

# Electronic Design<sup>®</sup>

FOR ENGINEERS AND ENGINEERING MANAGERS

VOL. 24 NO.

# 1

JAN. 5, 1976

## What's likely to develop in '76?

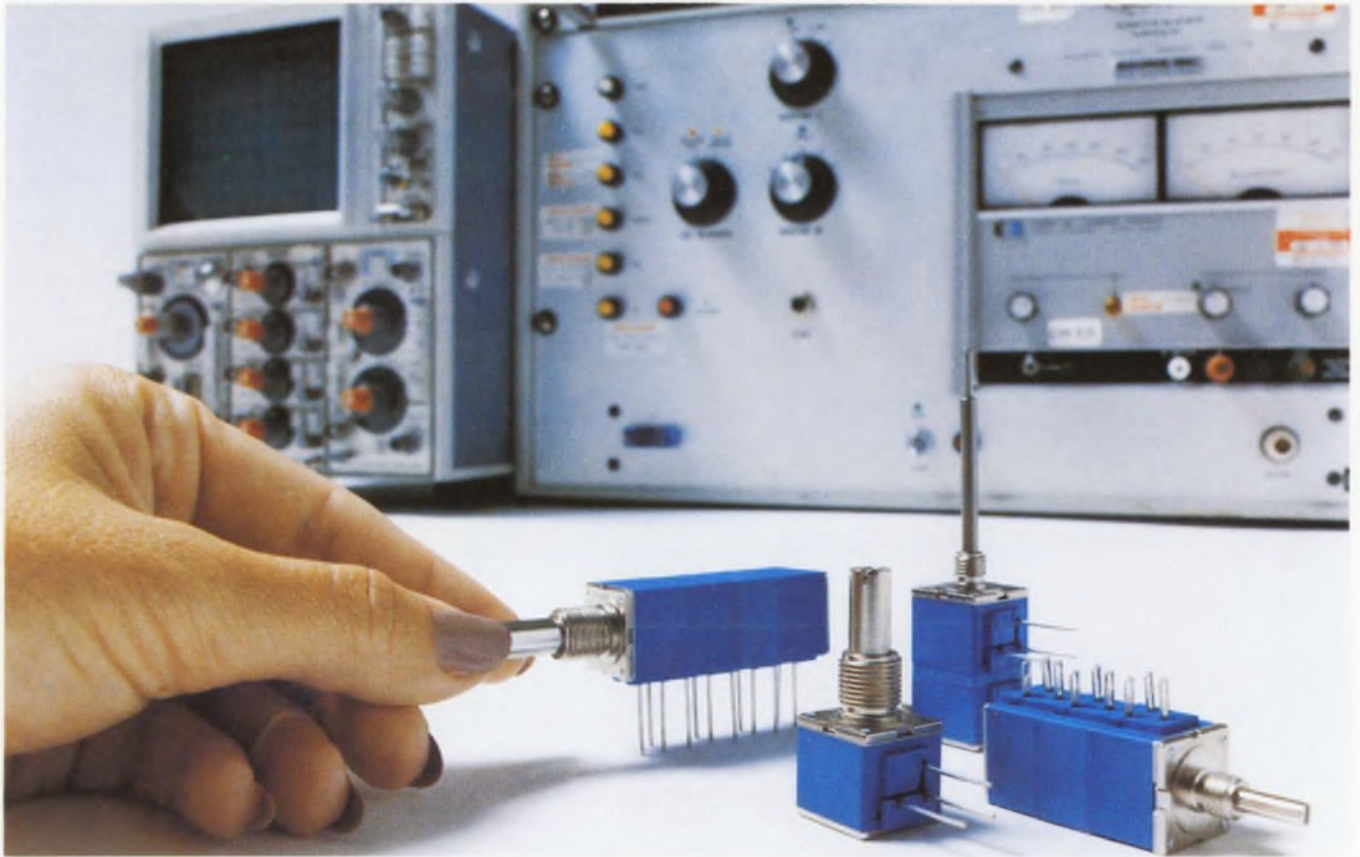
Microprocessors, PROMs and PLAs will be in the picture in a host of new products. Next year the focus will be on logic

analyzers and calculator-based systems. Also, keep a sharp eye on low-cost mini and  $\mu$ P 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!



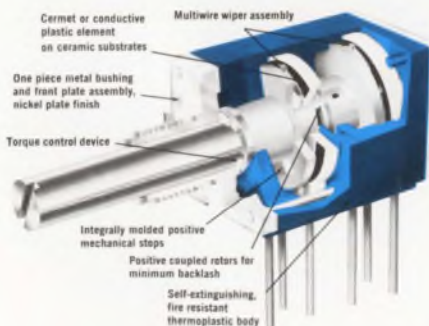
## BOURNS announces an **ADVANCED** building-block potentiometer...

... 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-



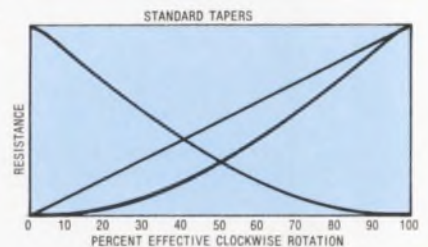
block construction ... with factory assembled reliability and quality control. All Model 80 potentiometers are built to your "prescription" by full-time production personnel, under the supervision and control of the industry's most respected quality assurance organization. High-volume assembly techniques, 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  $\pm 5\%$**  ... 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

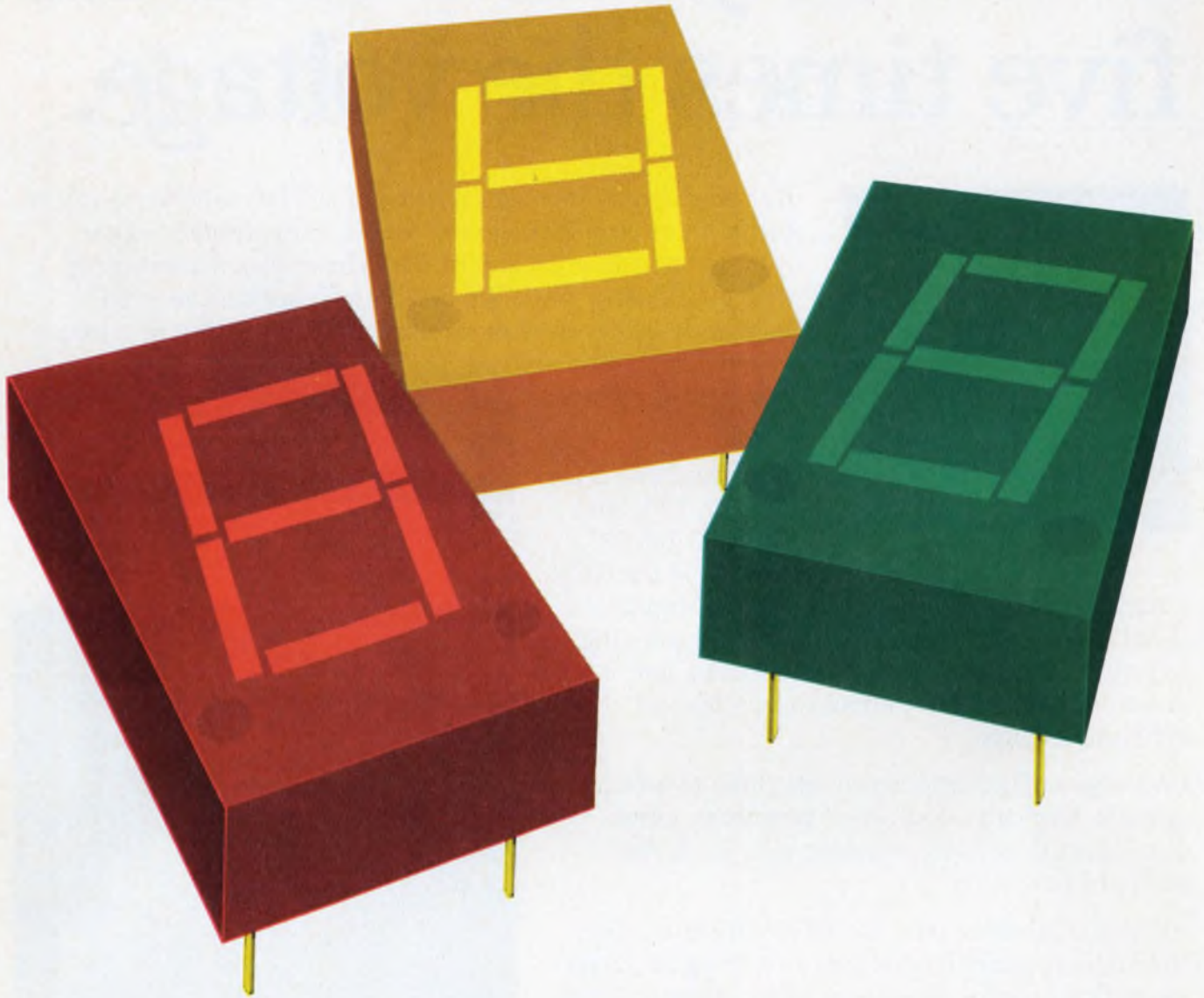
Write on your company letterhead and tell us about your application. We'll send you the Model 80 that best suits your needs.



### TRIMPOT PRODUCTS DIVISION

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

# 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.

HEWLETT  PACKARD

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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.

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.

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	



**TELEDYNE RELAYS**

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

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## NEWS

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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.
- 40 **Microprocessor chips are beginning to reshape** the data communications and computer industries.
- 46 **An Electronic Design special report**—If you're just getting into microprocessors? Odds are you'll end up with a kit.
- 55 **Washington Report**

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## TECHNOLOGY

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- 78 **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.
- 88 **Base your IC tester on a  $\mu$ P,** and you can carry the system into the field. Other benefits include data logging and low cost.
- 96 **Incorporate a calculator chip,** instead of a microprocessor, into your number-processing data system, and avoid software for math functions.
- 102 **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.
- 110 **Shozo Yokogawa of Yokogawa Electric Speaks On Interfacing Engineers with Others.**
- 116 **Ideas for Design:**  
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.
- 123 **International Technology**

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## PRODUCTS

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**Cover:** Photo by Art Director, Bill Kelly.

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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. Print 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".

**\$2900.\***

\*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.

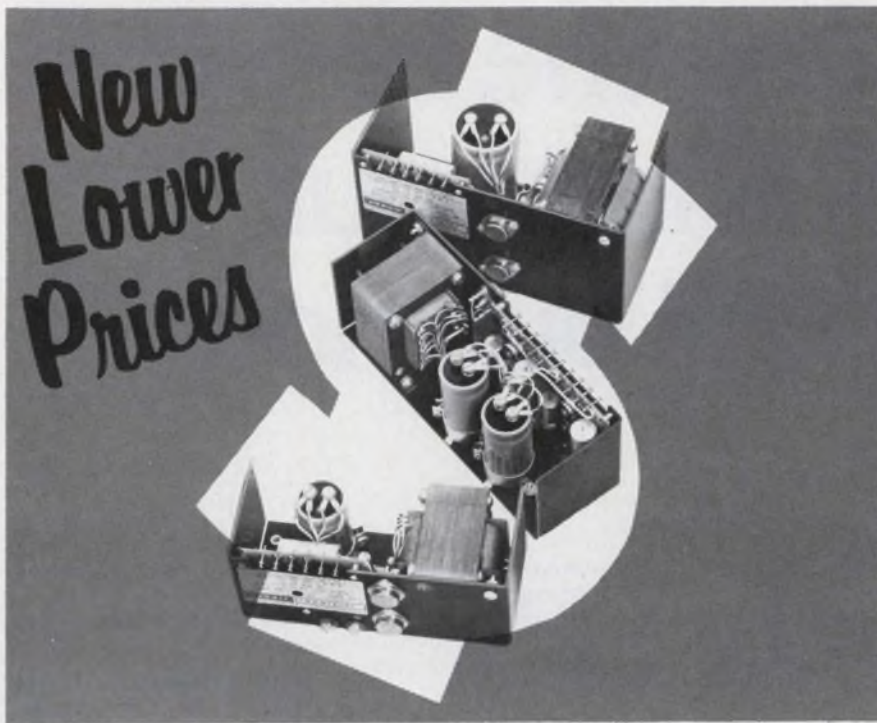
*HP computing calculators put the power where the problems are.*

HEWLETT  PACKARD

Sales and service from 172 offices in 65 countries  
P.O. Box 301, Loveland, Colorado 80537

095.17

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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INFORMATION RETRIEVAL NUMBER 5

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ELECTRONIC DESIGN 1, January 5, 1976



# 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  $\bar{Q}$  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  $\mu$ s 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 ELEC-

TRONIC 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.  
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TWX-910-860-5958

A black and white photograph showing a hand operating an AMP shuttle tool. The tool is a complex mechanical device with a cylindrical upper section and a base where a flat-cable connector is being terminated. The hand is positioned at the bottom left, holding the tool. The flat-cable connector is a wide, multi-stranded ribbon cable that is being inserted into the tool. The background is a plain, light-colored surface. The text is positioned in the upper right quadrant of the image.

# 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.

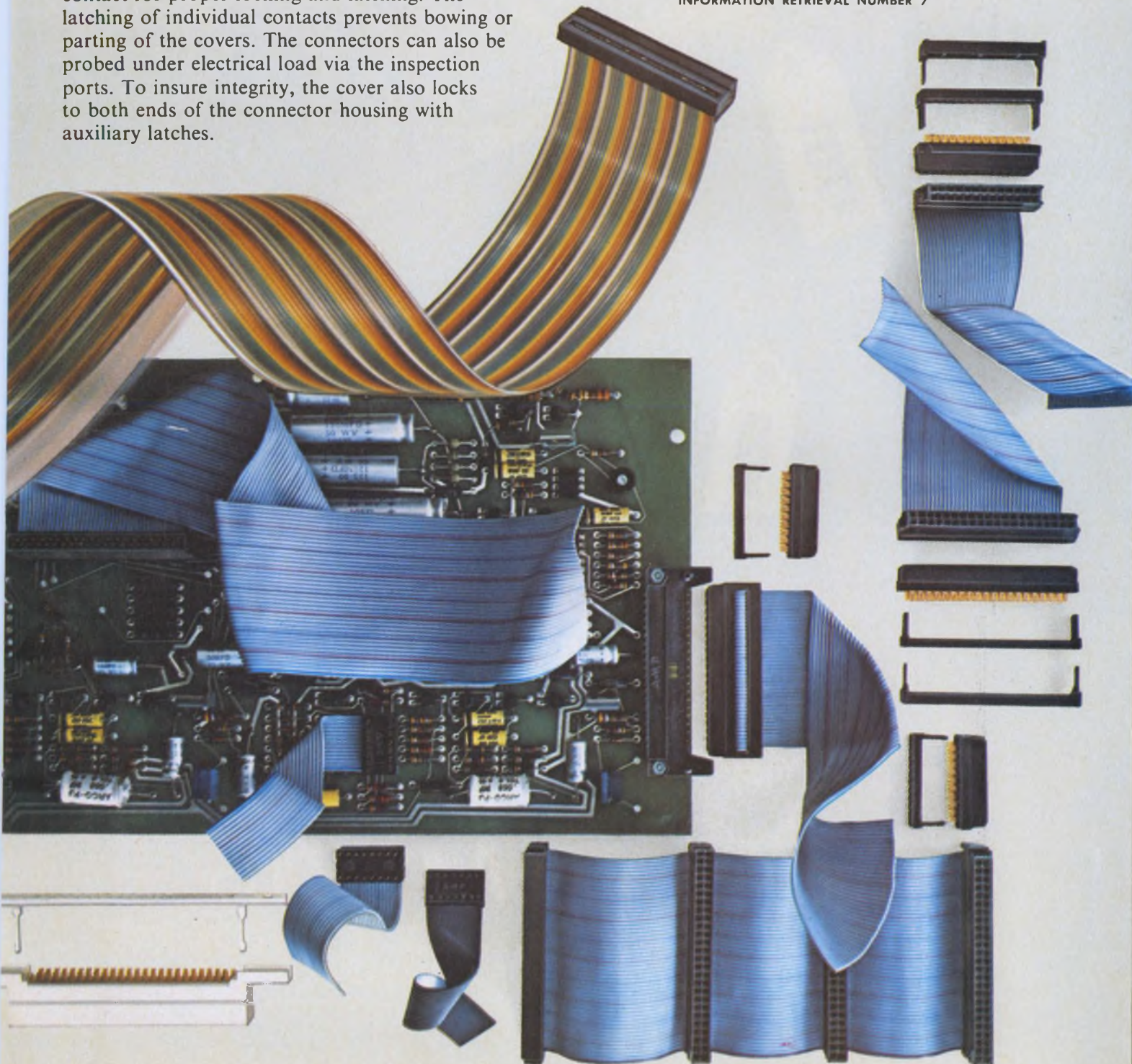
Ask your AMP representative for an in-plant demonstration. Or write for AMP Latch connector literature. AMP Incorporated, Harrisburg, Pa. 17105.

AMP is a trademark of AMP Incorporated.

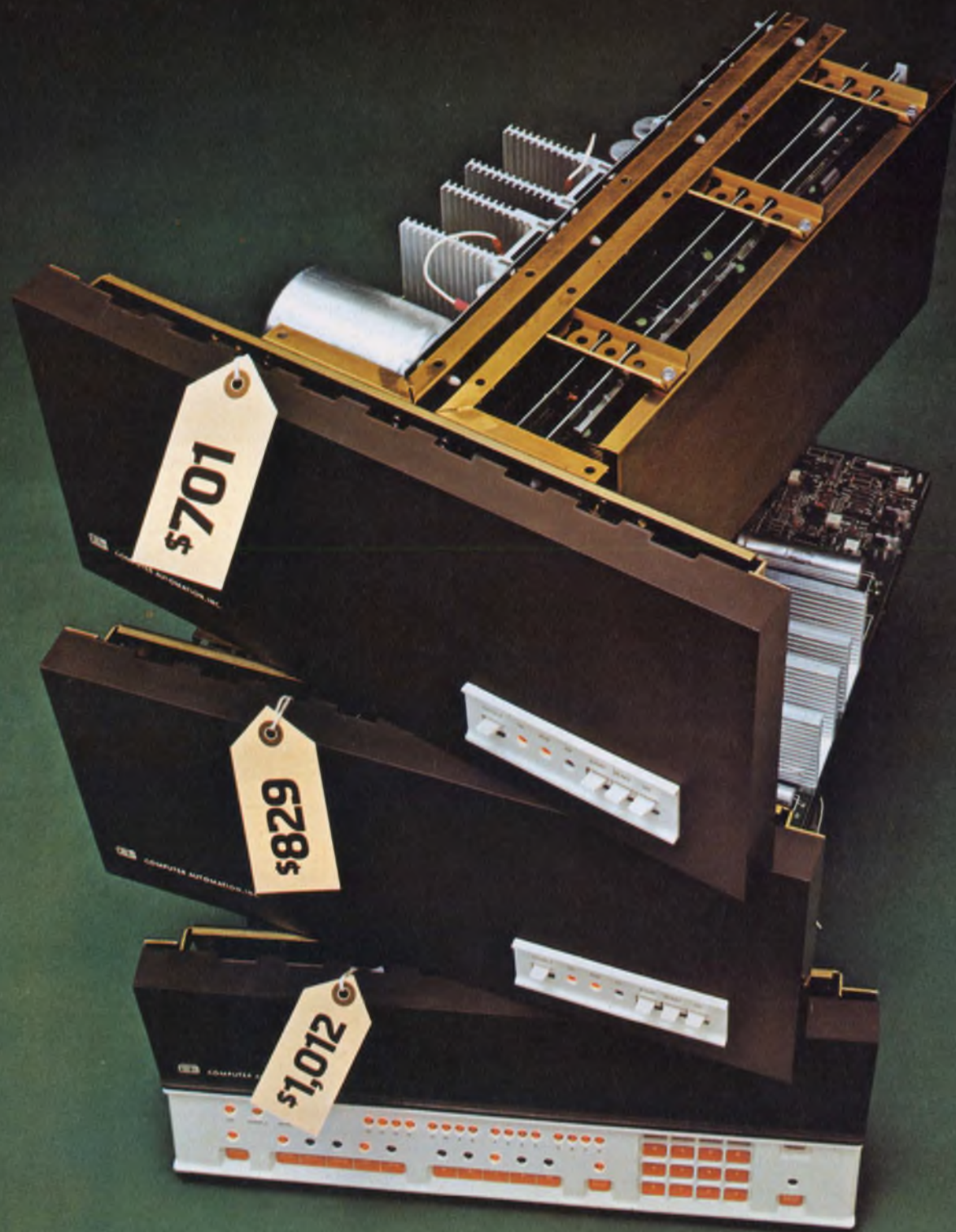
# AMP

## 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.

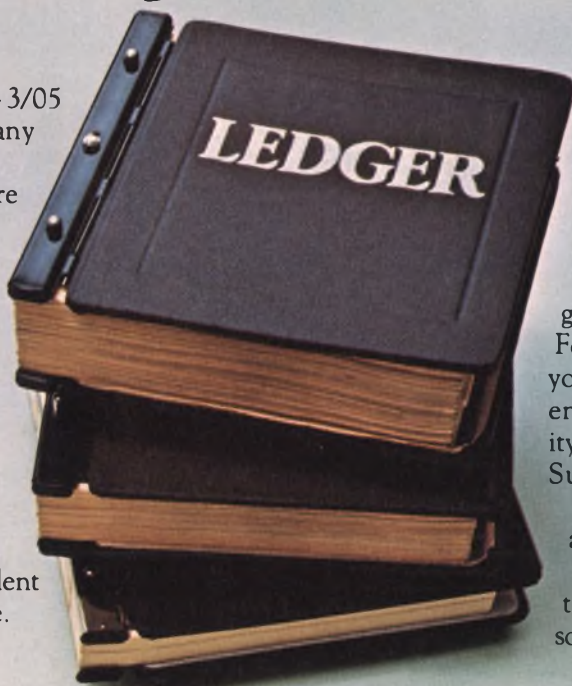
You also get the capability to configure your computer pretty well the way you want it. A choice of packaging, of course, that includes either the Operator's or the Programmer's Console, power supplies and so on.

A choice of two standard I/O options.

And a choice of optional memory configurations that



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



include RAM/ROM, RAM/EPROM and RAM-only in sizes from 256 words all the way up to 32K words. Totally addressable.

## 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.

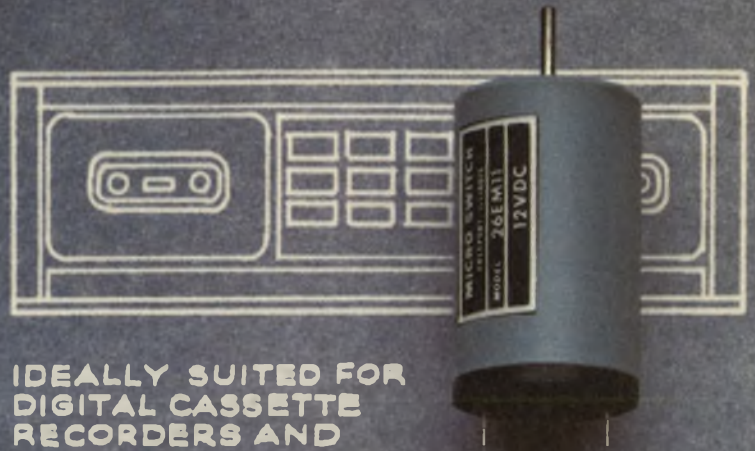
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NAKED MINI Division

U.S.A. 18651 Von Karman, Irvine, CA 92664  
(714) 833-8830

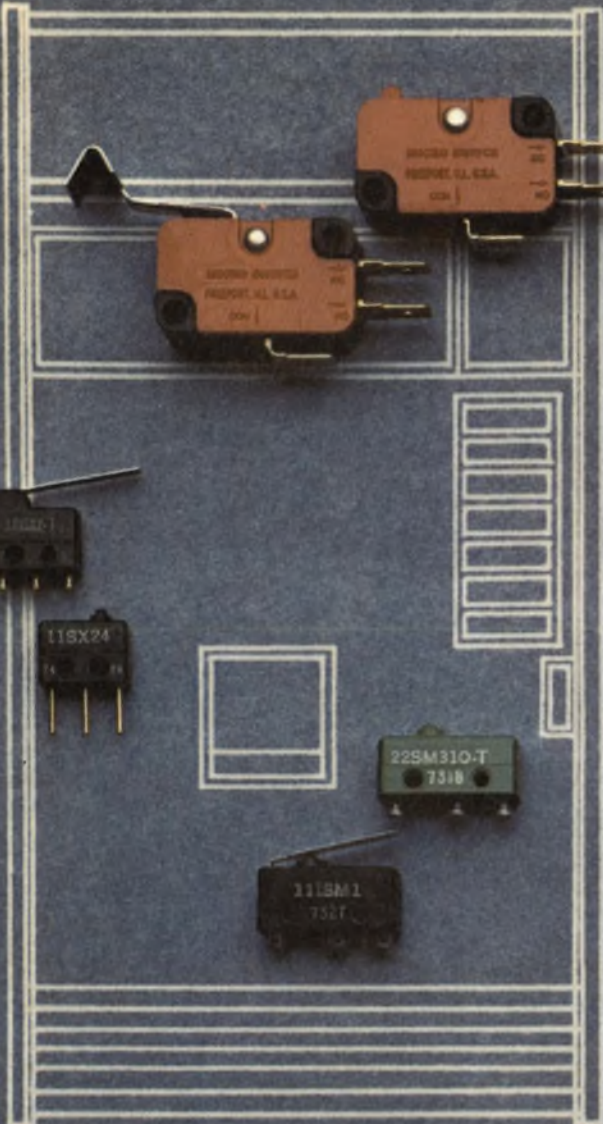
EUROPE 31/35 Clarendon Road, Watford,  
Hertfordshire, WD1 1JA England (0923) 39627

# Some of these components will probably

SNAP-ACTION VS, 5M AND 5X 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.



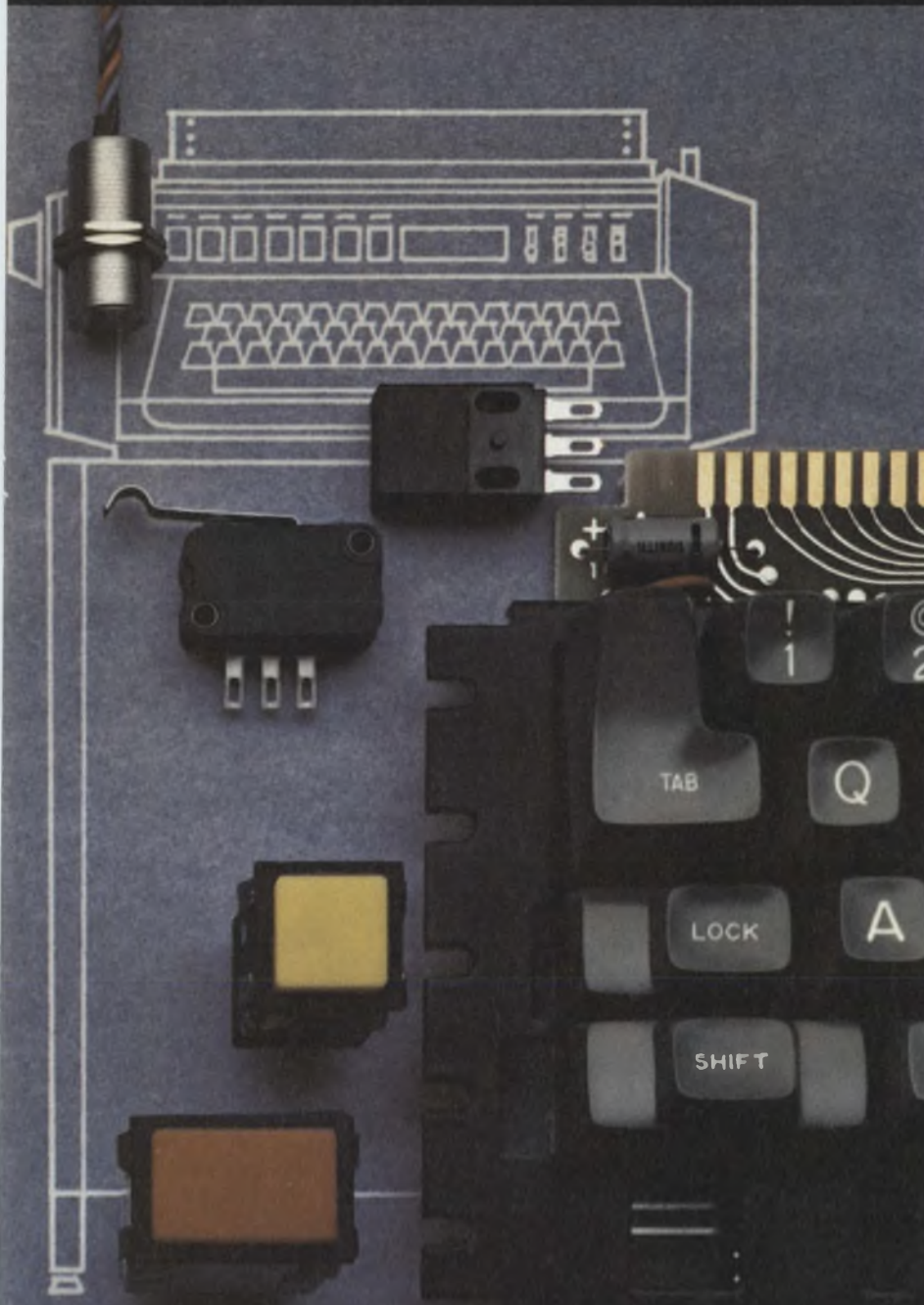
IDEALLY SUITED FOR DIGITAL CASSETTE RECORDERS AND CARTRIDGE DRIVES, THE 26EM MOTOR USES A HOLLOW ROTOR TO PROVIDE THE LOWEST POSSIBLE ROTOR MASS, RESULTING IN VERY LOW INERTIA. DIRECTLY INTERCHANGEABLE WITH MOTORS MADE OUTSIDE USA.



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 UN-LIGHTED 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

FREEMONT 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  $\theta_{jc}$  in the industry.  $62.5^\circ\text{C/W}$ . 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.

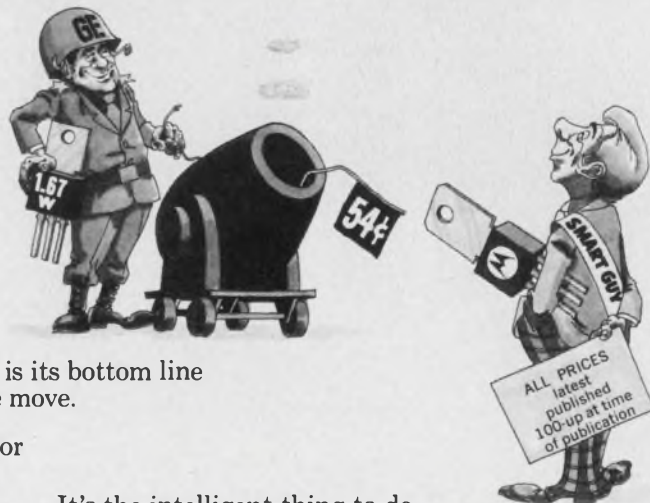
But enough technical brilliance.

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

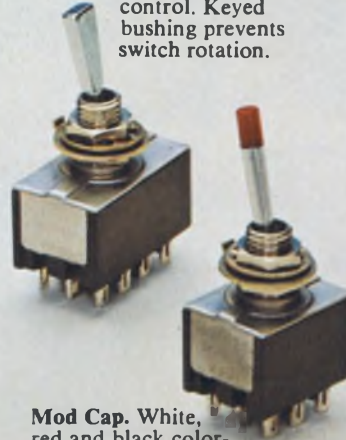
INFORMATION RETRIEVAL NUMBER 10



# 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."

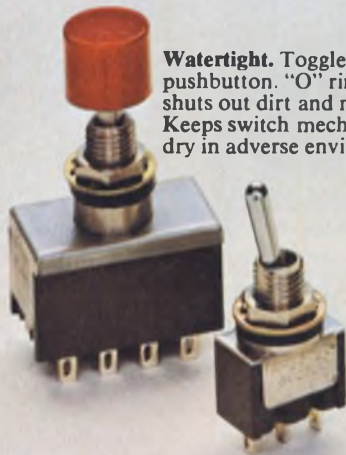
**Flat Lever.** Designed for comfortable, finger-tip control. Keyed bushing prevents switch rotation.



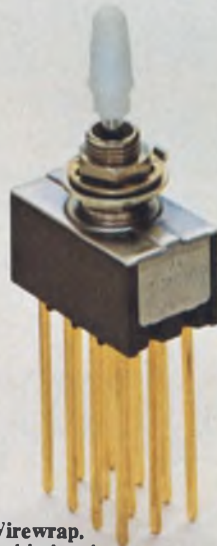
**Lever Lock.** Locks in position to assure precise control of vital or sensitive functions and equipment. No accidental operation.



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

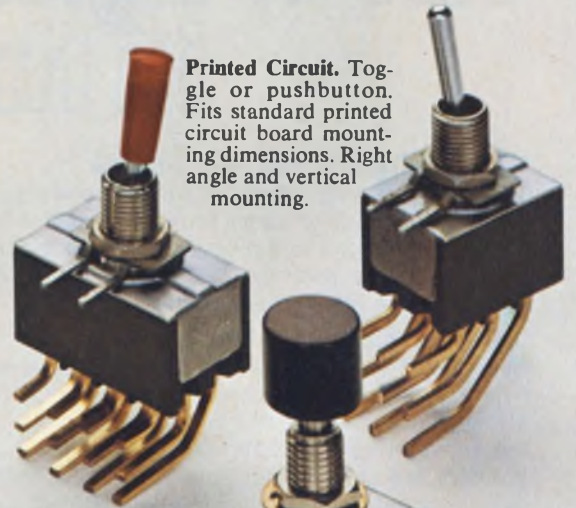


**Watertight.** Toggle or pushbutton. "O" ring seal shuts out dirt and moisture. Keeps switch mechanism dry in adverse environments.



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

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



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

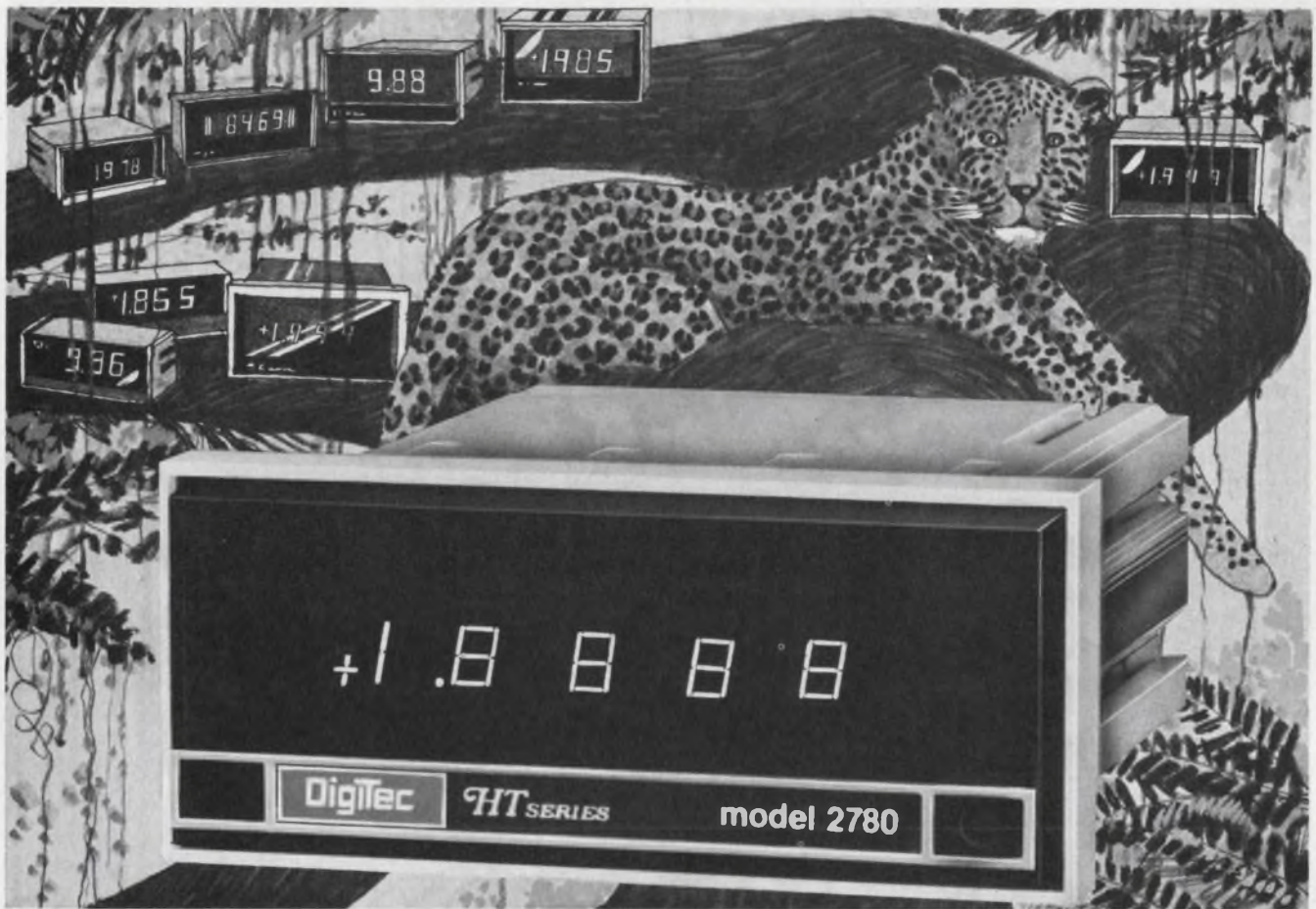
**Standard.** Toggle or pushbutton. One to four poles. Eight circuits. Two decorator cap styles in a variety of colors. Dry circuit capability, too.



 **Switch to No.1**

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





# 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.

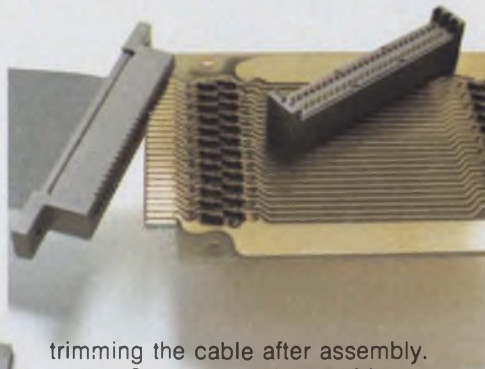
**DigiTec**

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

# 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.*



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

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.

**3M**  
COMPANY

# 3M's "Scotchflex" line.

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

INFORMATION RETRIEVAL NUMBER 14

**Thirteen**



# just became your lucky number!

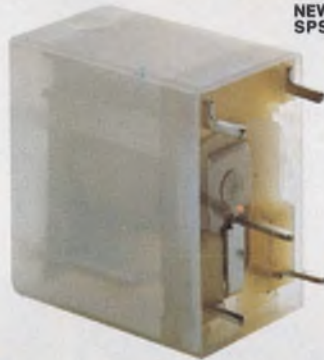


**Three new 10 amp relays give you 13 small enclosed relays from which to choose.**

**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 1345 SPST-NO, SPST-NC, SPDT**



**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*.



**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!**

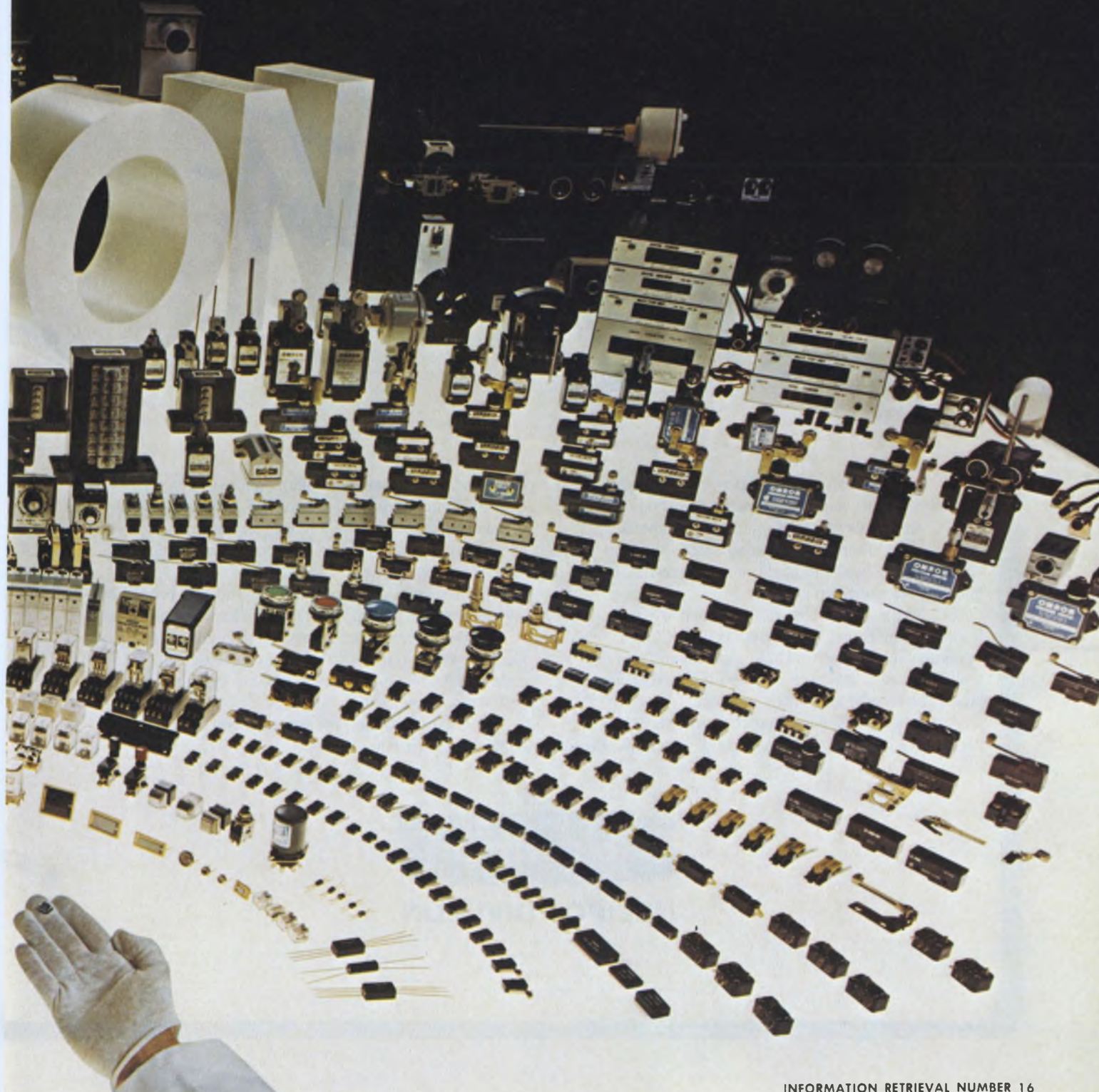


**Welcome  
to the family,  
little fella**



Omron Corporation of America  
Corporate Headquarters  
Sears Tower, Chicago, Illinois

Sales and Service  
1051 State Parkway  
Schaumburg, Illinois 60172  
Phone: (312) 885-9500



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 7/8" up to 3 5/16" diameters; from single-turn up to 40-turn. Most have  $\pm 20$  ppm/ $^{\circ}\text{C}$  wire for low tempco, and standard resistance ranges from 100 ohms to 100K ohms. Also, independent linearities are available to  $\pm .025\%$ , 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 7/8" pot with a 2-watt power rating, 125 $^{\circ}\text{C}$  maximum operating temperature, linearity of  $\pm 0.25\%$ , 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 1 5/16"-diameter Model 3371 (shown here) has a 1-watt power rating at 65 $^{\circ}\text{C}$ , linearity of  $\pm 0.5\%$ , 105 $^{\circ}\text{C}$  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 $^{\circ}\text{C}$ ), high temperature (up to 150 $^{\circ}\text{C}$ ) and high resistance applications (up to 1 megohm).

Our 7/8"-diameter, single-turn Model 6103 is a versatile example. It has exceptional resistance to environmental stresses, power rating of 3.0 watts at 85 $^{\circ}\text{C}$ , linearity available to  $\pm 0.3\%$ , wide standard resistance range from 150 ohms to 1 megohm, 150 $^{\circ}\text{C}$  (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, 7/8"-diameter pot with 2-watt power rating at 70 $^{\circ}\text{C}$ , 125 $^{\circ}\text{C}$  (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.

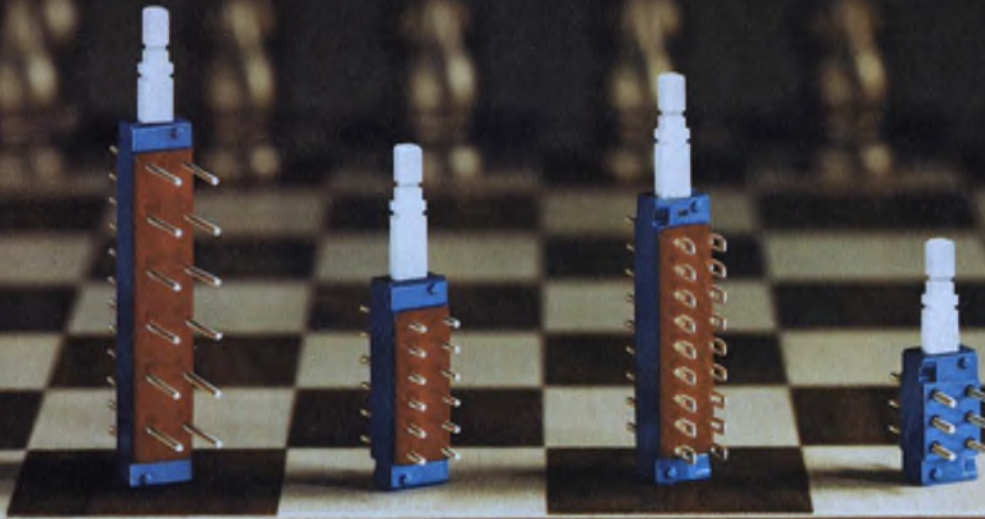
So, if precision pots—standard or custom—are in your plans, get full technical data on the Helipot line now.

Element Type	Wirewound	Conductive Plastic	Hybrid (Co 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.

©1976, Beckman Instruments, Inc.

# When it's your move ...check Centralab



## 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.

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

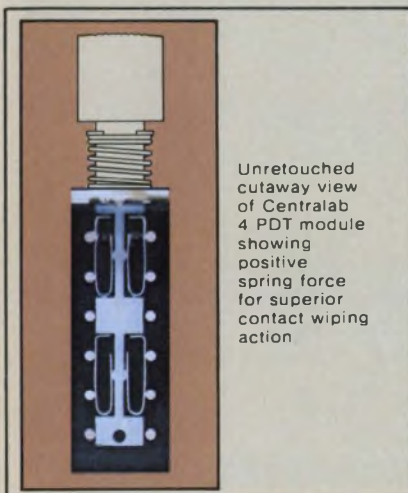
failure from solder flux and other contaminants.

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!



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

Isostat Licensed



**CENTRALAB**

Electronics Division

GLOBE-UNION INC.

P.O. BOX 858

FORT DODGE, IOWA 50501

## ACROSS THE DESK

(continued from page 7)

the timer display in the HH.MM-SS.UU 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- $\Omega$  output impedances, internal attenuators and off-sets 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



When it's  
your move  
check Centralab

High quality  
pushbutton  
switches at  
a low cost



Centralab switches are engineered for quality. Then they're produced on high-speed automated machines to keep your cost down. This means...

**Low Price:** A Centralab 2-pole lighted switch, for example, costs only \$1.36 including lamp, in 1,000 quantities.

**Quality:** Up to 250,000 MTBF in ganged assemblies. Over 500,000 operations on contact systems.

**Plus Options:** Diallyl phthalate housings • gold contacts • epoxy-sealed terminals • 2, 4, 6 and 8 poles • four types of lockouts • and much more for *only pennies more*.

**Newest Additions:** Non-lighted status indicator • low-cost lighted switch • 5 amp line switch.

When you can have quality and low price from Centralab, why settle for less? For full information, call your Centralab Pushbutton Distributor or send reader service card, or write...

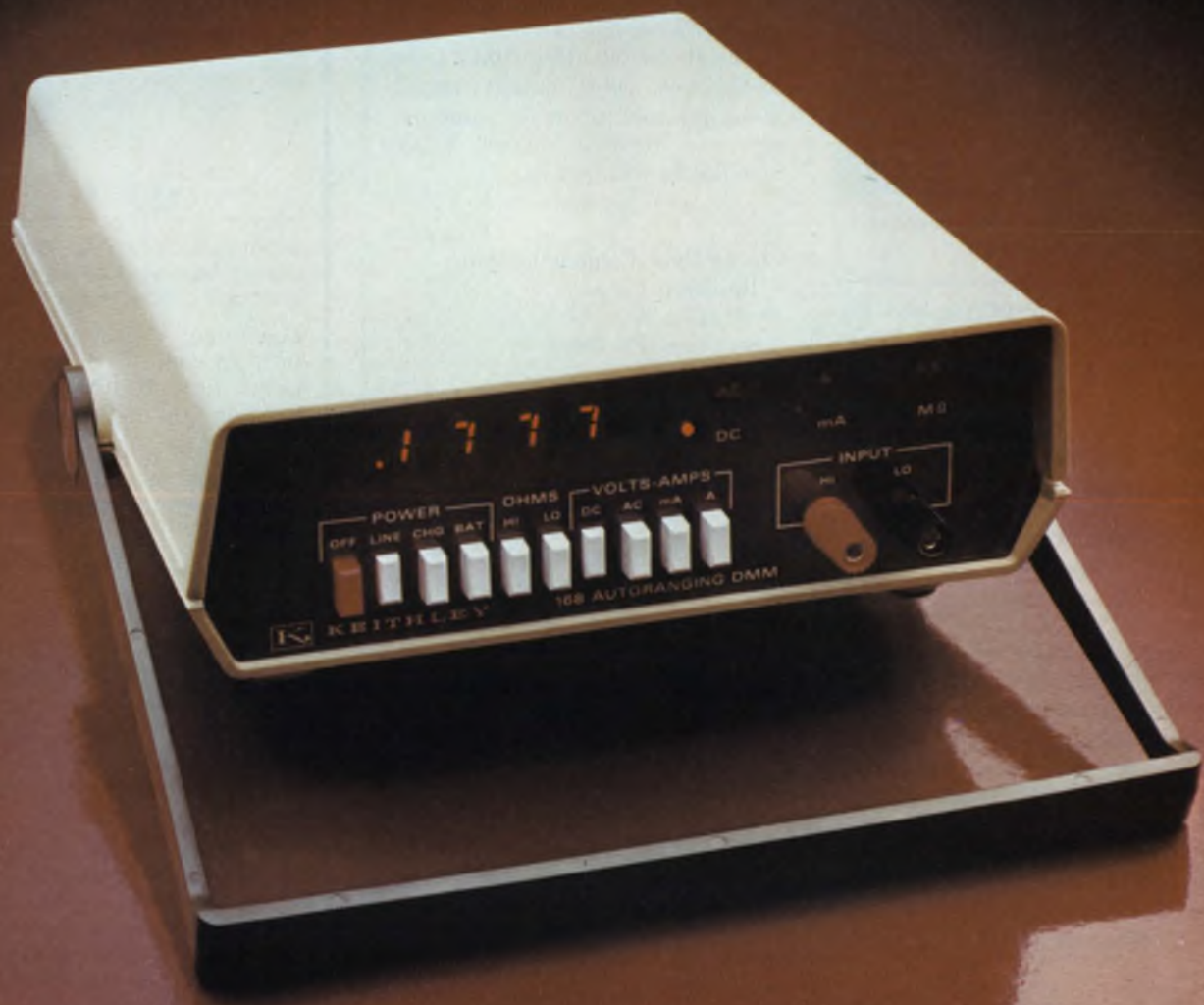
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CENTRALAB

Electronics Division  
GLOBE-UNION INC.  
P.O. BOX 858  
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**KEITHLEY OFFERS:  
A 3½-DIGIT MULTIMETER.  
4 EXCLUSIVE FEATURES.  
\$315.**



The Keithley 168 Digital Multimeter gives you every key performance feature offered by other first-line 3½-digit DMMs.

But only the Keithley 168 gives you 4 extra features—all useful and all at a competitive price. Compare our 3½ with the others and you'll come to an inescapable conclusion: the 168 is the best buy in 3½-digit DMMs.

#### For \$315: a superior DMM

For openers, you get a rugged, reliable, easy-to-read, general-purpose, 5-function DMM with more ranges than you'll normally need. Measure from 100 microvolts to 1000 volts dc, 100 microvolts to 500 volts ac, 100 milliohms to 20 megohms, 100 nanoamps to 1 amp, ac or dc. Basic accuracy is 0.1%. All modes fully overload protected. The 168 brings Keithley quality to general-purpose measurement.



#### 4 extra features, no extra cost.

- *Automatic ranging* gives you the most accurate reading, with decimal in the right place, faster than you could do it with switches. Saves you time every time you make a measurement.
- *HI-LO Ohms* lets you turn on a semiconductor junction to see if it's good or measure an in-circuit resistance without turning on a semiconductor.
- *2-terminal input* for all measurements on all functions. You can't get it wrong. Terminals accept banana plugs, alligator clips, spade lugs or bare wire.
- *Lighted function indicator* so you know precisely what you're measuring, instantly.



#### Surprise: more valuable features.

That's not all. We've packed even more value into the 168. Optional battery pack that you buy now or add later. Patented A-D converter to simplify circuitry. No-nonsense, full-year guarantee on parts, workmanship, and specs—including accuracy. Convenient calibration instructions right inside the cover. Light weight for easy portability.

#### Full complement of accessories.

Use these optional accessories to make your Keithley 168 DMM even more versatile: Wide-range RF probe. Test lead sets. Clamp-on ammeter. 50-amp shunt. High-voltage probe. Carrying case. Rack mount kit.



#### Now the logical choice.

The 168 is out-front in value. And it's backed up by our reputation for quality. Don't you wish all decisions were this easy?

Ordering a 168 is easy, too. Just contact: Keithley Instruments, 28775 Aurora Road, Cleveland, Ohio 44139. (216) 248-0400. Europe: D8000 München 70, Heighhofstrasse 5, West Germany. (089) 7144065.

#### DMMs for all your needs.

We know you have a variety of measurement requirements. So we offer a growing family of DMMs to meet your application and price objectives. Send for our Selector Guide.



# KEITHLEY

The measurement engineers.

**You can buy  
this Spectrum Analyzer  
and take a big chunk  
out of your budget.**

**You can rent  
this Spectrum Analyzer  
and get more  
equipment out of  
your budget.**



Even the best equipment budget can only go so far. And at the price you pay for electronic test equipment nowadays, that's not very far at all.

Unless you rent your equipment from REI.

When you rent from us, there's no large cash outlay. You pay only for the time you have your instruments, and you return them when you're through. So you never have to spend your money on idle equipment.

Getting more for your money is just one reason for renting from REI. Immediate delivery is another. We have over \$10 million in inventory in fully stocked centers around the country. And, when you have short-term needs, you can rent equipment for just as long as you need it, and make it pay for itself.

REI stocks over 8,000 fully checked-out test instruments, and they're ready whenever you are. For the full story on renting, as well as our low prices, send in the coupon for prompt delivery of our free illustrated catalog... or call us now for your immediate requirements.

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99 Hartwell Avenue, Lexington, Mass. 02173  
Please send me your free instrument rental catalog:

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**Rental Electronics, Inc.**

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INFORMATION RETRIEVAL NUMBER 21

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 rep-

resentative, 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"  $\mu$ P-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  $\mu$ P 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  $\mu$ P 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  $\mu$ P-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 wrist-watch-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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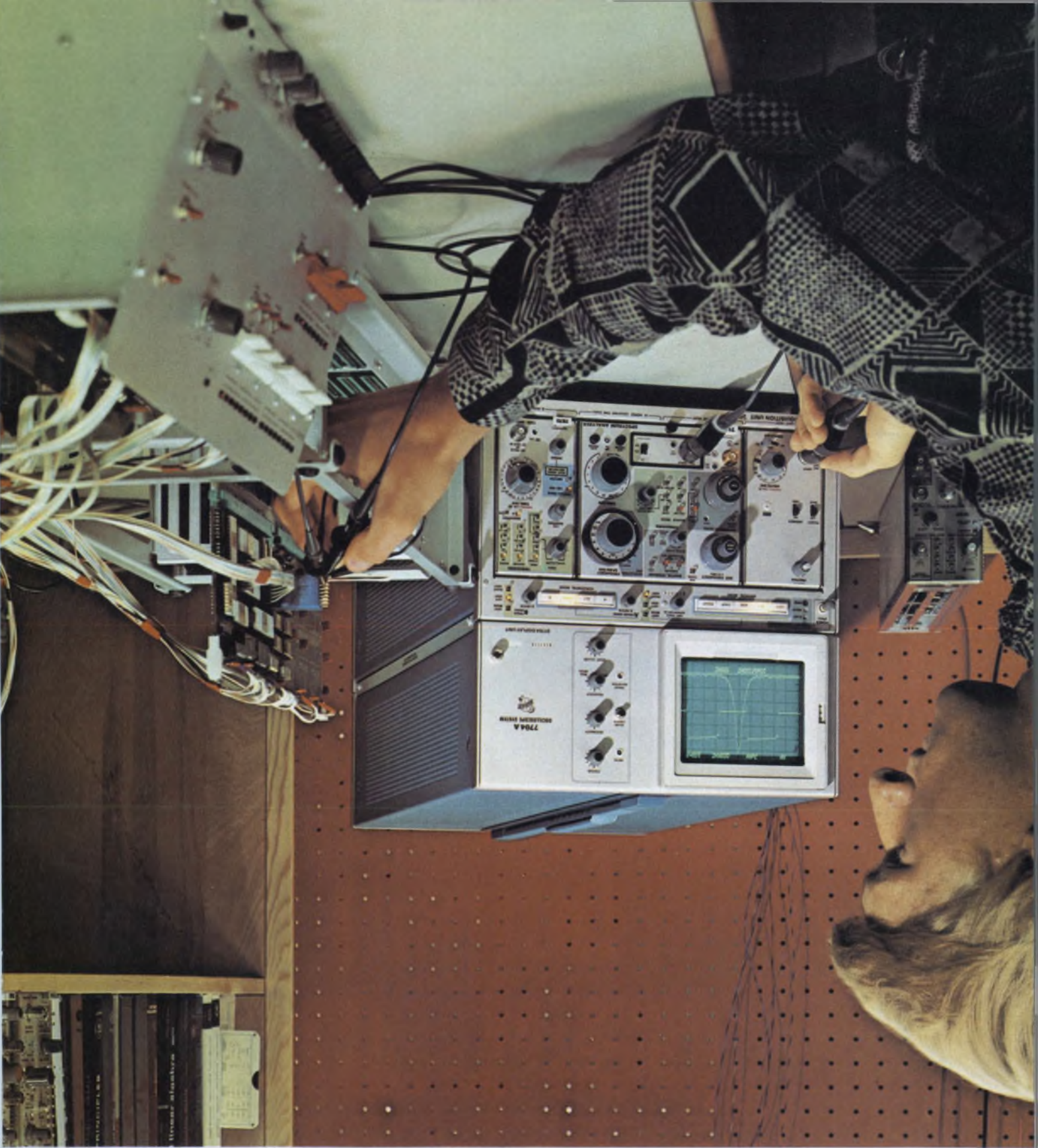


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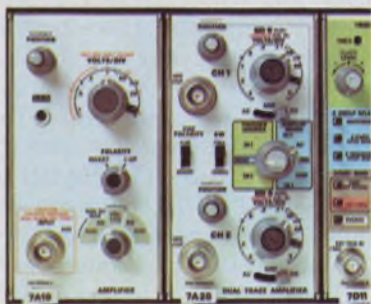
However, your space limitations, budget considerations and operator's convenience all demand that you get the maximum measurement flexibility from each instrument package.

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.



*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.*

**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.

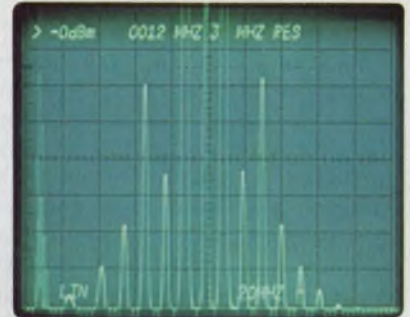


**DIFFERENTIAL INPUTS**—When common mode noise inhibits your measurement of low level signals, differential amplifiers (with up to 100,000:1 cmrr) can be included in your system.

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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.

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## 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.

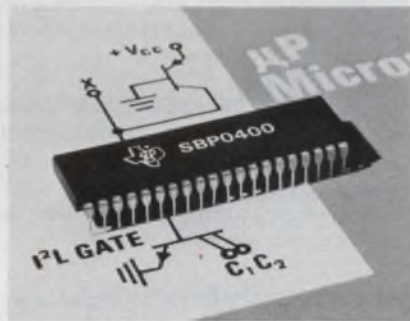
It's likely, therefore, that IC industry progress this year will be somewhat less dramatic than in the recent past. Though research will continue at a fast clip, manufacturers won't introduce new products until they can be manufactured and sold in volume. Successful products will be alternate-sourced 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<sup>2</sup>L)** 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



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

year the arena will be bit-slice microprocessors, and there may be some dark horses, like fast I<sup>2</sup>L, 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.

## Everybody's looking at I<sup>2</sup>L

Because of its many advantages most IC manufacturers are evaluating and developing I<sup>2</sup>L, 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<sup>2</sup>L is relatively inexpensive because it requires only four or five masking steps and uses conventional bipolar processes.

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

Because I<sup>2</sup>L 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<sup>2</sup>L chips for electronic organs and alarm clocks. A new British digital watch from Sinclair Radionics uses an ITT-made I<sup>2</sup>L chip. Panasonic offers three I<sup>2</sup>L circuits; these are flip-flops and frequency dividers suitable for use in electronic organs.

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

MOS chip.

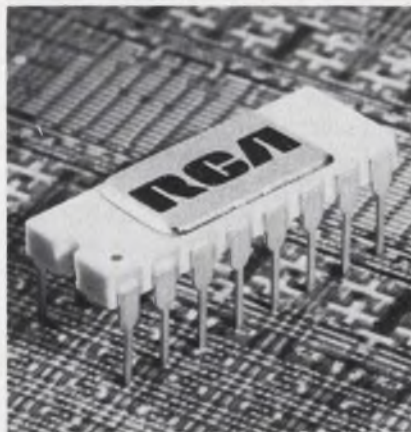
Motorola definitely has three I<sup>2</sup>L circuits slated for introduction within a few months. These are an 8-by-8 multiplier, a DMA controller and a programmable delay module. The chips are intended as peripheral circuits for the 6800 and other microprocessors. Several companies are working on I<sup>2</sup>L 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<sup>2</sup>L emphasized speed-power product rather than pure speed, recent refinements have boosted speed to the point where I<sup>2</sup>L 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<sup>2</sup>L 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<sup>2</sup>L, this technique should double chip density, more than double speed and perhaps cut costs by eliminating one or more mask steps.

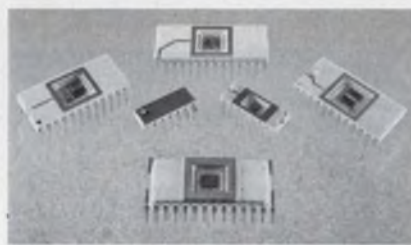
Mitsubishi in Japan has developed what it calls vertical injection logic (VIL). This is similar to I<sup>2</sup>L, except that the pnp injector transistor is fabricated vertically instead of laterally, thus allowing it to be made narrower. Compared with conventional I<sup>2</sup>L, the new configuration 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<sup>2</sup>L while yielding comparable packing density and speed-power product.

### No more logic families?

Despite its many advantages, it's not likely that I<sup>2</sup>L will evolve into a broad family of logic circuits as CMOS and TTL did. In



**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  $\mu$ W 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.

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<sup>2</sup>L circuits as part of a mixed technology bipolar LSI family. Motorola's Megalogic family embraces several bipolar technologies and includes I<sup>2</sup>L 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<sup>2</sup>L 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<sup>2</sup>L—despite all the hoopla—does have some serious drawbacks.

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<sup>2</sup>L is most useful when there are only a few interfaces to the chip.

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

The most immediate threat to I<sup>2</sup>L 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<sup>2</sup>L as a rising contender. And the arena for this bout is bit-slice  $\mu$ Ps. For these circuits, currently used mainly in minicomputers, speed is important so they can be micro-programmed and still cycle fast enough to work efficiently with available n-channel MOS memories. And as memories get faster, the  $\mu$ Ps will be forced to stay one jump ahead.

The current list of companies making bipolar  $\mu$ P 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<sup>2</sup>L 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  $\mu$ Ps 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<sup>2</sup>L 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<sup>2</sup>L 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<sup>2</sup>L 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  $\pm 0.05\%$ .**

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

### MOS leads for high density

Most 8 and 16-bit  $\mu$ Ps, however, are MOS types. Despite the enormous potential of I<sup>2</sup>L and Schottky TTL, MOS still yields the highest device densities on the chip. At present over 20 companies are selling MOS  $\mu$ Ps, 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  $\mu$ Ps and minicomputers.

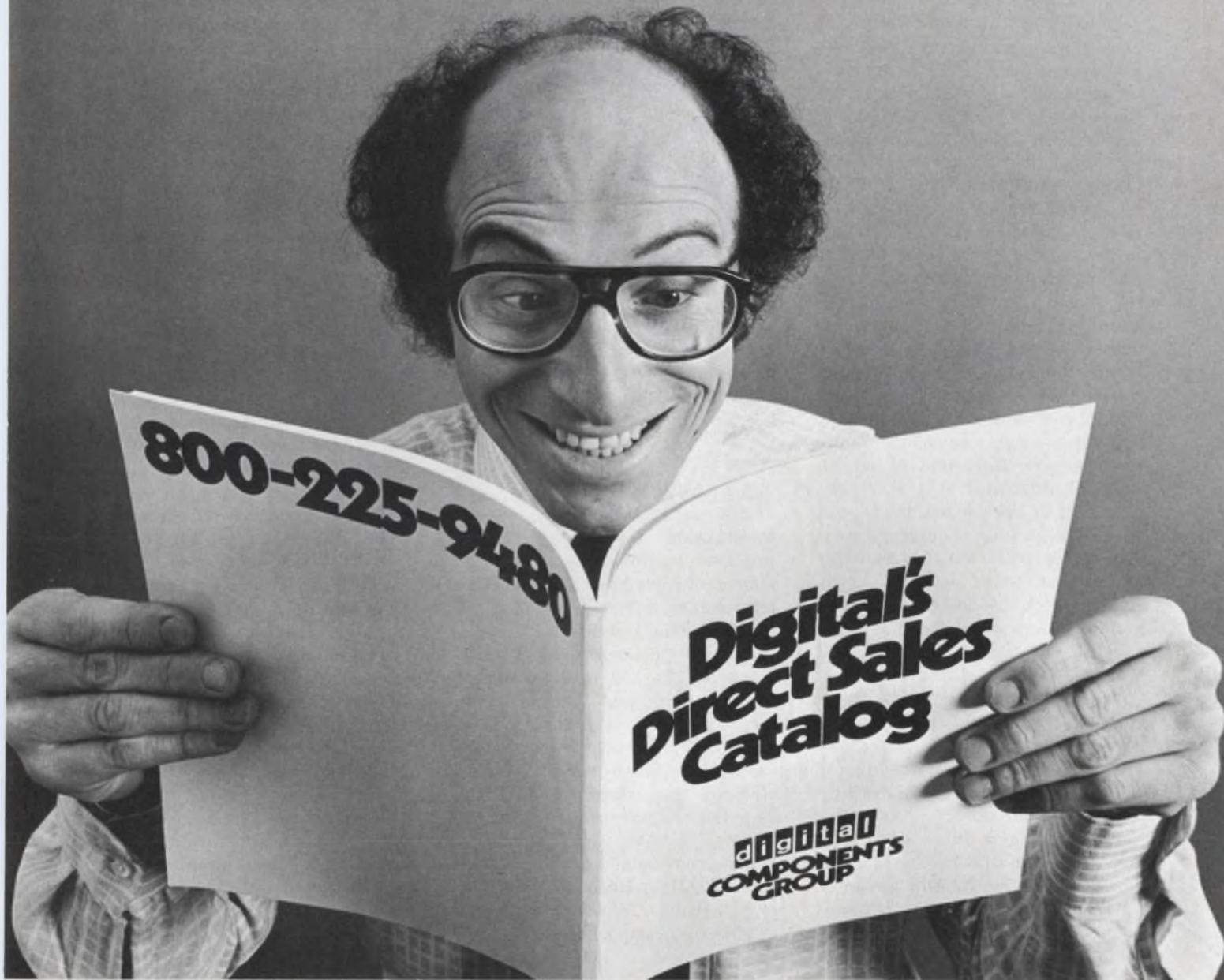
The real market payoff for today's high-density MOS, though, will be in memories rather than  $\mu$ Ps. The industry is expanding its capacity for volume production of 4-k RAMs, and 16-k versions will begin to appear this year.

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.

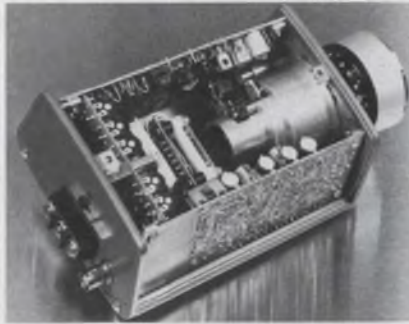
Another contender in the semiconductor memory race is, of course, the CCD. Though CCDs are slower than semiconductor RAMs, they offer potentially higher bit densities.

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  $\mu$ Ps 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 pro-



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.

vided 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.

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<sup>2</sup>L 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 $\mu$ P explosion

In the past two years alone, practically every category of instrument has been touched by the  $\mu$ P—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  $\mu$ Ps in instruments—is one who sees 488 as just one of many interfaces.

Hume analyzes the situation this way: "Once you've got a  $\mu$ P 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  $\mu$ P 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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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  $\mu$ P 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  $\mu$ P, dedicated automatic test systems will appear in the \$20,000-to-\$30,000 price range," he predicts, "but with performance rival-

ing 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 nose-dives 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  $\mu$ P lets a designer cut costs while simultaneously broadening performance, we may yet see a return

to the performance spiral of yesteryear. But the  $\mu$ P 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  $\mu$ Ps.

"It's inevitable," he postulates, "that we'll see a \$5  $\mu$ P in instruments that cost \$500. We don't know exactly what role the  $\mu$ P 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.

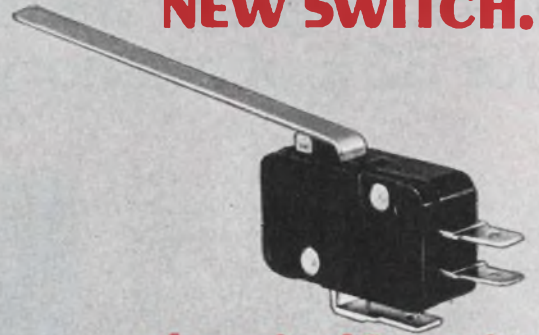
"Conceptually, it's possible to build an instrument in which the user has access to the  $\mu$ P. We've been playing around with that idea. The user's benefit is, of course, that he can reprogram to get not just one but any of a number of instruments. But this creates problems. For instance, how can 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  $\mu$ P has already invaded one synthesizer to bring hitherto unavailable features, and more such sources are likely to follow. ■■

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# 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  $\mu$ Ps.

- Double-density and two-sided floppy discs will become available in quantities.

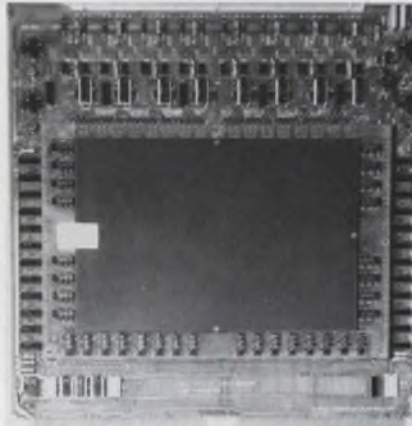
## More main memory

"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



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.

think that '76 will see semiconductor memory finally overtaking core."

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-



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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 $\mu$ P

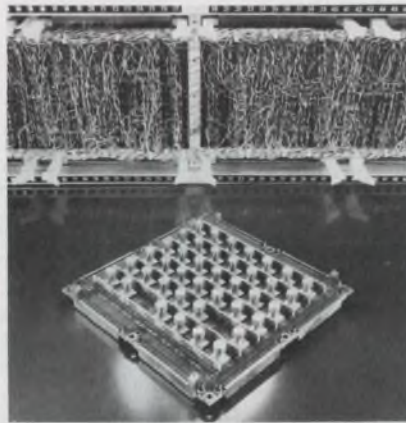
Microprocessors are being designed into a raft of new minicomputers, most of which will be introduced this year. Already several minis are on the market with  $\mu$ P CPUs. Last year Digital Equipment introduced the LSI/11, the heart of which is a MOS/LSI  $\mu$ P. Recently three minis have been introduced with bipolar bit-slice  $\mu$ Ps 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. Wieselmann, vice president of product programs at Dataproducts, Woodland



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 x 7 in. There are 51 multiple-chip carriers in the 470V/6 system.

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."

### 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 $\mu$ Ps 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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# Graphics \$150/mo

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.

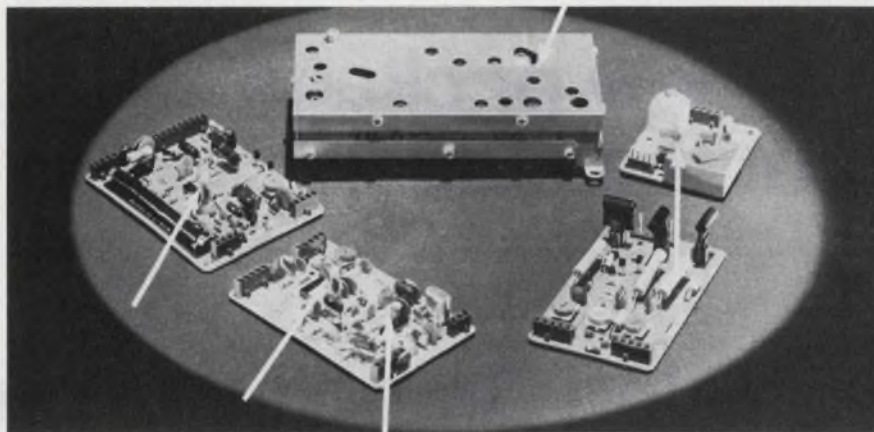
"There is a significant swing to varactor tuning," says William Newell, product manager of color TV at Magnavox, Fort Wayne, IN. "Varactor tuners are admirably suited for digital tuning systems.

"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



**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.

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

"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<sup>2</sup>L technology." The high packing density of I<sup>2</sup>L 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<sup>2</sup>L," he says. "While I think that problems with I<sup>2</sup>L 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<sup>2</sup>L chip."

Another thing, Smith says, "people I've talked to feel that there is no advantage whatever in the use of I<sup>2</sup>L 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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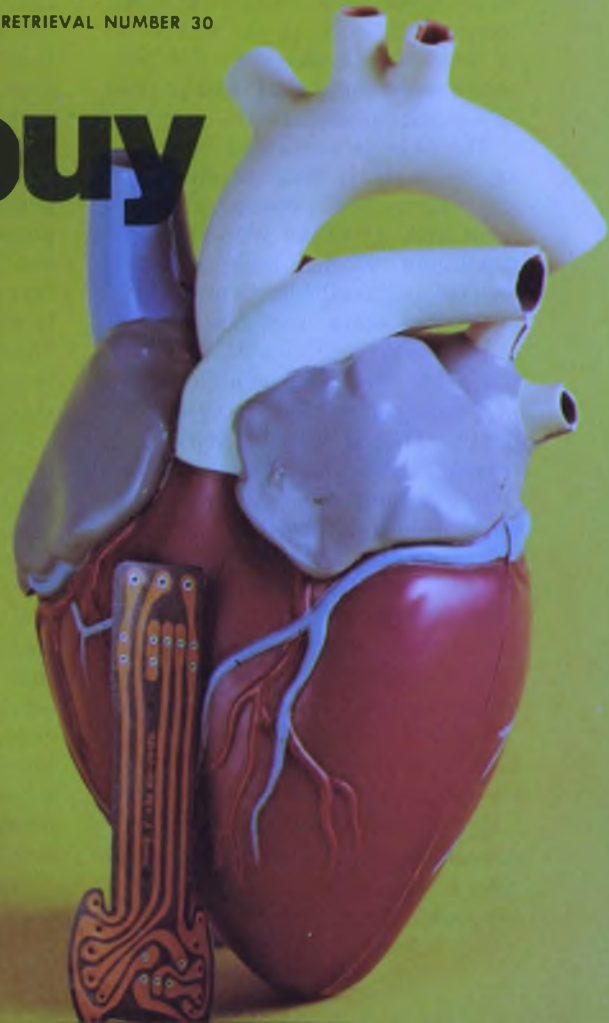
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## Would you buy it from the low bidder?



# From data to process systems, $\mu$ Ps 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  $\mu$ P 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  $\mu$ Ps. 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  $\mu$ Ps 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 Rehtin 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, hand-held 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. Baldrige, 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  $\mu$ P controllers, CRT displays that each use the CP 1600  $\mu$ P 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."

Baldrige 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," Baldrige 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

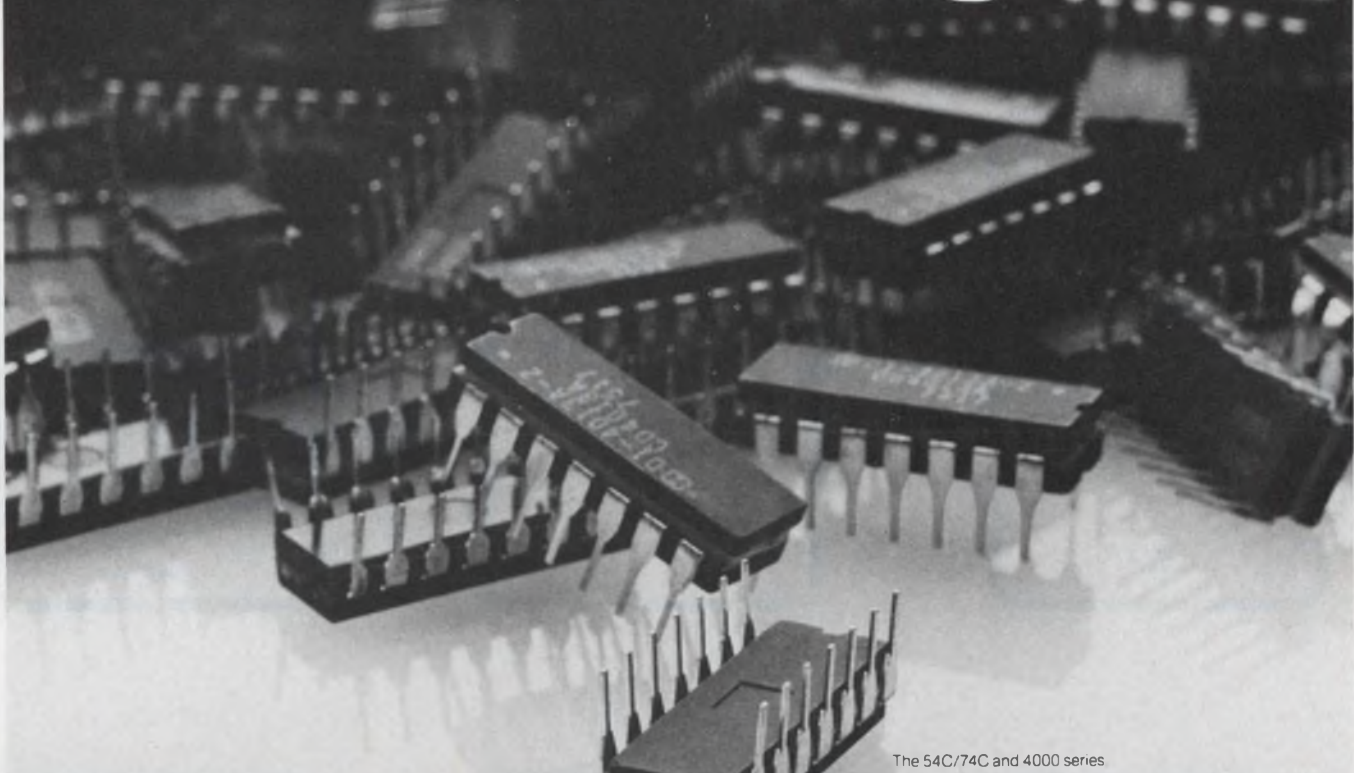
The aim at Measurex Corp., Cupertino, CA, has been to provide equipment that is cheap enough and small enough to make it worthwhile to automate facilities that haven't been worth the cost of automation. The company's 2000/Gemini, a digital multi-process control for the paper and pulp industry, is a twin-computer 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  $\mu$ P.

Intel also hopes to open doors. "We're going after new customers in 1976, people who've used electro-mechanical 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 hand-holding they need to feel comfortable with the product." ■■

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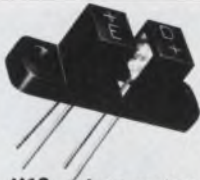
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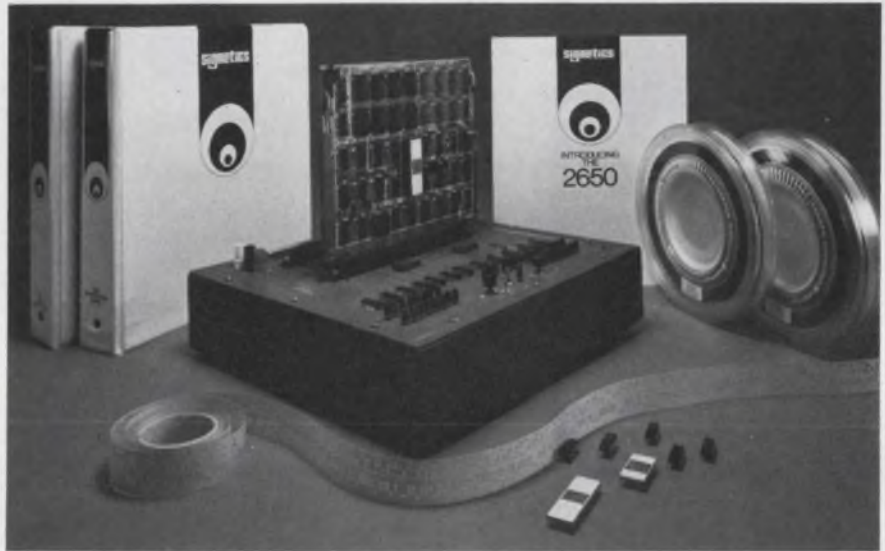
# Just getting into microprocessors? Odds are you'll end up with a kit

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  $\mu$ P 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  $\mu$ P 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  $\mu$ Ps 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



**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.**

or employ computer services.

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 unwieldy 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 to-

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  $\mu$ Ps. The Martin Research entry, called the Mike series, has a base price of less than \$300. The modular system allows



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

gether 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  $\mu$ P, 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

easy expansion, and it features interchangeable cards. Memory and I/O cards for one Mike unit can be used with the  $\mu$ P card of another.

### 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  $\mu$ P.

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.

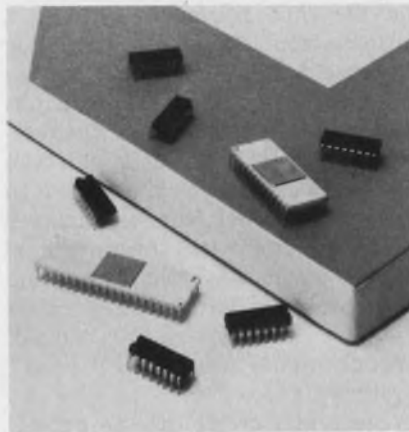
An alternative means for system expansion is to reduce the clock rate—a "solution" that limits the performance of the prototype.

### Kits and $\mu$ C development systems

Manufacturers that already have  $\mu$ C 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  $\mu$ Ps. 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  $\mu$ P enough time to make an "intelligent" move.

Kits from two manufacturers of CMOS  $\mu$ Ps—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  $\mu$ P, 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  $\mu$ P 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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For larger 990/10 systems requiring mass storage and rapid access to programs and data files, the DX10 Disc Operating System gives you all you need and eliminates most of the time-consuming work previously associated with system generations. It includes a utility for constructing and testing software, and controls our "Librarian" software package for source and object program files.

## Flexible Packaged Systems

TI offers two packaged program development systems and a prototyping system for the user who needs his own stand-alone system for software and firmware development of application programs.

These packaged systems provide a flexible method of implementing early project development. These include the low-priced 990/4 Program Development System and the powerful 990/10 Program Development System. The 990/10 system combines the power of



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.

And, we provide a wide variety of

program development utilities for the 990 family. There is communications software that supports either synchronous or asynchronous data transmission, and can operate with the TX990 or the DX10.

## Support from the start

In addition to software, the TI 990 family has another kind of support that's basic to every TI computer product. Complete training and applications assistance, plus a nationwide service network backed by TI-CARE†, our remote diagnostic, service dispatching and real-time field service management information system.

For complete details on the new 990 family, call your nearest TI office or write Texas Instruments Incorporated, P.O. Box 1444, M/S 784, Houston, Texas 77001.

Or, phone Computer Equipment Marketing at (512) 258-5121.



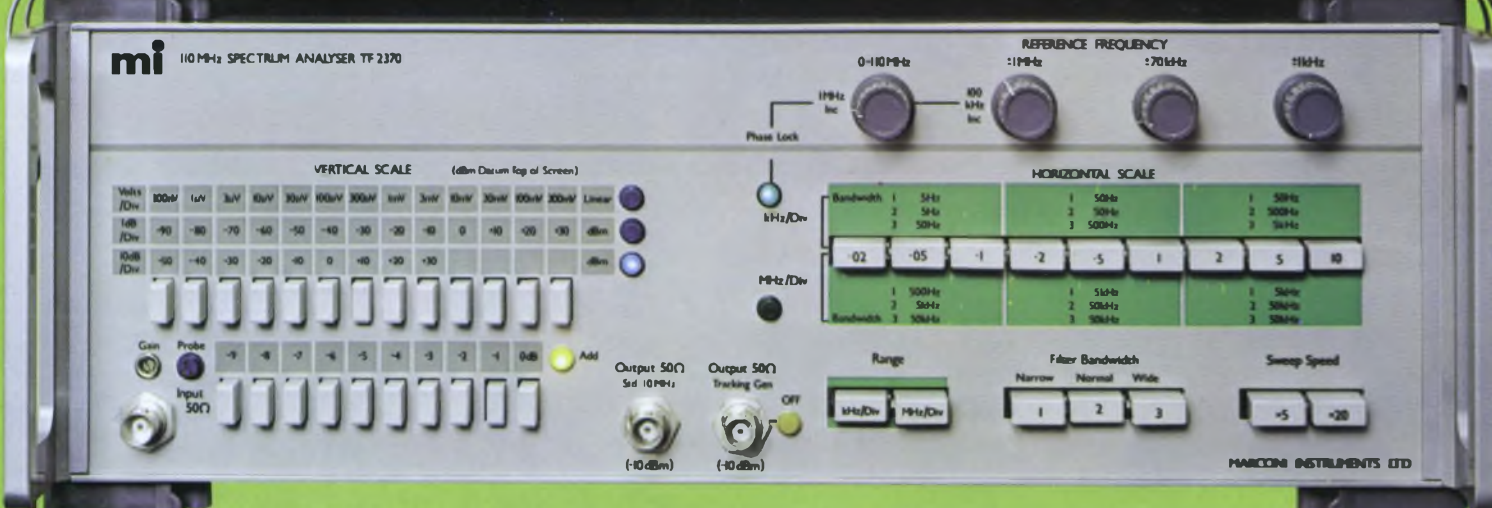
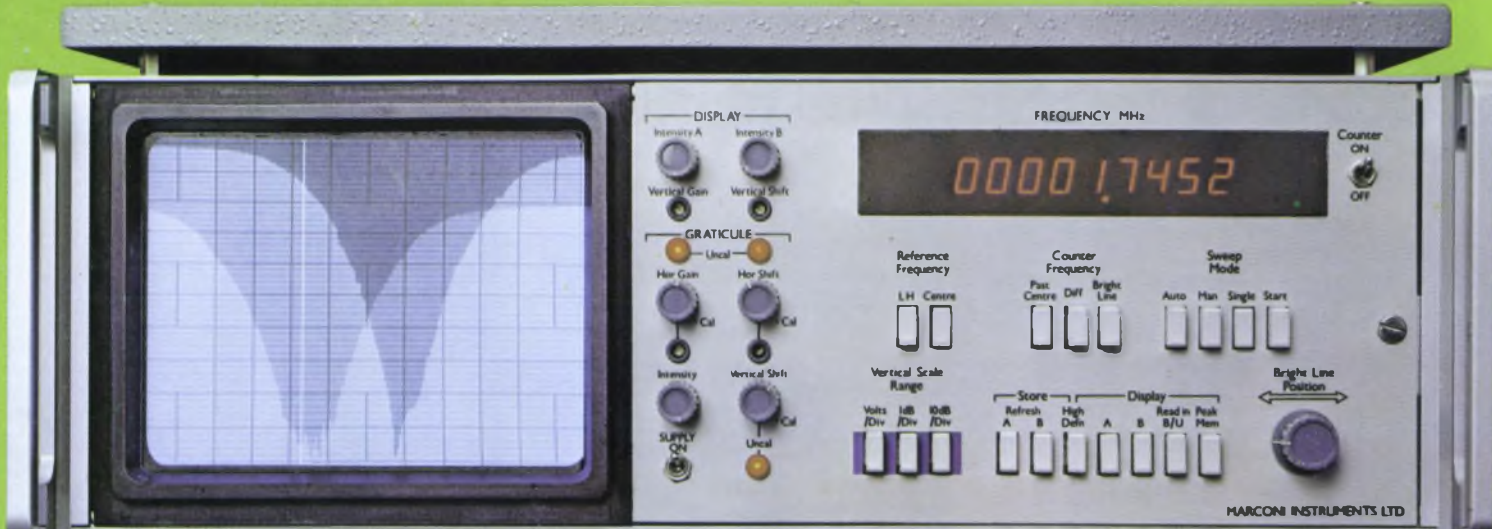
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INFORMATION RETRIEVAL NUMBER 264



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  $\mu$ P, 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 $\mu$ Ps 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  $\mu$ P. Mostek retails its Survival kits for \$297.

$\mu$ Ps are available at present only from  $\mu$ P manufacturers. And the bipolar- $\mu$ P 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  $\mu$ Ps—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  $\mu$ P 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- $\mu$ P 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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INFORMATION RETRIEVAL NUMBER 34

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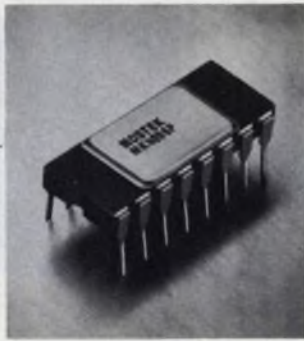
Every 4K RAM we ship has to live up to a rigid set of quality standards. We subject all of our 4K circuits to temperature cycling, centrifuge, pre-burn test, burn-in, and final test. The result is unmatched circuit reliability.

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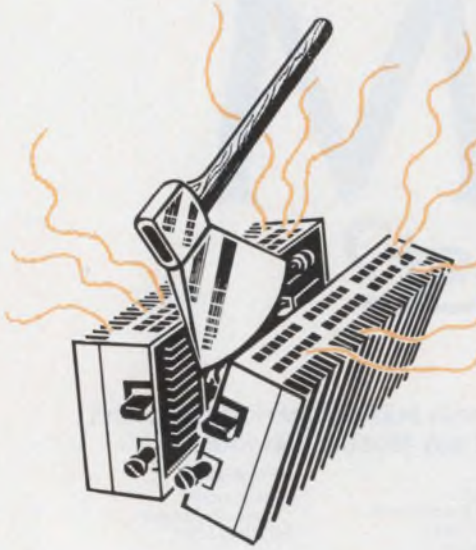
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INFORMATION RETRIEVAL NUMBER 36

# 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 re-started 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 eyeing 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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INFORMATION RETRIEVAL NUMBER 37

# AMI 6800: The whole Kit.

## Smart Terminal.

Complete program editing through CRT and keyboard. Also includes Modem communication to remote computers. (Avail. Feb.)

## Magnetic Tape.

Cross product software— assembler, loader, simulator.

## AMI 6800 Family.

It's all here: MPU, RAM, ROM, PIA, ACIA, PROM, USRT and Modem. By test, the best.

## Evaluation Board.

Includes everything you need to evaluate parts, program PROMs and, connected with a peripheral, run programs.

## Dual Floppy Disk.

Storage for resident software— assembler, editor, etc. (Avail. Feb.)

## Disk Program Storage.

500K bytes for program development and on-line data storage. Cuts out the paper tape! (Avail. Feb.)



Our AMI 6800 Kit is a big step forward in simplifying your design, evaluation and test programs. For example, our intelligent CRT is simple to operate with either resident or remote software. It really is smart, because it contains an S6800! And it's planned to have an in-circuit emulator added later.

Our dual disk is extremely useful for developing programs, and saves you hours of paper tape shuffling. And our Evaluation Board is loaded with

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Now for the Caboodle. The dictionary calls it a "package." You'll call it the neatest set of instructions for any kit you've ever bought.

Now why don't you call your nearest AMI sales office or distributor, and ask them for the whole Kit and Caboodle. Or write AMI, 3800 Homestead Road, Santa Clara, CA 95051. What could be easier?

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A rundown on AMI software products including assembler, loader and simulator.

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List of goodies. All you want to know about the AMI 6800 family.

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The why and wherefore of our Prototyping System, and how to make the most of it!

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All the magic necessary to work with National CSS time-sharing network.

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Describes the instruction set and how to use the AMI Assembler and Simulator.

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A detailed description of each component in the system, and how to make them work!



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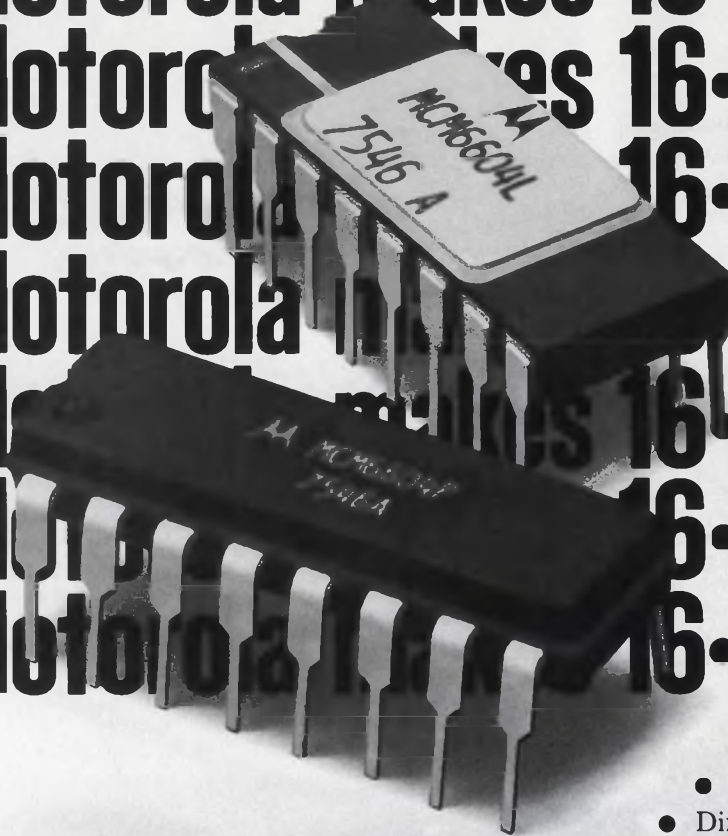
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INFORMATION RETRIEVAL NUMBER 39

Motorola makes 16-pin 4K RAMs

# Microprocessor Design

## 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  $512 \times 22$ -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 $\mu P$

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.
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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!

INFORMATION RETRIEVAL NUMBER 40

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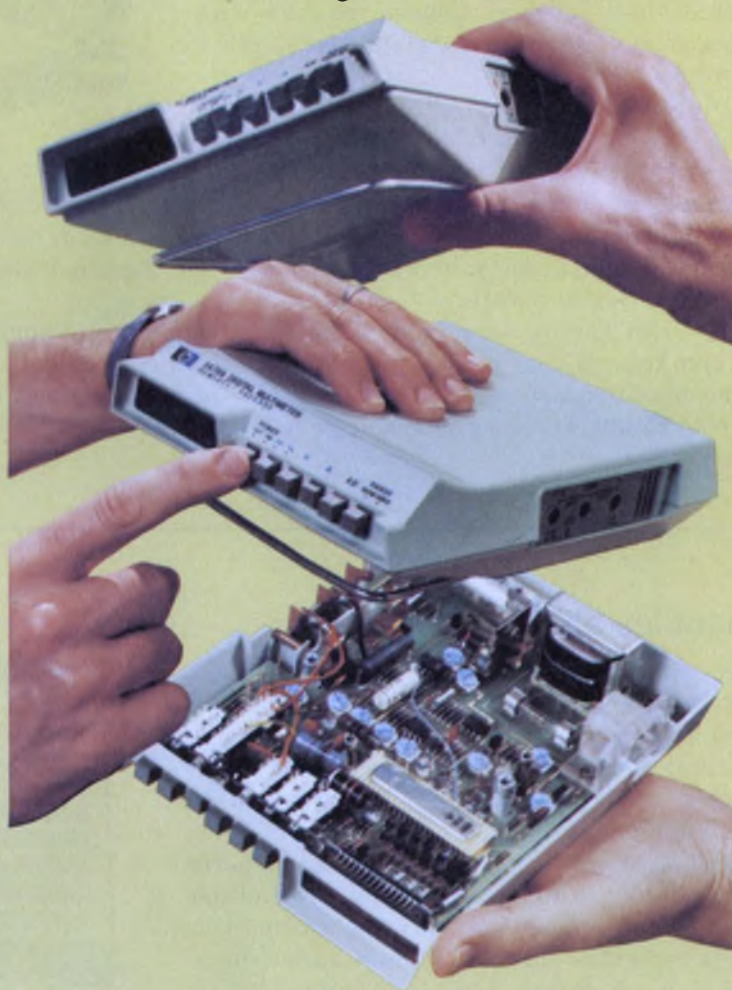
## Introducing HP's 3476A DMM

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.

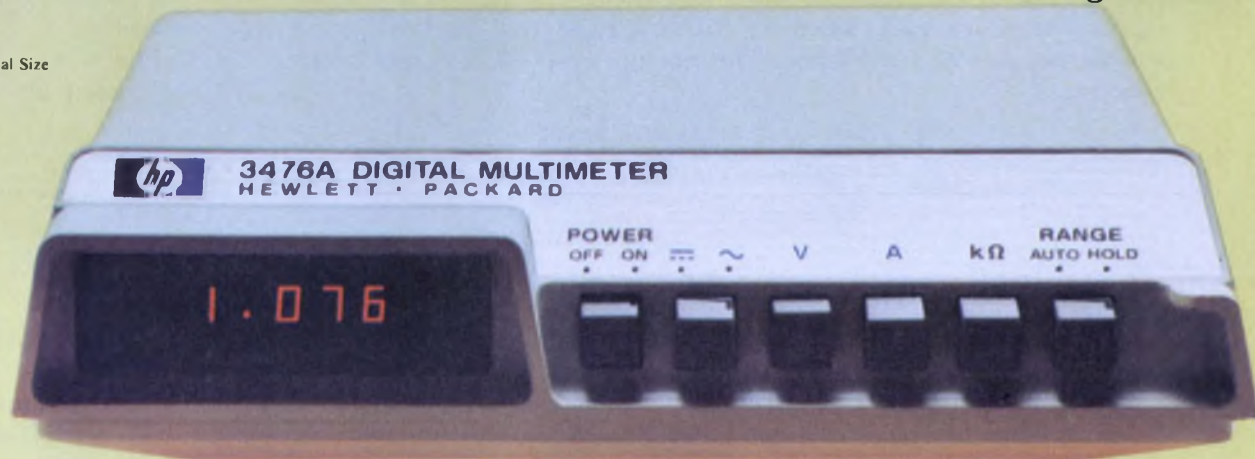
The 3476A is backed by HP's service organization... another big plus for a low-cost DMM. With these prices and features, why not put your hands on the 3476A for your 3-1/2 digit measurements? Your local HP field engineer can tell you how.


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Actual Size

085/52



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INFORMATION RETRIEVAL NUMBER 41

*(continued from page 62)* **$\mu$ C-based interface unit teams up with programmable calculator**

Thanks to a new  $\mu$ C-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  $\mu$ C 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  $\mu$ C 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

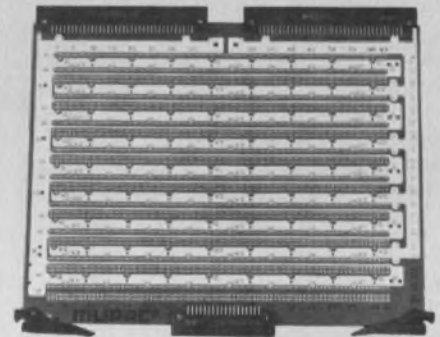
**Breadboard card handles all size packages**

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 laid 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

 **$\mu$ P cross assembler runs on most 16-bit minis**

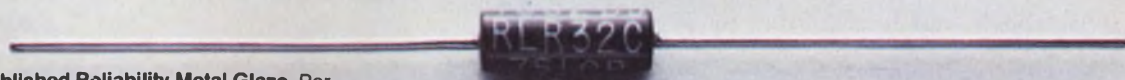
Mycro-Tek, Inc. (6631 E. Kellogg, Suite 214, Wichita, KS 67207. 316-686-3311) reports that software development time for 8080-based microcomputer systems can be significantly reduced with its cross assembler. The assembler is designed to give the programmer the advantages of large-scale computer processing, 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.

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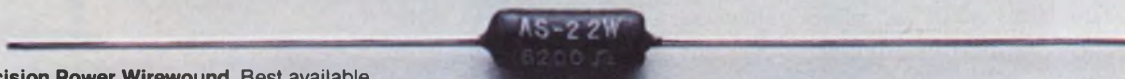
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**Precision Metal Glaze™.** Rugged performance at low cost. An industry standard for semiprecision and precision film resistor applications.



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**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.



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**TRW<sup>®</sup> IRC RESISTORS**  
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(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 $\mu$ P

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  $\mu$ C is available with extended Basic, a disc operating system and a text editor. It is built around the Intel 8080  $\mu$ P 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  $\mu$ P-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 $\mu$ P 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<sup>®</sup>... 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.

### 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.

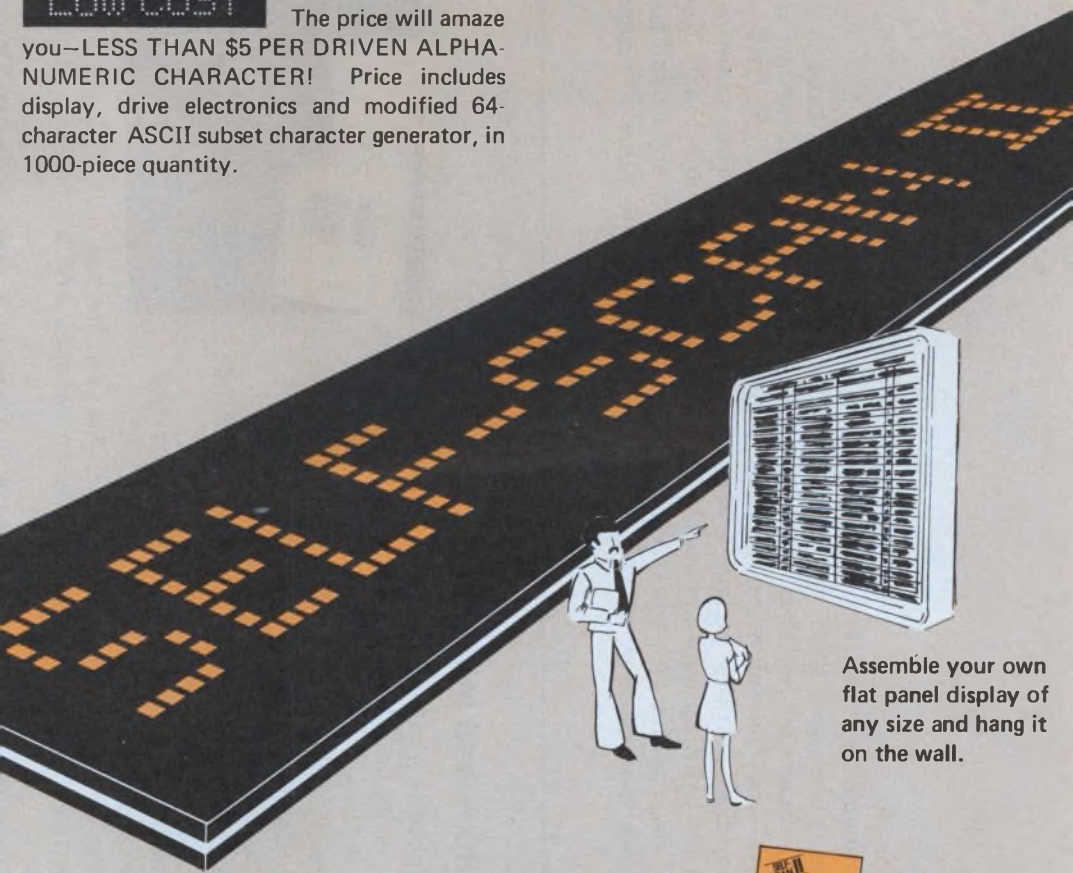
### UNIQUE

Combining the best of Burroughs' famous display products, SELF-SCAN and PANAPLEX<sup>®</sup> 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!



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

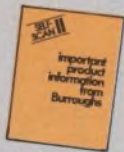


Assemble your own flat panel display of any size and hang it on the wall.

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.

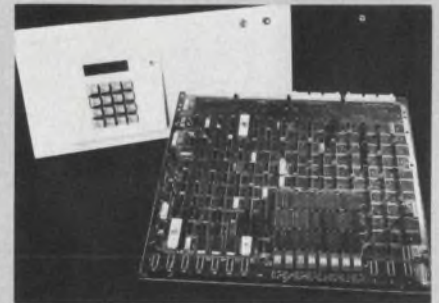
The assembler occupies less than 2-k bytes of memory and can economically be placed in PROM or ROM. Language features of the assembler include all Intel-defined instruction mnemonics and the following program pseudo-ops—DB, DW, DS, ORG, EQU and END. Execution-time features include a bias-address offset 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  $\mu$ P.

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 ★

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/√Hz at 10 Hz, 2-3 nV/√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  $\pm 5$  to  $\pm 18$  V, and features independent frequency, gain, and Q adjustments, a Q range to 500, and operation to 10 kHz.

## MD<sup>2</sup> 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—MD<sup>2</sup>™ 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 MD<sup>2</sup>'s uniform segments, uniform digit-to-digit brightness, and good contrast.

Clocks, clock radios, appliance timers, instrumentation—you name it and MD<sup>2</sup> can handle it. Not only are dozens of display combinations possible, but MD<sup>2</sup> interfaces directly to MOS clock chips, MOS segment and digit drivers, DPM chips, even microprocessors and transducers.

MD<sup>2</sup> 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 MD<sup>2</sup> 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.

## 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-1 $\frac{3}{4}$  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.

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.

## 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 3 $\frac{1}{2}$ -digit counter.

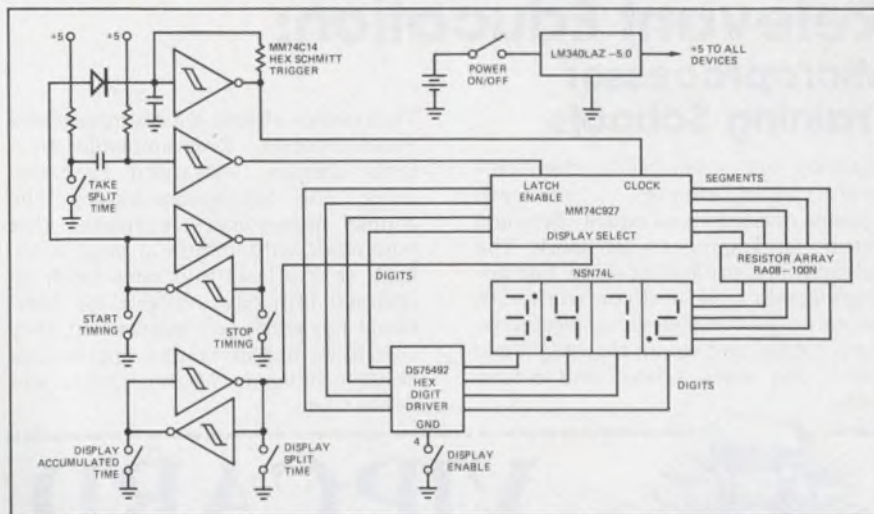
# APPLICATIONS CORNER

## 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 $\mu$ V/ $^{\circ}$ C max.
$I_{OS}$	10 pA max.
GBW	4 MHz min.
Slew Rate	10 V/ $\mu$ s min.
0.01% Settling	1.4 $\mu$ s typ.
$e_n$	12 nV/ $\sqrt{\text{Hz}}$ , 1 KHz; 15 nV/ $\sqrt{\text{Hz}}$ , 100 Hz (typical)
$i_n$	0.01 pA/ $\sqrt{\text{Hz}}$ 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.

# 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.



## INDEX

Please send me the literature that I have circled:

- LF156 Op Amp, Page 1, Col. 1
- MM5270 4K RAM, Page 1, Col. 1
- MD<sup>2</sup> Displays, Page 2, Col. 1
- Durawatt 92-Plus, Page 2, Col. 2
- NF/PF5101-3 FETs, Page 1, Col. 2
- MM5303 UAR/T, Page 3, Col. 2

# VIP CARD

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

- LM199 Zener, Page 4, Col. 3
- NSL4944 Lamp, Page 2, Col. 2
- AF100 Active Filter, Page 2, Col. 1
- MM74C925-928 Counters, Page 2, Col. 3
- Small-Signal Transistors, Page 1, Col. 3
- RAM Support Circuits, Page 1, Col. 3
- Microprocessor Schools, Page 4, Col. 1

## 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-MOS Encoder plus PROM Yield Quick-Turnaround Keyboard Systems
- AN-139 Using a Microprocessor Beyond Apparent Speed
- AN-142 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
- $\mu$ Spec 7 POWR I/O
- $\mu$ Spec 9 IMP-16 Assembler Programs
- $\mu$ Spec 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: \_\_\_\_\_

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  $\pm$ 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  $\mu$ Vrms 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  $-55^{\circ}$  to  $+85^{\circ}$ C, the LM199 shows a 1-ppm max. TC (0.3 ppm typ.), which increases to only 15 ppm max. (5 ppm typ.) at  $+125^{\circ}$ C. And it shows these TCs at currents from 500  $\mu$ A 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  $-25^{\circ}$  to  $+85^{\circ}$ C; or our LM399—0.3 ppm (typ.) to 20 ppm (max.) from  $0^{\circ}$  to  $+70^{\circ}$ 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.

# 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

$\frac{5}{8}$ " and  $\frac{3}{4}$ " square,  $\frac{5}{8}$ " x  $\frac{3}{4}$ " and  $\frac{3}{4}$ " 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.

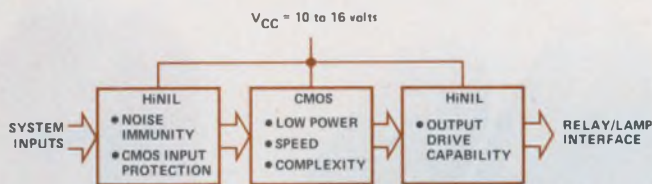


Figure 1. HiNIL input interface protects CMOS inputs while HiNIL outputs directly drive long lines and peripheral devices

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

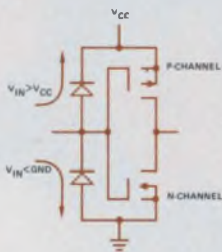


Figure 2A. CMOS latch-up causes

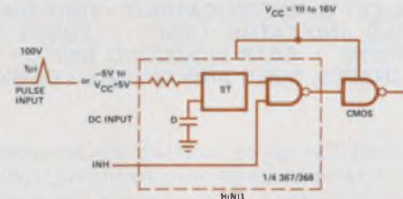


Figure 2B. HiNIL input protection

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

1300 Terra Bella Avenue, Mountain View, California 94043 Tel: (415) 968-9241 TWX: 910-379-6494 Telex: 34-8416

ENGLAND: Heathrow House, Cranford, Hounslow, Middlesex, Tel: (44) 01-897-2503 Telex: 851-935008

WEST GERMANY: Albert Gebhardtstrasse 32, 7897 Tiengen, Tel: 7741-5066 Telex: 841-792-1462

JAPAN: Nihon Seimei-Akasaka Bldg. (3F), 1-19, Akasaka 8-chome, Minato-ku, Tokyo 107, Tel: 03-405-5738 TWX: 781-2424241

Additional offices in West Germany, Hong Kong and the United States. Representatives and distributors worldwide.

## 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?

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CIRCLE # 293

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

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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.

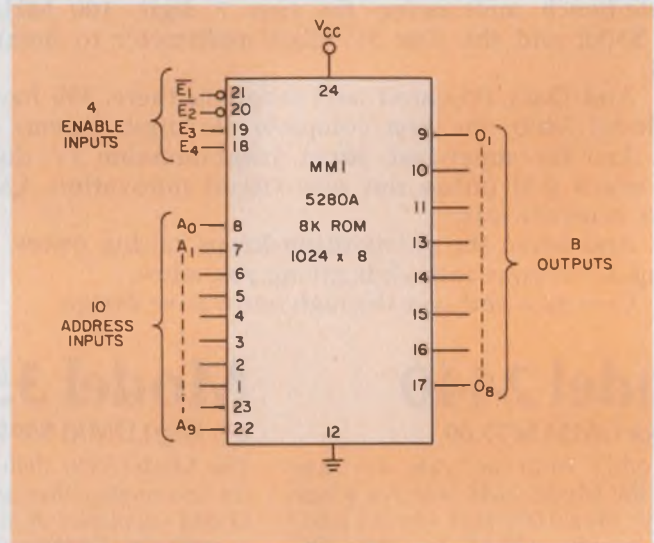
Actually PLAs can be thought of as "different kinds" of ROMs that can be replaced by conventional ROMs in almost every application. But in some cases the PLAs, though harder to expand, are a lot cheaper and faster.

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  $1024 \times 8$ -bits to  $16,384$  (or  $2^{14}$ )  $\times$  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  $28 \times 96$  input-AND array and  $8 \times 96$  output-OR array may be programmed in or out.

The output-OR array resembles a  $96 \times 8$ -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



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.

addressed at a time.

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.

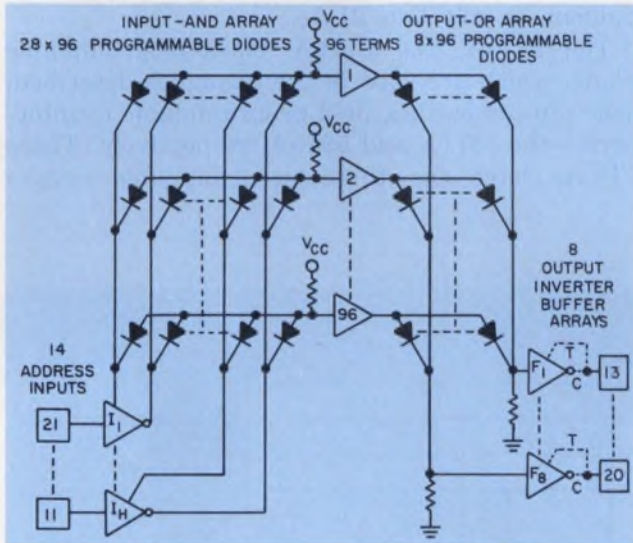
The last feature may seem redundant. If all eight output drivers were T buffers, for example, a diode could be programmed into the output-OR array wherever a HIGH output is required or it could be left out for a LOW output. Then the output drivers would not have to be programmed at all.

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

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.

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.

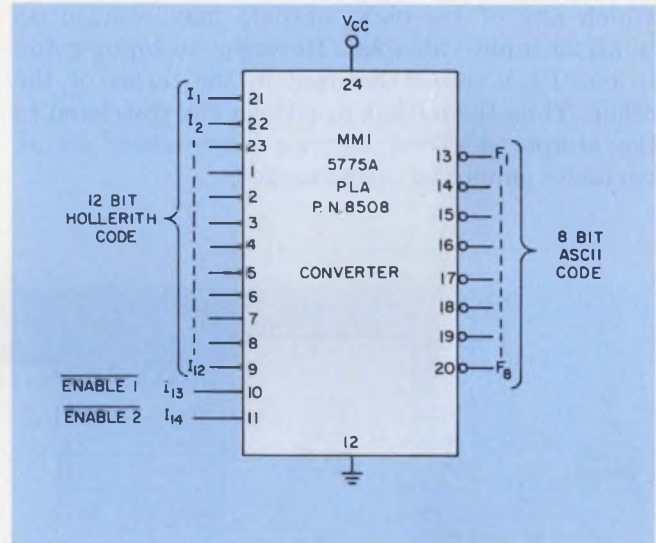
The  $F_8$  to  $F_5$  outputs are programmed as inverters. If the counter is not at any particular event time (no terms are addressed and the outputs are in the "off" state), all four outputs will go HIGH and disable all six decoders. The  $F_4$  to  $F_1$  outputs are programmed as buffers, so that 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



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.

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  $I_{O1} = 2.4 \text{ mA}$  at  $0.45 \text{ V}$ .

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.

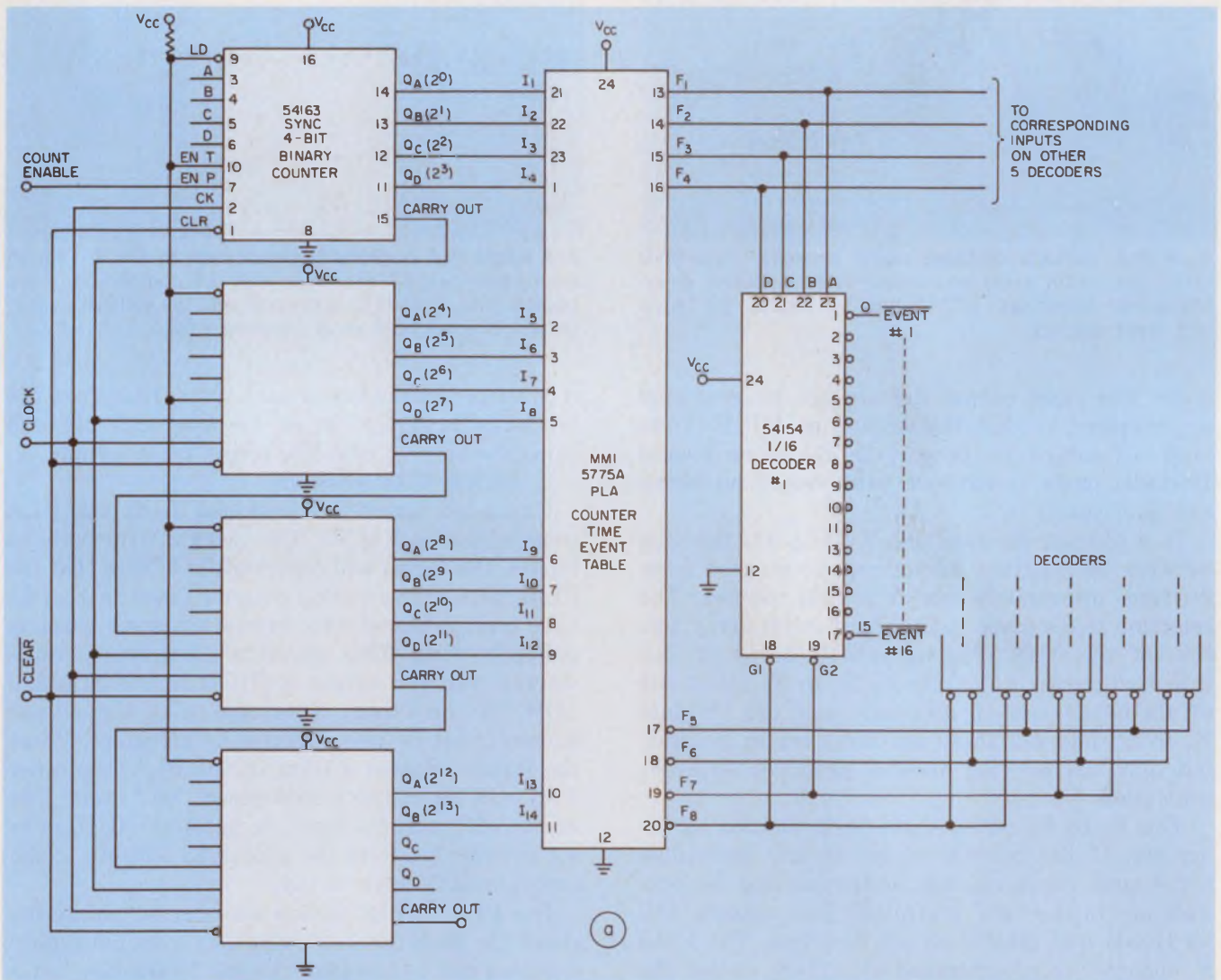
### 3. INPUT EXPANSION

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.

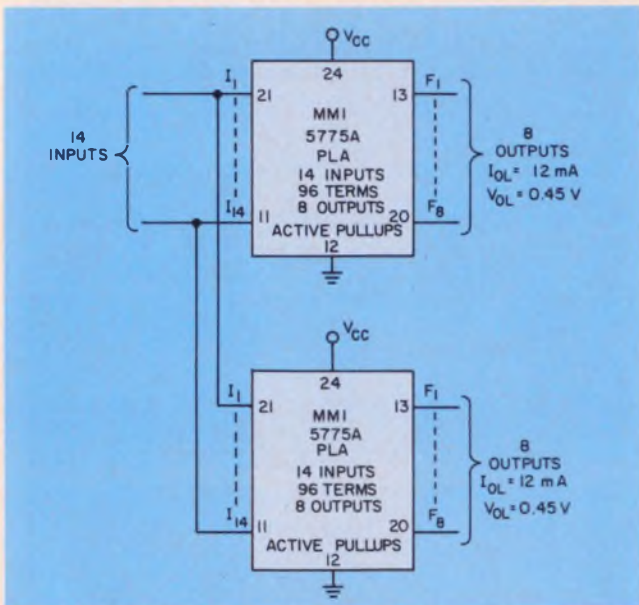
Input- AND Array														Output- OR Array												
H = Hi. Diode connected only to Input buffer output. L = Lo. Diode connected only to Input inverter output. X = Don't care. Diode not connected to buffer or inverter. (None here)														+ = Diode in = Hi input to Output Driver Blank = Diode out = Lo input to Out. Dr.												
Counter Output — Event Time	Term & Event No.													Decoder Selected				Decoder Binary Addr.				Decoder Selected	Dec. Bin. Addr.			
		11	10	9	8	7	6	5	4	3	2	1	23	22	21	20	19	18	17	16	15			14	13	
		I <sub>11</sub>	I <sub>10</sub>	I <sub>9</sub>	I <sub>8</sub>	I <sub>7</sub>	I <sub>6</sub>	I <sub>5</sub>	I <sub>4</sub>	I <sub>3</sub>	I <sub>2</sub>	I <sub>1</sub>	I <sub>23</sub>	I <sub>22</sub>	I <sub>21</sub>	F <sub>8</sub>	F <sub>7</sub>	F <sub>6</sub>	F <sub>5</sub>	F <sub>4</sub>	F <sub>3</sub>	F <sub>2</sub>	F <sub>1</sub>			
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	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 <sub>8</sub>	F <sub>7</sub>	F <sub>6</sub>	F <sub>5</sub>	F <sub>4</sub>	F <sub>3</sub>	F <sub>2</sub>	F <sub>1</sub>
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  $I_{OL} = 9.6 \text{ mA}$  instead of 12 mA.

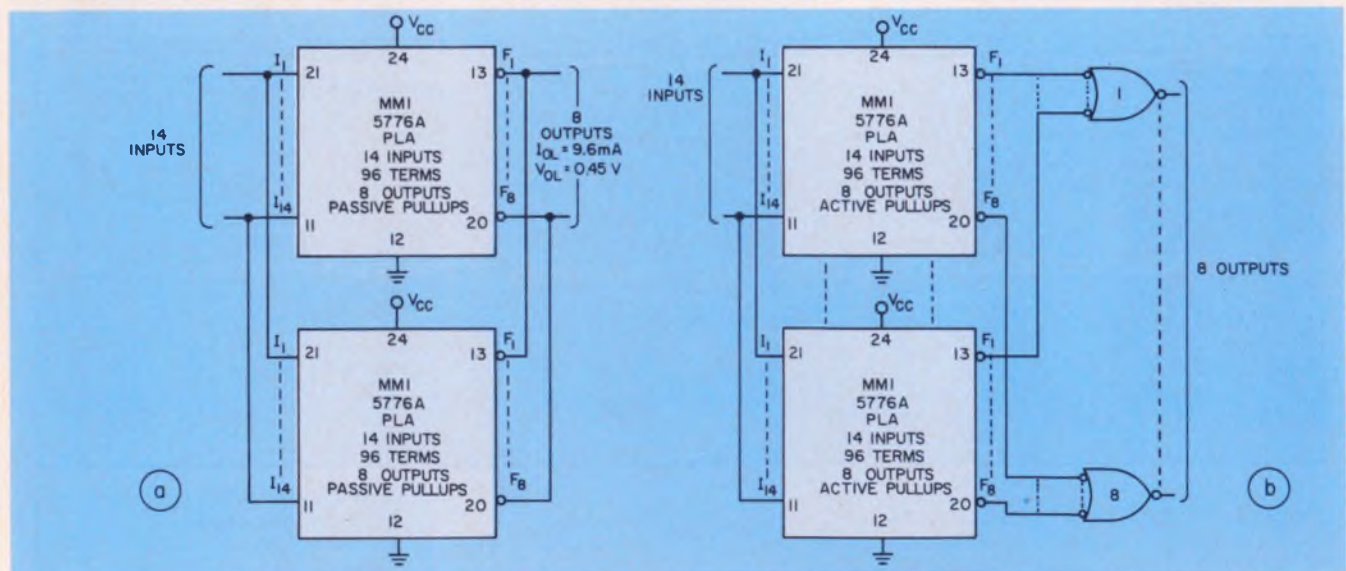
### Variations on a theme

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.

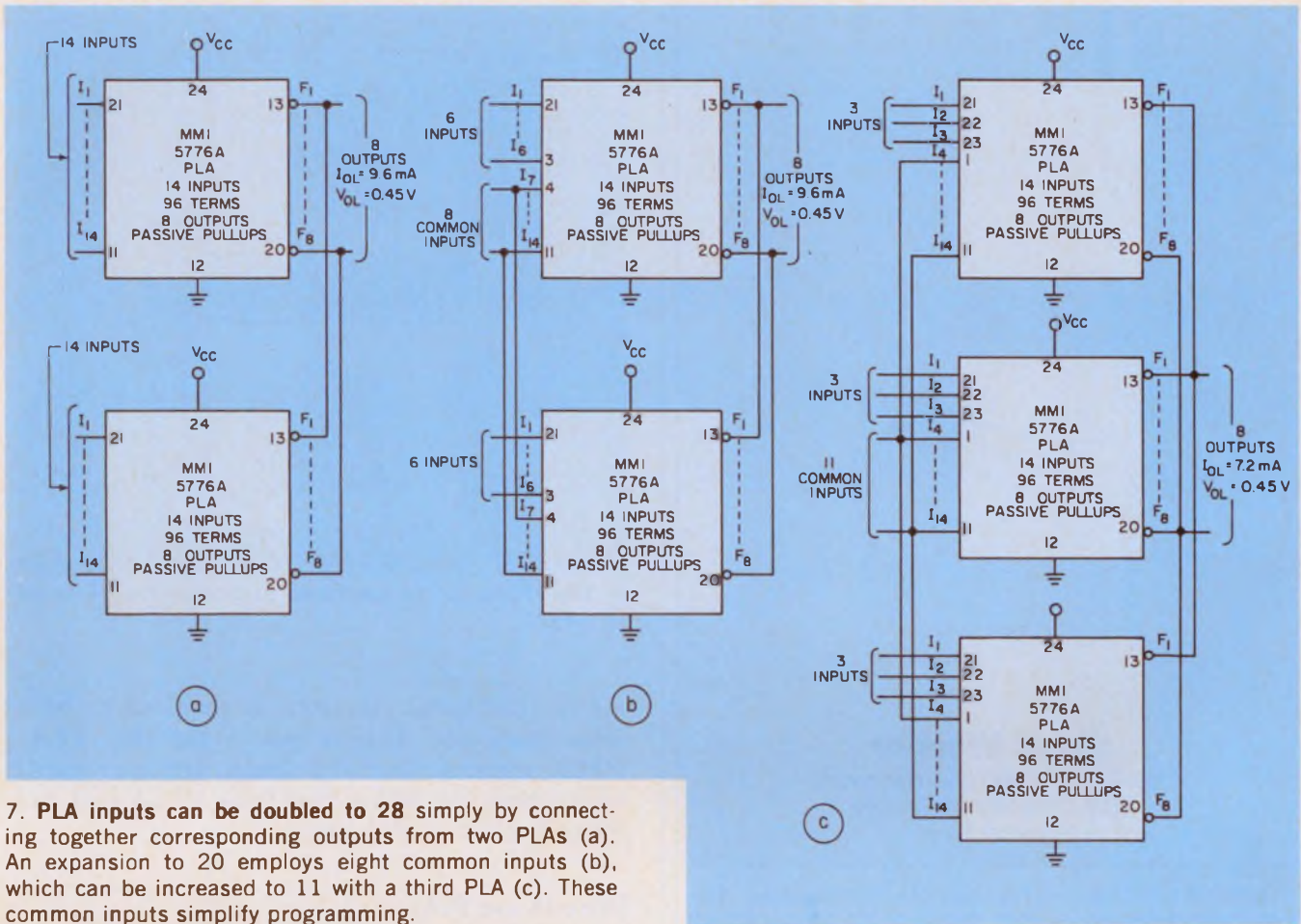
One PLA (in Fig. 3) is enabled with two address pins—a convenient use of leftover inputs. This is sufficient for active or passive-pullup PLAs. Three-state output PLAs can also be made, but these would require the addition of special chip-enable input pins.

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).



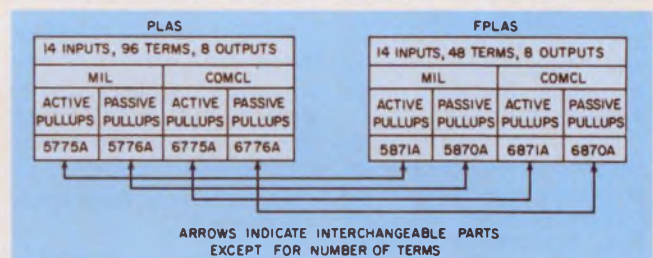
7. PLA inputs can be doubled to 28 simply by connecting together corresponding outputs from two PLAs (a). An expansion to 20 employs eight common inputs (b), which can be increased to 11 with a third PLA (c). These common inputs simplify programming.

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 normal 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



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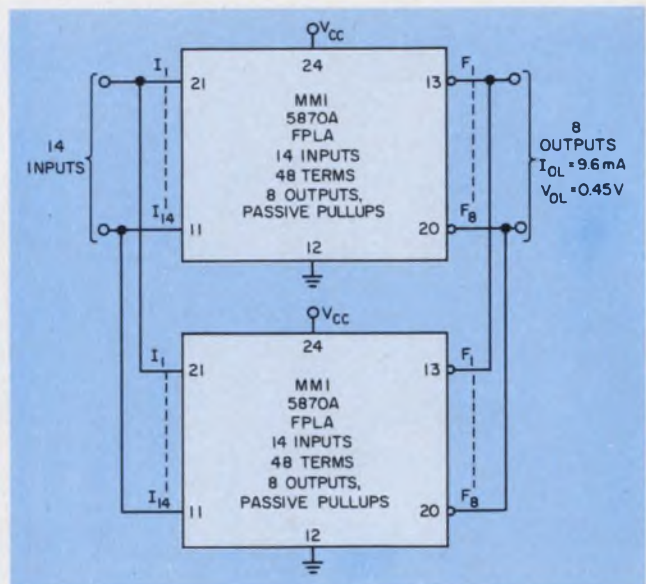
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9. Two FPLAs can be combined to provide the 96 terms of a PLA.

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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**Unimax Switch**

INFORMATION RETRIEVAL NUMBER 49

Another data domain

# Breakt

With two new ways to get inside your



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.

What does this mean to you? It means a better way to see hardware and software in action... a faster way to spot problems and find solutions. For example:

**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

# through

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.

If 16-bit words aren't enough, our new 1600S, priced at \$6,800\*, displays words up to 32 bits wide. This powerful system includes both the 1600A and our new 1607A Logic State Analyzers. Hook it up to your 16-bit machine, and in single clock you can look at both the data and address simultaneously. In dual clock, you can view two independent active tables of 16 bits each—synchronized together through the bus triggering capabilities.

When you have all the details, you'll see how these new logic-state analyzers put you inside your logic programs for a better overall picture...and for a clear detailed look. And you'll see how they can save you

hours in design, debugging and troubleshooting. For the complete story, just contact your local HP field engineer. Or, write for our new 8-page data sheet on Logic State Analyzers.

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## Base your IC tester on a $\mu P$ , 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.

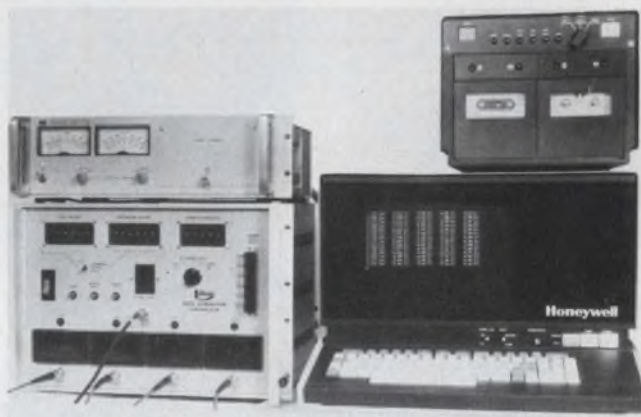
A look at the requisite control and communication capabilities reveals that a substantial amount of intelligence is needed. Since most of the data manipulation involves BCD digits, and the control and speed requirements are not excessive, a four-bit  $\mu P$ —such as the Intel 4004—is all that is necessary. 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

---

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



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  $\mu P$ .

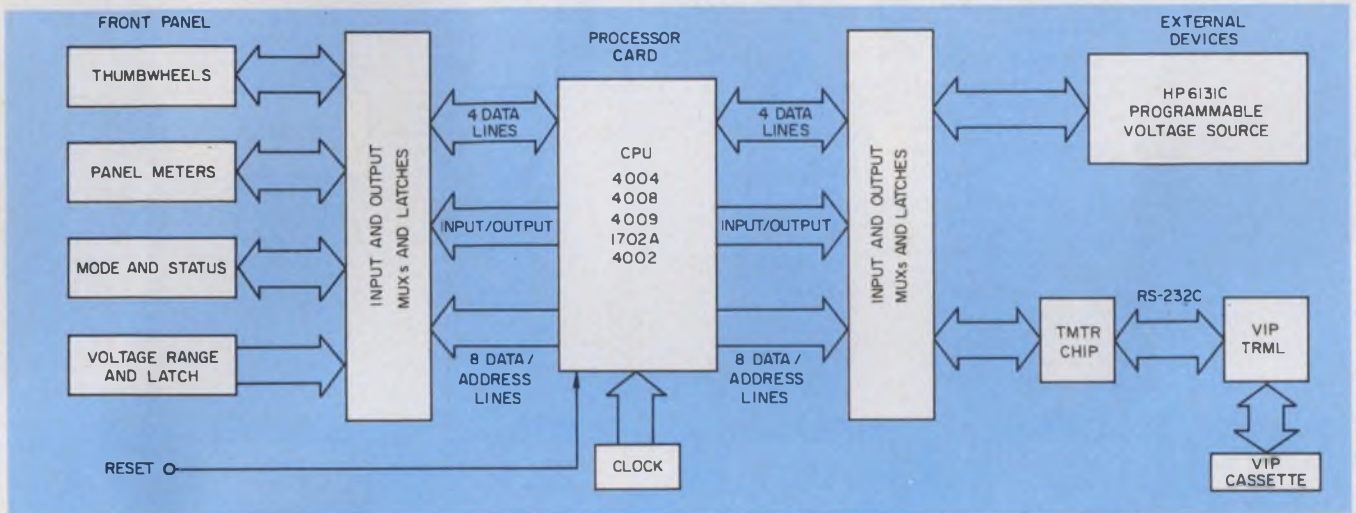
met by a programmable transmitter chip interfaced to the  $\mu P$ : The Western Digital PT1482B provides synchronous data transfer at the specified baud rate, generates a lateral parity bit and handles all serial communication.

### 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.

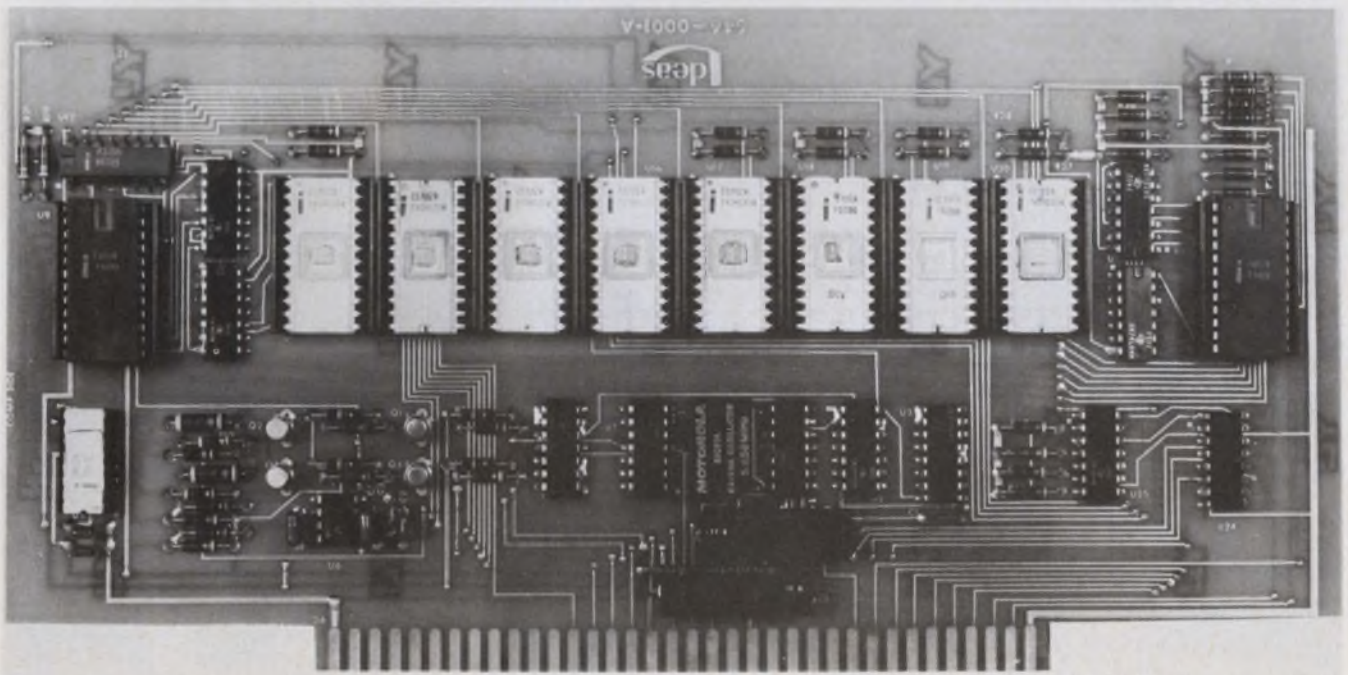
The four analog input channels present a design challenge. To operate as a stand-alone option, the channels must have display capability. With a digital panel meter, such as the Datal AR-2000 autoranger on each input, there's no need for analog design or separate display electronics. As an externally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

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



1. A four-bit  $\mu P$  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  $\mu P$ . Major interfaces are to the front panel, the

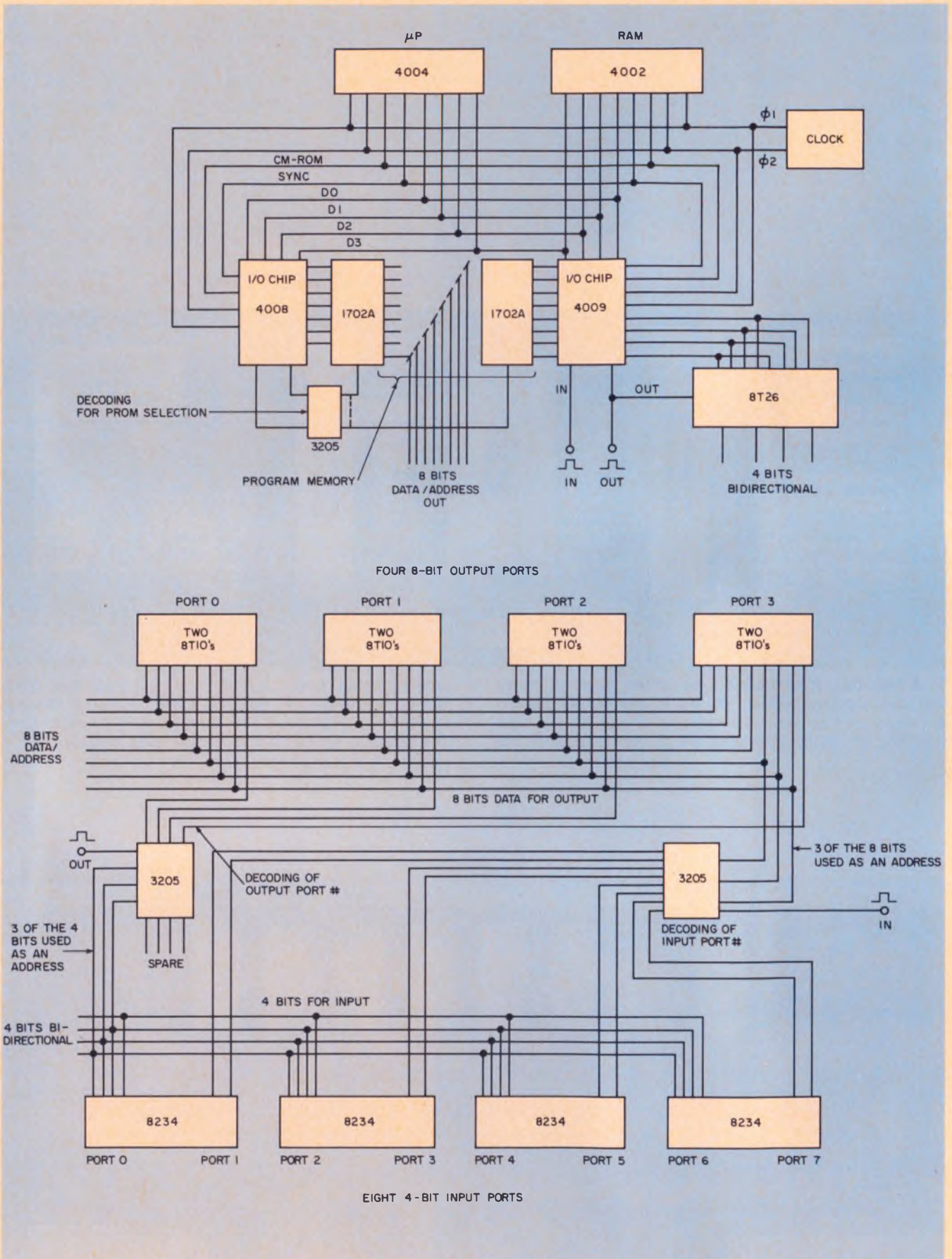
programmable power supply and a transmitter chip. The chip provides an RS232C communications channel to control a Honeywell VIP terminal and cassette unit. The terminal works off-line from a large computer.



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  $\pm 100$  V, any channel in which the voltage magnitude might exceed 20 V—the DPM's highest scale—must have a  $\div 10$  probe in its path. A toggle switch for each panel meter illuminates a  $\times 10$  LED and signals both the  $\mu$ P 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 $\mu$ P 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,  $\mu$ P-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  $\mu$ P 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 CP 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
```

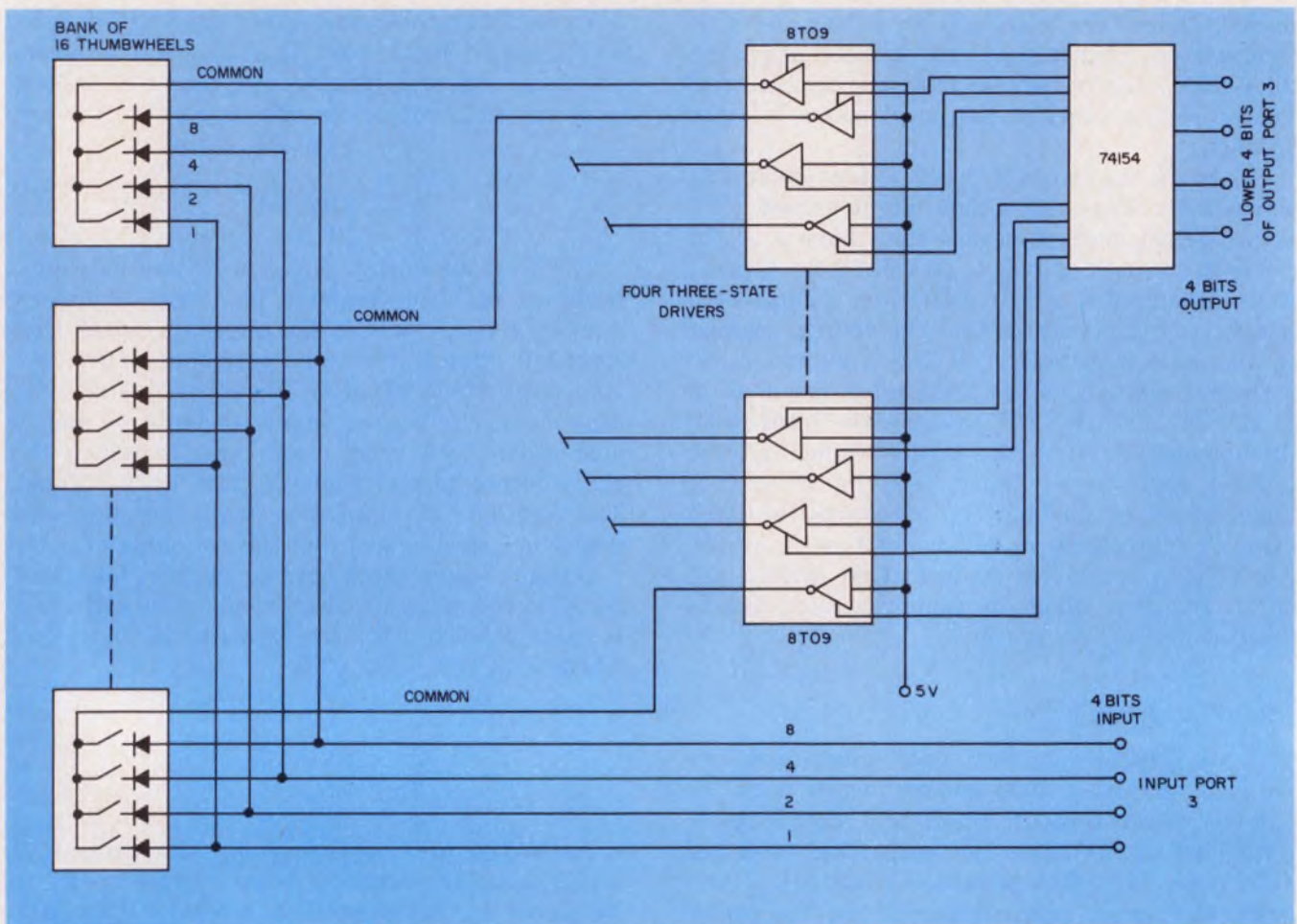
As in the previous program, statements 0, 1 and 2 cause the eight-bit binary number "Y" to be placed on the eight lines labeled DATA ADDRESS in Fig. 3. Statement 3 loads a four-bit number, "X," into the accumulator of the 4004. Statement 4 generates an output strobe during the interval in which the value "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  $\mu$ P.

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  $\mu$ P 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  $\mu$ P 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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# MICROPHOTOS



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

22X magnification, unretouched.

**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.

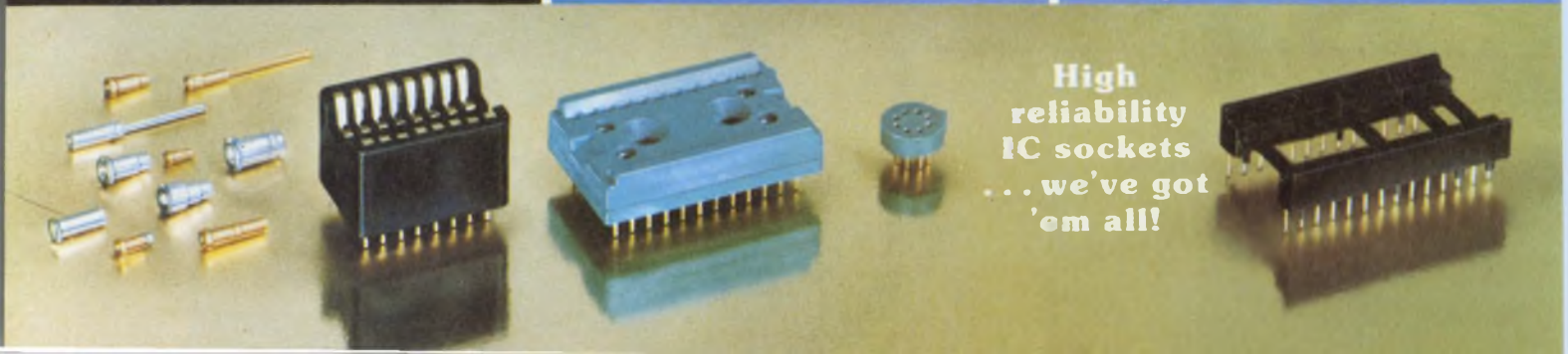
Arrows indicate contact surface still smooth, clean, free from abrasions.

22X magnification, unretouched.

**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**

Here's microscopic proof that high reliability Robinson-Nugent "side-wipe" DIP sockets make 100% greater contact than any edge-bearing socket on the market. This advance design provides constant low contact resistance, long term dependability—trouble-free IC interconnects. Yet RN high reliability DIP sockets cost no more than ordinary sockets!

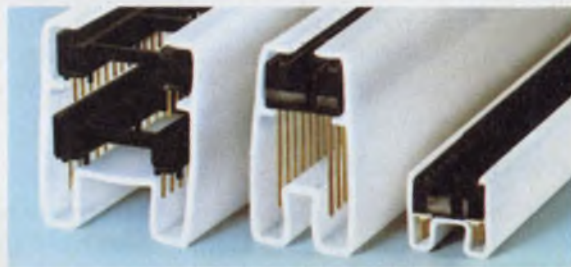


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Get the high reliability that eliminates trouble. RN "side-wipe" DIP sockets make contact with the wide, flat sides of your IC leads. You get 100% greater surface contact for positive, trouble-free electrical connection.

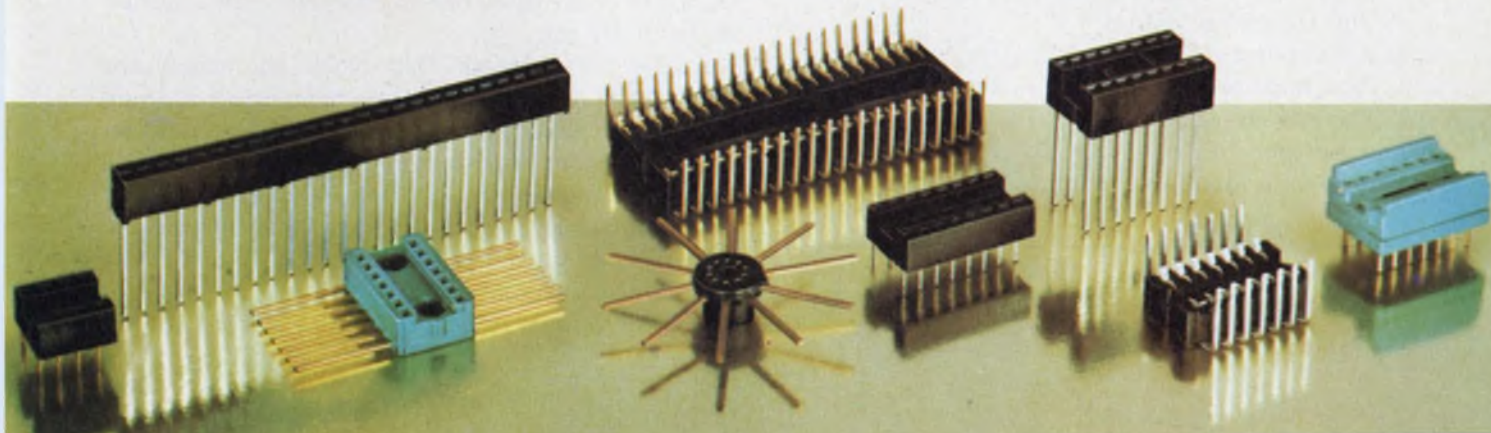


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INFORMATION RETRIEVAL NUMBER 52



# 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  $\times$  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.

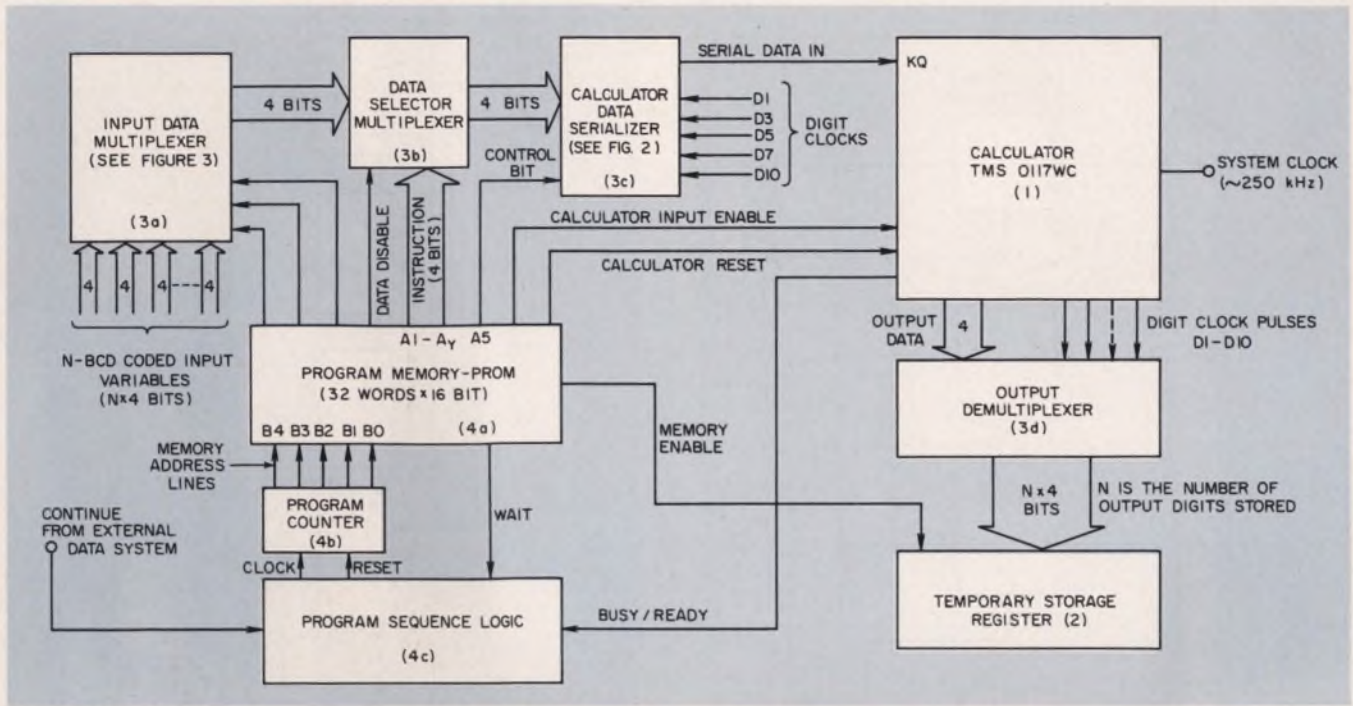
Pulses D1 through D10 clock the calculator chip's BCD output data into a temporary storage register, so that the complete 10-digit output can be displayed, or transferred elsewhere, as a single word. And pulses D1, D3, D5, D7 and D10 clock the serializer (Fig. 2) to convert the 5-bit instruction code, A1 through A5, into serial data for the calculator-chip input.

A 5-bit binary program counter addresses the

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Kurt Skytte, Electronic Engineer, Rucker Control Systems Div., 4700 San Pablo Ave., Oakland, CA 94608.



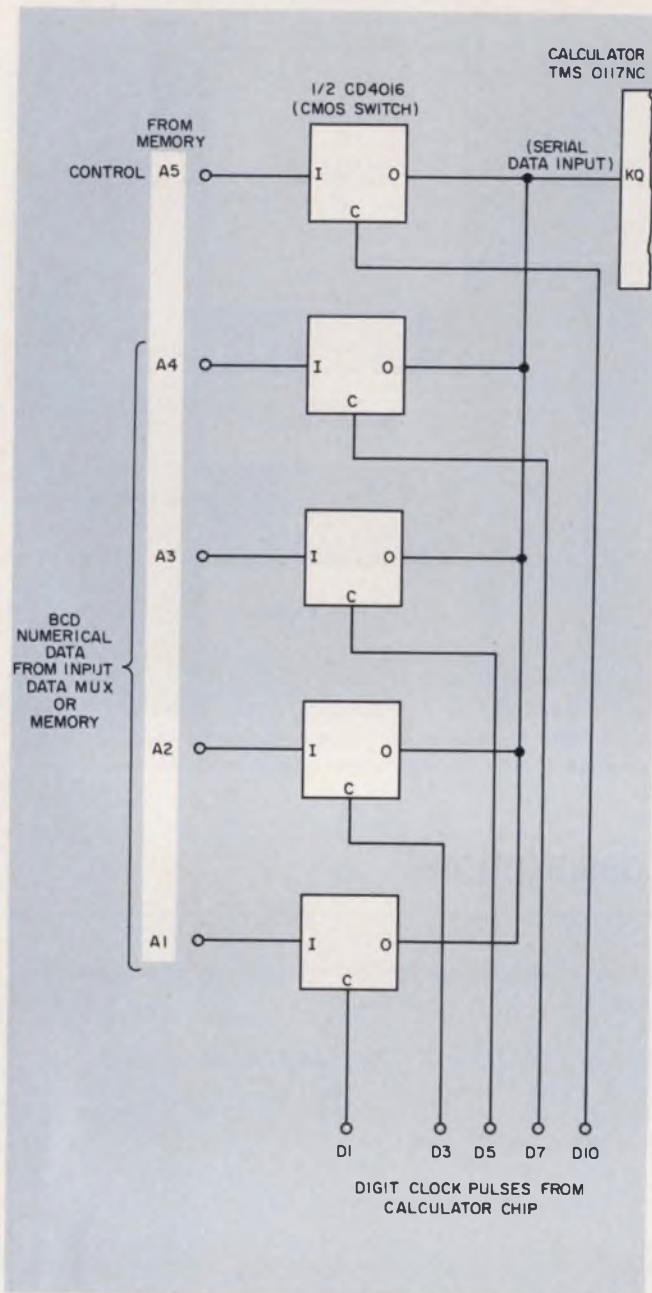


1. A calculator chip, when controlled by a PROM and with the help of several mux/demux circuits, can handle

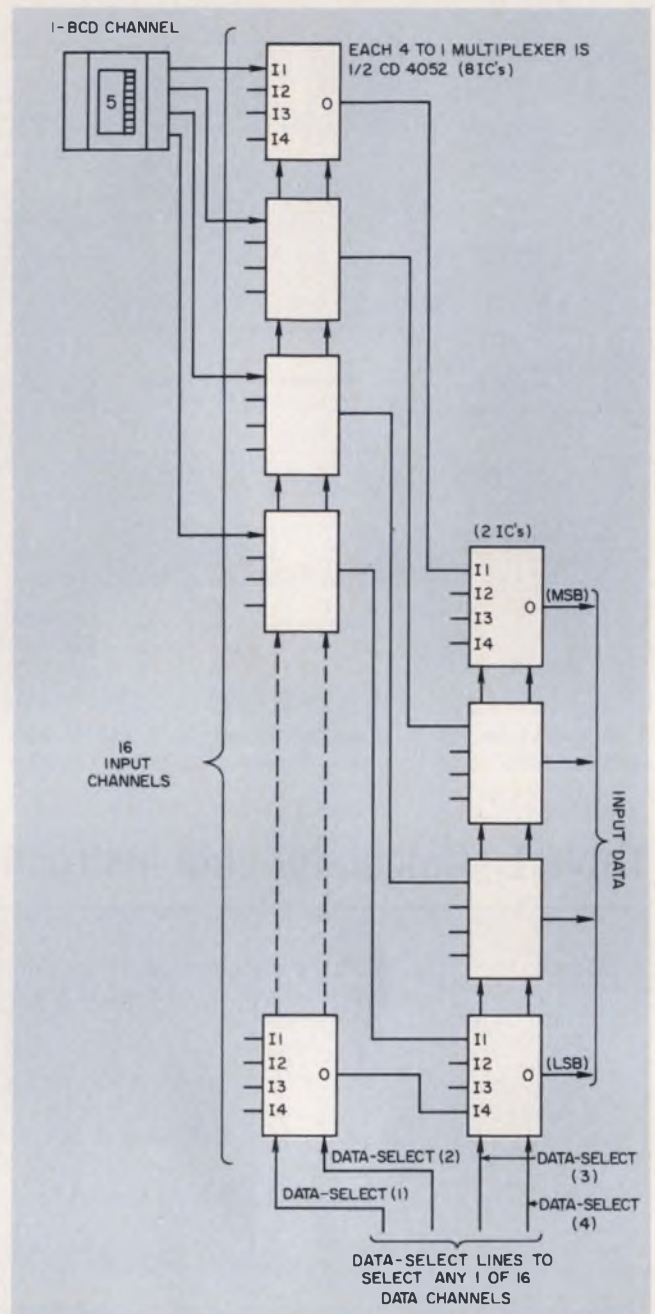
arithmetic computation more efficiently than a micro-processor, and the calculator needs no software.

**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

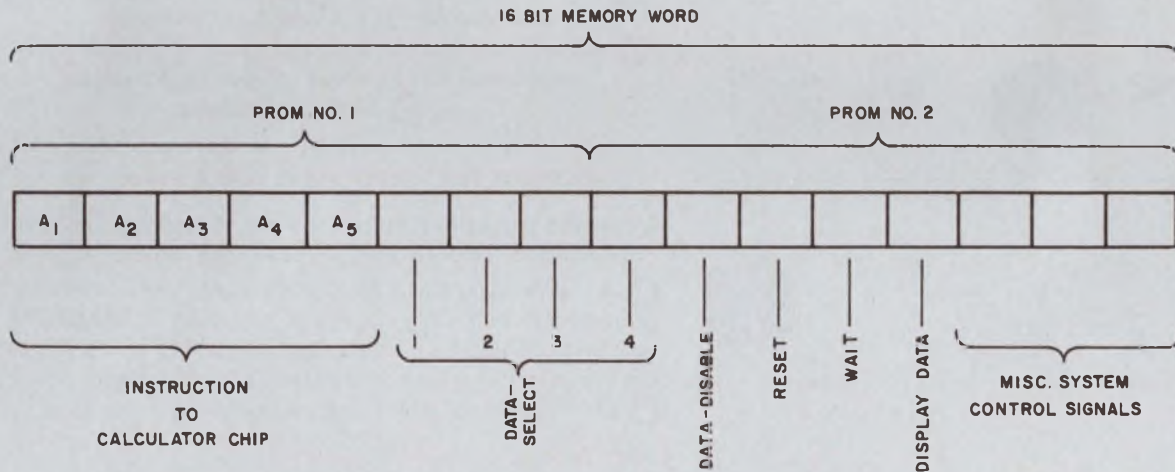
Function	Time
Numeric Entry	5.2 ms (maximum)
Operation Instruction Entry	6.9 ms (maximum)
Shift Left or Right	1.72 ms
Increment or Decrement	3.4 ms
Exchange Operands	5.2 ms
Add, Subtract	8.6 ms
Multiplication	70 ms (maximum)
Division	80 ms (maximum)

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.

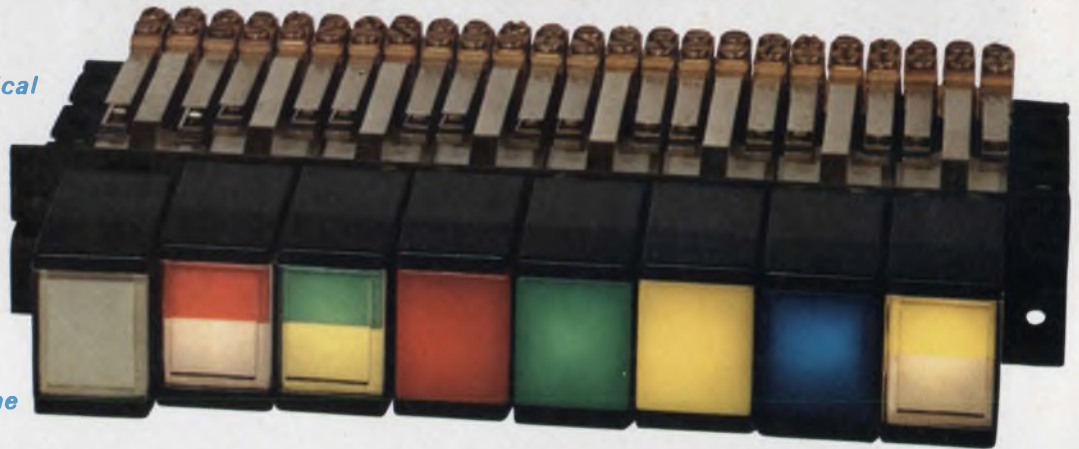
A practical digital instrumentation system based upon a calculator chip can be built with roughly 50 ICs for about \$100. A system program for 30 instructions has a cycle time of about 250 ms. Different programs loaded into several PROMs that easily plug into the circuit allow quick change of the system's 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.



## 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

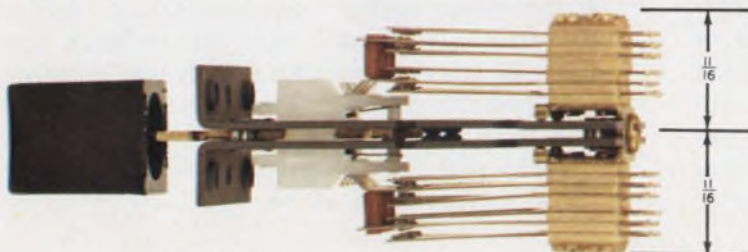
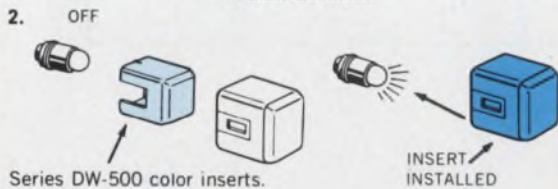
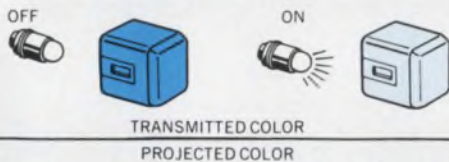
You're working with low-level signals and are specifying dry circuits—circuits with voltages and currents too low to break down contact surface films or corrosion. What kind of contacts should you specify in your pushbutton switches?

- Silver
- Cadmium oxide
- Gold
- None of these

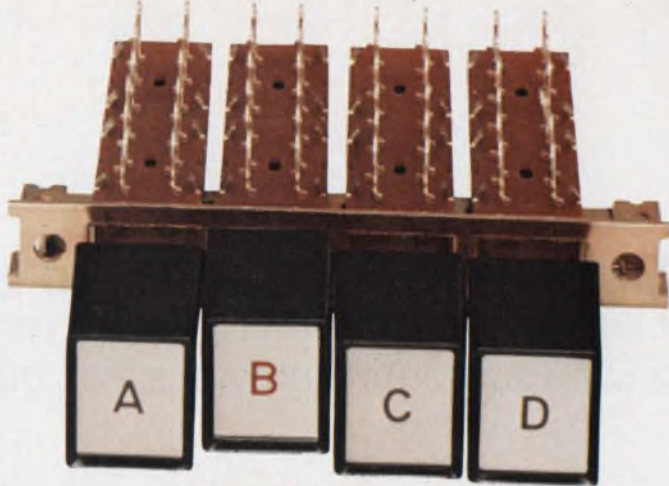
## 4. A POWERFUL PROBLEM

Pushbutton 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.

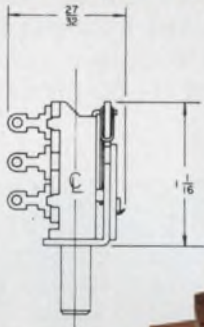


## 5. WATCH OUT FOR THIS ONE

“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 1 1/4" 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.

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ZIP \_\_\_\_\_

# 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.

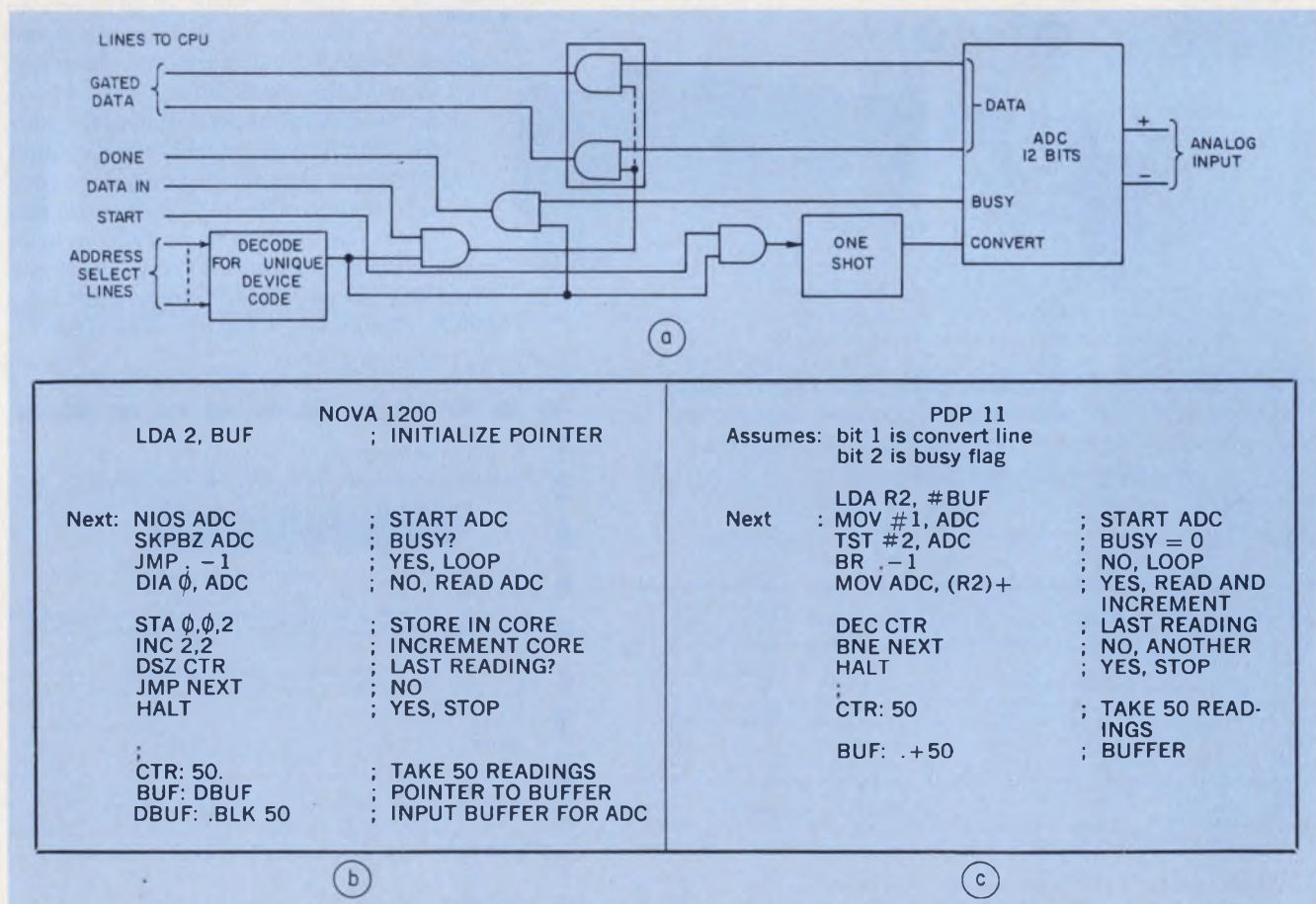
Whether you use a minicomputer or a microprocessor to control an analog data collection system, interfacing the analog-to-digital converter to a processor needn't be difficult. Two basic types of interfaces can be used with almost any a/d converter: a low-speed flag check or a high-speed data channel 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.

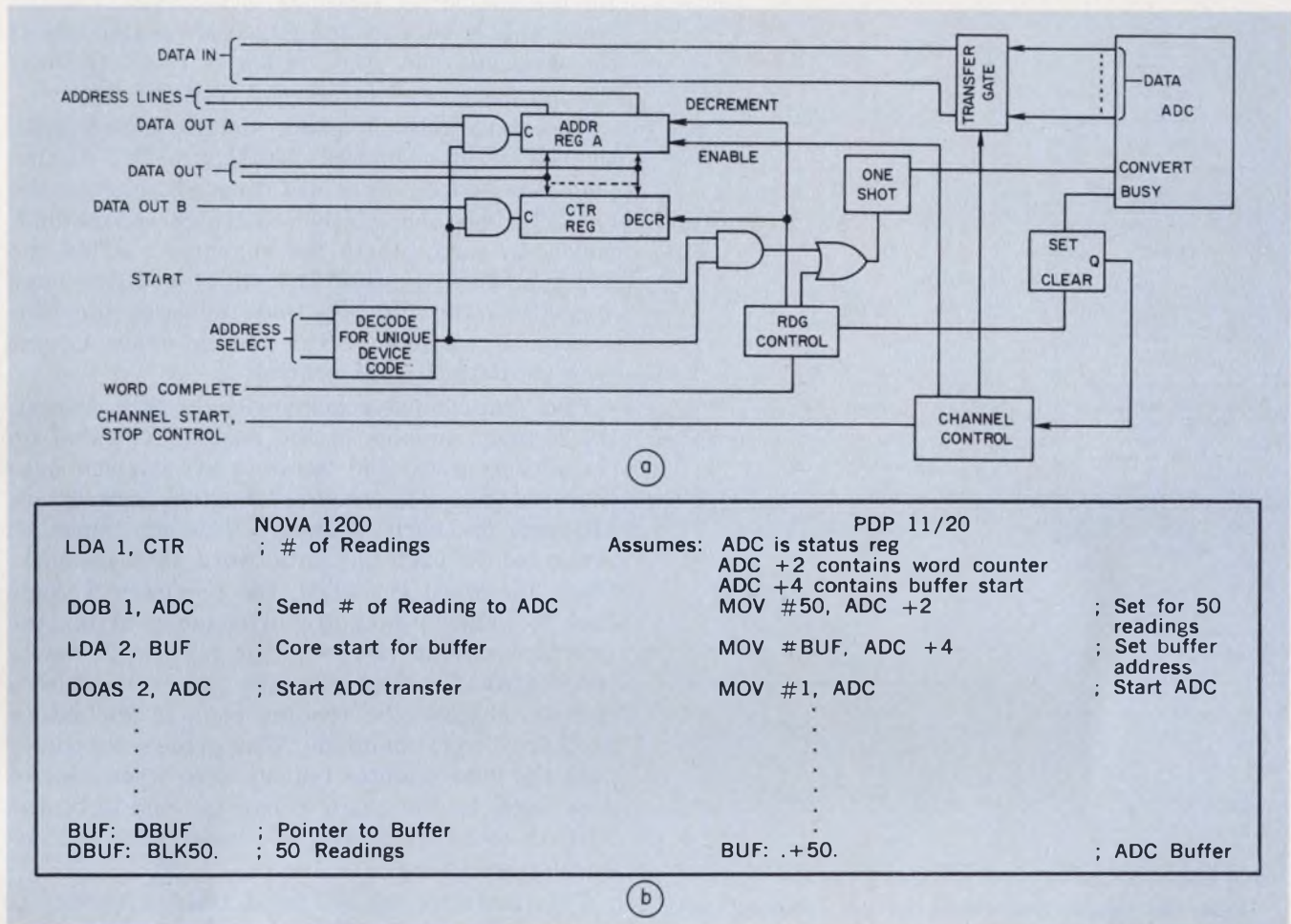
A/d's are available in a wide range of speeds, accuracies and costs. Typical limits might be 14 bits at 100 kHz, 16 at 20 kHz and 6 bits at 250 MHz. Prices for top units like these are usually over \$10,000. At the lower end of the performance

**Ralph D. Taylor**, Senior Project Engineer, Brooks Research & Manufacturing Inc., 5612 Brighton Terrace, Kansas City, MO 64130.



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.



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.

is decoded by some selection logic and then ANDed with a one-shot, which, in turn, starts the a/d converter.

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.

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).

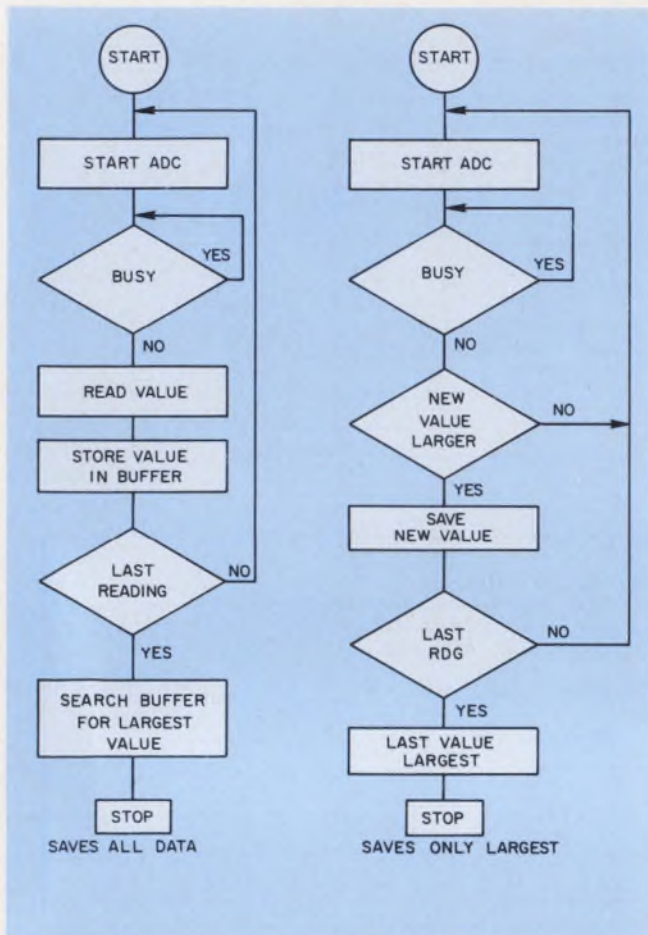
### Interface the a/d with software

When the flag is sensed, the program breaks out of the loop and goes to the DIA  $\phi$ , ADC statement, which tells the processor to read the data from the converter into accumulator  $\phi$ . 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  $\phi$ , they must be stored in memory or they will be lost when more data enter the accumulator.

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).

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

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



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  $\mu$ s for the Nova and 15  $\mu$ s 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.

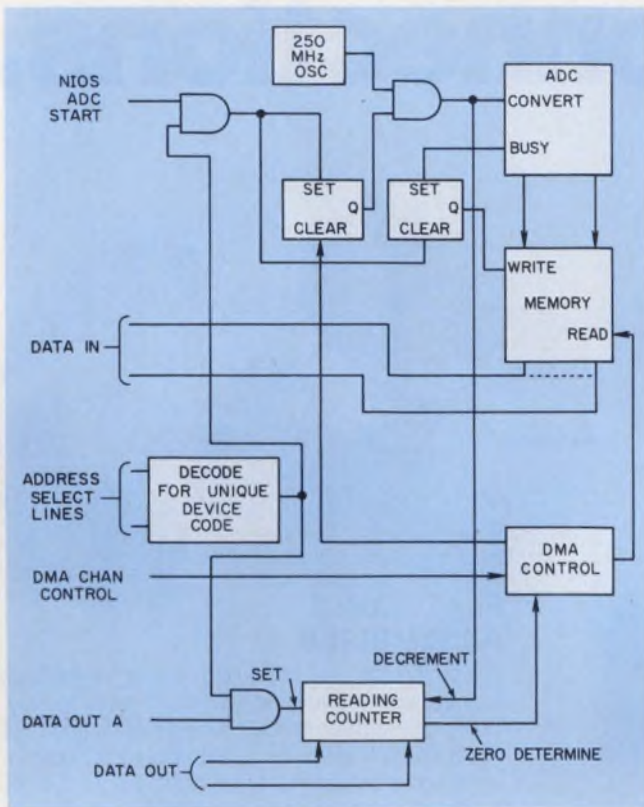
The hardware needed for a DMA interface is much more complex than for the flag-checking method. The important signals for the DMA interface are: data out, start and channel control. Since this interface operates faster and needs accurate timing, it is more sensitive to noise and other interference. Typical 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.

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

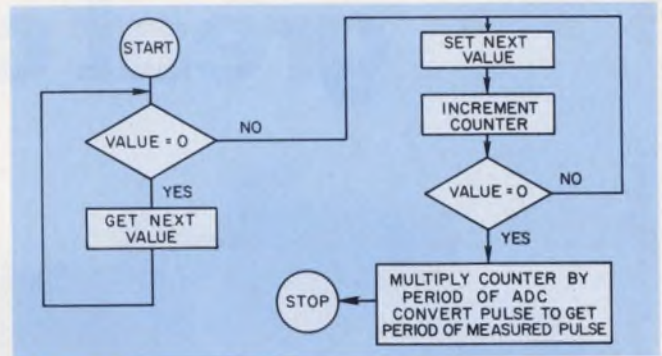
Let's consider some typical circuit applications of these interfaces. For the low-speed interface, let's try to monitor a 1-kHz signal and measure the high and low values. To do this, the first step is to select an a/d and a sample/hold, if they are not already built into the a/d. According to Shannon's Sampling Theorem, a sampling rate of at least 2 kHz must be used. This provides a sample interval of 500  $\mu$ s, and thus any signal or spike with a width of less than 500  $\mu$ s 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:

$$S_1 = 1/P \text{ (for digital signals) or,}$$

$$S_1 = N/P \text{ (for analog signals),}$$

where  $S_1$  is the sample interval,  $P$  is the narrowest pulse interval to be detected and  $N$  the number of readings per pulse interval.



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.

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  $\mu$ s. 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...



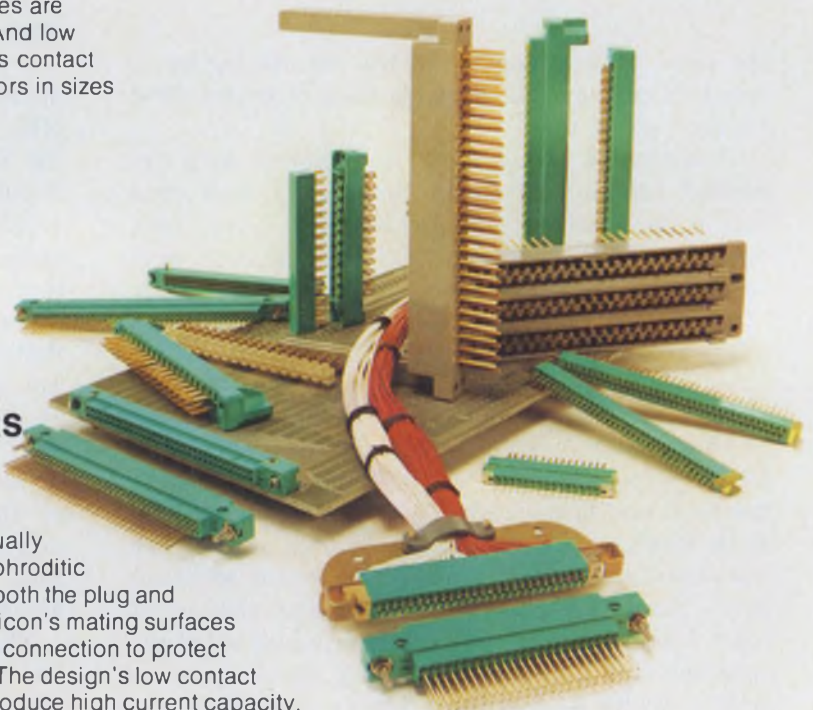
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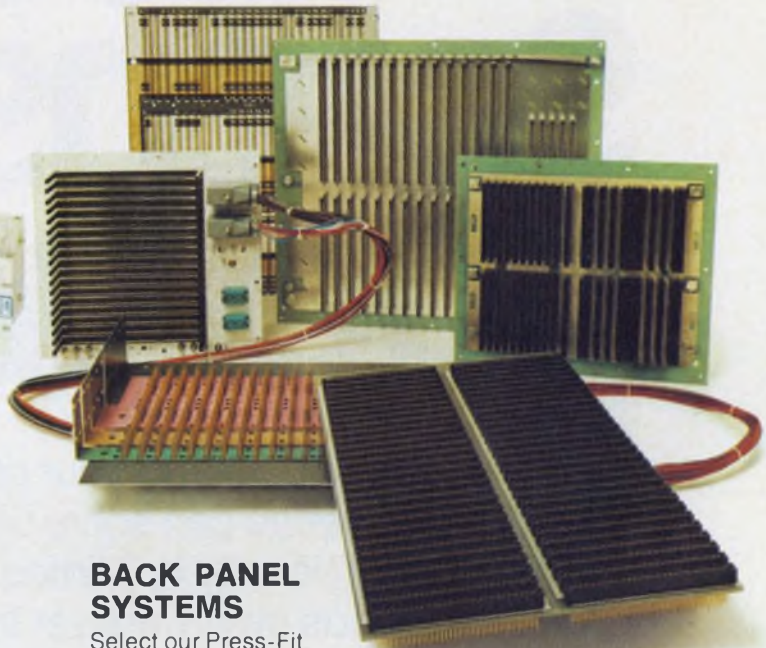
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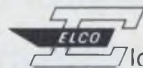
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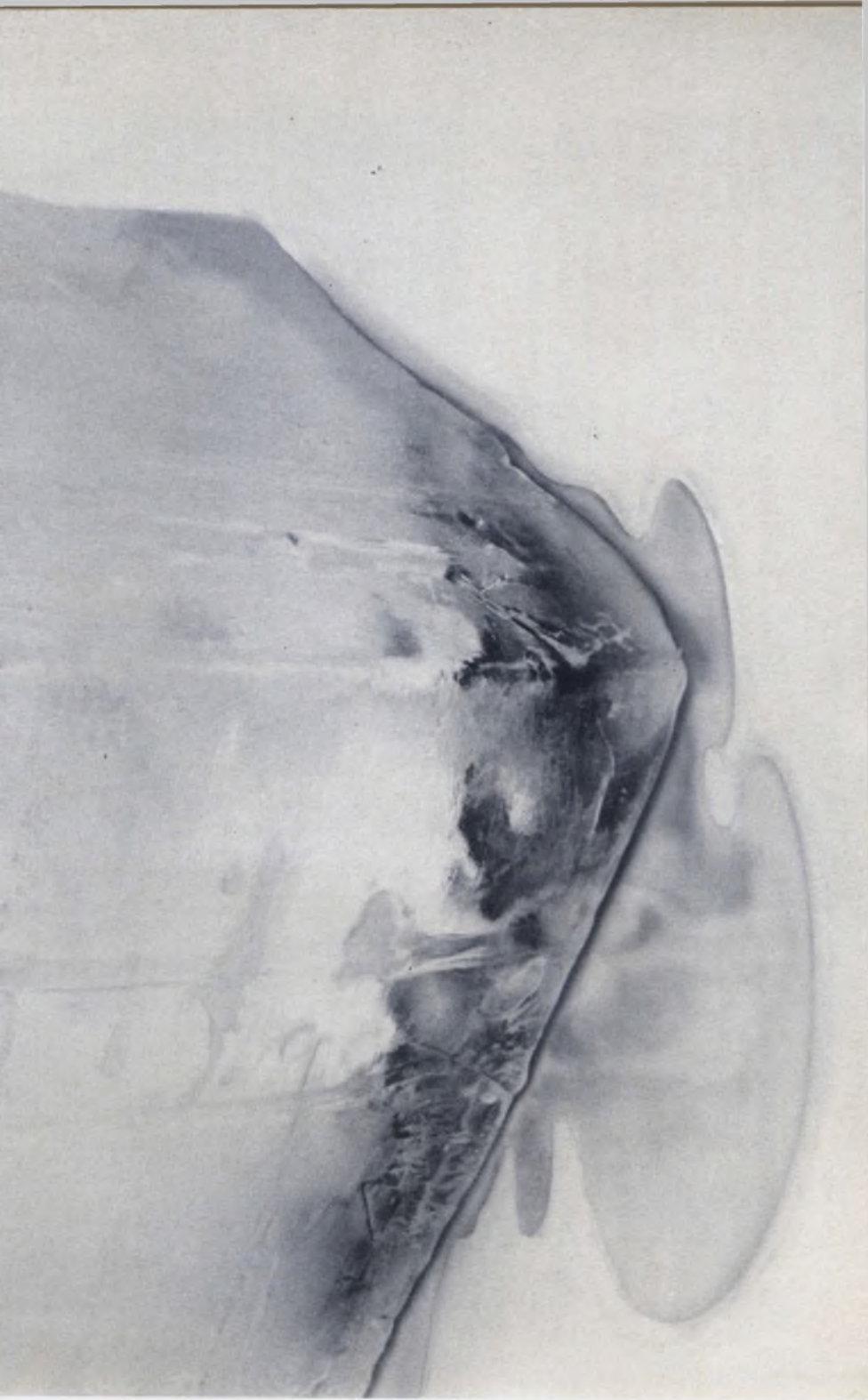
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**Shozo Yokogawa of  
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When our engineers designed a product years ago, it was certain to sell well. Everything sold well. The economy was booming. All our products enjoyed great success. In addition, 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 through-

out 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 every-

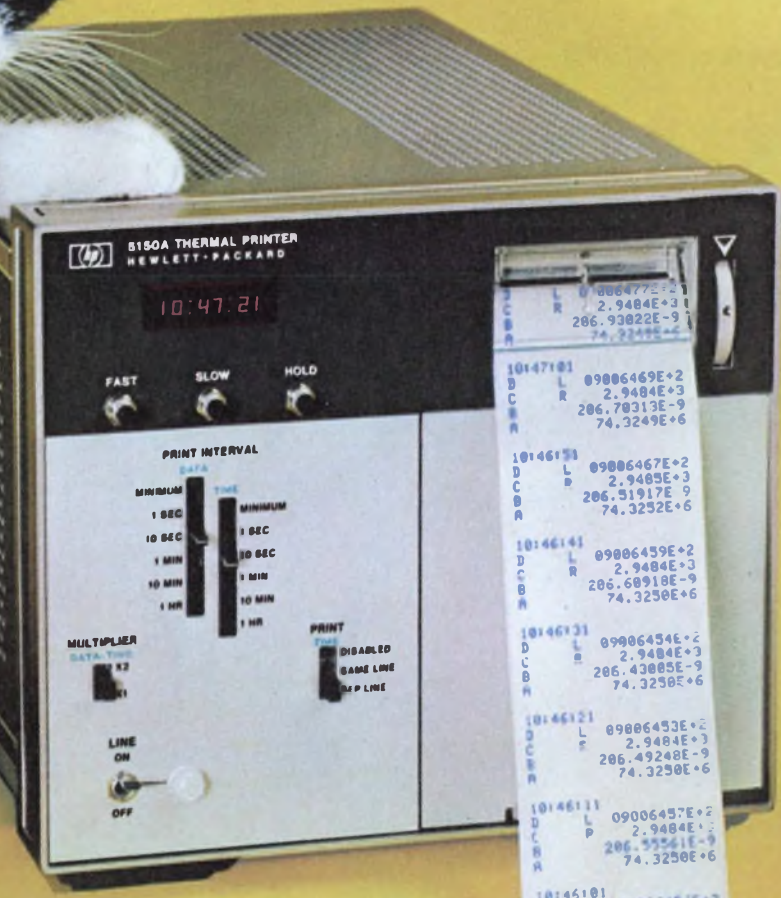
thing down and without having to take it to a service shop where everything is convenient.

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 goodbye 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.

That's just a beginning. Built-in flexibility and plug-in options mean that, at last, there is a printer that you can custom-tailor to your data printout needs without delay or compromise.

**Alphanumeric printout.** A full 64-character upper case ASCII printing set, with figures and symbols that read and reproduce clearly. Print speed is three lines per second.

**ASCII Interface option.** Interfaces to most ASCII coded sources or HP Interface Bus. Full 64-character, 20-column printout.

**BCD Interface option.** Interfaces with BCD  $\pm$  8421 sources. Prints standard 16-character set, but can draw on the full 64-character complement of the 5150A. Ten or 20 columns.

**Scanner option.** The 5150A can function as a system controller for up to 13 instruments on the HP Interface Bus, providing automatic data-acquisition capability.

**Clock option.** With it, an entirely new order of convenience, flexibility and control becomes possible. Simple, front-panel controls let you record the time of day and select the time interval between samples.

**Special BCD printouts.** Special formats or re-interpretation of BCD inputs can be provided at minimum cost.

**The price is right.** Only \$875\* for the 5150A mainframe.

Plug-in options range from \$125\* to 350\*. At the price, no other printer matches its flexibility, quietness and reliability. Write, or call your nearby HP field engineer, for complete technical specifications or a demonstration.

\*Domestic USA prices only.

5150A THERMAL PRINTER  
HEWLETT-PACKARD

10:47:21

FAST SLOW HOLD

PRINT INTERVAL

MINIMUM TIME MINIMUM  
1 SEC 1 SEC  
10 SEC 10 SEC  
1 MIN 1 MIN  
10 MIN 10 MIN  
1 HR 1 HR

MULTIPLIER  
DATA-TIME  
X2  
X1

PRINT  
DISABLED  
SAME LINE  
NEW LINE

LINE  
ON  
OFF

```

10:47:21 09006477E+2
          2.9484E+3
          206.70313E-9
          74.3249E+6
    
```

```

10:47:01 09006469E+2
          2.9484E+3
          206.70313E-9
          74.3249E+6
    
```

```

10:46:59 09006467E+2
          2.9485E+3
          206.51917E-9
          74.3252E+6
    
```

```

10:46:41 09006459E+2
          2.9484E+3
          206.68918E-9
          74.3250E+6
    
```

```

10:46:31 09006454E+2
          2.9484E+3
          206.43885E-9
          74.3258E+6
    
```

```

10:46:21 09006453E+2
          2.9484E+3
          206.49248E-9
          74.3258E+6
    
```

```

10:46:11 09006457E+2
          2.9484E+3
          206.55561E-9
          74.3258E+6
    
```

```

10:45:01 09006456E+2
          2.9484E+3
          206.62194E-9
          74.3258E+6
    
```

```

10:45:51 09006455E+2
          2.9484E+3
          206.64314E-9
          74.3251E+6
    
```

```

10:45:41 09006452E+2
          2.9485E+3
          206.54988E-9
          74.3249E+6
    
```

```

10:43:01 09006473E+2
          2.9483E+3
          206.63879E-9
          74.3252E+6
    
```

```

10:43:01 09006476E+2
          2.9484E+3
          206.63879E-9
          74.3252E+6
    
```

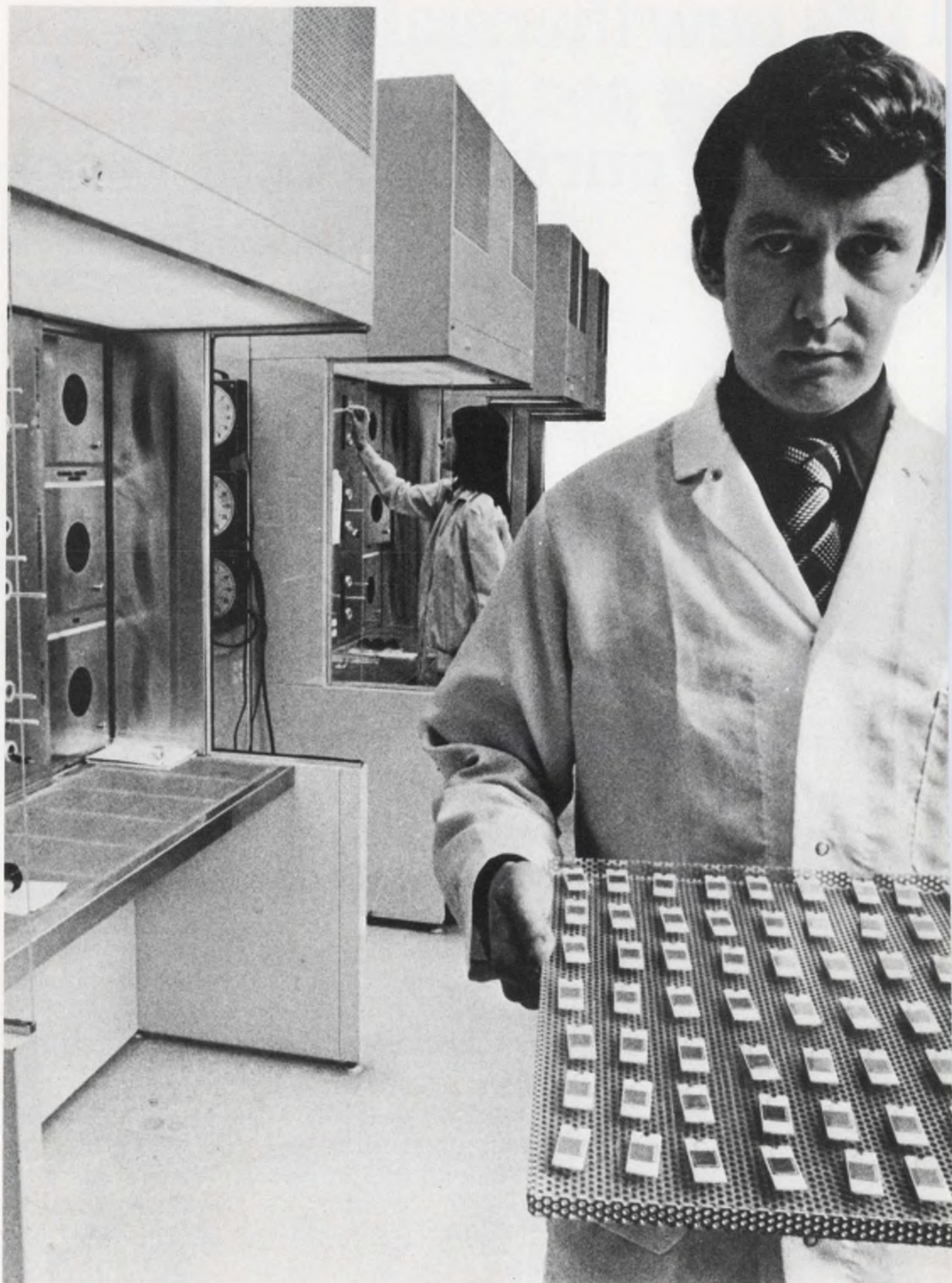
```

10:42:51 09006474E+2
          2.9483E+3
          206.46813E-9
          74.3252E+6
    
```

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INFORMATION RETRIEVAL NUMBER 56



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Each is available in a variety of performance and package options. One just right for your process instrument or data handling system.

## D/A CONVERTERS

Resolution	Linearity Error	Model Number
8 bits	$\pm 0.2\%$	AD559
8 bits (CMOS)	$\pm 0.2\%$	AD7530J
8 bits (CMOS)	$\pm 0.2\%$	AD7520J
8 bits (CMOS)	$\pm 0.2\%$	AD7522J
9 bits (CMOS)	$\pm 0.05\%$	AD7530K
9 bits (CMOS)	$\pm 0.05\%$	AD7520K
9 bits (CMOS)	$\pm 0.1\%$	AD7522K
10 bits (CMOS)	$\pm 0.05\%$	AD7530L
10 bits (CMOS)	$\pm 0.05\%$	AD7520L
10 bits (CMOS)	$\pm 0.05\%$	AD7522L
12 bits	$\pm 0.0125\%$	AD563
12 bits	$\pm 0.0125\%$	AD562
12 bits (CMOS)	$\pm 0.05\%$	AD7521L

## A/D CONVERTERS

8 bits (CMOS)	$\pm 0.2\%$	AD7570J
10 bits (CMOS)	$\pm 0.05\%$	AD7570L

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# Ideas for Design

## 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.<sup>1</sup>

The circuit's output impedance is greater than 100 k $\Omega$  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,  $Q_1$ . 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  $Q_1$  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  $Q_3$ .

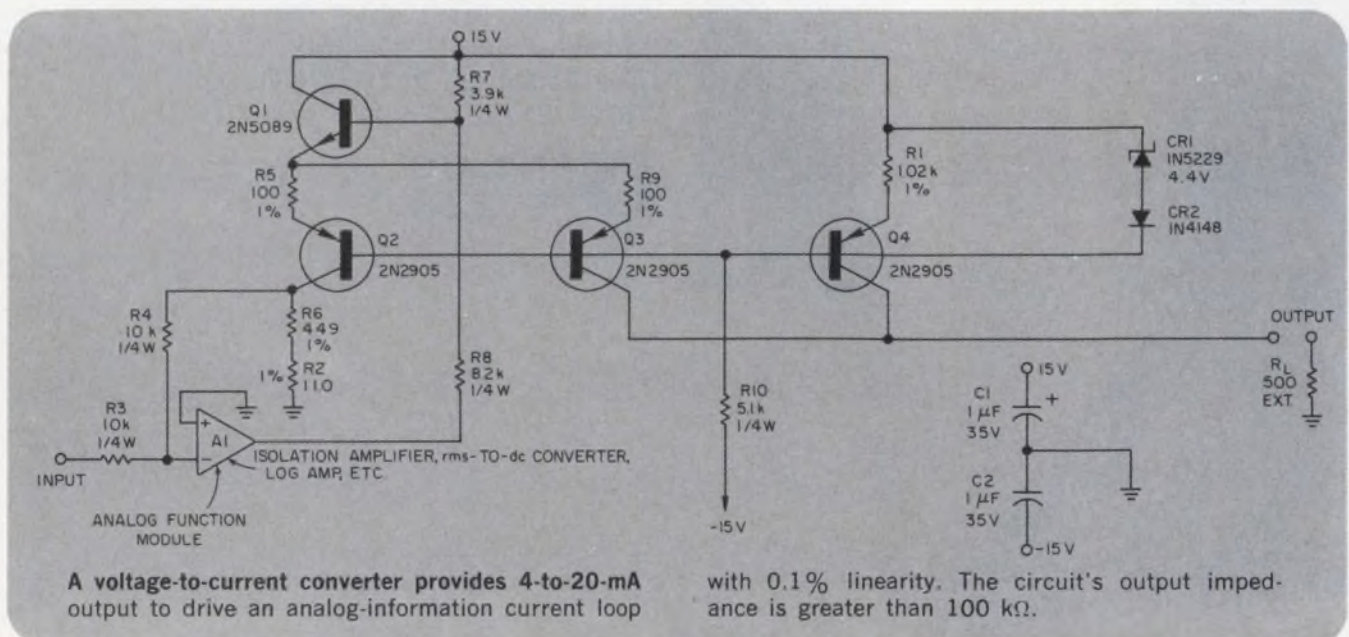
Transistor  $Q_1$  is the fixed-current source that provides the 4-mA offset. The offset value can be adjusted by  $R_1$  and the circuit gain by  $R_2$ . The offset and gain values are within 1% with the fixed resistor values shown.

### Reference

1. Graeme, J., "Improve Analog Data Transmission," *Electronic Design*, Jan. 4, 1975, pp. 94-101.

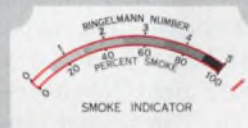
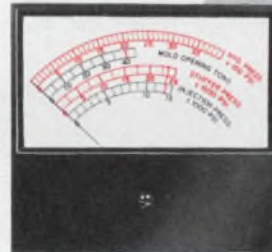
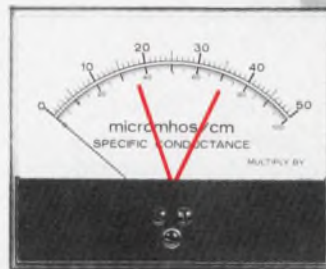
*Bucky Crowley, Senior Engineer, Intronics, 57 Chapel St., Newton, MA 02158.*

CIRCLE NO. 311



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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<sub>1</sub> and its circuitry form a current source. Its output current is

$$I = V_1/R_1,$$

where V<sub>1</sub> is one of the input variables. This current charges capacitor C<sub>1</sub> and generates a ramp at the positive input of comparator A<sub>2</sub>. Capacitor C<sub>1</sub> 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<sub>1</sub>. The second input variable, voltage V<sub>2</sub>,

$$V_o = -V_2^2/V_1.$$

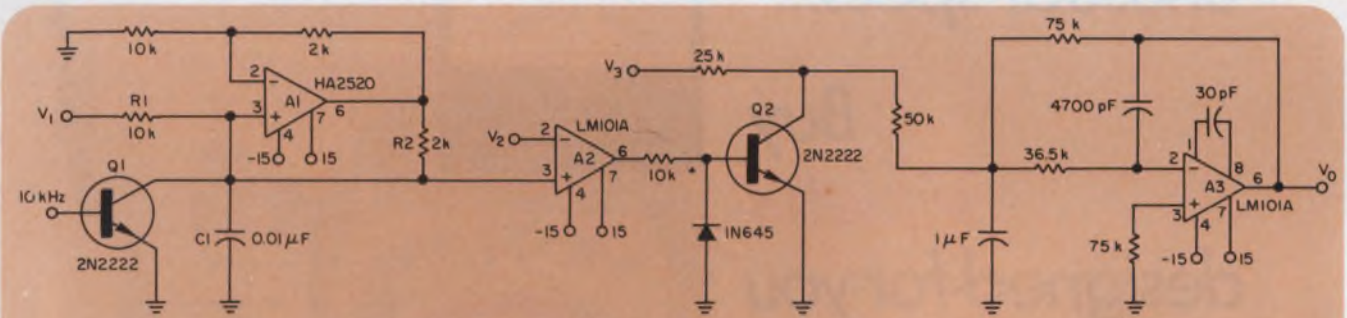
All three input voltages must be positive. However, if a FET or chopper transistor, such as a 2N2945 or 2N2432, is substituted for Q<sub>2</sub>, V<sub>3</sub> can be negative or positive. Also A<sub>1</sub> can be operated differentially so that

$$I = (V_1^+ - V_1^-)/R_1.$$

Low-drift components should be used for R<sub>1</sub>, R<sub>2</sub> and C<sub>1</sub> for stable operation in varying temperatures. The variable input voltages, V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub>, are limited to about +10 V, and V<sub>2</sub> must always be somewhat less than V<sub>1</sub>.

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<sub>1</sub>C<sub>1</sub>. Then the output is V<sub>o</sub> = -V<sub>2</sub>V<sub>3</sub>/V<sub>1</sub>.

is applied to the inverting input of A<sub>2</sub>.

In Fig. 2, note that the ramp reaches voltage level V<sub>2</sub> after time interval

$$t_A = V_2 R_1 C_1 / V_1,$$

and that the output from A<sub>2</sub> has the following duty cycle:

$$t_A/T = V_2 R_1 C_1 / (V_1 T).$$

This controlled duty-cycle signal modulates the third input variable, V<sub>3</sub>, via the chopping action of Q<sub>2</sub>. Amplifier A<sub>3</sub> averages this signal to yield a final output:

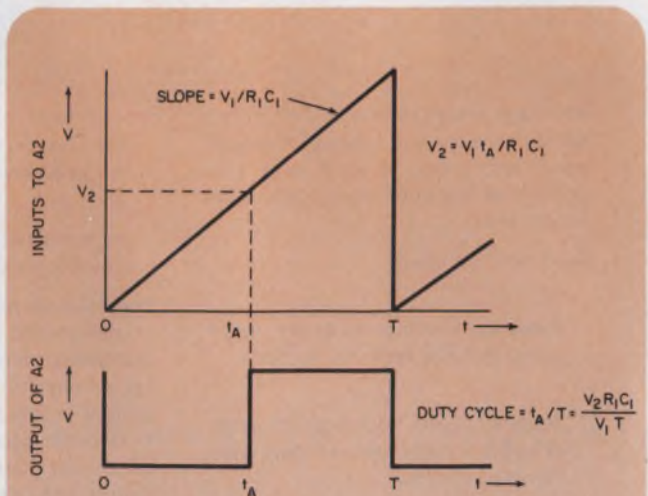
$$V_o = -R_1 C_1 V_2 V_3 / (V_1 T).$$

If the time constant R<sub>1</sub>C<sub>1</sub> is made to equal T, then

$$V_o = -V_2 V_3 / V_1.$$

The component values in Fig. 1 make T = R<sub>1</sub>C<sub>1</sub> = 10<sup>-4</sup> s. The low-pass filter made with amplifier A<sub>3</sub> has a double pole at 45 Hz.

Keep V<sub>2</sub> constant, and the circuit operates as a divider. Fix V<sub>1</sub>, and the result is a multiplier. Connect V<sub>2</sub> and V<sub>3</sub> to a common input, and the result is a squaring operation:



2. The voltage across C<sub>1</sub> rises until it equals V<sub>2</sub>, where it causes the output of the comparator to go HIGH. The rate of charge of C<sub>1</sub>, which is proportional to input voltage V<sub>1</sub>, controls the duty cycle of the output of the comparator.

# ANNOUNCING

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# Expand a system's memory capacity without mounting hardware and board space

Have you run out of room to expand the memory in your microcomputer or other circuit? Fig. 1 shows a packaging technique that neither needs mounting hardware nor uses any additional board space. The method can be applied to memory chips or other ICs that have similar mechanical and electrical constraints.

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.

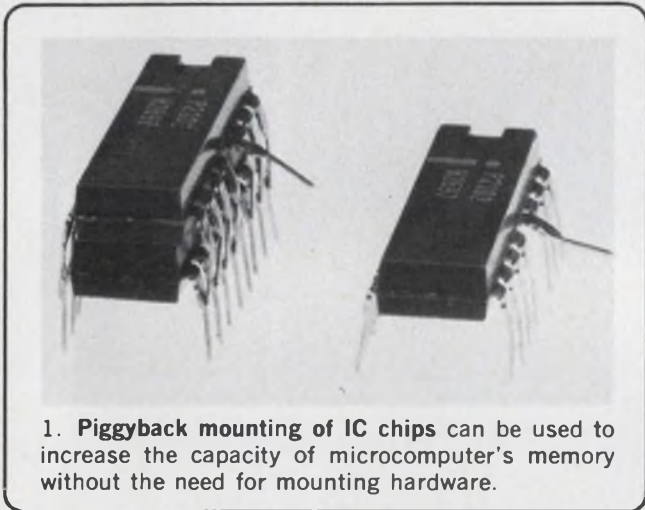
Fig. 2 is a memory board that has been doubled in capacity, with the original interboard spacing retained. Of course, you must take care of the increased power dissipation and be sure that you have adequate drive capability. Also, the tech-

nique uses some kluge wiring, which must be carefully done to avoid shorts and noise problems.

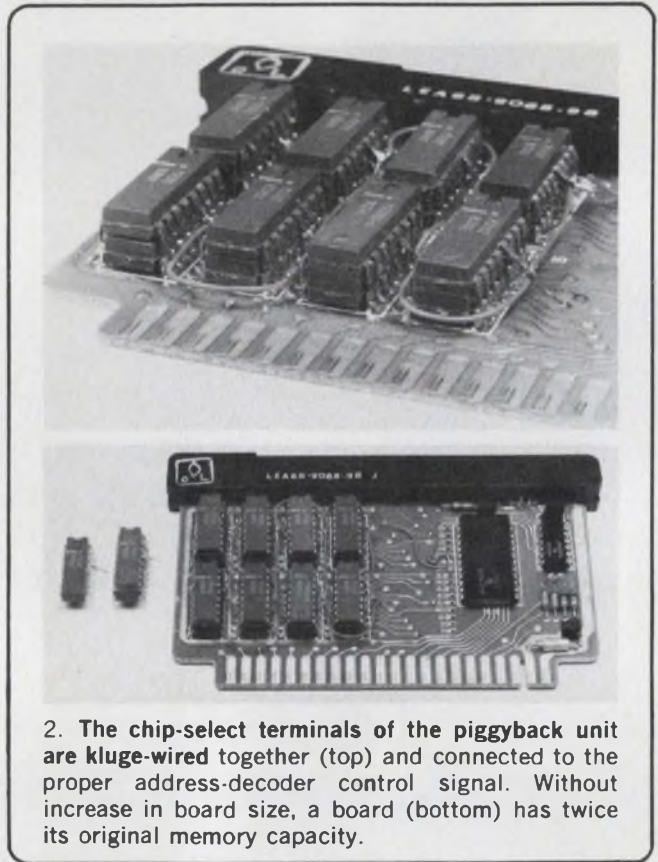
But for a low-cost fix to a design, this solution is hard to beat.

*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

**Eugene Zuch**, Senior Engineer, Datal Systems, Inc., 1020 Turnpike St., Canton, MA 02021. His idea "Drift-Free Integration with a V/F Converter and Digital Counter" has been voted the Most Valuable of Issue Award.

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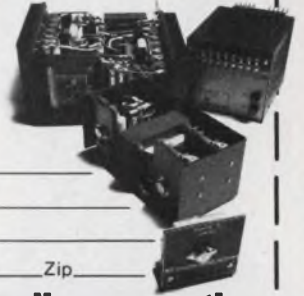
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Company \_\_\_\_\_ M/S \_\_\_\_\_

Address \_\_\_\_\_

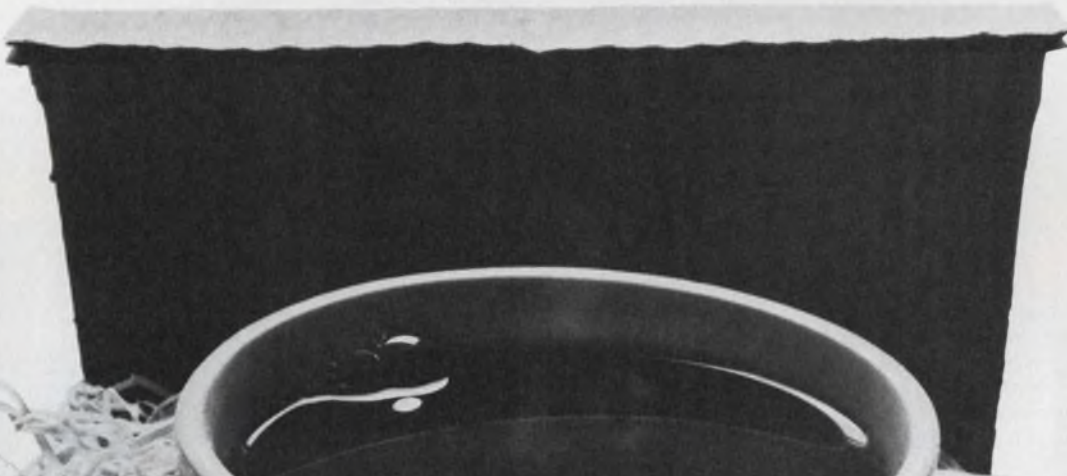
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Back-to-back SCR's are superior to triacs in many applications.

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INFORMATION RETRIEVAL NUMBER 61

## 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 wash-

ing-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 lock-out 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 OS4000, 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



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



Scan Converter Shield



Radar Display Tube Shield



CRT Shield



Motor Shields



Small Transformer Shield



CRT Deflection Yoke & Neck Shield ("L" locking)



Specialized CRT Shield



Hydroformed CRT Shield



Magnetic Isolation Chamber



Geo-Magnetic Investigation Chamber



Movable Multi-Layer Controlled Magnetic Environment Chamber



Presidential Model Tape Data Protector



Hydroformed Storage Tube Shield



Video Recorder Head Assembly Shield



Special 5-Layer PM Shield



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.

## 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.

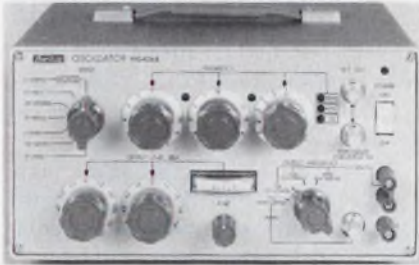
**Our 3rd Decade of Magnetic Shielding Leadership**

**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  $\pm 0.5\%$  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  $\Omega$ ).

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 Boulevard & Woodfield Boulevard, 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  $\pm 1$  part in 10 million.

CIRCLE NO. 304

## Indirect synthesizers fill frequency slots

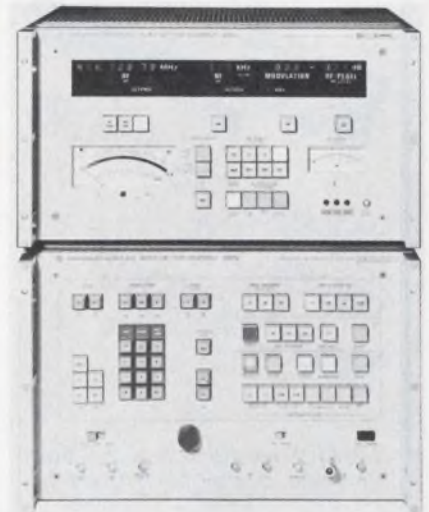


*Logimetrics, Inc., 121-03 Dupont St., Plainview, NY 11803. (516) 681-4700. Start at \$2800; stock-60 days.*

The 4000 and 5000 series are designed for systems and use indirect synthesis rather than direct or hybrid methods. Size is 5-1/4  $\times$  19  $\times$  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,  $\pm 1$  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

The world's leader  
in solid state power amplifiers

SEE  
Electronic Design's  
**GOLD BOOK**  
FOR COMPLETE  
TECHNICAL  
SPECIFICATIONS

## INSTRUMENTATION

### 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-k $\Omega$  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  $\pm 0.0055\%$  of reading + (0.02%  $\div$  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  $\times$  256-bit memory. Thresholds are adjustable through the range of  $\pm 10$  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 non-sinusoidal 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  $\mu$ V to 1000 V with a maximum crest factor of up to 5. As a dc voltmeter, the unit handles 100  $\mu$ V to 1000 V with a basic accuracy of  $\pm 0.04\%$  of reading + 1 count. Five full-scale ranges are offered. Resistance ranges from 600 m $\Omega$  to 60 M $\Omega$  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

# 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 packag-

ing 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.



**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.



Forward and reverse voltage protection.  
Barrier block interface.  
Infinite resolution adjustments.  
Full interchangeability.  
115/230 vac, 47-440 hz.

Socketed IC regulation system.  
Filters meet mfrs. ripple ratings.  
Glass epoxy PC boards.  
Loss of sense protection.  
Designed for U.L. Recognized Component Index.



Socketed power semiconductors.  
Iridited aluminum chassis.  
Computer grade electrolytics.  
Special circuits to protect IC.

Choose from these models:

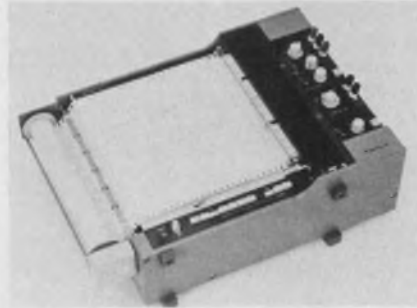
Size A Model No.	Size B Model No.	Size C Model No.	Size D Model No.	Size F Model No.
volts — amps	volts — amps	volts — amps	volts — amps	volts — amps
Q 5 — 3.0	Q 5 — 6.0	Q 5 — 9.0	Q 5 — 12.0	Q 5 — 18.0
Q 6 — 3.0	Q 6 — 6.0	Q 6 — 9.0	Q 6 — 12.0	Q 6 — 18.0
Q 12 — 1.7	Q 12 — 3.4	Q 12 — 5.7	Q 12 — 7.0	Q 12 — 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: 4 7/8 x 4 1/8	Dimensions: 5 3/4 x 4 x 2 1/2	Dimensions: 7 x 4 1/2 x 2 3/4	Dimensions: 9 x 4 1/2 x 2 3/4	Dimensions: 14 x 4 7/8 x 2 3/4
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.**

## INSTRUMENTATION

### 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  $\pm 0.3\%$  and maximum sensitivity of  $5 \mu\text{V}/\text{cm}$ . 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  $\mu\text{F}$ . Input impedance on ac and dc voltage measurements is 10 M $\Omega$  on all ranges. Pushbutton selection of ranges and functions in the Model 370 speeds measurements and avoids switching through unwanted steps. True auto-polarity 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 handheld, 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%  $\pm 1$  count. Input impedance is 100 k $\Omega$  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

**INTEGRATED CIRCUITS**

**CMOS clock chip has 10-ns edge speed**

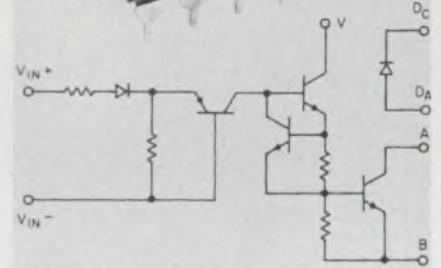
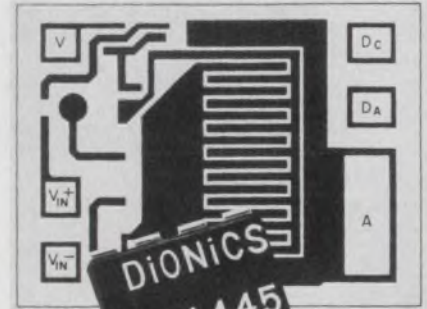
*Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. \$2.40 (100-999).*

The ICM7209 CMOS clock generator can be used with microprocessors such as Intersil's IM-6100 CMOS  $\mu$ P or in other applica-

tions 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

**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 x 41-mil chip features back-side 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

**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 CORPORATION**

11520 W. Jefferson Blvd.  
Culver City, CA 90230  
(213) 870-7014



INFORMATION RETRIEVAL NUMBER 67

**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

1843

**PICHER**
**Carefree<sup>®</sup>**  
**RECHARGEABLES**

# LEAD-ACID BATTERIES

- SEALED ● RUGGED
- NO MAINTENANCE
- SAFE ● SPILL-PROOF
- WIDE TEMPERATURE OPERATING RANGE
- LONG LIFE


**RELIABLE ECONOMICAL  
RECHARGEABLE POWER**  
 for

- Alarm Systems
- Emergency Lighting
- Electromedical Apparatus
- Telephone Carrier Equipment
- Portable Television
- Communication Equipment
- Portable Instrumentation
- Computer Standby Systems
- And Many More

 To Find Out How to Make  
 Your Battery System

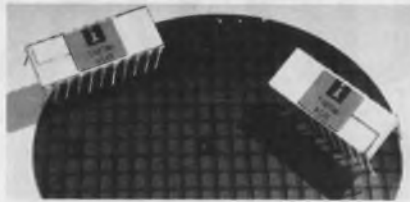
**Carefree<sup>®</sup>**

Call or Write

 EAGLE-PICHER INDUSTRIES, INC.  
 Commercial Products Dept. ED  
 P.O. Box 130, Seneca, Mo. 64865  
 Telephone (417) 776-2258

## INTEGRATED CIRCUITS

### 4-k dynamic RAM chooses 22-pin DIP

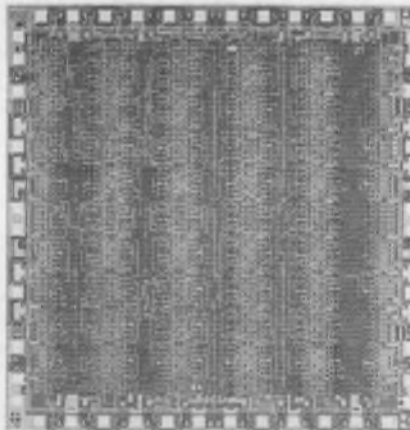


*Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. \$24.25 to \$29.25 (100-999).*

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 Laurence 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.

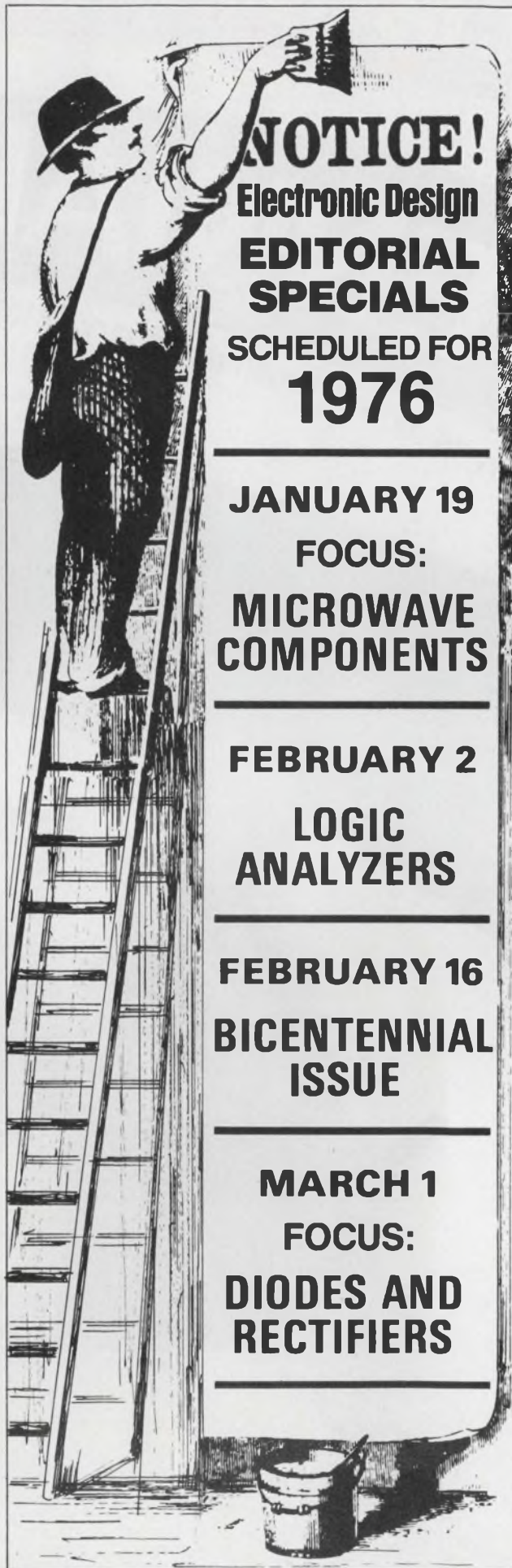
CIRCLE NO. 331

### 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



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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

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**

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INFORMATION RETRIEVAL NUMBER 70

## DISCRETE SEMICONDUCTORS

### 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 micro-wave hyperabrupt tuning diodes provides  $\pm 1.5\%$  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 ( $I_r = 10 \mu\text{A}$ ) of 22 V, maximum reverse leakage current ( $V_R = 20 \text{ V}$ ) of 50 nA, maximum capacitance temperature coefficient ( $V_R = 4 \text{ V}$ ) of 400 ppm/ $^\circ\text{C}$ , minimum Q ( $-4 \text{ V}$ ,  $f = 50 \text{ MHz}$ ) of 500 and typical junction capacitances for the DKV6550A of 1.2 pF at  $-4 \text{ V}$  and 0.4 pF at  $-20\text{-V}$  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  $\mu\text{cd}$  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  $V_{\text{CEO}}$  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  $\mu\text{s}$  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 ( $V_{\text{DROM}}$ ) 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

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1000 pF, 5%, 50WVDC	12¢	16¢	16¢
BME <sup>TM</sup> "S" DIELECTRIC (X7R)	BME-Chip <sup>TM</sup>	BME-Axial <sup>TM</sup>	BME-Radial <sup>TM</sup>
.01 $\mu$ F, 20%, 50WVDC	3.5¢	5.8¢	5.8¢
.1 $\mu$ F, 20%, 25WVDC	9¢	16¢	14¢
1.0 $\mu$ F, 20%, 25WVDC	52¢	—	73¢
BME <sup>TM</sup> "R" DIELECTRIC (Z5U)	BME-Chip <sup>TM</sup>	BME-Axial <sup>TM</sup>	BME-Radial <sup>TM</sup>
.1 $\mu$ F, +80 -20%, 25WVDC	5.7¢	8.8¢	8.8¢
.47 $\mu$ F, +80 -20%, 25WVDC	13¢	16.5¢	16.5¢
1.0 $\mu$ F, +80 -20%, 25WVDC	19¢	27¢	25¢
2.2 $\mu$ F, +80 -20%, 25WVDC	35¢	—	49¢

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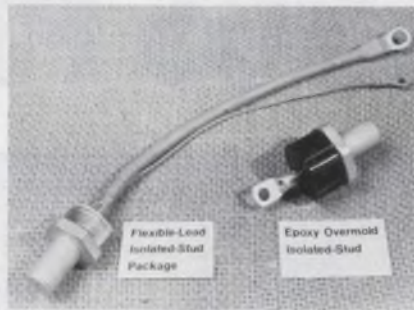
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INFORMATION RETRIEVAL NUMBER 72

## DISCRETE SEMICONDUCTORS

### 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 (TAS8610, TAS8611, TAS8612, TAS8613) and isolated-stud (TAS8620, TAS8621, TAS8622, TAS8623) 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 optocouplers/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 x 0.35 x 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  $\mu$ s 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  $\mu$ s 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  $\mu$ s, 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.

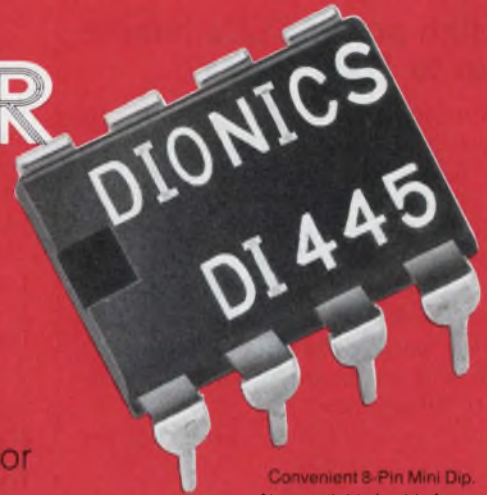
The MA-48500 series of GaAs varactors is specifically designed for use in both room temperature and cryogenically cooled parametric amplifiers. High gain-bandwidth products can be achieved using these diodes over 1 to 35 GHz with pump frequencies as high as 90 GHz. All varactors are available in a choice 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

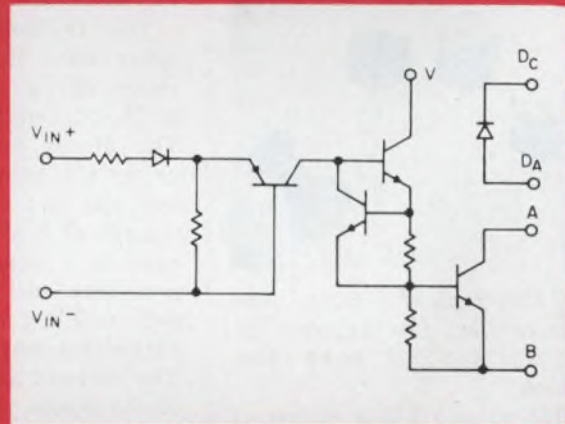
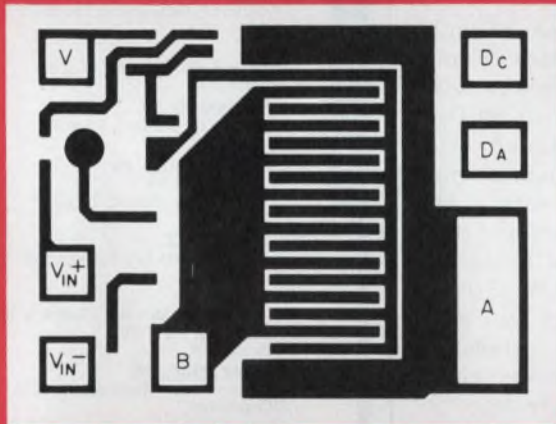
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## DISCRETE SEMICONDUCTORS

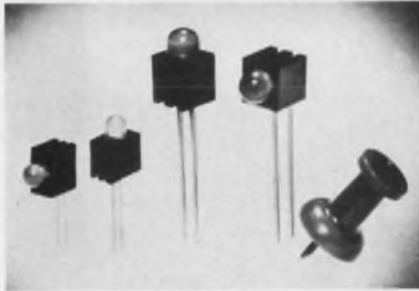
### High power SCRs handle up to 1200 A rms

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  $\mu$ s 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 [ $V_{CE(R(SUS))}$ ] 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  $\mu$ s 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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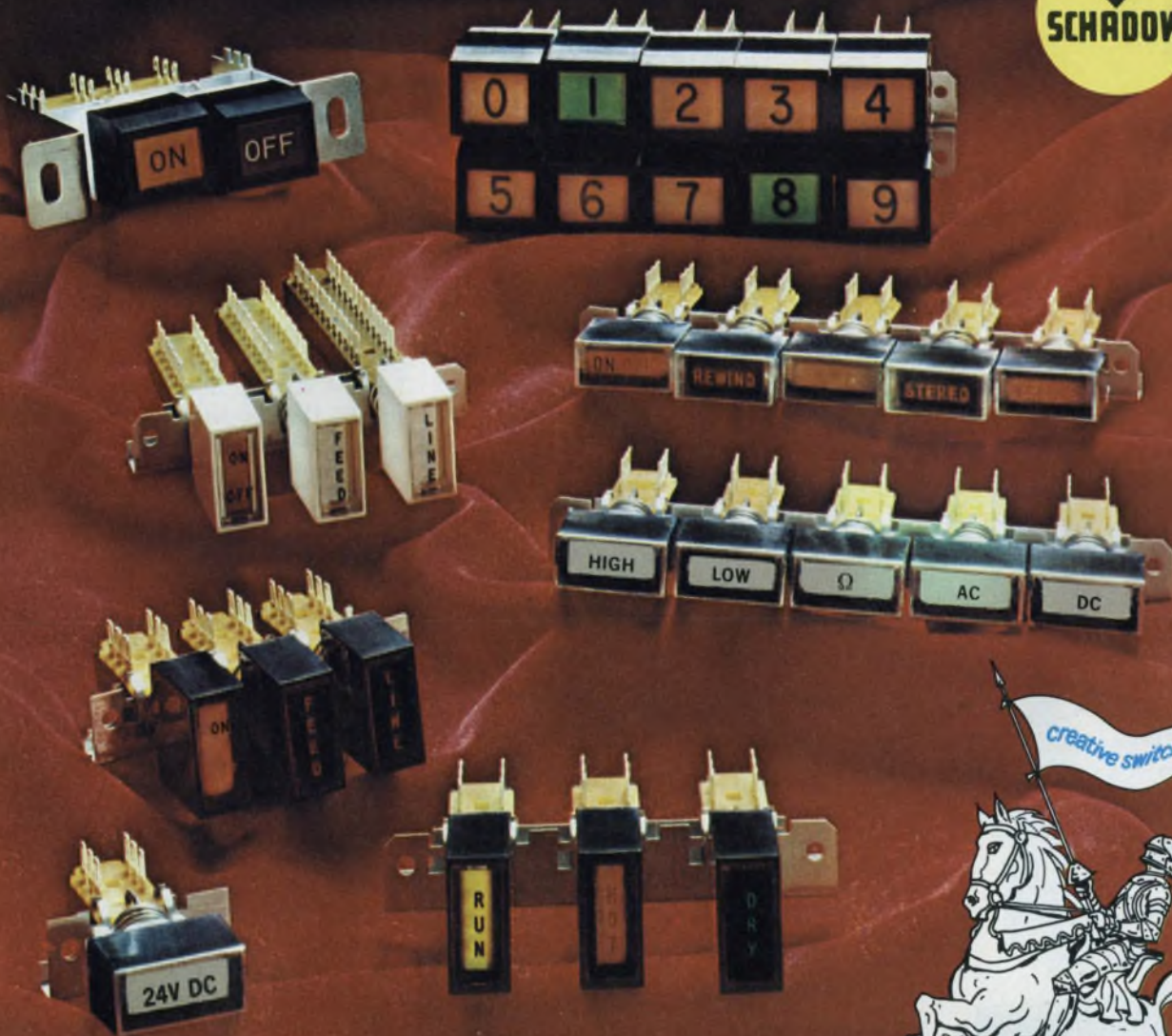
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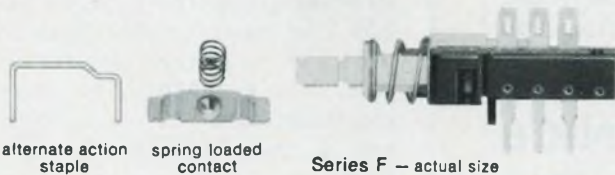
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spring loaded contact

Series F — actual size

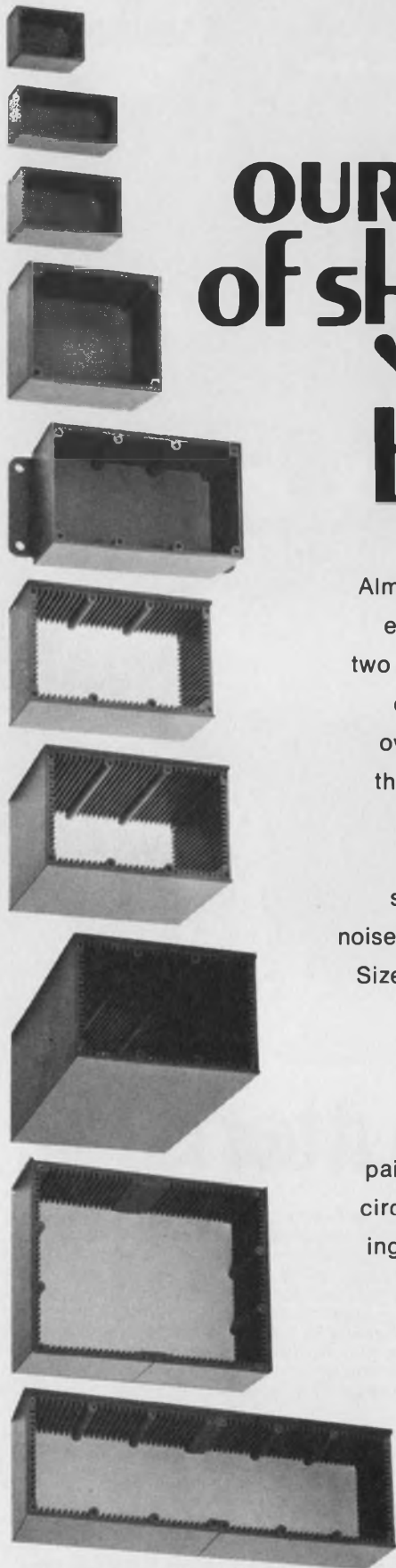


**IEE/SCHADOW inc**

612/944-1820 • TWX 910-576-2469 • TELEX 29-0556  
8081 Wallace Road, Eden Prairie, MN 55343

Manufacturing facilities in Minneapolis, Minnesota, Einbeck, W. Germany and W. Berlin





# MEET OUR family of shielded "black BOXES"

Almost 10 years ago (1966 to be exact) we introduced our first two series of shielded electronic enclosures. They became an overnight success. Since then the demand for different sizes, shapes and applications has increased our family to ten series of models, each with a noise rejection greater than 70db. Sizes range from 1.50" x 1.13" x 0.88" to 4.13" x 2.68" x 6.0"; in blank versions or with a complete choice of coaxial connectors; painted or unpainted; with or without printed circuit card guides; with mounting flanges or bottom mounting plates. All models supplied with aluminum covers and mounting screws.

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INFORMATION RETRIEVAL NUMBER 76

## DISCRETE SEMICONDUCTORS

### 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  $r_{EC}(\text{sat})$  of 2  $\Omega$ . 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

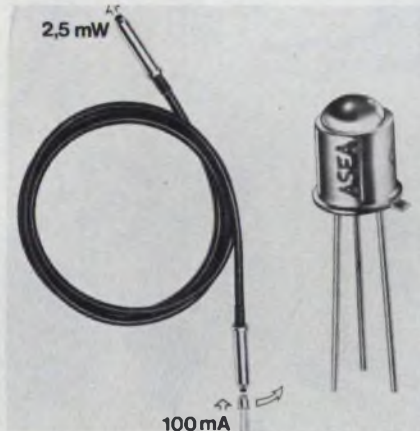


Microwave Associates, South Ave., Burlington, MA 01803. (617) 272-3000. \$25 (1 to 9); 2 to 3 wk.

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.

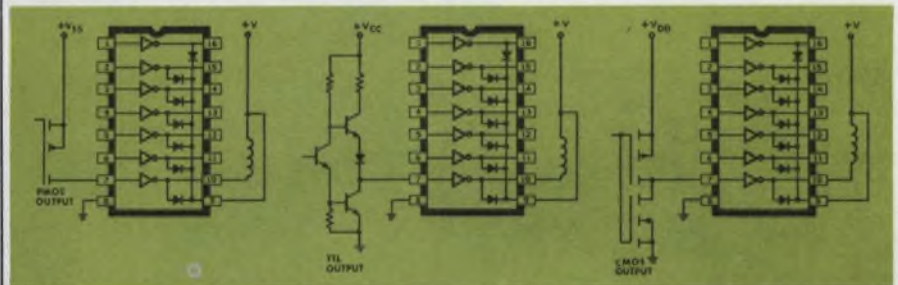
The 1A83 infrared emitting diode is specially designed for efficient coupling to 2-mm diameter optical fiber bundles. The diode is housed in a TO-18 case with a lens cap. At 100 mA, the total emitted radiant flux is at least 7 mW and typically 10 mW. The radiant flux output from an ordinary fiber bundle 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  $0.6 \mu\text{s}$  at 100 mA and  $0.3 \mu\text{s}$  at 1 A.

CIRCLE NO. 352

# INTERFACE



## For High-Voltage, High-Current Interface with PMOS, CMOS, TTL, DTL... Sprague Darlington Transistor Arrays Have No Equal



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.

With broad commercial/industrial application, these unique arrays are an excellent choice for interfacing to LEDs, solenoids, relays, lamps, and small stepping motors in printing calculators, cash registers, and control equipment.

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.

For the name of your nearest Sprague Semiconductor Distributor, write or call Roger Lemere, Sprague Products Company, North Adams, Mass. 01247. Tel. 413/664-4481.

455-5101

# SPRAGUE

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THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

INFORMATION RETRIEVAL NUMBER 77

If you design  
with ECL or TTL,  
You need  
to know about  
Tektronix  
TM 500



**If You're into High Speed Logic,**  
The Tektronix TM 500 provides the test and measurement instruments you need to TTL or ECL or 200 MHz. The TM 500 High-Speed Logic Analyzer (HSLA) provides 100 MHz of logic state resolution. The TM 500 Digital Storage Oscilloscope (DSO) and 2-channel logic analyzer provide the test and measurement instruments you need to test high-speed logic. The TM 500 DSO provides 100 MHz of logic state resolution. The TM 500 DSO provides 100 MHz of logic state resolution. The TM 500 DSO provides 100 MHz of logic state resolution.

**The TM 500 Conceals**  
The TM 500 is a growing, compatible family of instruments providing the complete test and measurement laboratory right in your lab. It's a family of instruments that can be used for a wide variety of applications. It's a family of instruments that can be used for a wide variety of applications. It's a family of instruments that can be used for a wide variety of applications.

If you  
can't bring  
your  
troubleshooting  
into your lab,  
roll Tektronix  
TM 500  
to the problem.



- digital multimeters
- counters
- generators
- amplifiers
- power supplies
- oscilloscopes
- a blank plug-in for your own circuitry
- and more

The TEKTRONIX Rollabout Configuration of TM 500 modular instruments helps you conveniently take your test and measurement "laboratory" right to the problem... whether it's routine maintenance, calibration, repairs, QC or production testing, or whatever. TEKTRONIX TM 500 modular instruments are designed to fulfill your needs in such widely divergent areas as: computer circuitry and data handling equipment, numerically controlled machines, laboratory instrumentation, communications equipment, and medical instrumentation.

The modular Rollabout Configuration provides up to six operating test and measurement instruments, which you can tailor from a growing line of 29, plus the TEKTRONIX portable or plug-in oscilloscope of your choice... all on a SCOPE-MOBILE™ cart. TM 500 modular instruments can work together through a common interface circuit board within their mainframe enclosures, and they can also function totally independently. Some are general purpose, such as DMMs, some are highly specialized, such as those for oscilloscope calibration. They comprise a test and measurement system that is difficult to duplicate with "monolithic" instruments.

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 500, 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.

Find out what TM 500 instrumentation can do for you. Send for the TM 500 Booklet A-3072 with full specifications and suggested selections of instruments for typical applications. Or contact your local Tektronix Field Engineer for a demonstration of how TM 500 instruments can solve 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.



It makes  
audio communications  
measurements  
too...



Tektronix  
TM 500



- digital multimeters
- counters
- generators
- amplifiers
- power supplies
- oscilloscopes
- a blank plug-in for your own circuitry
- and more

The TEKTRONIX modular Audio Frequency Instrumentation group provides the test and measurement instruments you most frequently need... for only \$1370. These compact light weight instruments work together as a system or independently within a TM 500 power module mainframe.

The above TM 500 configuration features a digit reading digital multimeter with 3 1/2 digit display and 100 MHz bandwidth measurement capability (a solid-state device circuit problem); the 50 MHz Audio Oscilloscope (100 MHz) with 100 MHz sine and square wave input; the OC 504 Digital Counter with 30 MHz to 50 MHz input and 100 MHz output; the 50 MHz LED display of frequency to 80 MHz and period resolution to 1 μs; and the 50 MHz Oscilloscope.

range as a single-channel 20-to-100 MHz modular instrument with triggering sweep and manual measuring to resolution.

All TM 500 plug-ins are ready interchangeably within the mainframe. The common interface circuit board of the TM 500 system. The common interface circuit board of the TM 500 system. The common interface circuit board of the TM 500 system.

The TM 500 is a growing, compatible family of 29 plug-in modular instruments, accessories, and one. There are rack and six-compartment mainframes providing the common power supply. The modular Rollabout Configuration can accommodate two TM 500, 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.



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 OC production test or built-in test equipment a highly sophisticated line of test instruments... TM 500. They are designed to work with plug-ins to make it easier for you to build in your own testing circuits compatible with the TM 500. The RTM 500 rack-mounting power module mainframe (only 5 1/2" high) provides the knowledge of TM 500 compatible TM 500 plug-in for laboratory (RTM 500) and production (TM 500) use. It is available for reconfiguration of repair, 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 testability of assembling your special circuits in TM 500 plug-in kits.

A common interface circuit board within the mainframe permits the reconfiguration of repair, 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 testability of assembling your special circuits in 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; ac, power line frequency, audio, and (1 to 500 MHz) oscilloscope and other instrumentation; calibration; and even medical instrumentation calibration. They represent Tektronix standards of quality in design, performance, and ease of use.

# TEKTRONIX ANNOUNCES

## A new concept in portable instrumentation

The TEKTRONIX TM 500 System is your answer to selecting from more than 30 plug-in modular instruments. Plug in the power module and you have the convenience of a portable, rack-mountable instrument system. Plug in the DC 505A or DM 502 and you have the convenience of a portable, rack-mountable instrument system. Plug in the DC 505A or DM 502 and you have the convenience of a portable, rack-mountable instrument system.

You can improve a TM 500 system to your needs by selecting from more than 30 plug-in modular instruments. Plug in the power module and you have the convenience of a portable, rack-mountable instrument system. Plug in the DC 505A or DM 502 and you have the convenience of a portable, rack-mountable instrument system.

The TM 500 system is your answer to selecting from more than 30 plug-in modular instruments. Plug in the power module and you have the convenience of a portable, rack-mountable instrument system. Plug in the DC 505A or DM 502 and you have the convenience of a portable, rack-mountable instrument system.

# 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.



FOR TECHNICAL DATA CIRCLE #285  
FOR DEMONSTRATION CIRCLE #286

## Get Tektronix TM 500 versatility in a counter/DMM combo



DC 505A / DM 502 for only \$1900

When you plug in a TEKTRONIX DC 505A Universal Counter alongside a DM 502 Digital Multimeter, you get more than a 220 MHz counter and a full-function DMM. The TM 500 mainframe that receives these plug-in modular instruments shares a common interface circuit board, allowing the instruments to work together and with other instruments. For example, with the interface connections set up, you can read counter trigger level on the DMM at the touch of the INT (Internal) pushbutton. Touch INT again, and you have separate and simultaneous universal counter and DMM capability. Adding other examples, a TM 500 counter/DMM combo can work with the TEKTRONIX 31-53 Programmable Calculator for applications such as obtaining data



The 10 nanosecond clock rate of the DC 505A Universal Counter (3198) means you get single shot resolution to 10 nanoseconds in period or time interval measurements... and resolution to 100 picoseconds in repetitive events when you set the averaging to 10 cycles. A single function switch selects FREQUENCY (inverts), A, PERIOD (inverts), B, A. For the wide switch on the front panel to CH A or CH B to read connected through the rear plug-in interface, or an 800K instrument, such as an oscilloscope, through the top jacks on the rear panel. The DM current, dBV, and resistance. Temperature (1212) ranges. A pushbutton control provides dB resist of all functions in line of all the rear plug-in interface trigger level from an adjacent DC 505A counter or 200 MHz voltage (routed to that point, but the DM 502 is even more versatile. Internal jumpers provide readout in mV or dBV ranges. And the temperature probe lets you check for abnormal operating components in a single package circuitry.

The TM 500 Product Line includes mainframes with 1, 3, 4, 6, and 8 mainframe (1810) or the equivalent of a monolithic instrument, offering maximum capabilities... the DC 505A/DM 502 Counter/DMM. Like the additional compartments for later expansion, selecting from sources, power supplies, oscilloscopes, and more.

Contact your local Tektronix Field Engineer for a DC 505A / DM 502 demonstration, or write Tektronix for the TM 500 Catalog containing full specifications and applications discussions. 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.



As Price FOB Beaverton, Oregon  
TEKTRONIX  
committed to technical excellence

# 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-1 $\frac{3}{4}$  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-1 $\frac{3}{4}$	40.0 mcd	28°
5252**	Green	T-1 $\frac{3}{4}$	15.0 mcd	28°
5352**	Yellow	T-1 $\frac{3}{4}$	45.0 mcd	28°
5752**	Red	T-1 $\frac{3}{4}$	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.

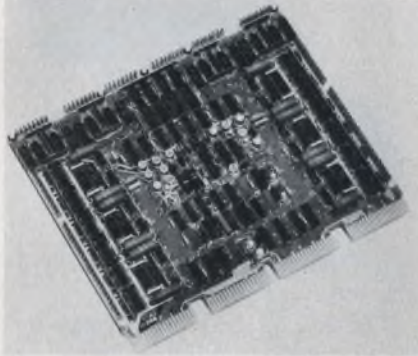
For product information, circle the service number or call your local Monsanto man. Or write Monsanto Electronics Division, 3400 Hillview Avenue, Palo Alto, CA 94304.

Putting innovation to work.

**Monsanto:**  
the science  
company.

## DATA PROCESSING

### 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.

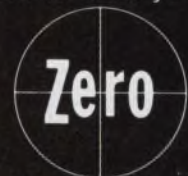
When your customer takes your equipment into the field, be prepared for the worst to happen.

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.



The Final Touch



ZERO MANUFACTURING CO.

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FOR PRODUCT DEMONSTRATION CIRCLE #163  
FOR LITERATURE CIRCLE #164

## DATA PROCESSING

### 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

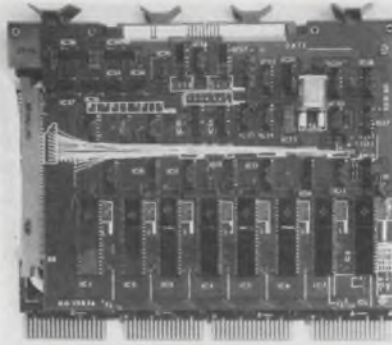


Data I/O Corp., P.O. Box 308, 1297 N.W. Mall, Issaquah, WA 98027. (206) 455-3990.

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

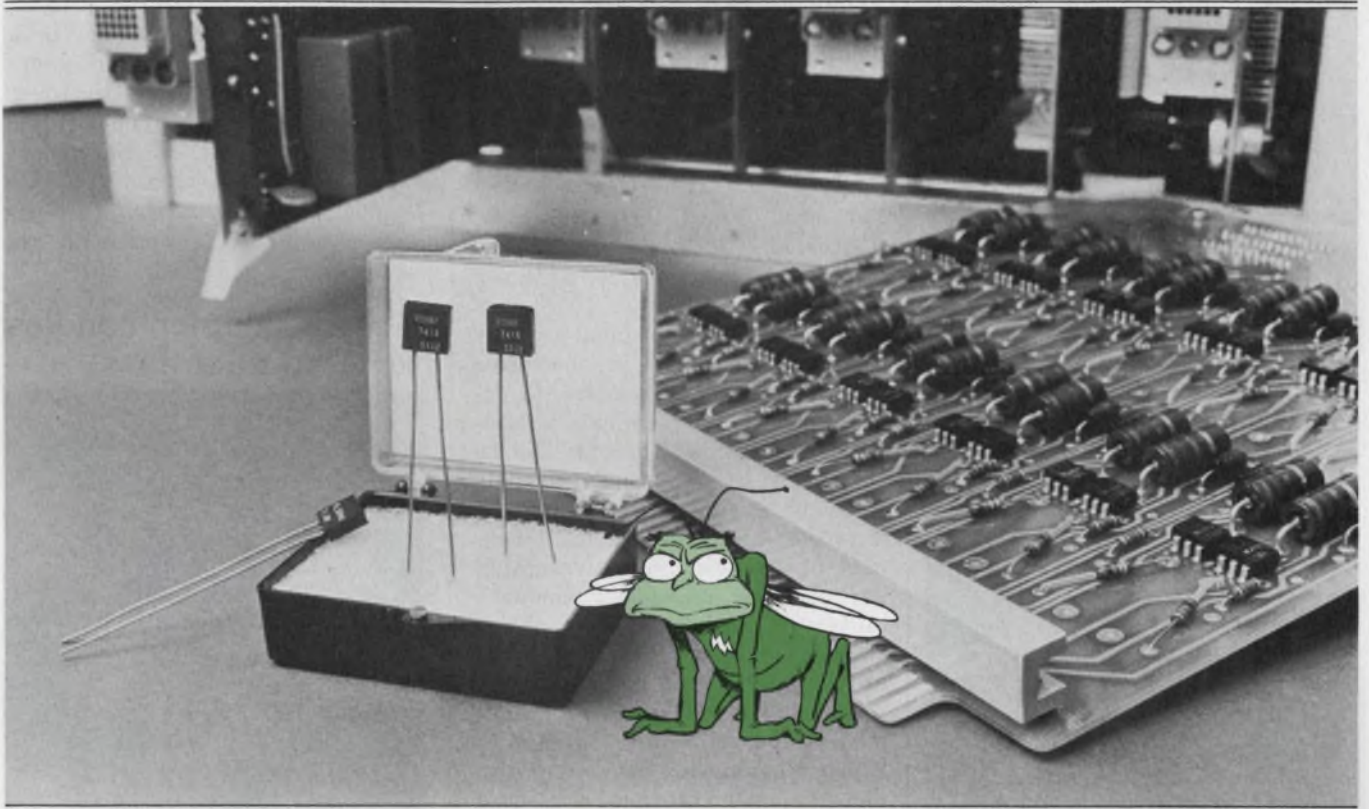
### Translucent tablet helps digitize data

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  $0 \pm 1$  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.



**Only Vishay resistors give you all six top performance specs.**



**TCR**  
to  $0 \pm 1$  ppm/°C



**TOLERANCE**  
to .001%



**As low as 1-ns  
RISE TIME—  
NO INDUCTANCE**



**TRACKING**  
to  $\frac{1}{2}$  ppm/°C



**STABILITY**  
to 5 ppm/yr



**NO NOISE**

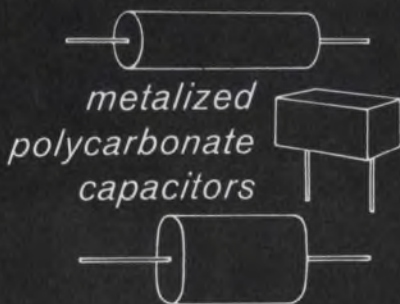


If you can't stand  
the heat

stay out  
of the  
kitchen!



Here are components that stand the heat . . . and the cold ( $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ) 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



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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  $1024 \times 780$  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



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# 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.

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CAN GET THE *RIGHT* ONE**

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INFORMATION RETRIEVAL NUMBER 85

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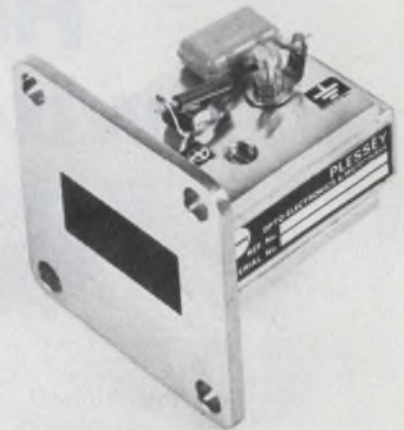
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Hawthorne, NJ 07506  
201—427-3100

Servo-Tek of California, Inc.  
8155 Van Nuys Blvd.  
Van Nuys, CA 91402  
213—786-0690



## MICROWAVES & LASERS

### 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  $\pm 25$ -MHz or  $\pm 250$ -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  $\pm 20$  to  $\pm 300$  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  $\pm 100$  MHz to  $\pm 200$  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  $\pm 25$ -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

**MICROWAVES & LASERS**

**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  $\pm 1.0$ -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  $2 \times 1 \times 0.26$  in. The internal crystal provides  $\pm 0.003\%$  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.



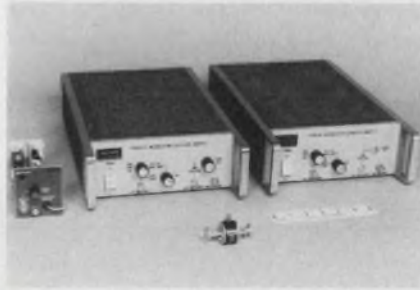
Sales and service from 172 offices in 65 countries. 1501 Page Mill Road, Palo Alto, California 94304

02503

INFORMATION RETRIEVAL NUMBER 87

## MICROWAVES & LASERS

### 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  $\Omega$ , 1.5-dB insertion loss, and 25-W power-handling capability. The unit comes with BNC connectors and an uncalibrated dial.

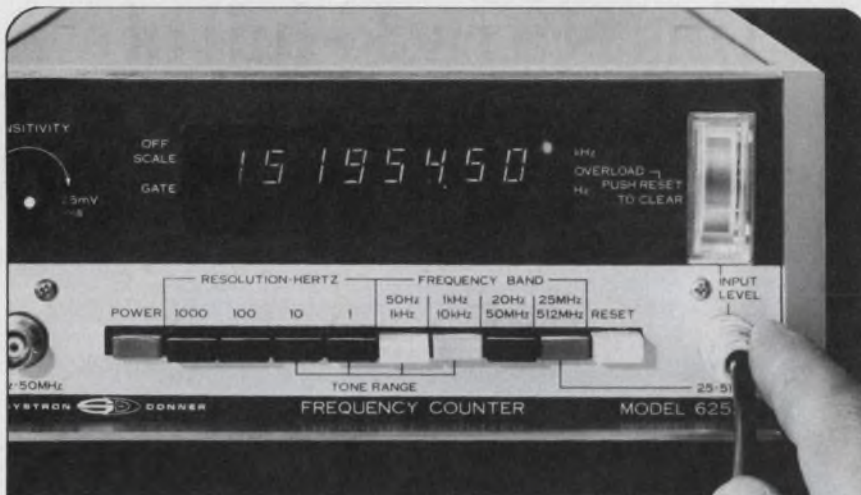
CIRCLE NO. 374

### 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  $\pm 1\%$  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



## Will your next frequency counter have all these features?

- **Frequency Range:** 20 Hz to 512 MHz
- **Input Protection:** 45 Watts instantaneous, 2 Watt continuous
- **Metered Input:** Visual indication of high/low signal strength
- **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.

#### Meet the whole family:

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  $0.94 \times 1.5 \times 2.13$  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- $\mu$ s switching time (20- $\mu$ s 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  $\mu$ s. 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  $\mu$ . A multi-mode 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  $\mu$ .

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  $\pm 0.0025\%$  with stability rated at  $\pm 0.0025\%$ . The oscillators measure as small as  $0.69 \times 0.67 \times 0.49$  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  $\pm 1$ -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  $\pm 1\%$  at all sweep speeds.

CIRCLE NO. 381

Advertisement

ELECTRONIC PACKAGING

## Versatile enclosures come in 10 sizes



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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## 500 lb. capacity cabinet won't tilt, won't sway



Bud Radio, Inc., 4605 E. 355 St., Willoughby, O. 44094, (216) 946-3200. Immediate delivery.

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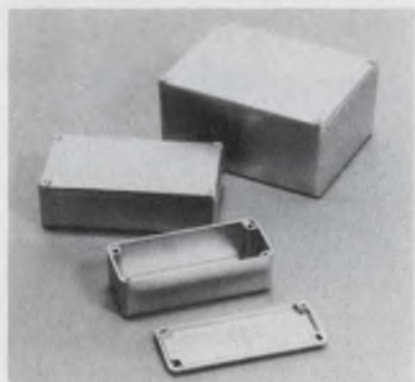
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Bud Radio, Inc., 4605 E. 355 St., Willoughby, O. 44094, (216) 946-3200. Cast aluminum construction.

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## MICROWAVES &amp; LASERS

Bandpass filter  
withstands 13 kW pk

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 x 1.63 x 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 x 14.5 x 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 T1, 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.  
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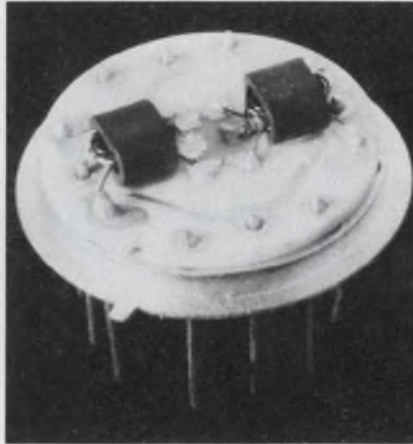


# If/rf building blocks now in hybrid form

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 flatpaks (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, cen-

trifuge, 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  $1 \times 10^6$  h and is  $2 \times 10^5$  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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Prices subject to change without notice.

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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.  $\pm 0.9$  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  $\pm 15$  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- $\mu$ s conversion speeds for 8 to 12-bit resolution. Models are available for 8, 10 and 12-bit resolution and have a  $\pm 1/2$ -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  $\pm 20$  ppm/ $^{\circ}$ C and  $\pm 15$  ppm/ $^{\circ}$ C for the 12-bit unit. Maximum conversion speeds and corresponding maximum linearity errors are 0.88  $\mu$ s and  $\pm 0.2\%$  for the 8-bit model, 1.88  $\mu$ s and  $\pm 0.05\%$  for the 10-bit, and 3.5  $\mu$ s and  $\pm 0.025\%$  for the 12-bit unit. All converters are complete with internal clock, reference and user selectable analog input ranges of  $\pm 2.5$ ,  $\pm 5$ ,  $\pm 10$ , 0 to +5, 0 to +10, and 0 to +20 V. The ADC60s are housed in 2  $\times$  4  $\times$  0.75-in. modules and require only  $\pm 15$  and +5 V supplies.

CIRCLE NO. 387

# TRIDENT

## CUSTOM HYBRID MICRO CIRCUITS

by

# CTI

will be aboard!

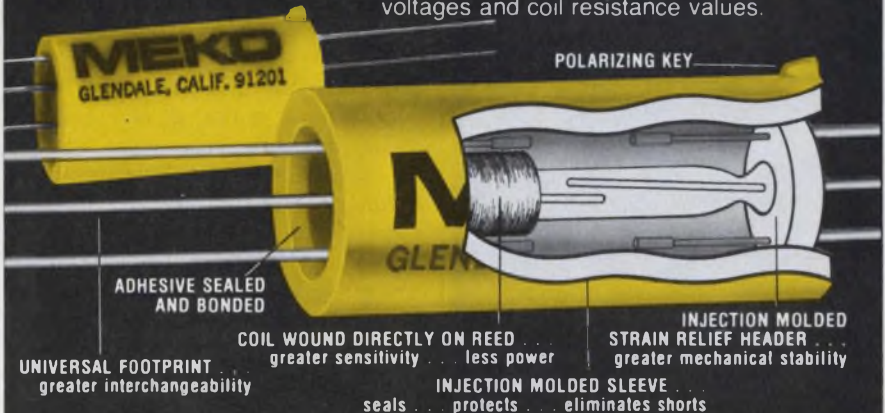
Circuit Technology, Inc.  
160 Smith Street, Farmingdale, N.Y. 11735  
Phone (516) 293-8686 • (213) 374-7446

Exterior close-up of evaluation model U.S. Navy photo.

INFORMATION RETRIEVAL NUMBER 102

## now! Injection Molded Reed Relays.

- Injection molded strain reliefs prevent shorts, opens and broken reeds. ■
- Coil wound directly on reed switch for greater sensitivity. ■
- Universal foot print for greater interchangeability. ■
- Completely sealed to eliminate contamination. ■
- One hundred percent in-process and final dynamic tests. ■
- Available in a full range of form configurations, voltages and coil resistance values. ■



Available in DIP and encapsulated packages

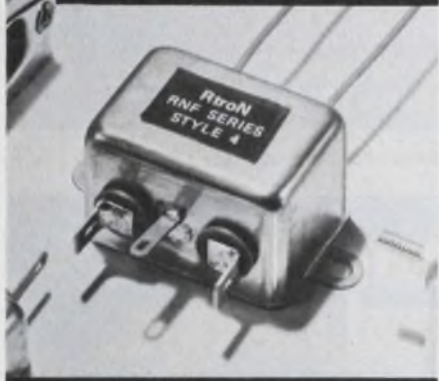
# MEKO

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INFORMATION RETRIEVAL NUMBER 103



now you have  
a choice!



## RFI/EMI FILTERS

For Data Processing,  
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Rtron's RNF Type Filters represent three series of the most widely used, low cost filters available. Over 100 combinations of current and case style to choose from: "L" Series - low cost for general applications to combat line to ground noise; "P" Series - for suppression of line to line as well as line to ground interference; "T" Series - most effective for low impedance load applications. All types are U.L. Recognized and meet C.S.A. requirements. Rated at 115/250 VAC. Low leakage current insures safety.

For complete catalog and  
details, write

**Rtron** corporation

P.O. Box 743, Skokie, Illinois 60076  
(312) 679-7180

## 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  $\pm 10$  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- $\Omega$  load. Power requirements are less than 5 W total. Size of the synthesizer is 6.5 x 4.5 x 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  $\Omega$  and the insertion delay is less than 20 ns (including uncertainty of  $\pm 500$  ps). Programming time is less than 100 ns and the worst-case jitter between leading and trailing edge pulse is  $\pm 200$  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

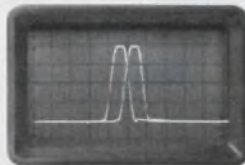
durations, periods? Simply adjust the two intensified markers to coincide with the points you want to measure between.



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

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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, ruggedized 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

## MODULES & SUBASSEMBLIES

### 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, 1/2, 1/4, 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.

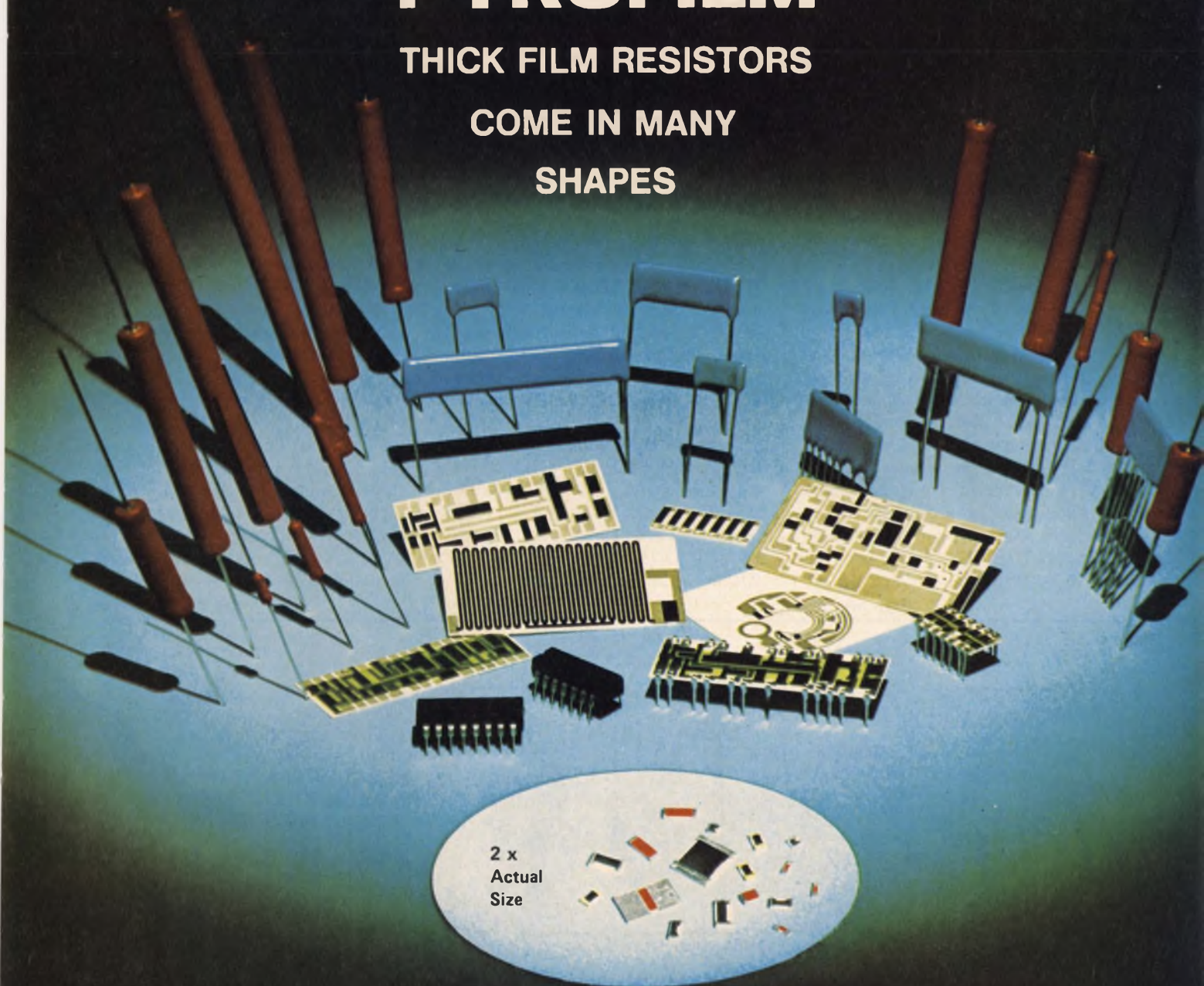
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**THICK FILM RESISTORS**

**COME IN MANY**

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### 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  $\pm 2\%$  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 ( $359.9^\circ$ ) can be handled by the module while the outputs represent  $10 \sin \theta$  and  $10 \cos \theta$  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 ( $50 \Omega$ ), 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  $\pm 50$  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  $1\text{-}13/16 \times 5\text{-}1/8$  in.

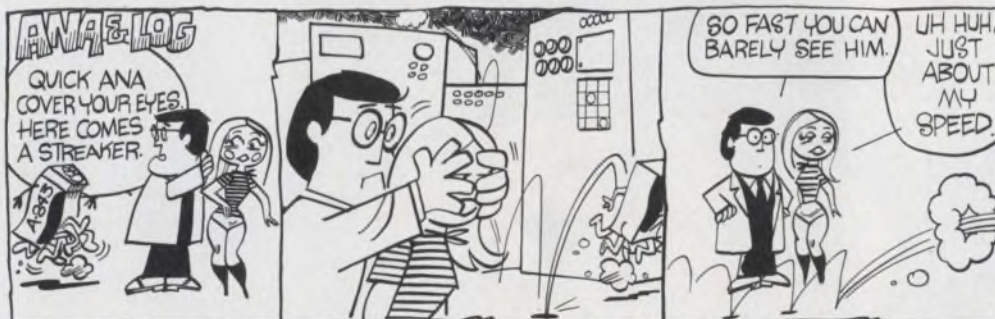
CIRCLE NO. 400

### 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 Volt sensor 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  $1.4 \times 0.6 \times 0.5$ -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  $\pm 5$  to  $\pm 16$  V, or from a single 5-to-32-V supply.

CIRCLE NO. 401



**ANALOGY**  
GET THE BARE FACTS ON THE A-843 VOLTAGE TO FREQUENCY CONVERTER. STREAKS YOUR SYSTEM AT 0.1MHZ IN A STRAIGHT LINE  $\pm 0.01\%$ . NEAT LITTLE  $1\frac{1}{2} \times 3$  PACKAGE. RUN OUT AND GET ONE.

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# 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*<sup>®</sup>

Alfa-Numerical Display



FG209M2

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

Instruments & Large Calculator Display



FG179F2

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

Instruments & Terminal Units Display



FG512A1  
ef = 3.5V  
ec = eb = 24Vp-p  
ic = 4mA-p-p  
ib = 3mA-p-p  
Wd. 100 mm  
Lg. 40 mm  
Segment 12 mm

Digital Clock Display



FG425A1

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

Linear Analog Display



FG120S1

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

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INFORMATION RETRIEVAL NUMBER 109



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QUIET

SCI

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  $\pi$  input filter as well as SCI's unique converter design and regulation techniques. The result is a guaranteed output ripple of  $<5\text{mV p-p}$ .

Model 30C5-15D100Q — 5V<sub>in</sub>,  $\pm 15\text{V}$  @ 100mA out — \$74.95 (1-9).

Other input and output ratings are also available. For full information, contact Ron Garmon at 617-373-9104.

Another excellent value from the No. 1 source



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INFORMATION RETRIEVAL NUMBER 110

Built  
to work  
no  
matter  
how  
you  
use it.



The Crown 800  $\frac{1}{4}$ " mag tape transport is rugged<sup>1</sup>, computerized<sup>2</sup>, professional<sup>3</sup> and adaptable<sup>4</sup>. 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  $\frac{1}{4}$ " mag tape capabilities, ask Crown to explain the 800 transport.



**CROWN INTERNATIONAL**

1718 W. MISHAWAKA ROAD ELKHART, INDIANA 46514 219-294-5571

1.  $\frac{3}{4}$ " thick aluminum front plate. Anodized or plated metal parts. Only 10 moving parts. All sub-assemblies are plug-in.

2. Logic circuit automatically sequences transport, regardless of command sequence, to prevent tape spill or breakage. Remotable.

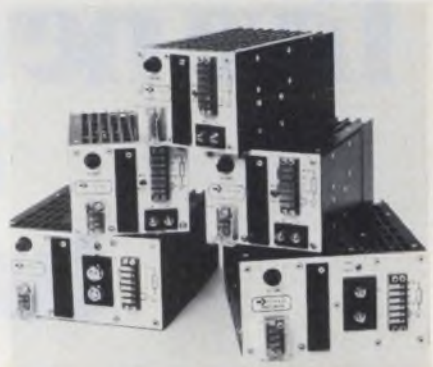
3. Three motor drive. DC braking. Automatic end-of-tape braking. 19" rack mount. Wow and flutter 0.09% @ 7  $\frac{1}{2}$  ips guaranteed maximum.

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

POWER SOURCES

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  $\pm 12$  or  $\pm 15\text{-V}$  auxiliary outputs. Switching frequency is greater than 30 kHz. Other specs include: regulation of 0.1% max for 100% load change and  $\pm 10\%$  line change, ripple of 10 mV rms, 50-mV pk-pk max; and a tempo of  $\pm 0.01\%/^{\circ}\text{C}$ . 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/ $^{\circ}\text{C}$  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...

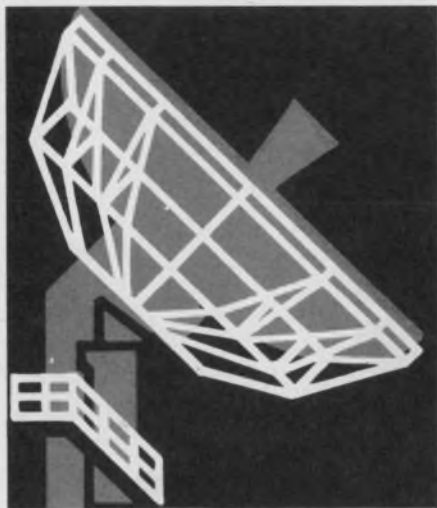
... loud and clear. You'll get more attention with these exceptional new piezo crystal solid state audio indicators. Many models to choose from. Series X10 (continuous tone) or Series X11 (pulsing) with pins, wires, or fastons, for computer terminals, remote control fault detection devices ... Series 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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lengths and  
give you  
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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

170

## 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

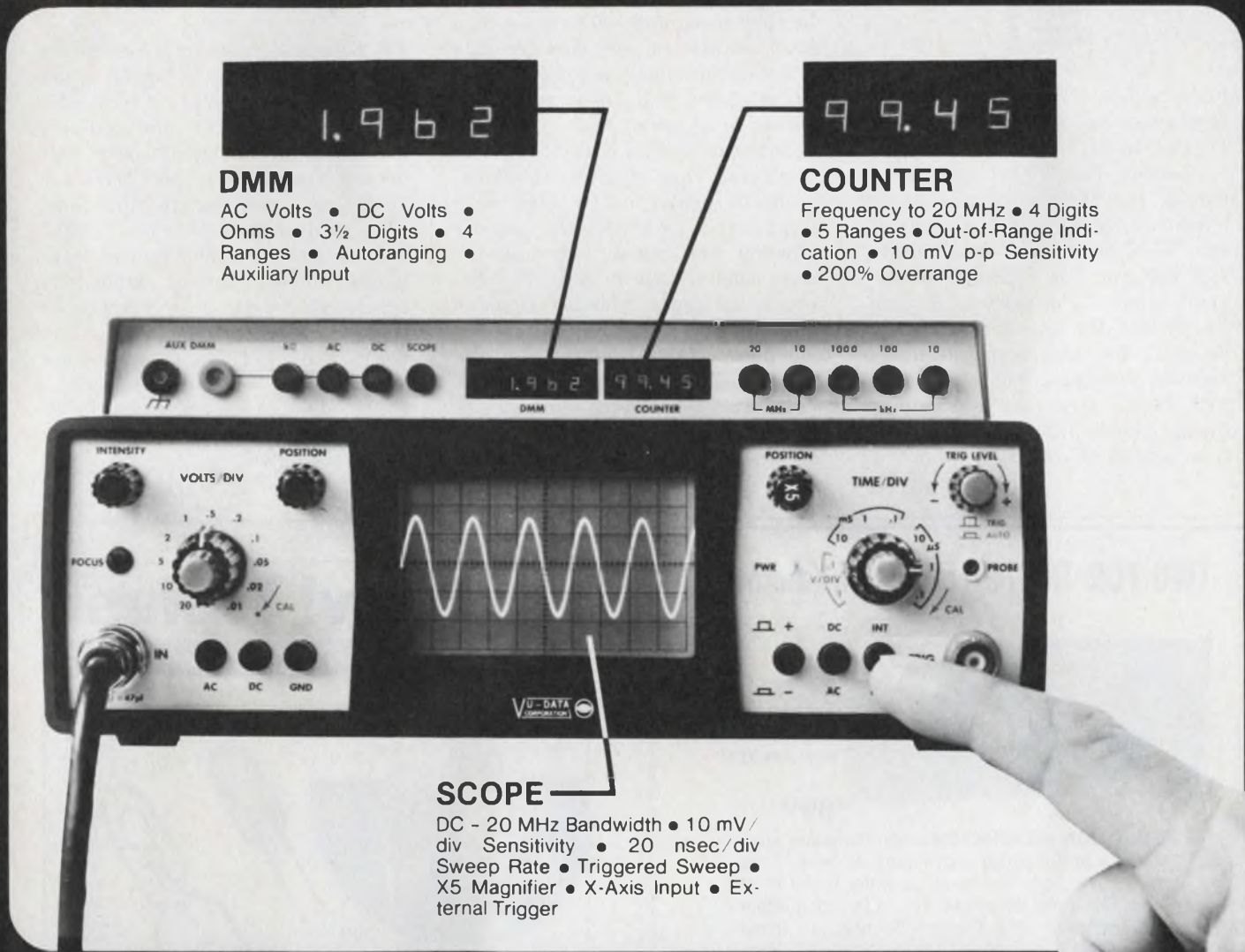


Signal Laboratories, 202 N. State College Blvd., Orange, CA 92668. (714) 634-1533. \$495.

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



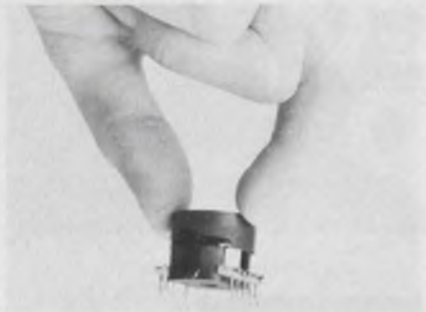
Model PS915/975 DMM - Counter - Mini-scope \$1250\*  
Model PS915 Mini-scope \$825\*

\*U.S. Sales Price, F.O.B. San Diego, California

INFORMATION RETRIEVAL NUMBER 114

COMPONENTS

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 x 7 dot matrices. They provide an alphanumeric display 0.7-in. high with light output exceeding 300  $\mu$ cd 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- $\Omega$  source and load terminations. Any bandwidth from  $\pm 1$  to  $\pm 10\%$  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<sup>95</sup>

**FUNCTION GENERATOR**—Simultaneous sine, square and triangle wave outputs from 1 Hz to 1 MHz  $\pm 5\%$  accuracy, stability  $\pm 200$  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.



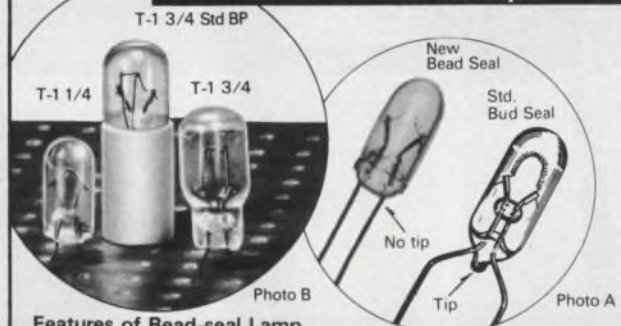
\$79<sup>95</sup>

**PULSE GENERATOR**—Pulse width continuously 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

ELECTRONIC DESIGN 1, January 5, 1976

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		
$I_c$	$P_o$	TYPE
1200A	2100W	PPS 1200
500A	625W	PP 500
250A	325W	PPS 250
150A	325W	TO-114
90A	325W	TO-63

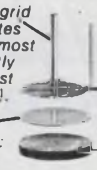
Copper grid distributes current most efficiently for lowest  $V_{ce(sat)}$ .

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.

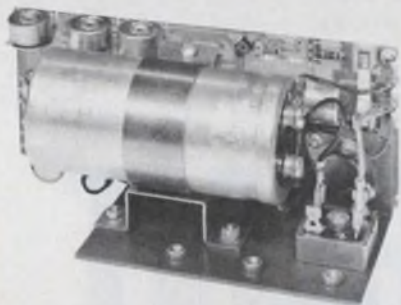


# HIGH CURRENT TRANSISTOR PACKAGING UNLIMITED



**PowerTech, Inc.**  
 "BIG IDEAS IN  
 BIG POWER"

## 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:



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  $1 \times 10^{-12}$ . 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

## PACKAGING & MATERIALS

### 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 M $\Omega$ /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 tempo of less than 50 ppm/ $^{\circ}$ 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  $\Omega$ /sq. to 1 M $\Omega$ /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 opera-

tion, and a high degree of control, the new systems have continuous duty motor ratings of  $\frac{1}{12}$ ,  $\frac{1}{10}$  and  $\frac{1}{8}$  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

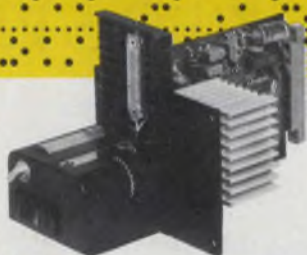
**BODINE  
ELECTRIC  
COMPANY**

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, in 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

## 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

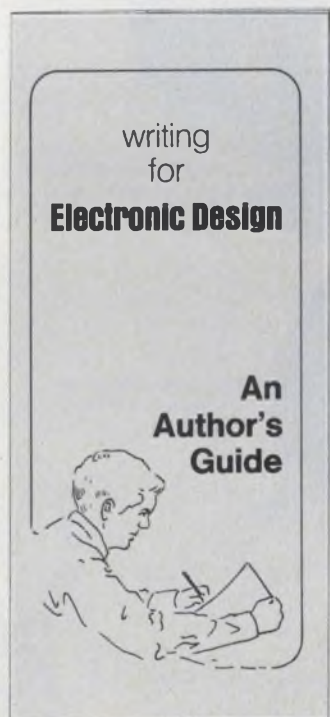
CIRCLE NO. 422

### 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

# 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 engineers-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.

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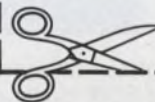
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Remember, Sescosem's range provides a complete selection of TTL components and our quality control is second to none. Two factors to facilitate your task. As for price, being a leading european high volume components manufacturer, they are more than competitive. Prove this yourself - Just cut out and return the reply coupon.



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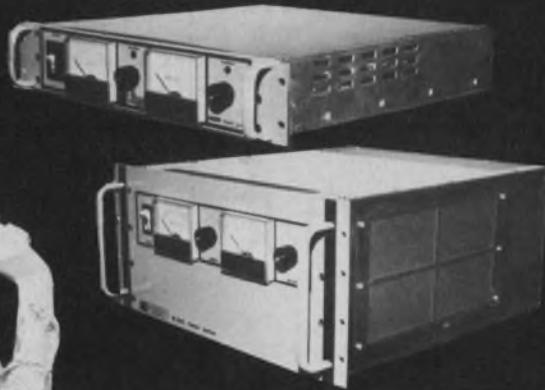
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Sales offices or representatives throughout the world.

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
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- \* Optional Input Voltages

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SCR MODELS										
VOLTS	1 $\phi$ INPUT								3 $\phi$ INPUT	
	500 Watts		800 Watts		1600 Watts		2400 Watts		2500 Watts	10,000 Watts
	A	\$	A	\$	A	\$	A	\$	A	\$
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0 - 7.5			100	650	180	850	250	1100	300	1600
0 - 10	40	450	80	600	150	850	210	1100	250	1500
0 - 20	25	450	40	600	80	800	120	1000	125	1400
0 - 30									100	1400
0 - 40	13	425	20	500	40	750	60	900	60	1400
0 - 50									125	1800
0 - 60	9	450	13	500	26	850	40	1000		
0 - 80	6	450	10	500	20	850	30	1000	30	1400
0 - 100									60	1800
0 - 120										
0 - 150	3	425	5	500	10	850	15	1000	20	1400
0 - 160									40	1800
0 - 250										
0 - 300	1.5	475	3	550	5	850	8	1000	15	1400
25 - 500									30	1800
0 - 600	.75	500	1.5	650	3	850	4	1100	20	2900



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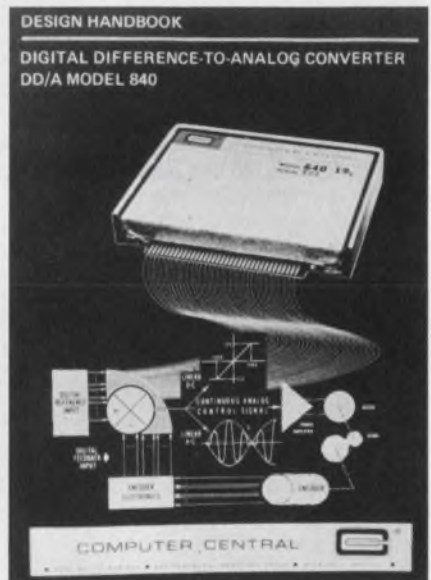
INFORMATION RETRIEVAL NUMBER 123

## 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

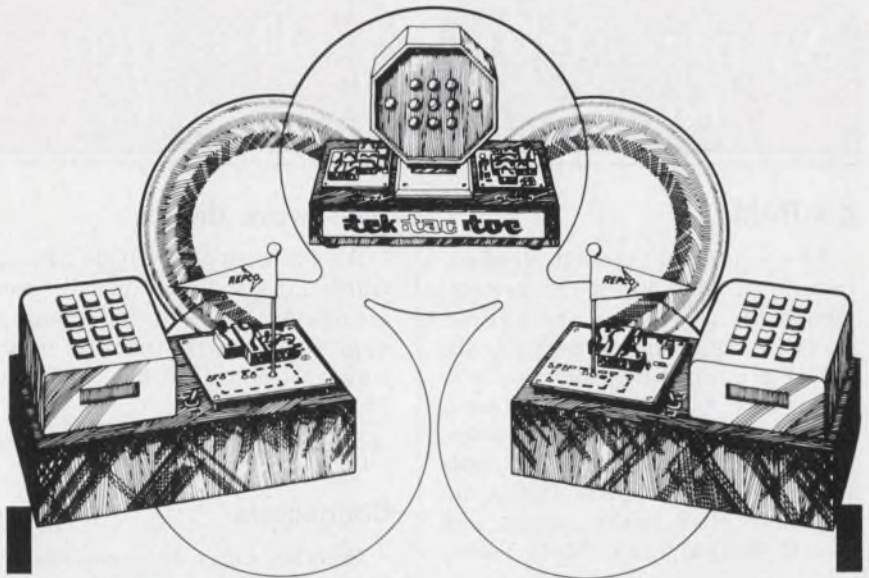
Microprocessor hardware, software and peripherals are featured in a 20-page guide. Wintek, Lafayette, IN

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 Recco'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 Recco's RF links. But one of the characteristics of creative engineers is to develop commercial 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 Recco'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 Recco, 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 Recco, 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!

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## 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 semiconductor devices 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

### $\mu$ P 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  $\pm 1\%$  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.

CIRCLE NO. 447

### Low-profile socket

A sample package contains an actual US-2 16-pin socket as well as a description of its main features. Scanbe Manufacturing.

CIRCLE NO. 448

### Aluminum mounting base

An aluminum mounting base used with cable ties provides an inexpensive, secure bond in demanding harnessing applications. The mount comes in two styles: with or without adhesive backing. A #10 screw hole is included in the mount to accommodate screw-mounting, if desired. The mount measures 1  $\times$  0.5 in. Panduit Corp.

CIRCLE NO. 449

# NEW! CURTIS CHAMP THERMOPLASTIC TERMINAL BLOCKS



bends...twists...  
takes impact...  
helps end breakage  
problems!



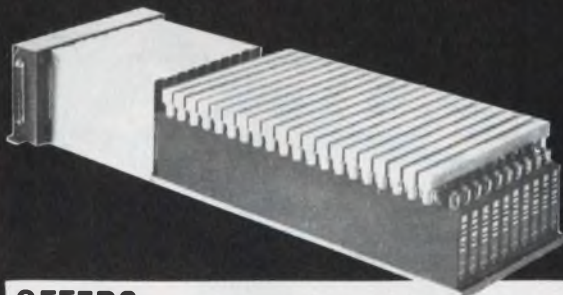
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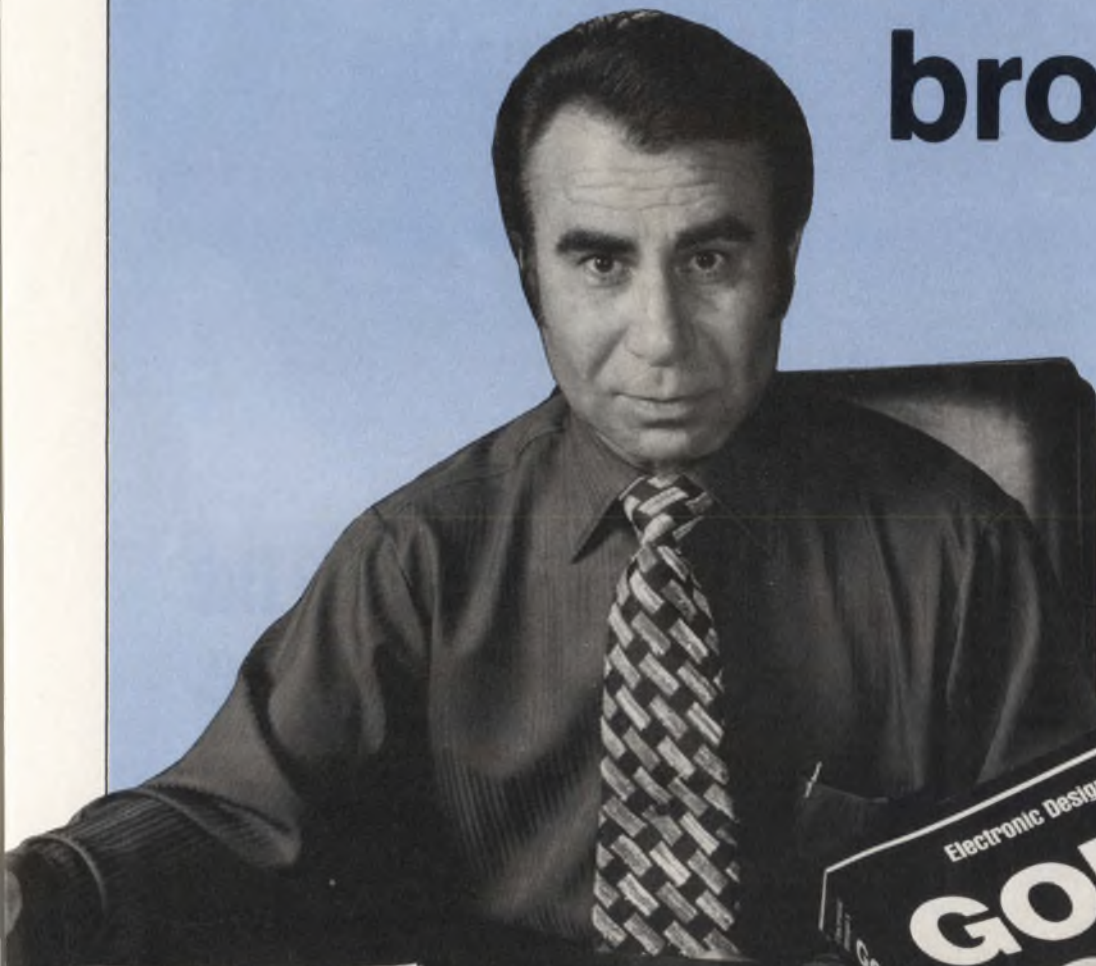
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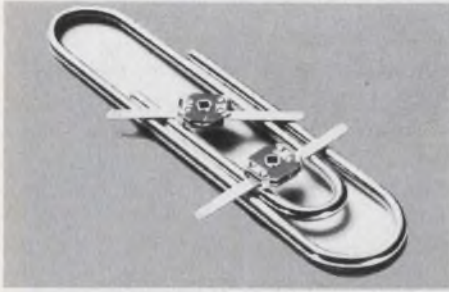
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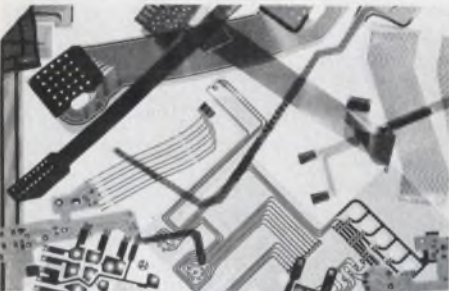
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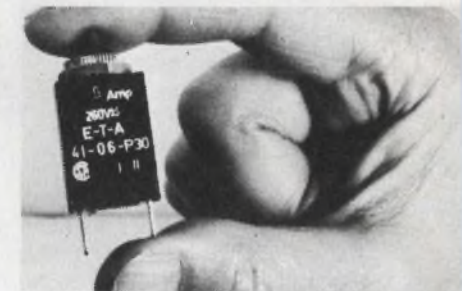
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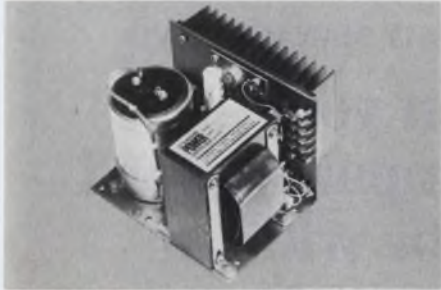
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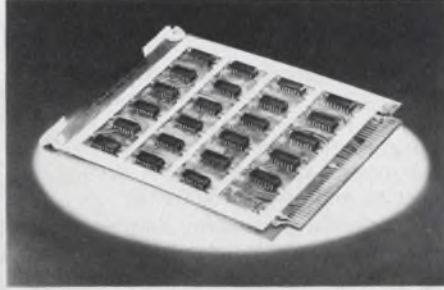
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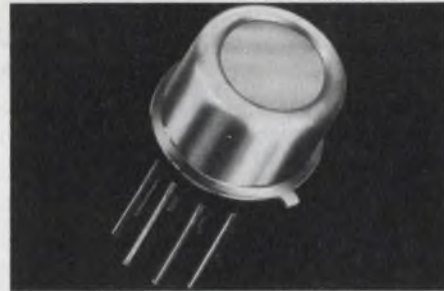
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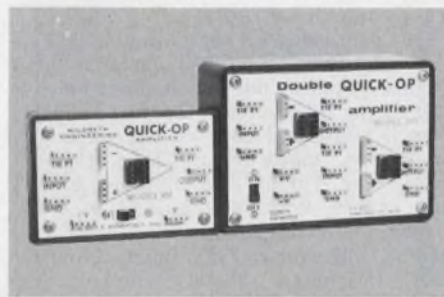
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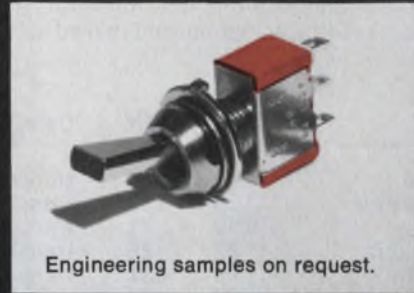
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No plastic inserts...  
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Self-locking,  
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When you need to fasten, mount, hold, align or lock . . . you need PRESSERTS. Easiest of all to install, 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 . . .



**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.

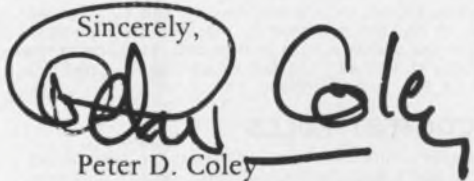
## **ELECTRONIC DESIGN'S BICENTENNIAL ISSUE -- FEBRUARY 16th --**

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, thought-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 engineer-

ing 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  $40 + (2 \times 12) = 64$  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.

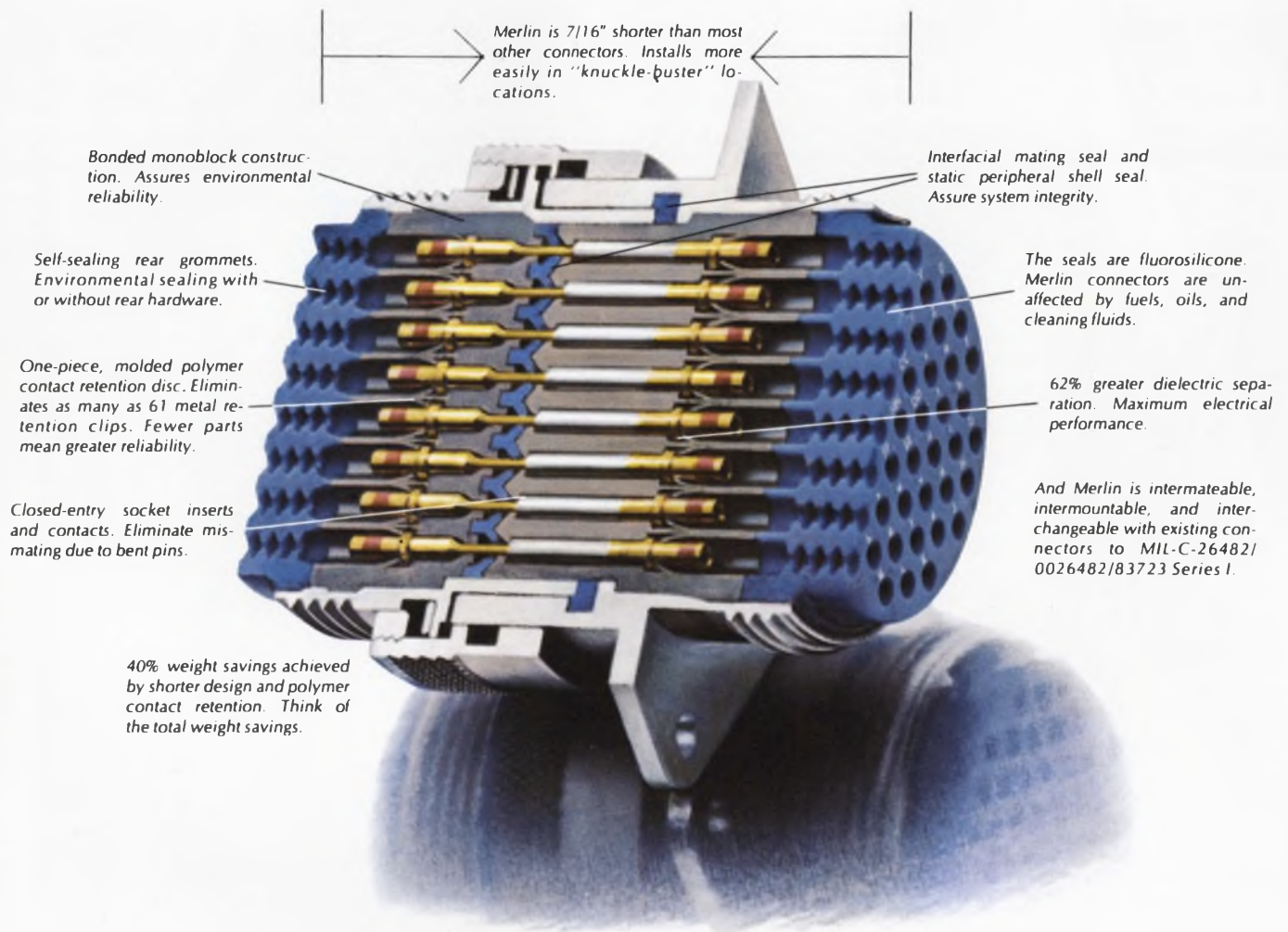
**FOR A COMPLETE DESCRIPTION OF PRIZES  
FOR BOTH READER AND ADVERTISER CONTESTS  
SEE PAGES 132 AND 133**

## 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.



**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

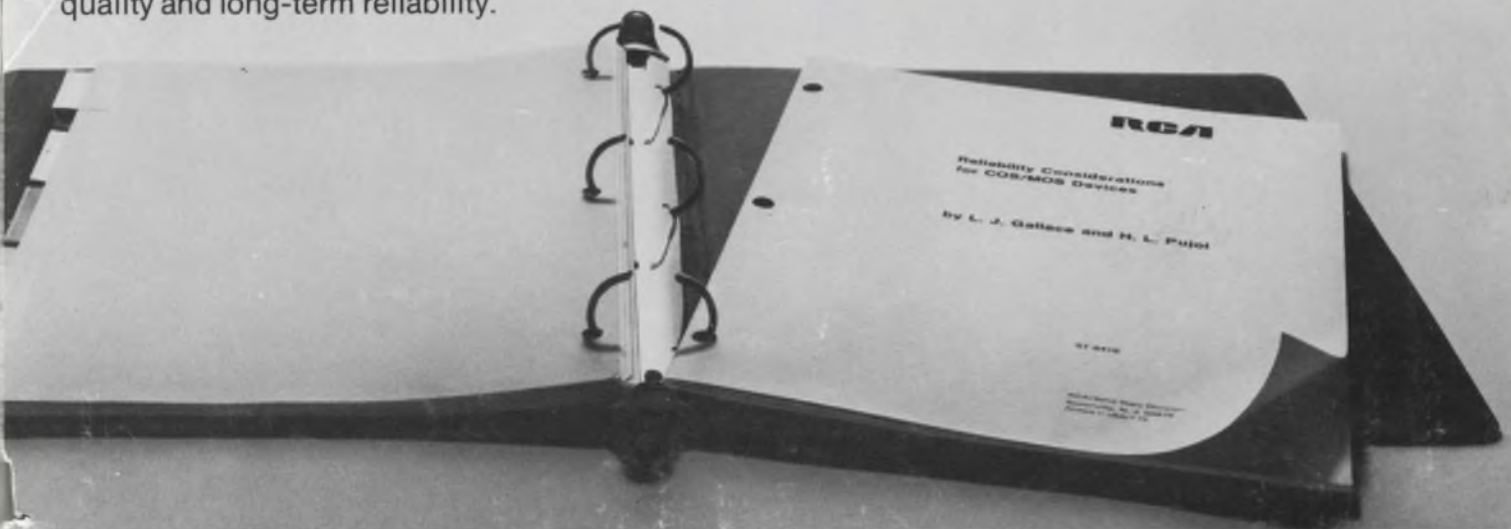
The paper details how RCA's comprehensive specifications help designers match device to application. Typical RCA specs and test circuits are shown. You'll see how a 4-step testing routine and real-time indication tests assure product quality and long-term reliability.

## 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.

The RCA logo is displayed in a large, bold, sans-serif font. The letters are black and set against a white background.

RCA. First house in CMOS.

INFORMATION RETRIEVAL NUMBER 248