX 710-990-5023

INFORMATION RETRIEVAL NUMBER 118

NEW! INSTANT FREQUENCY DIFFERENCE!

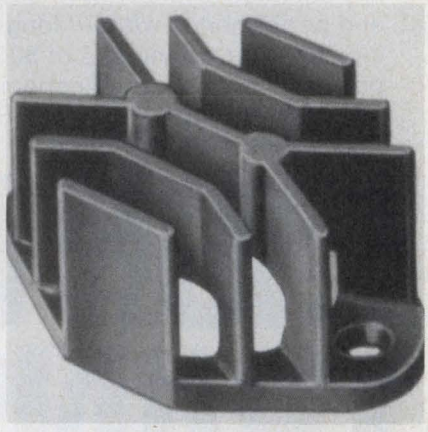
Tracor Model 527A measures frequency difference instantly, precisely. For precisely $2,950. Front-panel meter reads directly to parts per 10^{11}. Allows adjustment of two oscillators to the same frequency, adjustment to a specific offset, determination of offset — all instantly. Plus both short-term and long-term stability analysis. Internal oscilloscope extends precision to 1 x 10^{-12}. Reference and signal frequencies need not be the same. Write or call for full technical and application information.

Tracor Industrial Instruments

6500 Tracor Lane • Austin, Texas 78721 • AC 512/926-2800

INFORMATION RETRIEVAL NUMBER 135

Heat sinks for TO-3 cases clamp right to package



DAU Ltd., 42 A Main Rd., Barnham, Bognor Regis, West Sussex, PO22 OES, England.

The AKK-191 and AKK-127 are die-cast to TO-3 heat sinks. They can be clamped over the top of the TO-3 case. The heat sink comes in two heights: 19.1 mm for the AKK-191 or 12.7 mm for the AKK-127. Thermal coefficients for the heat sinks are 12 C/W or 14 C/W. respectively.

CIRCLE NO. 413

Thick-film compositions have Rs up to 1 MΩ/sq.

DuPont Co., Public Affairs Dept., Wilmington, DE 19898. (302) 774-2358. $3.10 to $3.35 gram.

The "Birox" 1500-Series of thick-film resistor compositions is claimed to be the only available resistor compositions with a resistance tempco of less than 50 ppm/°C across the full resistivity range. Contact resistance variation of the 1500-series resistors is less than 0.1% across the full resistivity range with brush-type wipers. Resistors made with the 1500-Series compositions can meet the following military specifications: Contact Resistance Variation, MIL-R-22097, Contact Noise, MIL-R-27208 and Rotation Life, MIL-R-22097C. The series offers five compositions with sheet resistivities of 100 Ω/sq. to 1 MΩ/sq. Processing conditions are: Screen printing to a dried-film thickness of 25 microns and firing in air to a peak of 850 C.

CIRCLE NO. 414

New 32D permanent magnet fhp motors and 32D-5F right angle gearmotors join the growing Bodine PM family.

Perfectly matched with Bodine's PM controls, 32's offer the same performance characteristics as the 42's—in a smaller package. Only 3.55"in diameter. Built for high starting torque, low speed operation, and a high degree of control, the new systems have continuous duty motor ratings of 1/12, 1/10 and 1/8 Hp at 2500 Rpm. New right angle gearmotors are available in six standard ratios.

All PM systems have grounding provisions for safe operation. Bodine PM motors are totally-enclosed, nonventilated and reversible.

Optional "L" bracket mounting kits, terminal endshield kits, and other accessories are available. Bodine also offers D-C motors for use with your own controls. See your Bodine Distributor or write for Catalog CDC-PM.

Contact Bodine Electric Company, 2500 W. Bradley Pl., Chicago, IL 60618. Phone (312) 478-3515.

Bodine's PM drive systems family is growing...smaller.

We've added 2 new 32-frames

42D-E Parallel Shaft Control Gearmotors
Torques through 350 Lb-in.

DPM Controls—
Encased type.

DPM Controls—
Chassis type.

42D Control Motors
1/8 through 1/4 Hp at 2500 Rpm.

32D Control Motors
1/12 through 1/8 Hp at 2500 Rpm.

32D-5F Right Angle Control Gearmotors
Torques through 55 Lb-in.

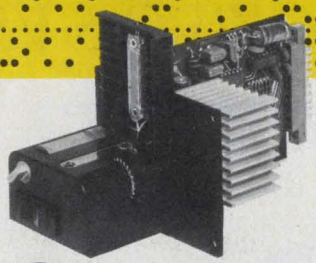
ADE (After Delivery Economies) make Bodine a better fhp buy

INFORMATION RETRIEVAL NUMBER 119

BODINE ELECTRIC COMPANY

BODINE MOTORS
GEARMOTORS
SPEED CONTROLS

$250 PHOTOELECTRIC PAPER TAPE READER



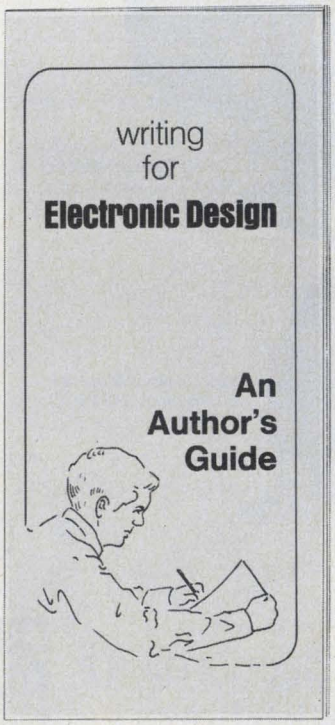
This highly-reliable reader has only one moving part, reads 150 cps, and is priced as low as mechanical readers. The solid state read head can be purchased alone or with a case, interface and power supply. A fanfold box or spooler is available. Write for specifications.

ADDMASTER CORPORATION
416 Junipero Serra Drive
San Gabriel, California 91776

Designers and manufacturers of MARCHANT calculators and office equipment, and ADDMASTER computer peripherals — parallel entry printers and accessories.

INFORMATION RETRIEVAL NUMBER 120

AUTHOR'S GUIDE



If you've solved a tricky design problem, if you have developed special expertise in a specific area, if you have information that will aid the design process... share it with your fellow engineer-readers of *Electronic Design.*

Articles you have authored not only raise your own professional status, but help build your company image as well. The readers benefit, your company benefits.

To help you prepare material that meets *Electronic Design's* high editorial standards, our editors have prepared a special author's guide entitled *"Writing for Electronic Design."* It covers criteria for acceptability, form, length, writing tips, illustrations, and payment for articles published. It's available without cost.

It's easy to write for *Electronic Design,* but it's often hard to get started. Send for your copy of our Author's Guide today.

Circle No. 895

New Literature

Power supplies

Electrical specifications, operating parameters, dimensional charts and prices for over 3000 standard power-supply modules are given in a 60-page catalog. Abbott Transistor Labs, Los Angeles, CA

CIRCLE NO. 421

Switches

A 164-page multiline catalog illustrates and describes position-sensing and manual-control switches. Features of the catalog are easy-to-follow product selection guides, extensive use of metric measurements on all drawings and a consistent ordering procedure for all product lines. Operating characteristics are given in metric as well as English units. Micro Switch, Freeport, IL

CIRCLE NO. 422

Wire and cable

A nifty design kit includes an electronic wire and cable design guide, design aids and a 72-page catalog, which describes the company's products. Belden Electronic Div., Geneva, IL

CIRCLE NO. 423

Sescosem: a free TTL sample kit already has your name on it

Please send me free your component sample kit

name _____

title _____

company _____

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92403 Courbevoie/France

you want proof? cut here...

The complete Sescosem TTL range is at your disposal - and particularly those in our free sample kit, which is yours for the asking. You need only complete and return the reply coupon.

Remember, Sescosem's range provides a complete selection of TTL components and our quality control is second to none. Two factors to facilitate your task. As for price, being a leading european high volume components manufacturer, they are more than competitive. Prove this yourself - Just cut out and return the reply coupon.

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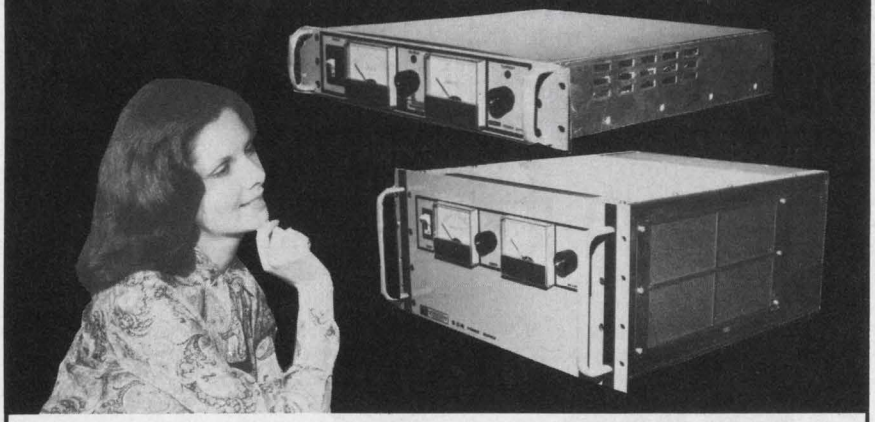
Téléphone 788.50.01/Télex Sescom 61560F

Sales offices or representatives throughout the world.

INFORMATION RETRIEVAL NUMBER 122

SCR POWER SUPPLIES YOU CAN RELATE TO



Enter into a permanent relationship with either of these Phase Controlled E/M Power Supplies. The SCR model on top is a single phase input unit offering from 500 to 2,400 watts of power and precise 0.1% regulation in both voltage and current modes.

The bottom unit is our three phase input SCR model boasting power ratings in the 2,500 through 10,000 watt range. It too features 0.1% regulation. Both types offer the highest power output per mechanical volume in the industry.

Check these superior benefits:

* High Efficiency
* Remote Sensing
* Remote Programming
* Series or Parallel Operation
* 5 Year Warranty
* Rack or Bench Mount
* Overvoltage Protected
* Constant voltage or current with automatic crossover
* Optional Input Voltages

For technical information, Phone TOLL FREE (800) 631-4298

SCR MODELS														
VOLTS	1ϕ INPUT								3ϕ INPUT					
	500 Watts		800 Watts		1600 Watts		2400 Watts		2500 Watts		5000 Watts		10,000 Watts	
	A	$	A	$	A	$	A	$	A	$	A	$	A	$
0 - 6											600	2300		
0 - 7.5			100	650	180	850	250	1100	300	1600				
0 - 10	40	450	80	600	150	850	210	1100	250	1500	500	2300		
0 - 20	25	450	40	600	80	800	120	1000	125	1400	250	1900	500	2900
0 - 30									100	1400	200	1900		
0 - 40	13	425	20	500	40	750	60	900	60	1400	125	1800	250	2700
0 - 50													200	2900
0 - 60	9	450	13	500	26	850	40	1000						
0 - 80	6	450	10	500	20	850	30	1000	30	1400	60	1800		
0 - 100													100	2900
0 - 120									20	1400	40	1800		
0 - 150	3	425	5	500	10	850	15	1000						
0 - 160									15	1400	30	1800	60	2700
0 - 250									10	1400	20	1900	40	2900
0 - 300	1.5	475	3	550	5	850	8	1000						
25 - 500									5	1600	10	2300	20	2900
0 - 600	.75	500	1.5	650	3	850	4	1100						

ELECTRONIC MEASUREMENTS INC.
405 Essex Road, Neptune, N. J. 07753
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Specialists in Power Conversion Equipment

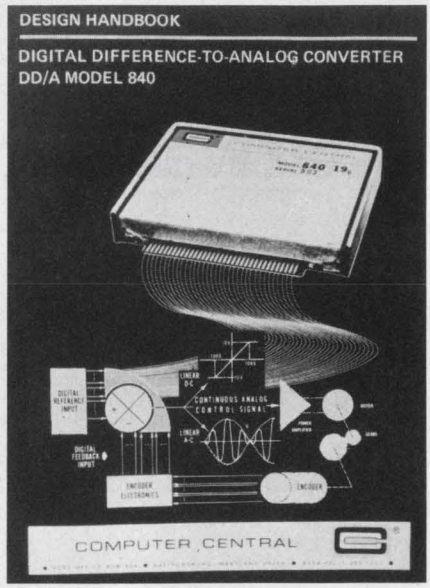
INFORMATION RETRIEVAL NUMBER 123

NEW LITERATURE

IR detectors

Descriptions and specifications of infrared detectors, associated electronic and cryogenic devices, detective assemblies, special IR systems and electro-optical instrumentation are provided in a 56-page catalog. The outer cover opens to provide charts and graphs of spectral response characteristics of IR detectors and materials. Santa Barbara Research Center, Goleta, CA

CIRCLE NO. 424



Digital d/a converter

How to gain the advantages of both the digital and analog worlds is shown in the "Digital Design Handbook." It includes applications where digital-difference-to-analog (DD/A) converters serve as the interface between the command and feedback digital quantities as well as the analog power components of the system. Computer Central, Gaithersburg, MD

CIRCLE NO. 425

Power supplies

Performance and specifying information for the company's complete line of power supplies are offered in a 16-page catalog. Photo illustrations and dimensional drawings are included along with a two-page chart that provides quick comparison of the company's power supplies. Sola Electric, Elk Grove Village, IL

CIRCLE NO. 426

Ionizing work station

A grounded/ionizing work station for production of MOSFETs and other static-sensitive devices is described in a four-page brochure. Another bulletin covers a meter that indicates the presence of static electricity. Static, Inc., Lee, MA

CIRCLE NO. 427

Strip-chart recorders

Over 200 models of 10-in. strip-chart recorders are highlighted in a catalog. Houston Instrument, Austin, TX

CIRCLE NO. 428

50 and 60-Hz UPS

How three-phase uninterruptible power systems (UPS) machines work and how to specify the right machine for a particular application are discussed in a 28-page book. International Power Machines, Mesquite, TX

CIRCLE NO. 429

Interconnections

"Innovative Interconnections," a 40-page booklet, covers various types of connectors. The booklet is amply illustrated with color photographs and includes a pull-out six-page connector guide. ITT Cannon, Santa Ana, CA

CIRCLE NO. 430

Data-acquisition system

A 28-page brochure describes the TN-11 data-acquisition and analysis system. This system features a PDP-11 computer. Tracor Northern, Middleton, WI

CIRCLE NO. 431

μP hardware, software

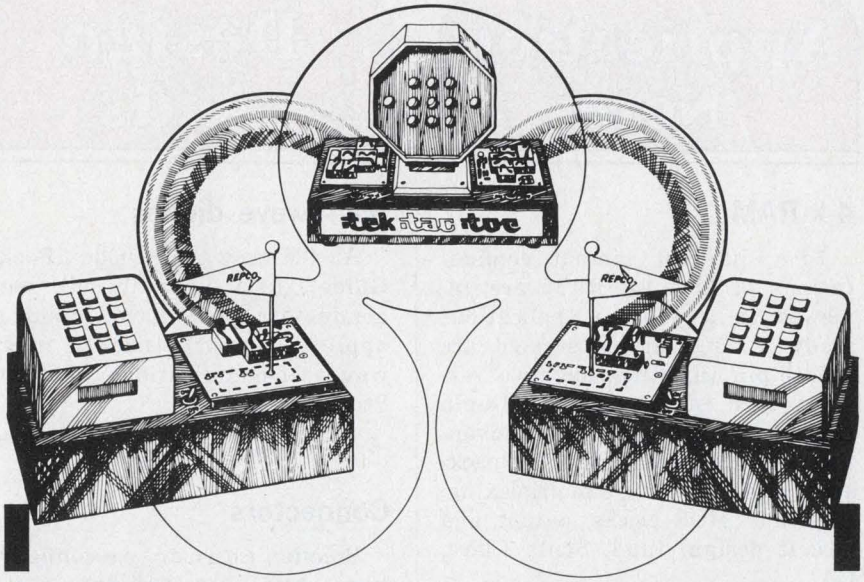
Microprocessor hardware, software and peripherals are featured in a 20-page guide. Wintek, Lafayette, IN

CIRCLE NO. 432

Beryllium oxide

A 16-page design guide provides information on the characteristics and properties of Berlox beryllium oxide. The guide is illustrated with 25 graphs and drawings and provides application data. National Beryllia, Haskell, NJ

CIRCLE NO. 433



Undiscovered genius contest.

The slightly zany, yet fully workable idea illustrated is an RF link-controlled tic-tac-toe game using Repco's modular RF links. It was developed by our engineers to demonstrate the potential and versatility of our RF links. We figured, since creativity is widespread, other design engineers could come up with even more clever ideas.

And the Undiscovered Genius Contest was born.

Sure, there are limitless practical applications for Repco's RF links. But one of the characteristics of creative engineers is to develop commerical applications while jiving around with off-the-wall ideas.

We'd like you to enter our Undiscovered Genius Contest. The payoff is 12 fantastic prizes for our 6 winners and 6 runners-up.

If you're one of the six winners, you'll receive a Texas Instruments SR51 calculator — retail value $149.95. Six runners-up win Texas Instruments SR50 calculators — retail value $99.95.

But just for entering, we'll send you a bright button which identifies you as an Undiscovered Genius. It also makes a neat, semi-deadly frisbee on days there's nothing much doing around the lab.

Just draw a quick sketch or diagram illustrating your clever (but workable) idea incorporating Repco's RF links on an 8½" x 11" sheet of paper and sign it. We **absolutely** will not appropriate or use your idea in any way except for advertising purposes. Your entry constitutes permission for us to use your drawing in our advertising.

Please send your entry directly to Repco, and for further information and contest details pull reply card in this magazine. Contest expires April 30, 1976.

• decision of judges is final • limit one entry per person • void where prohibited by law, or where taxed • all entrants will be notified of winners • employees of Repco, Scope, Inc., or their advertising agency are not eligible (darn!) • and all prizes will be awarded.

Don't delay . . . enter now, and become an undiscovered genius!

REPCO Incorporated
A subsidiary of SCOPE Incorporated

P.O. Box 7065, Orlando, Florida 32804 • (305) 843-8484

INFORMATION RETRIEVAL NUMBER 124

Application Notes

4-k RAM

Five different pin-out configurations of the 4-k RAM are reviewed in a 10-page applications study. Configurations studied are the 16-pin variation, and two versions each of the 22 and 18-pin models. Advantages and disadvantages are discussed, including package size, density, multiplexing, TTL and MOS clocks, output and circuit design. Intel, Santa Clara, CA

CIRCLE NO. 434

Dielectric materials

Formulas and definitions all having to do with the propagation of electromagnetic energy in dielectric and/or magnetic materials in microwave applications are given in a four-page brochure. Emerson & Cuming, Canton, MA

CIRCLE NO. 435

Semiconductor assemblies

"Special Considerations for Semiconductor Assemblies," gives 19 common pointers for the proper application of high-power semiconductor assemblies. Westinghouse Electric, Youngwood, PA

CIRCLE NO. 436

Current measurements

"X-Ray Tube Current Measurements" shows a simplified block diagram of an X-Ray machine and the theoretical current pulses for the output. It also gives a step-by-step procedure for current-pulse measurements and shows photographs of actual waveforms. Tektronix, Beaverton, OR

CIRCLE NO. 437

Calculator applications

Statistical applications of HP pocket-sized and desktop calculators are described in a 12-page booklet. Illustrations of sample problems and printouts are given with each calculator description. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 438

Design Aids

Microwave diodes

A "Microwave Diode Pocket Guide" lists virtually all semiconductors that have found an application in the field of microwave communications to date. State Labs.

CIRCLE NO. 439

Connectors

Popular connector configurations, both standard and special, are listed in a six-page guide. It is designed to help you select the proper connector series and the appropriate catalog from which to specify. ITT Cannon Electric.

CIRCLE NO. 440

Vidicon guide

55 main Vidicon-camera tube categories are presented in a four-page interchangeability guide. General Electric, Microwave and Imaging Devices, Tube Products Dept.

CIRCLE NO. 441

Motor speed controls

Dimensions, ratings, type of mounting, standard and optional features as well as typical applications of solid-state motor speed controls for ac and dc motors up to 2 hp are detailed in a four-page guide. KB Electronics.

CIRCLE NO. 442

Power supplies

Individual chart comparisons of "nearest equivalent" units for six popular types of standard off-the-shelf power supplies are shown in a cross-reference brochure. Sola Electric.

CIRCLE NO. 443

μP guide

"The Microprocessor User's Guide," a 36-page booklet, gives information on how to select and use microprocessors. Pro-Log.

CIRCLE NO. 444

Evaluation Samples

Switches and lights

Along with a 24-page catalog describing the company's switches, lights and custom products comes a business-reply card that when filled out and returned enables the reader to receive a sample of any product shown in the catalog for evaluation. Chicago Switch.

CIRCLE NO. 445

Temperature recorders

As miniature, self-contained ±1% accuracy temperature recorders are exposed to heat exceeding their calibrated temperature, they turn permanently and irreversibly black. Rated temperatures are printed at each sensor window. Standard models are available with diameters as small as 0.19 in., with one to eight indicators and cover a 100-to-1100-F temperature range. William Wahl Corp.

CIRCLE NO. 446

Insulated wire

Cross-linked polymeric insulated wire is UL listed and rated at 150 C and 600 V. It is available in AWG sizes 22 through 4/0. Haveg Industries.

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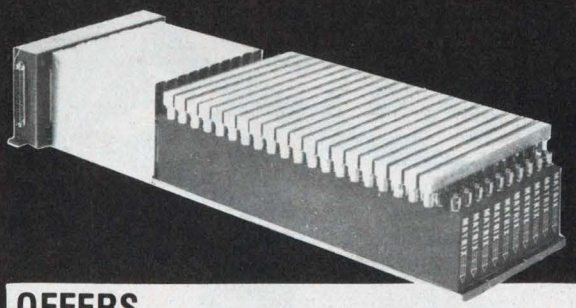

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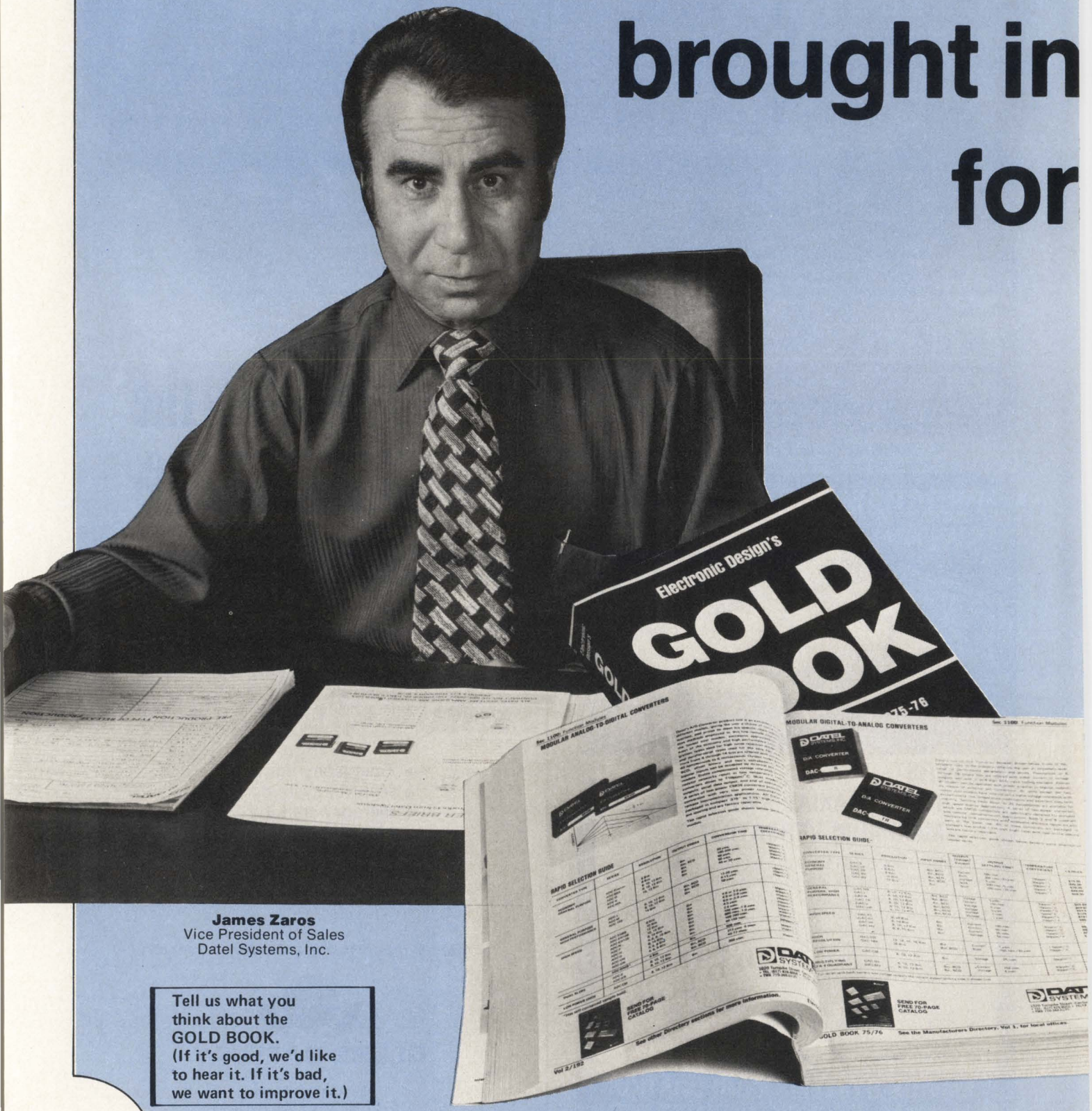

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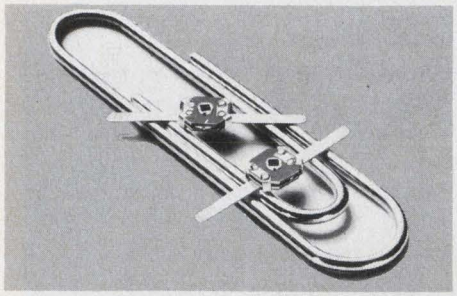

Thin-Trim variable capacitors provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors, Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

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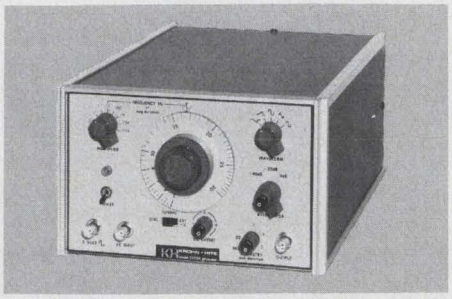

MULTI-PURPOSE FUNCTION GENERATOR Krohn-Hite's Model 5100A offers 8 types of waveforms; sine, square, triangle, pos. & neg. ramps, sawtooth, and pos. & neg. pulses from 0.002Hz to 3MHz. The symmetry control allows a 100:1 range for waveform variation. It has a 1000:1 (VCO) range and features a calibrated (dB) attenuator. Ideal for a broad scope of applications. Only $495. Krohn-Hite Corp., Avon Industrial Park, Avon, MA 02322 (617) 580-1660

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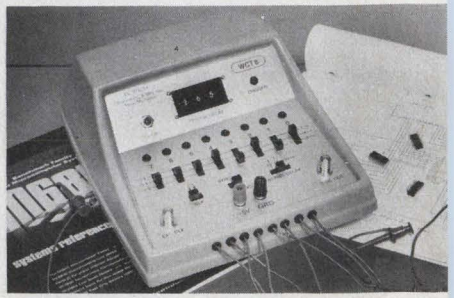
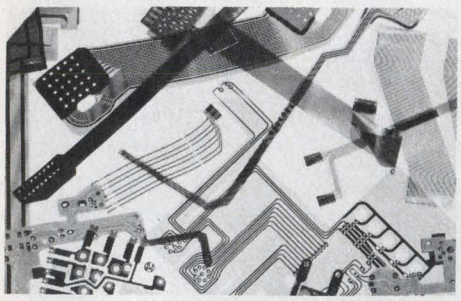


Logic analyzer with display works in parallel synchronous or asynchronous mode pattern trigger selectable up to 8 bits generated trigger can be delayed after pattern recognition up to 999 clock pulses input is stored and displayed coincidentally with delayed trigger pulse, $265. Computel Engrg & Mfg Co. 2848 Charter #207 Troy, MI 48084 (313) 524-2284.

LOGIC ANALYZER **607**



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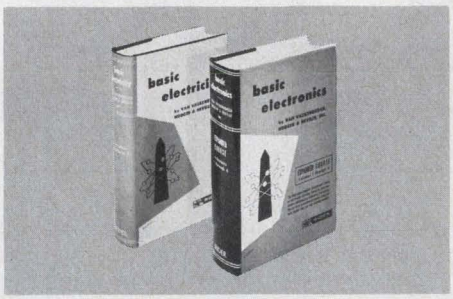

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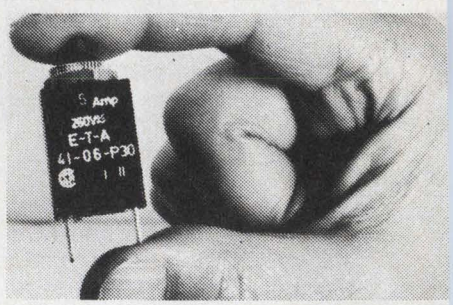

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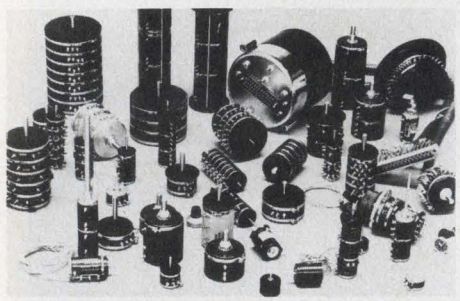

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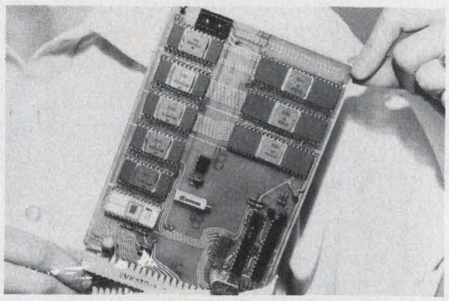

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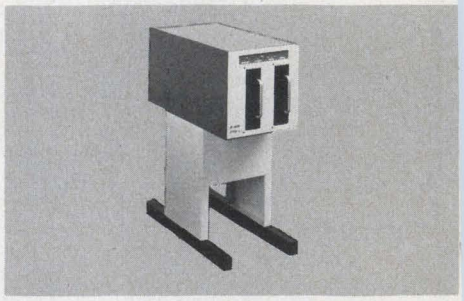
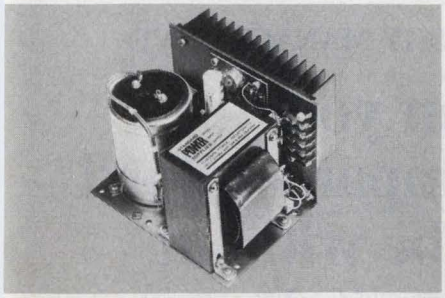


ASCII DISC DATA SYSTEM: BRD D-474 Floppy Disc System, RS-232 plug compatible for any serial ASCII central processor or other ASCII I/O device. Features: 277,504 alphanumeric character storage; only 8 basic ASCII instruction characters; Fully buffered I/O memories; Selectable 110-9600 baud rates; Average 200 millisecond access time per sector. BRD inc, Box 10237, Bainbridge Island, Wash. 98110 (206) 842-4777

DISC SYSTEM **609**



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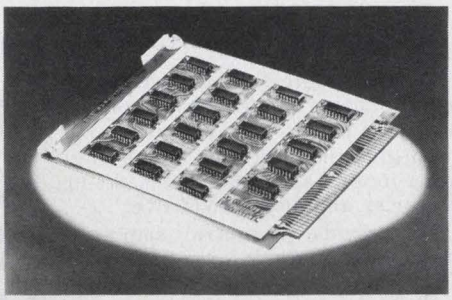
CONSTANT-CURRENT DC SUPPLIES **610**



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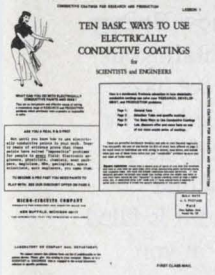

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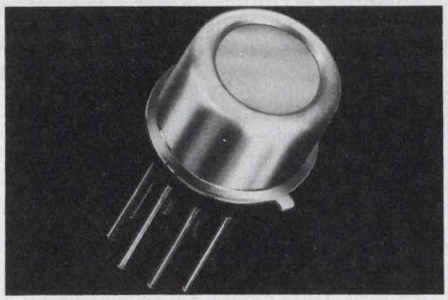

MODEL 404 pyro IR detector system has the detector, voltage mode amplifier and current mode amplifier integrated and hermetically sealed into a TO-99 housing. The detector is Lithium Tantalate. Standard window is germanium. The system can be operated any one of 3 ways: Detector only, voltage mode, high gain current mode. Optical bandwidth = 2 · 15μ. D* = 1.7 x 10^8cm $\sqrt{\text{Hz}}$/W. Price: $245 (1) Delivery: 2 weeks. ELTEC INSTRUMENTS, INC. PO BOX 9610 DAYTONA BEACH/FL 32014 (904)252-0411

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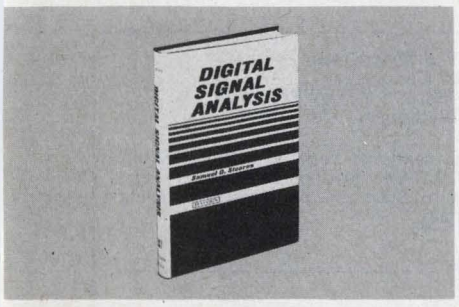

DIGITAL SIGNAL ANALYSIS, S. Stearns. Contains the most recent advances, brand-new design material, and a comparison between continuous and digital systems, making it an ideal master reference to today's signal processing techniques and systems. #5828-4, 288 pages, $18.95. Circle the Info Retrieval Number to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co., 50 Essex Street, Rochelle Park, N.J. 07662.

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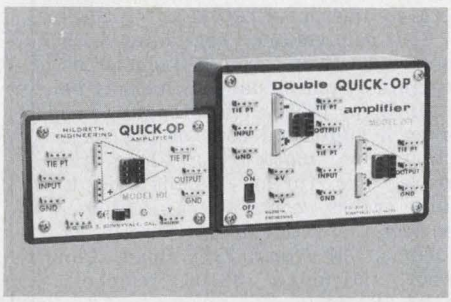

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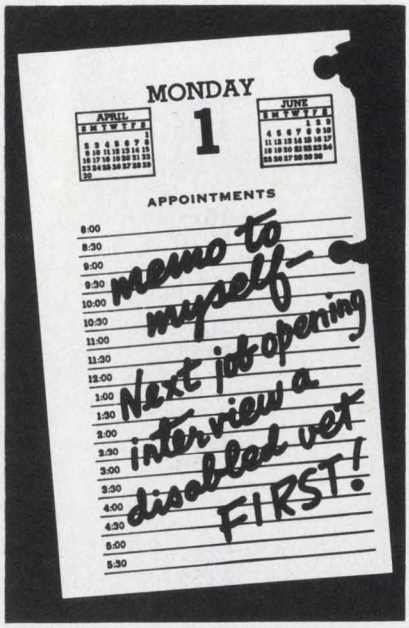

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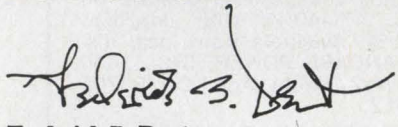

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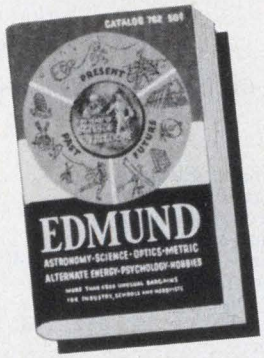

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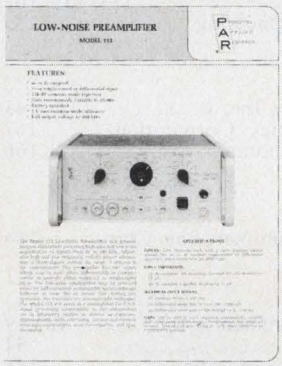

Complete specifications of a variable-bandwidth high-gain preamplifier are contained in the Model 113 data sheet, T-224. Included are typical noise figure contours illustrating the amplifier's exceptionally low noise, which is as low as .05 dB at mid frequencies with a 1 megohm source. Other illustrations include typical plots of the equivalent input noise and common mode rejection, which exceeds 100 dB at 60 Hz at all gain settings. The data contained in the specification sheet will be of interest to all engineers and researchers looking for a preamplifier with calibrated gain and rolloffs from dc to 300 kHz.

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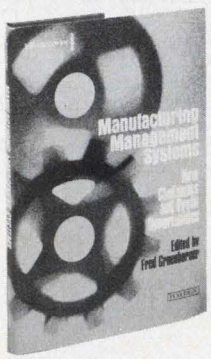
New Challenges and Opportunities Edited by Fred Gruenberger



By crystallizing the results of the 1973 Informatics/UCLA Symposium, this book offers a powerful blend of technical and managerial expertise for enhancing the overall success and profitability of today's manufacturing management systems. Some of the nation's top industrial and technical leaders speak freely and in depth of their organization's objectives and specific operations, as well as their personal strategies and methods. You'll find the newest computerized tools available to manufacturers . . . crucial managerial skills for directing progressive systems . . . the tact and care needed for the sensitive human problems of system implementation, and more. **#5940-x, 160 pages, $10.50.** Circle the Info Retrieval No. to order a 15-day exam copy. When billed, remit or return book. No obligation.

CIRCLE NO. 173

Hayden Book Company, 50 Essex St., Rochelle Pk, N.J. 07662

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GREAT MOMENTS

..... in electrical history

. . . . our day of fame in the laundry room, when one of our employees doffed his socks, paired them with a copper Mueller Mini-gator Clip, sent the mates through washer, through dryer, into his drawer, and divorced them only when ready to don them again. Spared the matchmaking, his wife now has the whole family do it with everything worn in pairs! Electrical or not, can *you* match this creative connectivity with your Mueller Clips?

At Jobbers everywhere.

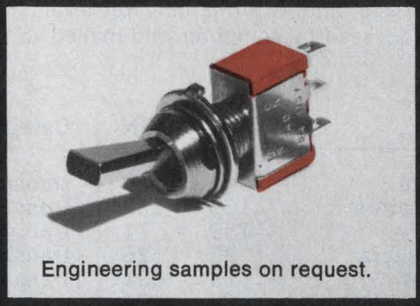
Write factory for FREE sample clips and catalog.

Mueller Electric Co.

1580H East 31st Street • Cleveland, Ohio 44114

INFORMATION RETRIEVAL NUMBER 131

Unlike beer, tires, and Italian actresses, C&K's Flatted Toggle Switch is appealing because it's flat.



Engineering samples on request.

It's also competitively priced, made in America for rugged high-quality performance, and available in SPDT, DPDT, 3PDT and 4PDT models. A sleek,modern-looking visual design element that's as flat as Twiggy.

For more information, contact:
C&K COMPONENTS, INC.,
103 Morse St., Watertown, MA 02172
Tel: (617) 926-0800. TWX: 710-327-0460
TELEX: 92 2546

INFORMATION RETRIEVAL NUMBER 132

LOOKING FOR A DISTRIBUTOR NEAR YOU?

Electronic Design's GOLD BOOK lists 5,700 distributors with access both **alphabetic,** by distributor name, and **geographic** by location.

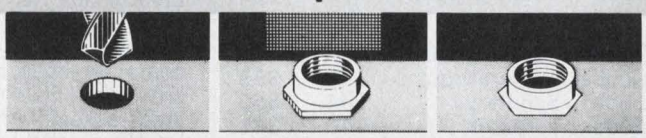
When you need information . . .

Electronic Design's GOLD BOOK

IS THE PLACE TO LOOK

No staking...
No lock washers...
No plastic inserts...
No knurling...

Self-locking, one-piece, PRESSERT captive hardware



DRILL | **PRESS** | **THAT'S IT!**

When you need to fasten, mount, hold, align or lock . . . you need PRESSERTS. Easiest of all to install, and once in place they're permanent. You get vibration proof fastening to soft brass, mild steel, aluminum materials. Presserts won't push, pull or torque out. Available in studs, floating nut, flush and extension types. Send for complete catalog to. . . .

PMP (PRECISION METAL PRODUCTS)

PRECISION METAL PRODUCTS CO.
41 ELM ST., STONEHAM, MASS. 02180
Telephone: (Area Code 617) 438-3650

INFORMATION RETRIEVAL NUMBER 133

Product Index

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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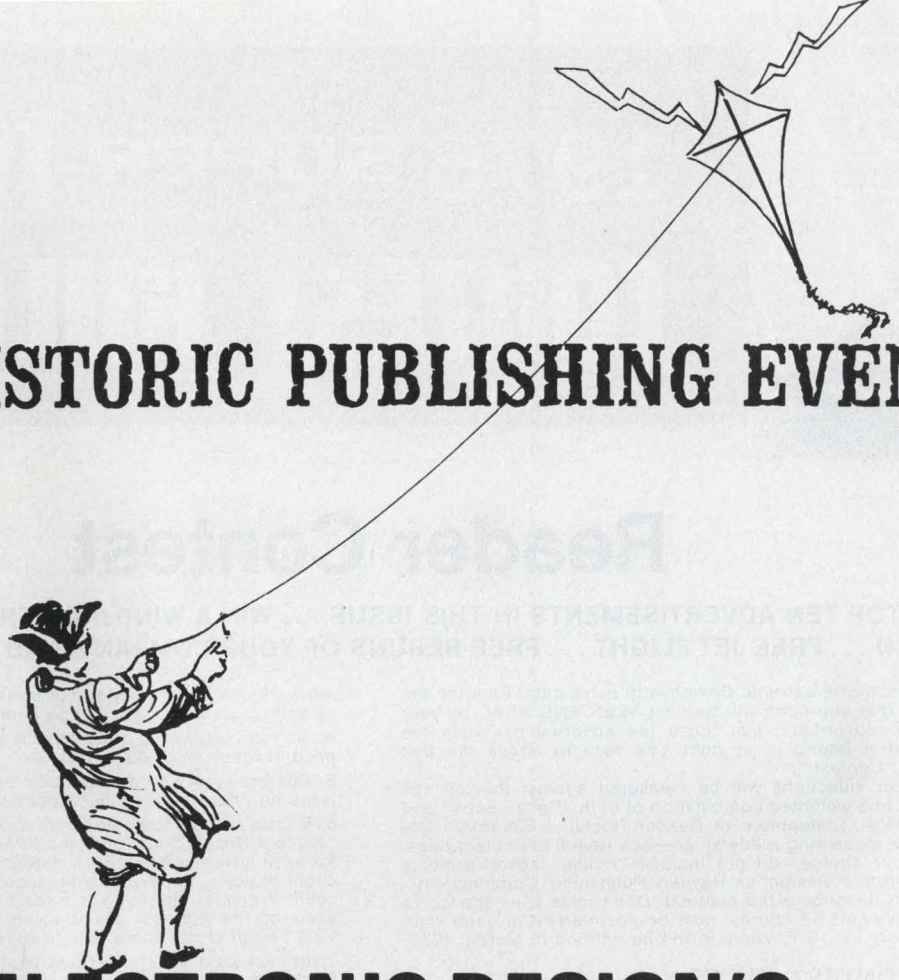


AN HISTORIC PUBLISHING EVENT.

ELECTRONIC DESIGN'S BICENTENNIAL ISSUE -- FEBRUARY 16th --

Unquestionably this issue is the most significant publishing effort ever undertaken by any electronics magazine anywhere in the world.

In a message from the White House to be published in the Bicentennial issue, President Ford commends this issue as a very special part of America's 200th Anniversary.

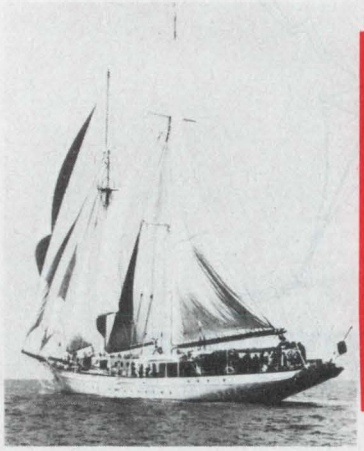
The Bicentennial issue traces the electronics industry from experiments in the Colonial period to today's large-scale integrated circuits. It shows how the industry has been shaped and re-shaped, not only by technological breakthroughs, but by the socio-economic, political and even the artistic climate of the times. It is informed, throught-provoking and authoritative.

This is an issue that everyone will want to read.

Sincerely,

Peter D. Coley
Publisher & Senior Vice President

Electronic Design
Hayden Publishing Company, Inc. • 50 Essex Street • Rochelle Park, N.J. 07662 • (201) 843-0550



1976 SUPER TOP TEN CONTEST RULES

Reader Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE . . . WIN A WINDJAMMER CRUISE FOR TWO . . . $1,000 CASH . . . FREE JET FLIGHT . . . FREE RERUNS OF YOUR COMPANY'S AD . . . 100 PRIZES IN ALL.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think will be best SEEN AND READ by your fellow engineer-subscribers. List these ten advertisements on the special entry form bound in at right. *(Be sure to check the box marked "Reader Contest.")*

This year, your selections will be measured against the ten ads ranking highest in a weighted combination of both "Recall Seen" and "Recall Read Most" categories of Reader Recall — *Electronic Design's* method of measuring readership — see item 6 in contest rules.

In making your choices do not include "house" advertisements placed by *Electronic Design* or Hayden Publishing Company, Inc. (such as this ad describing the contest). Don't miss your chance to be a Top Ten Winner! *All entries must be postmarked no later than midnight, February 29, 1976.* Winners will be notified in March, 1976.

READER CONTEST RULES

1. Enter your *Top Ten* selections on the entry blank provided, or on any reasonable facsimile. Be sure to indicate the name of the advertiser and *Information Retrieval Number* for each of your choices. Do *not* use page number. (Ads placed by Hayden Publishing Company in Electronic Design *should not* be considered in this contest.)

2. No more than one entry may be submitted by any one individual. Entry blank must be filled in completely, or it will not be considered. The box on the entry blank marked "Reader Contest" must be checked. *Electronic Design* will pay postage for official entry blanks only.

3. To enter, readers must be engaged in electronic design engineering work, either by carrying out or supervising design engineering or by setting standards for design components and materials.

4. No cash payments, or other substitutes, will be made in lieu of any prize, (except the $1,000 prize).

5. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winners.

6. Entries will be compared with a weighted combination of *both* the "Percent Recall Seen" and the "Percent Recall Read Most" scores for each advertisement. Each percentage point for "Recall Seen" will count 1 point. Each percentage point for "Recall Read Most" will count 2 points. The ten ads having the highest point scores will be declared the winners. Example: an ad with 40% "Seen" score and 12% "Read Most" score counts 40 + (2 × 12) = 64 points.

7. In case of a tie, the earliest postmark will determine the winner. Decisions of *Top Ten* contest judges will be final.

8. Free reruns of any advertisement will be made only from existing plates or negatives. If the advertisement qualifying for a free rerun is an insert, the winner's company may run a two-page spread from existing plates or negatives in up to 4-colors.

9. Hayden Publishing Company, Inc. reserves the right to schedule reruns at its discretion.

10. Only one free rerun awarded to any one company.

FOR A COMPLETE DESCRIPTION OF PRIZES FOR BOTH READER AND ADVERTISER CONTESTS SEE PAGES 132 AND 133

USE SPECIAL ENTRY BLANK BOUND IN AT RIGHT

(Additional entry blanks are bound inside the front cover)

Advertiser Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE . . . WIN A WINDJAMMER CRUISE FOR TWO . . . $1,000 CASH . . . FREE JET FLIGHT . . . COLOR TV . . . DIGITAL WRISTWATCH.

There's a separate contest open to all marketing and advertising personnel in companies, and to advertising agencies.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think will be best SEEN AND READ by *Electronic Design's* readers. List these ten advertisements on the special entry blank bound in the front or back of this issue. (Be sure to check the box marked "Advertiser Contest".)

In addition to valuable prizes, all ads that place in the Top Ten will be given free reruns. If you are a winner in the advertiser contest, and if you ran an ad in the January 5 issue that did not place in the a free rerun. See rules if the winning ad is an insert. Only one free rerun awarded to any one company.

ADVERTISER CONTEST RULES

1. All rules for the Reader Contest will similarly apply for this contest, with two exceptions: readers engaged in electronic design engineering work, as defined in the reader contest rules, are *not* eligible to participate in this special contest. The box on the entry blank marked "Advertiser Contest" must be checked.

2. Entrants in this contest may use the official reader contest entry blanks or any reasonable facsimile.

3. This special contest is open to marketing and advertising personnel only at all manufacturing companies and advertising agencies whether or not their companies or agencies have an advertisement in the January 5, 1976 issue. However, only those companies (or divisions thereof) advertising in the Jan. 5 issue, and the advertising agencies placing such advertisements are eligible for a free rerun of their advertisement should a member of their organization win.

4. Free reruns of any advertisement will be made only from existing plates or negatives. If the advertisement qualifying for a free rerun is an insert, the winner may run a two-page spread from existing plates or negatives in up to 4-colors.

5. Hayden Publishing Company, Inc., reserves the right to schedule reruns at its discretion.

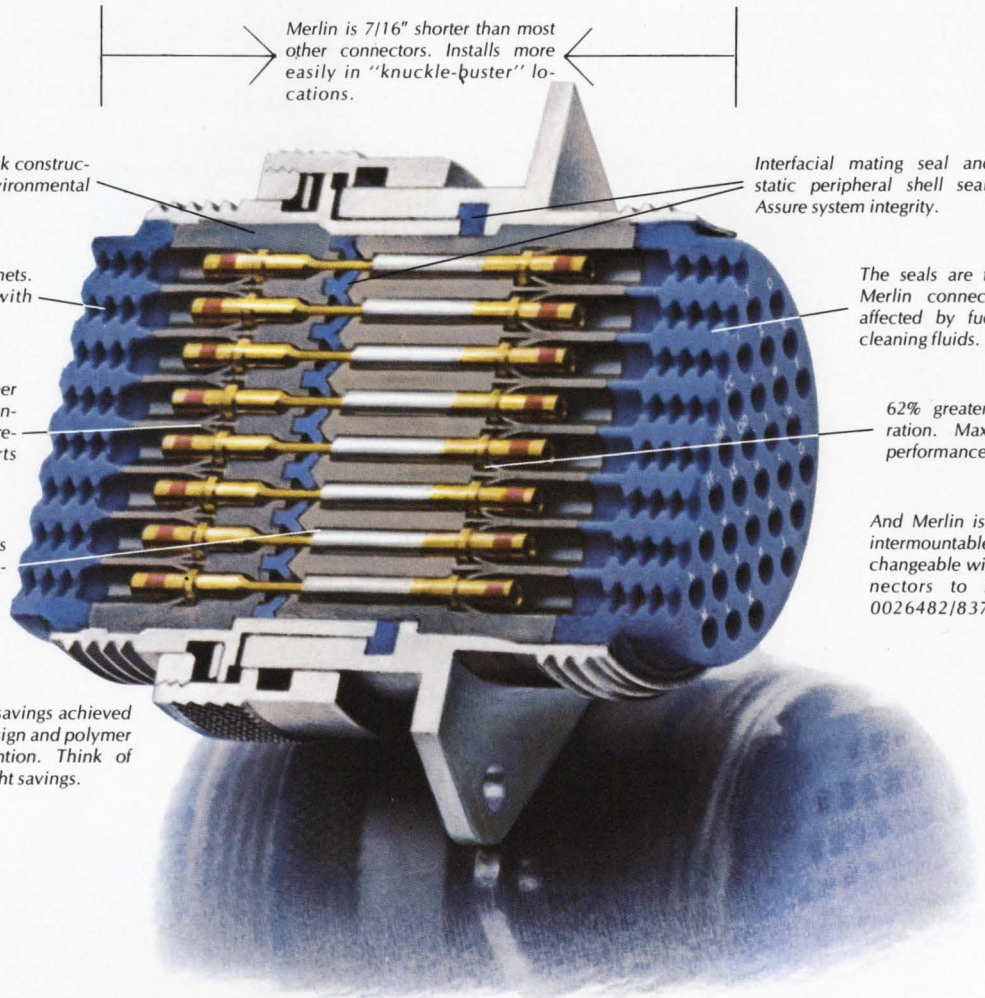
FOR A COMPLETE DESCRIPTION OF PRIZES FOR BOTH READER AND ADVERTISER CONTESTS SEE PAGES 132 AND 133

USE SPECIAL ENTRY BLANK BOUND IN AT RIGHT

(Additional entry blanks are bound inside the front cover)

Amphenol's MERLIN™ is lighter, shorter, and more reliable than most other MIL-C-26482/0026482/83723 connectors.

That takes guts:



Merlin—a quality connector you can connect and forget. At a competitive price. Ask for a quotation. Most sizes and styles are available, off-the-shelf, from your Amphenol Industrial Distributor. Or call or write: Wayne Zimmerman, Amphenol Connector Division, 2801 South 25th Avenue, Broadview, Illinois 60153. Phone: (312) 345-9000.

BUNKER RAMO

When you can connect it and forget it...that's quality.

AMPHENOL

INFORMATION RETRIEVAL NUMBER 247

What's new in solid state...

The last word on reliability. From the first house in CMOS.

Reliability has many aspects. You have to look at it from more than one angle. As the creator of the CMOS technology, RCA has years of experience in measuring and improving the various aspects of CMOS reliability to prove it.

A new 24-page technical paper explores the total RCA reliability test program. It describes how RCA determines and controls the growing reliability of COS/MOS integrated circuits, both plastic and ceramic. It includes RCA developed real-time test procedures and controls. Plus a discussion of circuit and device mechanisms. This information can help designers improve equipment value by increasing reliability without component costs. Where essential, RCA has an Extra Value Program that offers enhanced product.

New reliability test specs

The paper details how RCA's comprehensive specifications help designers match device to application. Typical RCA specs and test circuits are shown. You'll see how a 4-step testing routine and real-time indication tests assure product quality and long-term reliability.

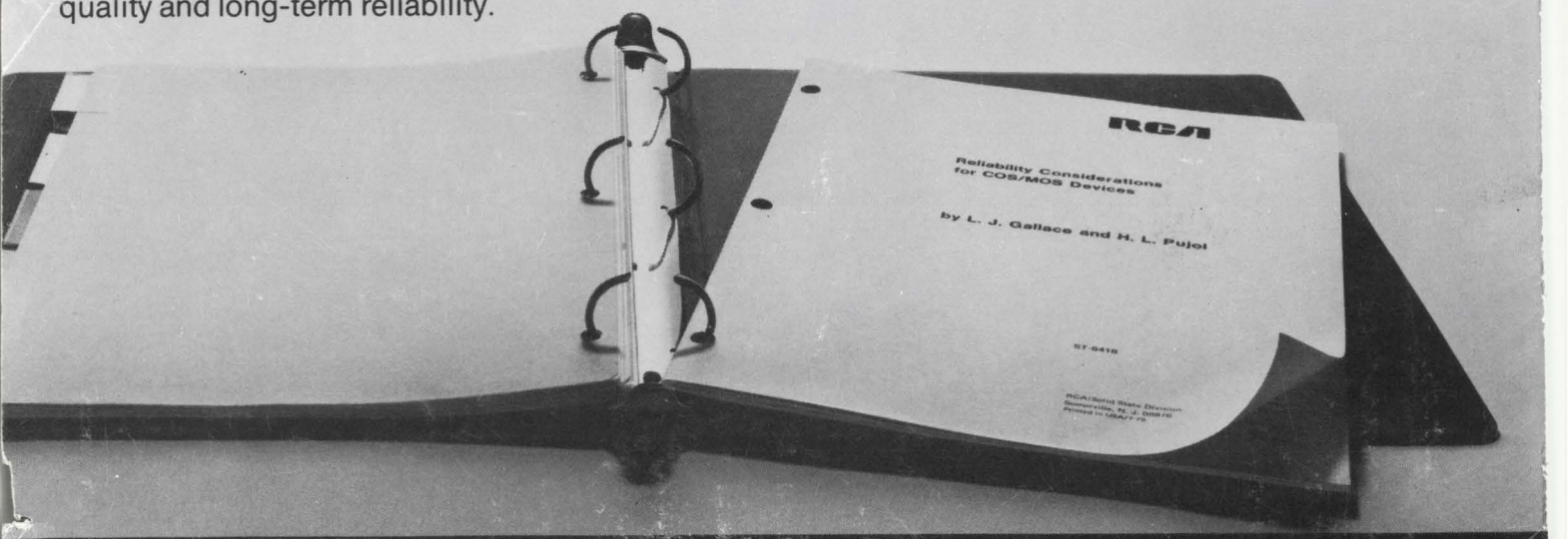
Designing for the environment

Curves and data in the paper reveal the effects of environmental extremes on various packaging systems such as plastic, frit seal and the new Gold CHIP. They show accelerated life and thermal cycling tests with high MTTF figures. An important section compares predictable life data of TTL vs. COS/MOS: under the same ambient temperature, COS/MOS would have a better failure rate by a factor exceeding 20.

There's much more in this important document, ST-6418. We want you to have it, free. Contact your local RCA Solid State distributor. Or RCA.

Write: RCA Solid State. Box 3200, Somerville, New Jersey 08876; Ste. Anne de Bellevue 810, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

RCA



RCA. First house in CMOS.

INFORMATION RETRIEVAL NUMBER 248