

# Electronic Design 14

VOL. 22 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

JULY 5, 1974

**Keeping electronics cool pays off** in longer equipment life. Trends to higher packaging density and power dissipation demand tight specification for lowest cooling

cost. But unfamiliar and often unqualified or ambiguous specs hamper cooling-device selection. For tips on how to evaluate your design problem, see page 62.







Ultra reliability in  
ultra-miniature  
transformers...

...and they're off the shelf!

PICO Electronics' patented construction combines mass production with the utmost in reliability to produce the smallest possible transformer.

These little giants handle up to 600 milliwatts at 1 KHz and 1.5 watts at 10KHz. They cover the frequency range of 300Hz to 250KHz. Primary or Secondary impedances of 3.2 ohms to 250K ohms. Pulse applications .05 $\mu$ s to

100 $\mu$ s. Construction can be TO-5 plug-in, insulated flexible leads or flat pack ribbon style.

Size variations from 1/4" dia. x 1/4" ht. to 1 1/2" dia. x 1/2" ht. Special designs with 1/4" dia. and .180" ht.

Pico Electronics is a Q.P.L. source. All transformers are hermetically sealed in a metal case and in strict compliance with MILT-27 specifications. Every Pico device has the added reliability feature of being

guaranteed for 25 cycles of thermal shock (MIL-STD-202D, method 107C).

Industrial and Commercial designs are also available for maximum economy.

*Over 600 standard transformers to choose from... Delivery—stock to one week... specials take a little longer—9 days.*

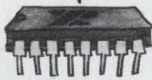
**Send for free 36 page catalog.**

**PICO Electronics, Inc.**

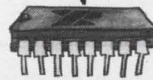
50 South MacQuesten Pkwy., Mt. Vernon, New York 10551 • Telephone 914-699-5514



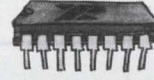
# YOU HUM THE TUNE, EXAR PLL WILL SING IT



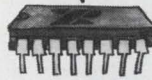
XR-2567



XR-210



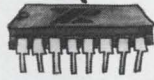
XR-215



XR-567



XR-S200



Exar PLL

We have the broadest chorus line of Phase Lock Loop circuits available today. Take a brief look at our ever-expanding PLL line:

The XR-210 is designed for FSK Modulation and Demodulation and features a self-contained output logic driver, compatible with RS-232C requirements.

Use the XR-215 for FM or FSK demodulation, frequency synthesis and filter tracking. It has a 5V to 26V supply range and 0.5 Hz to 35 MHz frequency bandwidth. What's more, it's bipolar logic compatible.

The XR-S200 is a do-it-yourself building block. With this you design your own PLL circuits by selecting external connections and components. You get instant pro-

totypes with minimum fuss and costs.

Moving right along . . . the XR-567 PLL is designed for tone and frequency decoding. It has a bandwidth adjustable from 0 to 14%, sinks up to 100 mA of load current and has a logic compatible output. Our dual version, the XR-2567, is a real hummer with even better temperature tracking and matching characteristics. Power supply rejection is improved by an order of magnitude over the single version. The dual outputs can switch up to 100 mA at 26 volts.

All together now. We would like to send you the complete musical score on our PLL products. Our data sheets are good and they're filled with applications data. Write now, write.

## EXAR SPEAKS YOUR LANGUAGE



R-OHM CORPORATION  
EXAR INTEGRATED SYSTEMS

P.O. Box 4455  
Irvine, CA 92664  
Telephone: (714) 546-8780  
TWX: 910-595-1721

**Rohm**  
QUALITY · RELIABILITY

R-OHM ELECTRONICS GMBH  
EXAR INTEGRATED SYSTEMS

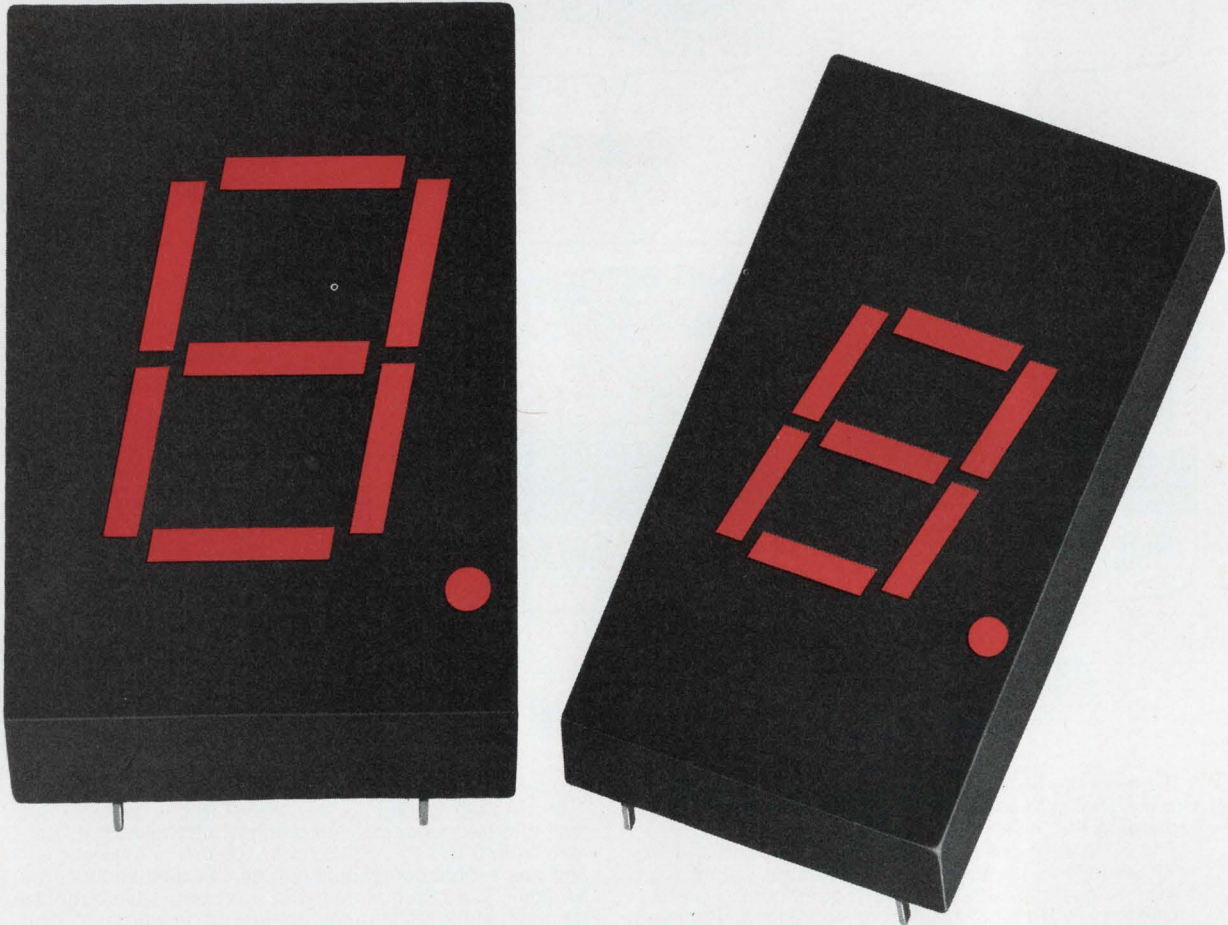
Mühlenstraße 70  
4051 Korschenbroich  
Telefon (02161) 298 05  
Telex 852330 rohm d

MEMBERS OF THE INTERNATIONAL R-OHM GROUP

INFORMATION RETRIEVAL NUMBER 2



# SURPRISE!



## HP displays are bigger than ever!

Now you can get a big, readable 0.43 inch LED display without sacrificing the simplicity and economy of single chip per segment design.

Bright enough to clearly see 20 feet away. HP's 5082-7750 series display features the same wide viewing angle, excellent readability and the same pin configuration as our 0.3 inch 5082-7730 series displays.

Just \$3.50 each in 100 quantities.\*

Contact Schweber, Hall-Mark or the Wyle Distribution Group for immediate delivery. Or, write us for more details. This is one display you won't want to miss.

01403

\*Domestic USA price only.

**HEWLETT  PACKARD**

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

INFORMATION RETRIEVAL NUMBER 3



---

## NEWS

- 29 **News Scope**
- 32 **A built-in heat pipe** has been proposed to cool power transistors operating in the GHz range.
- 34 **Multiple-beam antenna** increases communication satellite capacity.
- 38 **A super-thin copper-foil** for PCs uses up to 75% less of the metal.
- 40 **One-step process bonds copper** to ceramic without adhesives.
- 42 **Simplified waveform digitizer** uses TV camera to capture the trace.
- 53 **Washington Report**

---

## TECHNOLOGY

- 62 **FOCUS on cooling electronic packages:** A special report on the problems in specifying heat-removing devices—from simple heat sinks to thermoelectric coolers and heat exchangers.
- 76 **Liquid crystal displays are great—but . . .** they have lighting, temperature, voltage and drive limitations that must be considered before you design with LCDs.
- 84 **Why not use hybrids?** For small size, long-term reliability, true hermetic sealing and adaptability to the latest technologies, they're a good choice.
- 92 **Improve ROM systems with pROMs.** Here are two ways to use programmable ROMs to change words and increase memory size after a masked-ROM system is designed.
- 100 **Squeeze more from power supplies.** Efficiency rises when a forward-loop switching regulator is designed around a saturating magnetic core.
- 106 **Don't be a slave to a project schedule,** advises this manager, who believes that it's far more important to review a product constantly to test how practical it is.
- 110 **Ideas for Design:** Low power at ohmmeter's probes allows safe usage on most sensitive components . . . Improved dot-matrix generator ignores empty display positions . . . Combinatorial logic circuit calculates the absolute difference of numbers.
- 116 **International Technology**

---

## PRODUCTS

- |                             |                             |
|-----------------------------|-----------------------------|
| 119 Instrumentation         | 136 Packaging & Materials   |
| 122 Integrated Circuits     | 140 Components              |
| 126 Data Processing         | 146 Microwaves & Lasers     |
| 130 Modules & Subassemblies | 148 Discrete Semiconductors |

---

## Departments

- |   |                                |
|---|--------------------------------|
| 59 <b>Editorial:</b> Growing old youthfully |                                |
| 7 Across the Desk                           | 160 Product Index              |
| 150 New Literature                          | 162 Information Retrieval Card |
| 158 Advertisers' Index                      |                                |

**Cover:** Photo by Ernest A. Benner, courtesy of Wakefield Engineering.



# From CPU 8080 Microcom

Intel's new 8080 n-channel microcomputer is here — incredibly easy to interface, simple to program and with up to 100 times the performance of p-channel MOS microcomputers.

Best of all, the 8080 is real — in production at Intel and available in volume quantities, today. It's also available through distributors along with a growing line of peripheral circuits and a new version of the Intellec 8, a program and hardware development system for the 8080,

all supported with software packages, design documentation and manuals, and backed by more than 100 man years of microcomputer expertise.

The 8080 is the inevitable successor to complex custom MOS and many large discrete logic subsystems. It is the industry's first general purpose n-channel microcomputer and the first high performance single-chip CPU, with extremely simple interface requirements and straightforward programming. It runs a full instruction cycle in 2 microseconds.

As such, the 8080 extends the economic benefits of Intel's p-channel microcomputers to a new universe of systems that need fast, multi-port controllers and processors. These systems include intelligent terminals, point of sale systems, process and numeric controllers, advanced





# to software, the puter is here.

calculators, word processors, self-calibrating instruments, data loggers, communications controllers, and many more.

You can use 256 input and 256 output channels, handle almost unlimited interrupt levels, directly access 64 kilobytes of memory, and put many satellite 8080 processors around a single memory.

Interfacing is minimal and design is easy with the 8080 because all controls are fully decoded on the CPU chip itself and inputs and outputs are TTL compatible. There are separate data, address and control buses.

The 8080 microcomputer has 78 basic instructions, including the 8008 set plus new ones that make possible such features as vectored multi-level interrupt, unlimited subroutine nesting and very fast decimal and binary arithmetic.

Program development for the 8080 can be done either on a large computer using the Intel software cross products (PL/M systems language compiler, macro-assembler and simulator), or on an Intellec 8 development system with a resident monitor, text editor and macro-assembler.

The new 8080 product family includes performance matched peripheral and memory circuits configured to minimize design effort and maximize system performance. Large, low cost RAMs, ROMs, PROMs and I/O devices are available now and we will soon announce other 8080 LSI support circuits.

The 8080 is easier to use and more economical than any high performance microcomputer in sight. It's here now, in volume, from the inventors of the microcomputer and the people who lead the industry in production and design support.

Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.  
(408) 246-7501.

INTEL 8080	RAM MEMORIES		
	8101	256 x 4 STATIC	AVL: 3RD Q
	8111	256 x 4 STATIC WITH COMMON I/O	AVL: 3RD Q
	8102	1024 x 1 STATIC	AVL: NOW
	8107	4096 x 1 DYNAMIC	AVL: NOW
	ROM MEMORIES		
	8308	1024 x 8	AVL: 3RD Q
	8316	2048 x 8	AVL: NOW
	PROM MEMORIES		
	8702	256 x 8	AVL: NOW
	8704	512 x 8	AVL: 4TH Q
	8604	512 x 8	AVL: 4TH Q
	PERIPHERAL CIRCUITS		
	8205	1 of 8 DECODER	AVL: NOW
	8210	4K RAM CLOCK DRIVER	AVL: NOW
	8212	8 - BIT I/O LATCH	AVL: NOW
8216	BI-DIRECTIONAL BUS DRIVER	AVL: 3RD Q	
8201	COMMUNICATIONS INTERFACE	AVL: 4TH Q	

INTEL 8080 PRODUCT FAMILY

**intel**® Microcomputers. First from the beginning.



# CABLE-BILITY WOVEN'S FLAT GOT IT!

**Ribbon Cable  
IC Interconnects  
Custom Harnesses**

A total source for flat interconnect systems, Woven Electronics offers unlimited design capabilities combining signal/power transmission with specialized functions. Independently insulated conductors give tighter transmission control, more protection, allow easy lead exposure.

Specify sizes, color coding, insulations, custom break-outs without restrictions of other cable forms.

**Cable and ability. Get the best of both from one source.**

## **WOVEN ELECTRONICS**

P.O. Box 189 Mauldin, South Carolina 29622  
803/963-5131

**Vice President, Publisher**  
Peter Coley

### **Editors**

Editorial Offices  
50 Essex St.  
Rochelle Park, N.J. 07662  
(201) 843-0550  
TWX: 710-990 5071  
Cable: Haydenpubs Rochellepark  
**Editor-in-Chief George Rostky**

### **Managing Editors:**

Ralph Dobriner  
Michael Elphick

### **Associate Editors:**

Dave Bursky  
Jules H. Gilder  
Morris Grossman  
Seymour T. Levine  
John F. Mason  
Stanley Runyon  
Edward A. Torrero  
Richard L. Turmail

### **Contributing Editors:**

Peter N. Budzilovich  
Robert Wollins

### **Editorial Field Offices**

#### **East**

Jim McDermott, Eastern Editor  
P.O. Box 272  
Easthampton, Mass. 01027  
(413) 527-3632

#### **West**

David N. Kaye, Senior Western Editor  
2930 West Imperial Highway  
Inglewood, Calif. 90303  
(213) 757-0183  
Northe K. Osbrink, Western Editor  
112 Coloma St.  
Santa Cruz, Calif. 95060  
(408) 426-3211

#### **Washington**

Heather M. David, Bureau Chief  
2506 Eye St., N.W.  
Washington, D.C. 20037

### **Editorial Production**

Marjorie A. Duffy

### **Art**

**Art Director, William Kelly**  
Richard Luce  
Anthony J. Fischetto

### **Production**

**Manager, Dollie S. Vieblg**  
Helen De Polo  
Anne Molfetas  
Christopher G. Hill

### **Circulation**

**Manager, Evan Phoutrides**

### **Information Retrieval**

Peggy Long

### **Promotion**

**Manager, Jeffrey A. Weiner**  
Karen Kerrigan (Reprints)



## across the desk

### JEDEC registration defended as effective

From "Focus on Power Semiconductors" (ED No. 23, Nov. 8, 1973, p. 80), one might infer that EIA/JEDEC registration generally fails to ensure interchangeability of devices.

While this failure may occur in isolated instances, JEDEC registration is well-accepted in the industry as a generally effective system. Many engineers will argue that the only way to ensure interchangeability is to apply a use test in the specific application. However, in lieu of this impracticable solution, standardization and registration offer the best approach, and succeed in the vast majority of cases.

Undoubtedly you are aware that JEDEC committees meet regularly to establish standards, to formulate precise definitions, to devise registration formats that are adequate without being unduly cumbersome, to clarify test methods, and to engage in other activities that will ensure device interchangeability.

When shortcomings are noted, revisions are made. Recent formats, for example, require specification of both a minimum and a maximum  $f_t$ .

You state that another problem arises when some manufacturers resist a change in registered specifications proposed by another manufacturer.

Whether the proposed change would tighten or relax the specifications, the company proposing the change can take out a new registration number—if all the manufacturers aren't willing to accept these changes on a device already registered and in production at several

facilities. Unanimity is a prerequisite for reregistration and must continue to remain so.

*F. S. Stein, Chairman  
JEDEC Solid State Products  
Council*

P.O. Box 1104  
Kokomo, Ind. 46901

### 'TF 2370 is a fine instrument, but—'

In the New Products columns and front cover of the April 12 issue, the Marconi Instruments TF 2370 spectrum analyzer is described (ED No. 8, "Spectrum Analyzer Outperforms Rivals in 7 Areas—at a Price, p. 137).

From the account and after observing the equipment at the IEEE show, I have concluded that the TF 2370 is a fine instrument, but the claim that it "zooms ahead of all others in performance in at least seven key areas" is questionable in three of these areas:

1. The Ailtech 707 has 100 dB of display dynamic range, yet the TF 2370's 100-dB display dynamic range was claimed to be "highest by 30 dB."

2. The 707 has a maximum cw input of  $\pm 20$  dBm with 0 dB of rf attenuator setting, and +33 dBm cw input with 20 db or more of rf attenuator setting. The TF 2370 maximum input of +25 dBm was claimed to be "highest by 12 dBm."

3. The Ailtech 707 has a specified i-f filter factor of 5 to 1 and is typically 3.5 to 1 (ratio of 60 dB to 3 dB bandwidths) due to eight poles of crystal filtering. Yet the TF 2370 filter factor of 10 to 1

*(continued on page 11)*

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.

# THIN-TRIM<sup>®</sup> CAPACITORS FOR HYBRID-CIRCUIT DESIGNERS



ACTUAL SIZE



THIN-TRIM capacitors are a new development in miniaturized variable capacitors for application in circuits where size and performance is critical. The Thin-Trim concept provides a variable device to hybrid circuit designers which replaces fixed tuning techniques and cut and try methods of adjustment.

#### FEATURES

- Low profile for HYBRID CIRCUIT applications.
- High capacity values for BROADBAND applications.
- High Q - low capacity values for MICROWAVE applications.

U.S. Patent 3,701,932

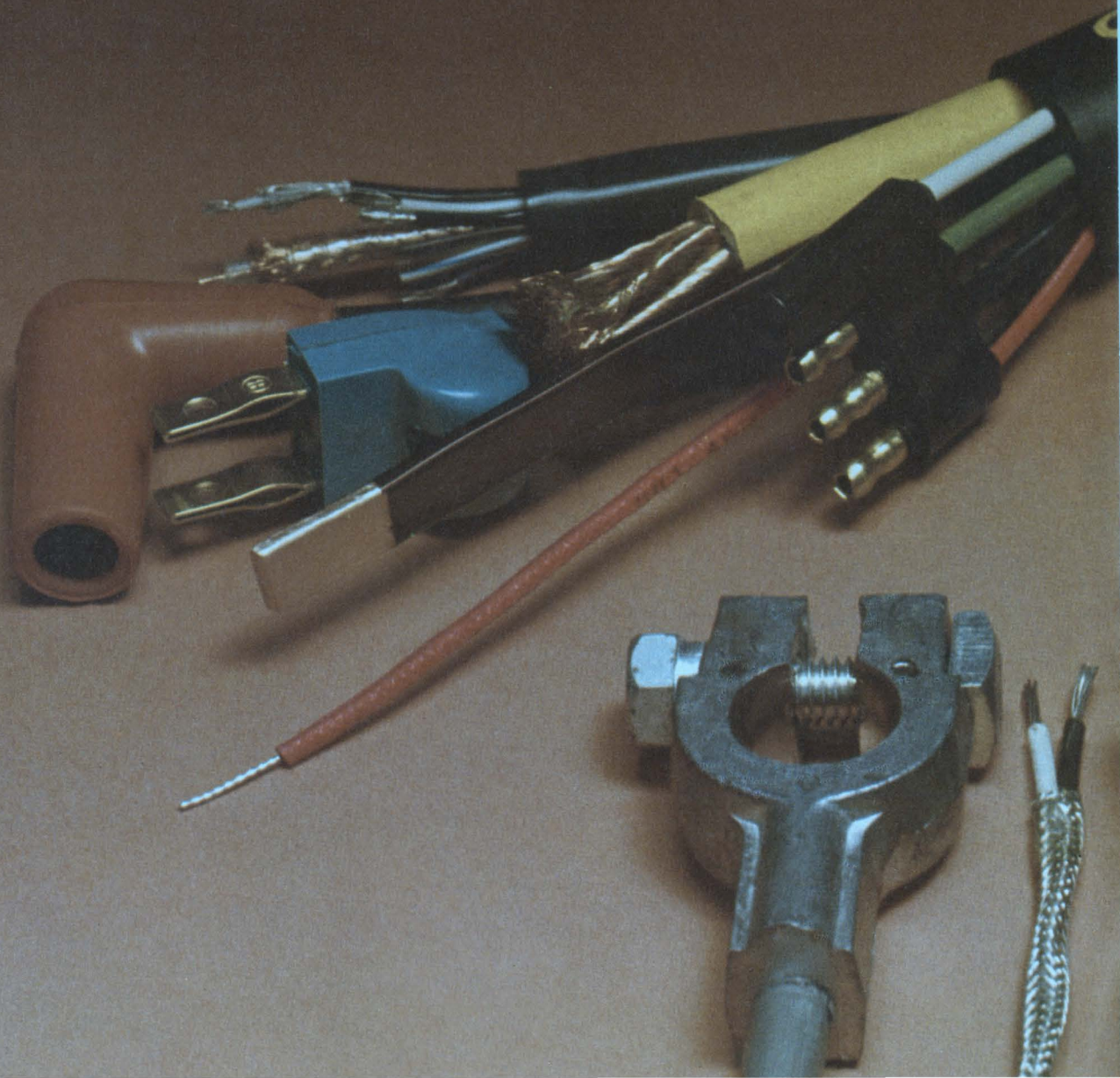
*Johanson*

MANUFACTURING CORPORATION

ROCKAWAY VALLEY ROAD  
BOONTON, N.J. 07005  
PHONE (201) 334-2676  
TWX 710-987-8367



# decoding the codes



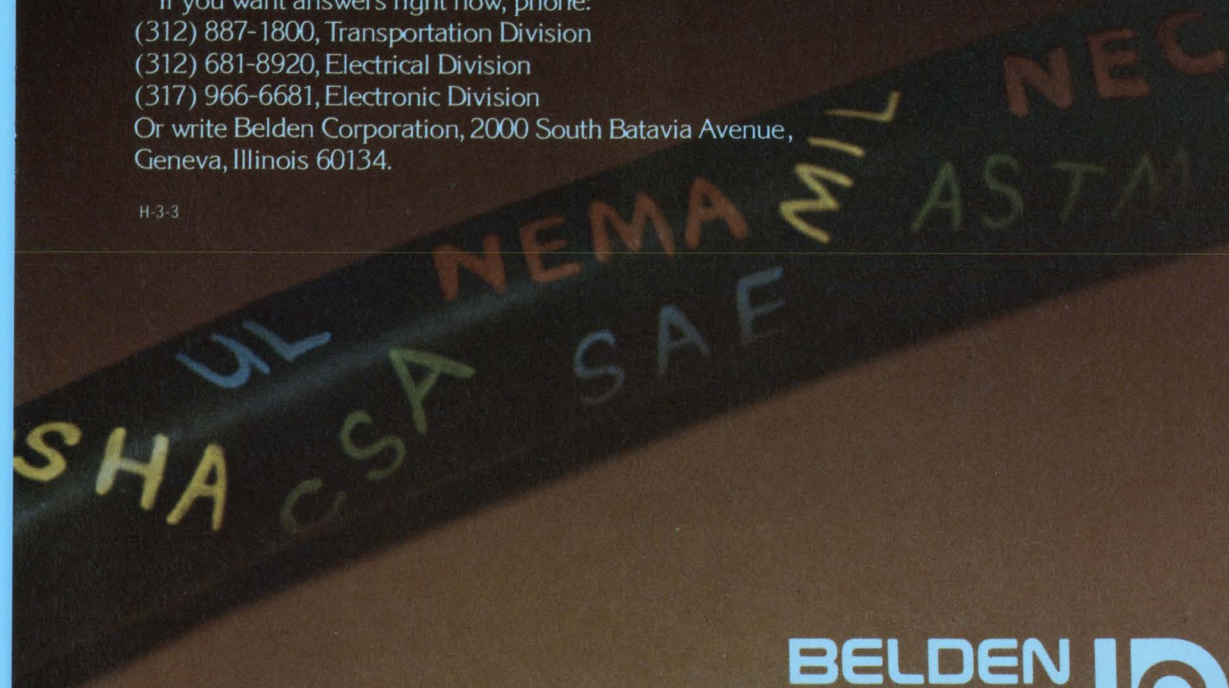


With ever-changing technology and increasing demands for innovative products, more precise safety guidelines are a must.

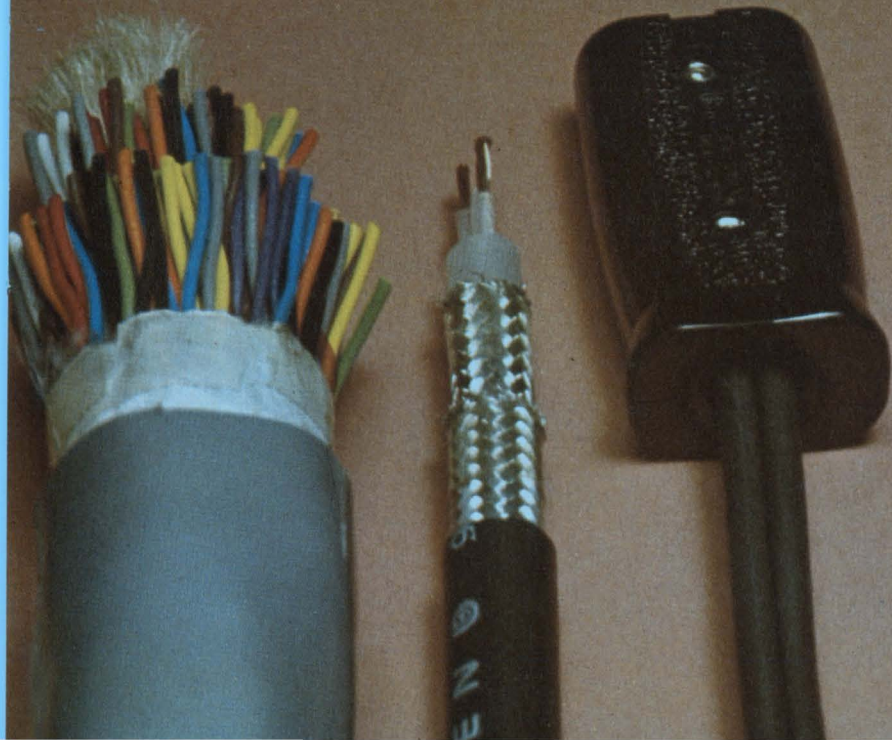
Belden knows the codes, standards, requirements and limits of acceptability in the wide world of industrial wire, cable and cord. As supplier of thousands of standard items for electrical, electronic and automotive needs we can readily help you select the right product for the job. Belden products meet or exceed industry code needs. And we can custom design and manufacture complex cable configurations to meet the most demanding specifications. If a code is puzzling you, or you have an application where you're not sure what the standards are, check with Belden. We cope with codes every day.

If you want answers right now, phone:  
(312) 887-1800, Transportation Division  
(312) 681-8920, Electrical Division  
(317) 966-6681, Electronic Division  
Or write Belden Corporation, 2000 South Batavia Avenue,  
Geneva, Illinois 60134.

H-3-3

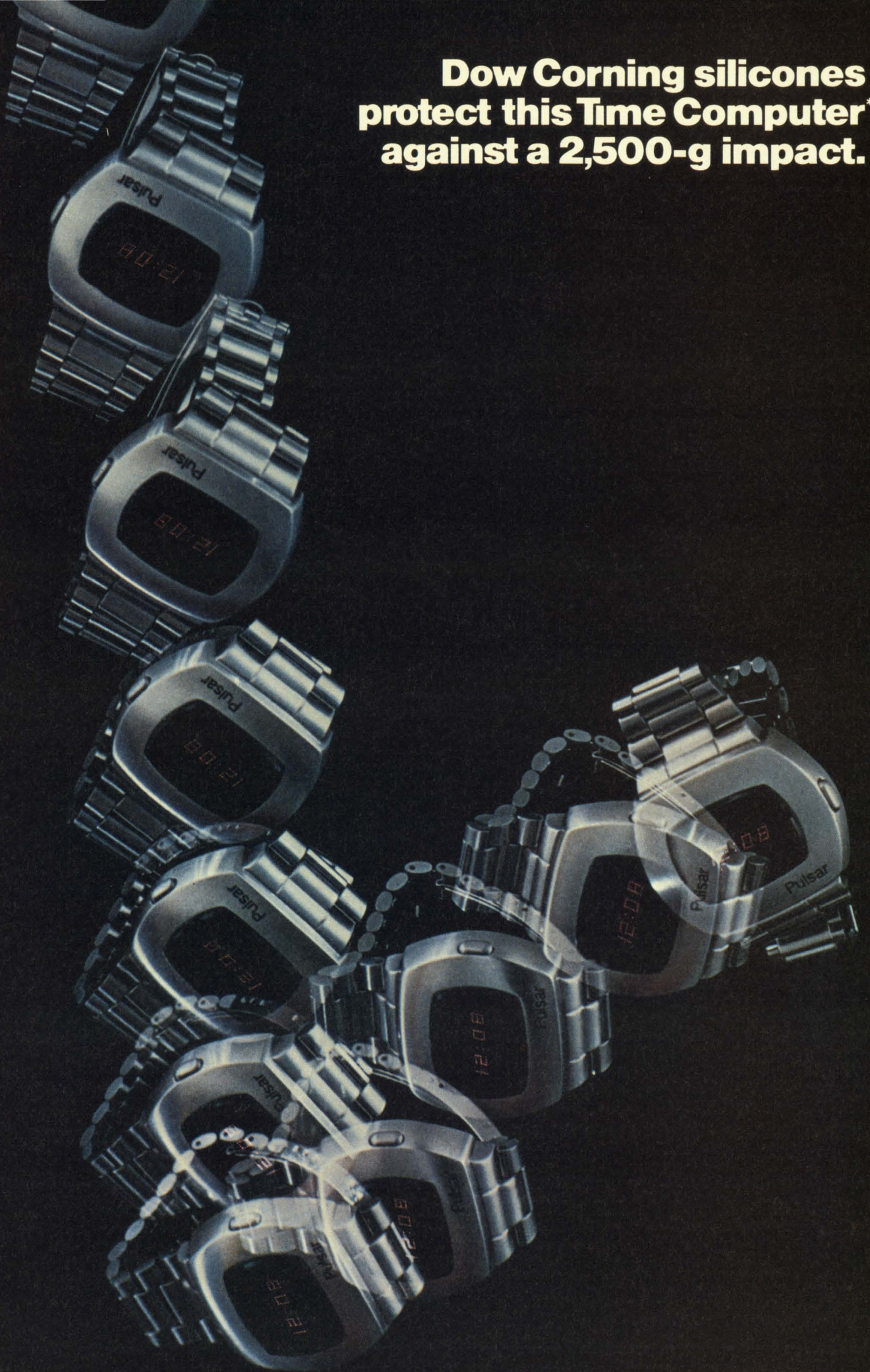


INFORMATION RETRIEVAL NUMBER 234



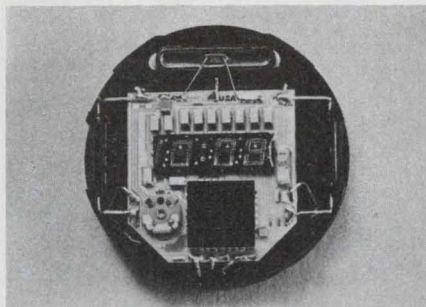


**Dow Corning silicones  
protect this Time Computer\*  
against a 2,500-g impact.**

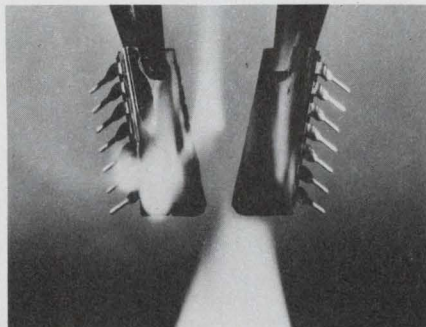




# They also protect against heat, moisture and thermal shock.



This Pulsar computer circuit uses Dow Corning silicones for shock protection, for positioning individual components, and as a moisture barrier. They all help Pulsar maintain an accuracy of  $\pm 5$  seconds per month. A major production advantage with silicones: only one hour primary cure is required before further assembly work. Yet if a circuit element is improperly placed or doesn't test out, the clear sealant can easily be cut away and the individual component replaced without complete rework. Circle No. 121.



ICs, MOS, CMOS, and other devices made with flame resistant silicone molding compounds provide in many applications the reliability of hermetics at about  $\frac{1}{3}$  the cost. These compounds are superior in moisture resistance, thermal life and electronic stability over other plastics. Their heat resistant and shock protective qualities make them especially valuable in the unusually harsh environments of automotive applications. And molding cycle times are as short as 30 seconds. Circle No. 122.

*Pulsar units withstand 2,500 g's, symbolized by this strobe illuminated scene. Courtesy Time Computer, Inc., subsidiary HMW Industries, Inc.*

\*Trademark of HMW Industries, Inc.

For cooling high-density, high-performance modules, silicone fluids thin out very little, and silicone heat-sink compounds won't melt. This results in more effective heat dissipation, required in high-voltage power supplies operating over a wide temperature range. Circle 123.

Silicone rubber insulated wire and cable, used in nuclear power-plant instrumentation and controls, provide reliable service in applications to 260 C without gumming or



melting. And they continue to function even after a fire because of their nonconducting ash. Circle No. 124.

These electronic-quality silicone products are representative of a complete line of silicones that have inherent properties making them ideal protectors for almost every circuit/system.

Send today for "Silicones for Electronic Design," a 24-page brochure full of special applications for improving electronic circuits. Dow Corning Corporation, Department A-3202, Midland, Michigan 48640. Or call your nearest Dow Corning distributor.

**Silicones; simply the best way to protect electronic circuits.**

## DOW CORNING

DOW CORNING

## ACROSS THE DESK

(continued from page 7)

was claimed to be "best of its class."

That the Ailtech spectrum-analyzer product line seems to have been overlooked is difficult to understand, since it has been on the market since 1970, described in *ED*, *EDN*, *Electronics*, *Electronic News*, *Microwave Journal*, *Microwaves*, *Telecommunications*, etc., and 1973 sales were a record high in the U.S., Canada and Europe.

Possibly the phrase "of its class" holds the explanation, since there are differences between the two. The 707 covers 1 MHz to 12.4 GHz with decreased sensitivity down to 10 kHz, and it costs \$11,900. The TF 2370 is rated to 110 MHz and costs \$14,750; however, it was only compared with the HP 8553B family, which also differs in quite a few ways.

*Richard T. Knadle Jr.*  
*Engineering Manager*

*Spectrum Analyzer Products*

Ailtech  
815 Broadhollow Rd.  
Farmingdale, N.Y. 11735

*Ed. Note: Obviously we can't compare a 100-MHz machine with a 12.4-GHz unit. The two aren't intended for the same application. By the same logic, we'd have to include 20-kHz analyzers, too, thus opening the flood gates to all analyzers.*

*When we review products, it's our policy to limit comparisons to what appears to be the closest competitive units.*

## Elliptic-filter idea needs debugging

The Idea for Design "Multiple-Feedback Bandpass Circuit Allows Use of Standard Capacitors in Elliptic Filter" (ED No. 7, April 1, 1974, p. 76) contains a number of errors that seriously affect its usefulness:

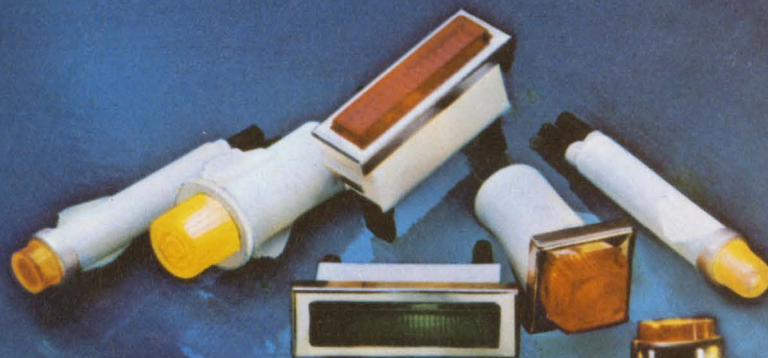
1. In Fig. 1, the  $\omega^2$  terms under  $|V_{out}|$  both have the same subscript "n." This is incorrect.

2. In Fig. 1, the stop-band ripple is diagramed incorrectly. (For a correct example, see Fig. 1 of

(continued on page 16)



# INTRODUCING LITTELITES FROM LITTELFUSE



## SNAP-MOUNT PLASTIC LITES

For rectangular,  $\frac{5}{16}$ " and  $\frac{1}{2}$ " diameter mounting holes. Flex arms insure positive retention and protection against shock and vibration.



## SUBMINIATURE LAMP HOLDERS

Eight series of holders for front or rear mounting into  $\frac{3}{8}$ ",  $1\frac{1}{32}$ ", or  $1\frac{1}{32}$ " clearance holes. For use with replaceable neon or incandescent midjet flanged base lamps.



## CARTRIDGE LAMPS AND LAMP HOLDERS

Available with solid state, incandescent, and neon lamps. Mating holders mount into  $\frac{3}{8}$ " clearance holes.



## MINIATURE LAMP HOLDERS

For front mounting into  $1\frac{1}{16}$ " clearance holes. Designed to accept replaceable bayonet based neon and incandescent lamps.

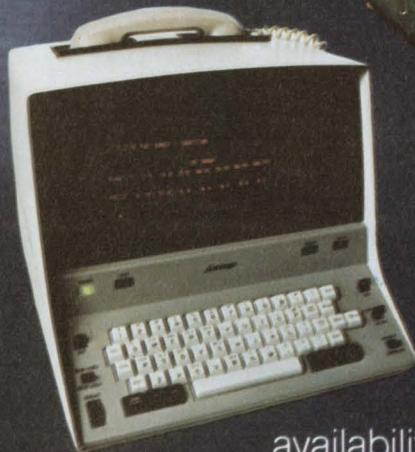
**The most unique indicator light  
and service program ever offered  
to manufacturers**



# We're out to win you over to Littelfuses with top quality, fast service, and hard facts. Judge for yourself:

**FACT 1.** Littelfuse is the only manufacturer that offers all four types of indicator lights, saving you time, paperwork, and money.

**FACT 2.** Littelfuse has all new tooling and total in-house production capabilities for top quality, better control, and faster processing.



**FACT 3.** Littelfuse has a computerized service center that can cross reference, price, and provide availability information . . . all within seconds.

**FACT 4.** Littelfuse means fast, prompt delivery.

**FACT 5.** Littelfuse has a Littelfuses team of R & D and sales engineers to assist you.



**FACT 6.** Littelfuse offers the widest selection of packaging available.

**FACT 7.** Littelfuse offers one-stop shopping for your additional circuit protection and control device needs.

## FOR MORE INFORMATION

Contact Littelfuse or your local Littelfuse representative and ask for our Littelfuses Product Guide or individual product catalogs:



Cartridge Lamps and Lampholders	Cat. No. LL-C574
Subminiature Lampholders	Cat. No. LL-S574
Miniature Lampholders	Cat. No. LL-M574
Snap-Mount Plastic Lites	Cat. No. LL-P574

# LITTELFUSE LITTELFUSES

Your indication of quality and service

800 E. Northwest Highway  
Des Plaines, Illinois 60016  
(312) 824-1188

Subsidiary of Tracor



# The new Keithley Model 168 autoranging DMM... ...vive la différence!

There really is a difference in Digital Multimeters, and once you've experienced Keithley's 168 you'll know why we say *vive*! If you're tired of "general-purpose" promises that turn into run-of-the-mill

performances; if you want that bit extra that'll make your job easier, then *vive la différence*... here's the DMM for you! Send for our DMM Selector Guide or call us for demo now. Phone (216) 248-0400.

**AC VOLTS**  
**DC** **AMPS**  
**OHMS**

**5 functions**

- 100  $\mu$ V to 1000 V dc
- 100  $\mu$ V to 500 V ac
- 0.1  $\mu$ A to 1 A dc
- 0.1  $\mu$ A to 1 A ac
- 100 m $\Omega$  to 20 M $\Omega$



**hi-lo ohms**

Select either of two voltage levels, 1 V or 100 mV, for ohms measurements. You can have your PN junctions either way you want 'em ... on or off.

**two-terminal input**

Simple to connect. You can't get it wrong. Eliminates the word "whoops" from your vocabulary. Saves temper, too.



**options & accessories**

Rechargeable batteries that you can install anytime. An RF probe for high frequencies. Test leads. A 50-amp current shunt too.

**price**

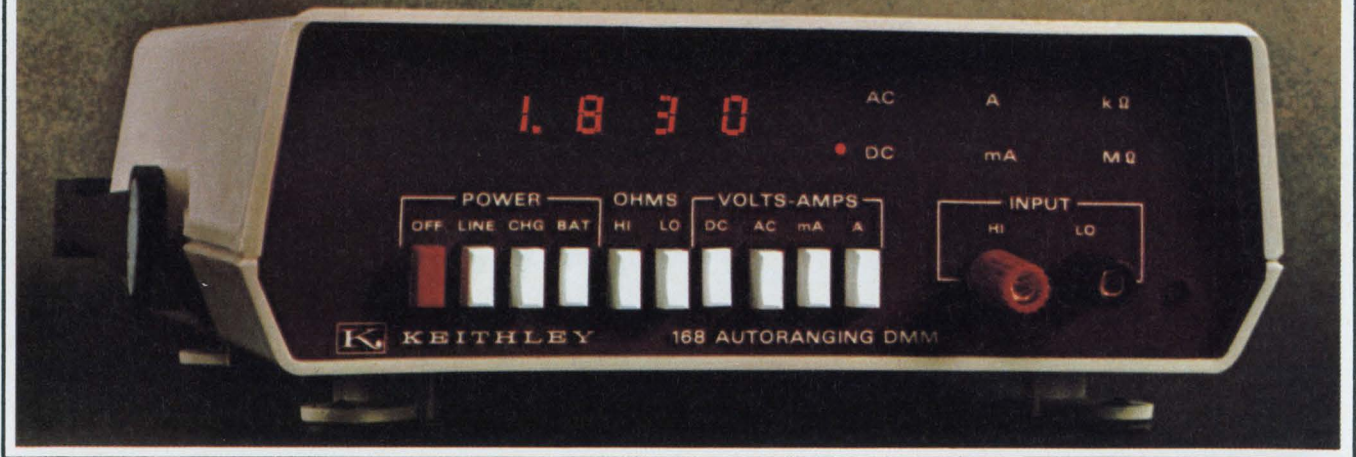
Enough said? Order one... or two... or three now!

**\$299<sup>00</sup>**



**automatic ranging**

You just connect the signal and push the function. The decimal point pops into position automatically and the display is direct reading. That does save time!



**KEITHLEY INSTRUMENTS**  
U.S.A.: 28775 AURORA ROAD, CLEVELAND, OHIO 44139  
EUROPE: 14, AVENUE VILLARDIN, 1009 PULLY, SUISSE



# Due to a major industry breakthrough it is now possible to automate the hamburger.



Until now, it was just too expensive and complex to use a computer for everyday, routine jobs.

The new NAKED MINI<sup>®</sup>/LSI from Computer Automation eliminates this problem. Because you can now buy this full-scale 16-bit computer for only \$990 in quantities of 200.

What this price breakthrough does for the hamburger business (or any other enterprise) is mind-boggling. Because for the first time it is economically feasible to run an entire fast-food operation with one NAKED MINI/LSI. It can keep inventories of all ingredients so there's a minimum of waste. Tell the head office what to supply, where and when. Pin down customer preferences in specific locations. Schedule personnel for peak or slack business hours. Record receipts and keep track of the dollar volume per hour.

But that's only the beginning. Because in any modern business, your profits depend on how well you control margin. Our new mini

gives you the power you need: a full-scale LSI processor with 168 instructions, 4K x 16 memory, plus fully implemented input/output for low-

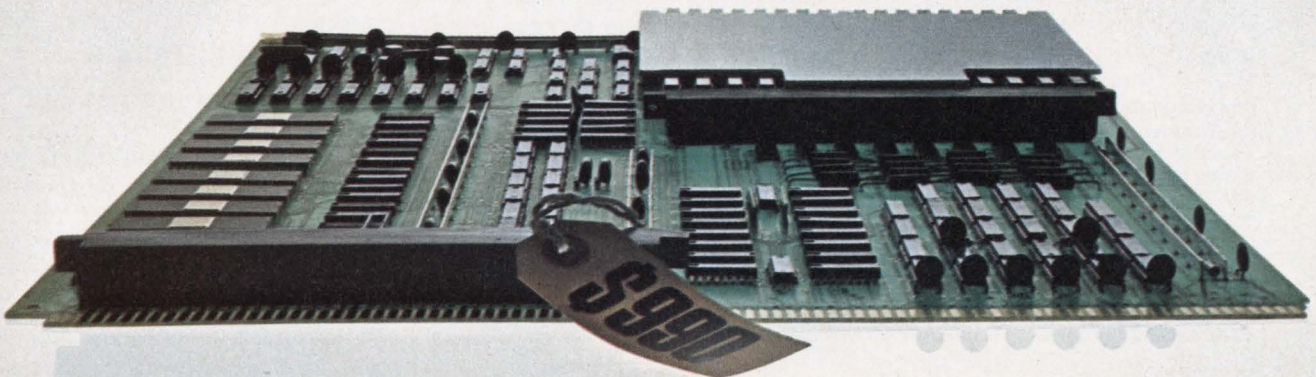
cost interfacing.

And bit by bit, our NAKED MINI/LSI can take over other operations. Like check-out and stock control in retail stores. The bank teller's job. Gas stations. You name it.

There's no telling where and how an OEM can use our pizza-size NAKED MINI/LSI. Especially since price is no longer the object. And if all this has whetted your appetite, contact us to explore your possibilities. Because \$990 for a full-blown computer is great food for creative OEM thinking.

Write or call: Computer Automation, Inc., 18651 Von Karman, Irvine, California 92664. Tel. (714) 833-8830. TWX 910-595-1767.

**THE NAKED MINI<sup>®</sup> COMPANY**  
**Computer Automation, Inc.**



\*NAKED MINI is a registered trademark of Computer Automation, Inc.





## No Offense

Non-PCB (polychlorinated biphenyl) . . . non-toxic . . . non-polluting. That's new Sprague ECCOL® A-C Capacitors . . . developed for today's ecology-conscious world.

Equipment manufacturers using capacitors with polychlorinated biphenyl impregnants are finding that some nations have prohibited the import of products containing PCB.

ECCOL® capacitors have been designed to meet industry needs for PCB-free capacitors. They exhibit essentially identical electrical performance characteristics to those of long-used askarel capacitors. Their operating life and reliability are also equivalent. Even the size of ECCOL® Capacitors is similar to previous designs, except for a slight increase in case height.

Drawn-case ECCOL® Capacitors are available in a wide range of capacitance values from 1 to 55μF, with four voltage ratings from 300 to 660 VAC.

For complete technical data, write for Engineering Bulletin 4550 to:  
**Technical Literature Service**  
**Sprague Electric Company**  
 347 Marshall Street  
 North Adams, Mass. 01247

4SP-4113



THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

INFORMATION RETRIEVAL NUMBER 14

## ACROSS THE DESK

(continued from page 11)

"Design Active Elliptic Filters Easily," ED No. 21, Oct. 14, 1971, pp. 76-79.)

3. In Fig. 2, the stop-band ripple is again diagramed incorrectly. The 0.3-dB passband ripple has no relationship to the ripple in the stop-band attenuation.

4. The caption to Fig. 2 says that the "prototype has a cutoff frequency of 640 Hz," but the diagram shows that  $\omega_s$ , not  $f_{co}$ , occurs at 640 Hz. The filter cutoff frequency (where the attenuation first exceeds the value of 0.3 dB) is not specified.

5. The Y-axis of Fig. 2 is incorrectly labeled.

6. What does the 4.4-dB level signify in Fig. 2?

7. The title of the article incorrectly implies that the final elliptic filter circuit provides a band-pass response. The first sentence, however, corrects any misinterpretation. In my opinion, the following would be a better title: "Elliptic L-P Filter Is Obtained From Multiple-Feedback Circuit Using Standard Capacitors." The fact that a "synchronously tuned B-P function is used" is of secondary importance.

8. The author's discussion is vague, terms are not explained, and no calculation example is given.

9. In Fig. 1, the resistors between the positive terminals of  $A_1$  and  $A_2$  and ground have no reference designation.

10. In Fig. 2, the procedure for selection of the value of the 0.047-μF capacitor, shown across  $R_6$  (12.7 k), is not explained.

Edward E. Wetherhold  
 102 Archwood Ave.  
 Annapolis, Md. 21401

## The author replies

The criticisms are accurate, on the whole.

In my original manuscript, Fig. 1 was labeled  $H\omega_n^2/\omega_d^2$  on the voltage transfer function plot for the circuit shown. Point 1 that Mr. Wetherhold refers to was a typographical error. Points 2, 3 and 4 are just plain mistakes on my

(continued on page 27)

INFORMATION RETRIEVAL NUMBER 240 ►





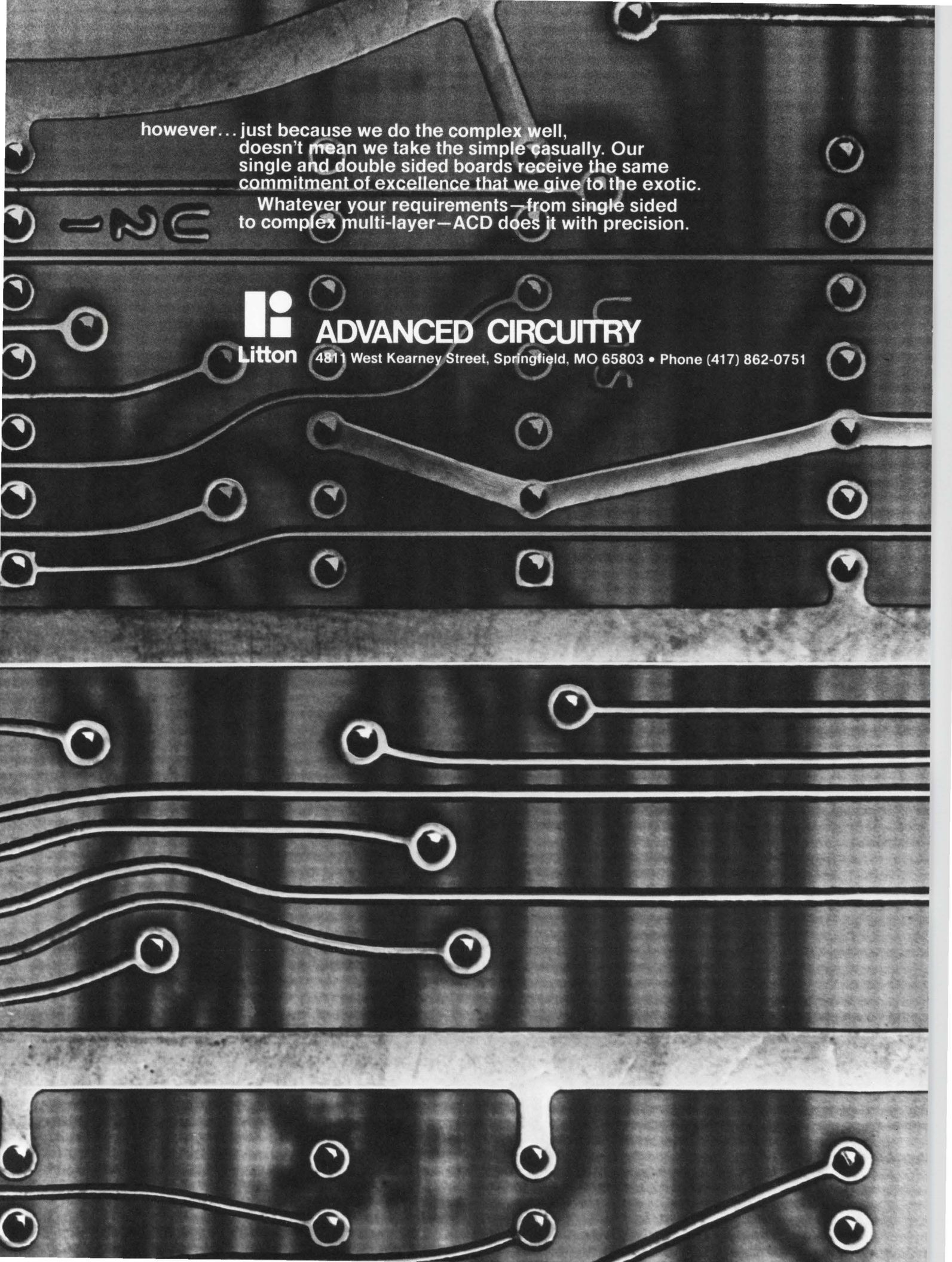
# It's precision— or it's nothing.

There's no "almost right" in a multi-layer board. It's precision or it's nothing.

We emphasize this every day at ACD. It's our commitment. From art to final assembly we build the very best and we've got the talent and the plant to do this.

however...





however... just because we do the complex well,  
doesn't mean we take the simple casually. Our  
single and double sided boards receive the same  
commitment of excellence that we give to the exotic.

Whatever your requirements—from single sided  
to complex multi-layer—ACD does it with precision.



**Litton**

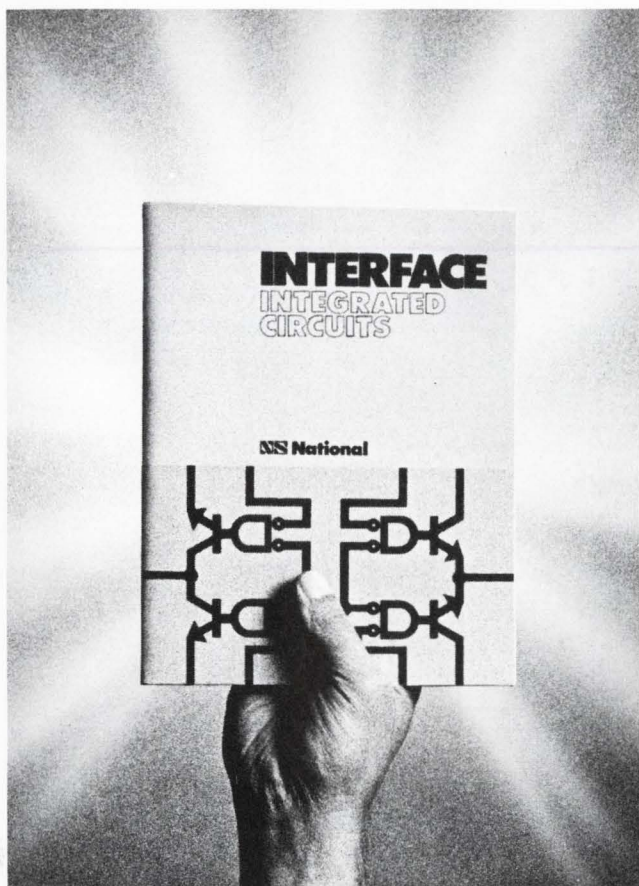
## **ADVANCED CIRCUITRY**

4811 West Kearney Street, Springfield, MO 65803 • Phone (417) 862-0751



# TADA!

No more going from this catalog to that for different types of interface devices.



We've got it all together (in more ways than one).

Our new 350-page interface handbook.

Interface devices from A to Z pulled from our many handbooks and put into one.

Linear, MOS, digital, hybrid, everything.

For yours, (it's free) write National Semiconductor Corporation, 2900 Semi-

conductor Drive, Santa Clara, California 95051.

## Here's one for the book.

LF 311 high input impedance comparator.

In addition to our industry-standard LM 111 we've got this new one with high impedance due to a FET input, which is unique in the comparator field. On a monolithic chip.

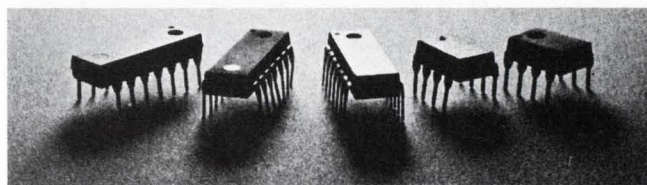
Here's some more new ones.

LM 360-361 high-speed comparators.

A pair of high-speed devices that operate in the 10-15 nanosecond range. And featuring essentially no speed change as the input changes (nobody else has got that, either).

And LM 339A quad comparator.

Half the input offset voltage of any other comparator: 2mv. And truly compatible with CMOS because—alone among all comparators—it offers the same advantage that CMOS offers.



Namely, very low power consumption, and operation over a wide range of supply voltages.

We make 14 kinds of comparators. About twice as many as anybody else.

So no matter what kind you may need, we'll have it for you.

Ta da!

# National

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051; Scottsdale, Ariz. (602) 945-8473; Mountain View, Calif. (415) 961-4740; Sherman Oaks, Calif. (213) 783-8272; Tustin, Calif. (714) 832-8113; Miami, Fla. (305) 446-8309; Chicago, Ill. (312) 693-2660; Indianapolis, Ind. (317) 255-5822; Lenexa, Kan. (816) 358-8102; Glen Burnie, Md. (301) 760-5220; Burlington, Mass. (617) 273-1350; Farmington, Mich. (313) 477-0400; Minneapolis, Minn. (612) 888-4666; Englewood Cliffs, N.J. (201) 871-4410; Syracuse, N.Y. (315) 455-5858; Dayton, Ohio (513) 434-0097; Dallas, Tex. (214) 233-6801.

INFORMATION RETRIEVAL NUMBER 141



# SEE THE INTERFACE FOREST

**PERIPHERAL DRIVERS**

- 75450A Dual Peripheral Driver
- 75450 Dual Peripheral Driver
- 75451A Dual Peripheral AND Driver
- 75451 Dual Peripheral AND Driver
- 75452 Dual Peripheral NAND Driver
- 75453 Dual Peripheral OR Driver
- 75454 Dual Peripheral NOR Driver

**TRANSLATORS / BUFFERS**

- 8T18 High Voltage to TTL Translator
- 8T80/90 Interface Buffers
- 54/7406 Hex TTL to High Voltage Buffer
- 54/7407 Hex TTL to High Voltage Buffer
- 54/7416 Hex TTL to High Voltage Buffer
- 54/7417 Hex TTL to High Voltage Buffer
- 54/7426 Quad 2 NAND TTL to High Voltage Gate/Buffer
- 1017 Dual TTL to ECL Translator
- 1039 Quad ECL to TTL Translator
- 10124 Quad TTL to ECL Translator
- 10125 Quad ECL to TTL Translator
- 10190 Quad MST to ECL Translator
- 10191 Quad ECL to MST Translator

**VOLTAGE COMPARATORS**

- 521 Dual Ultra High Speed Comparator
- 522 Dual Ultra High Speed Comparator
- 526 High Speed Comparator
- 527 High Speed Comparator
- 529 High Speed Comparator
- μA710 Differential Voltage Comparator
- μA711 Dual Voltage Comparator

**LINE DRIVERS/RECEIVERS**

- 8T09 Quad Tri-State Driver
- 8T10 Quad Tri-State D-Latch
- 8T13 Dual Party Line Driver
- 8T14 Triple Line Receiver
- 8T15 Dual Communications Line Driver
- 8T16 Dual Communications Line Receiver
- 8T23 Dual IBM Party Line Driver
- 8T24 Triple IBM Line Receiver
- 8T26 Quad Tri-State Transceiver
- 8T30 Dual Transceiver/MOS Port Controller
- 8T34 Quad Bus Transceiver
- 8T37 Hex Line Receiver
- 8T38 Quad Bus Transceiver
- 8T93/94 Hex Bus Receiver
- 8T95/96/97/98 Hex Tri-State Driver
- 8T380 Quad Line Receiver
- 10114 Triple Differential Line Receiver
- 10115 Quad Differential Line Receiver
- 10116 Triple Differential Line Receiver

**SIGNETICS INTEGRATED CIRCUITS**

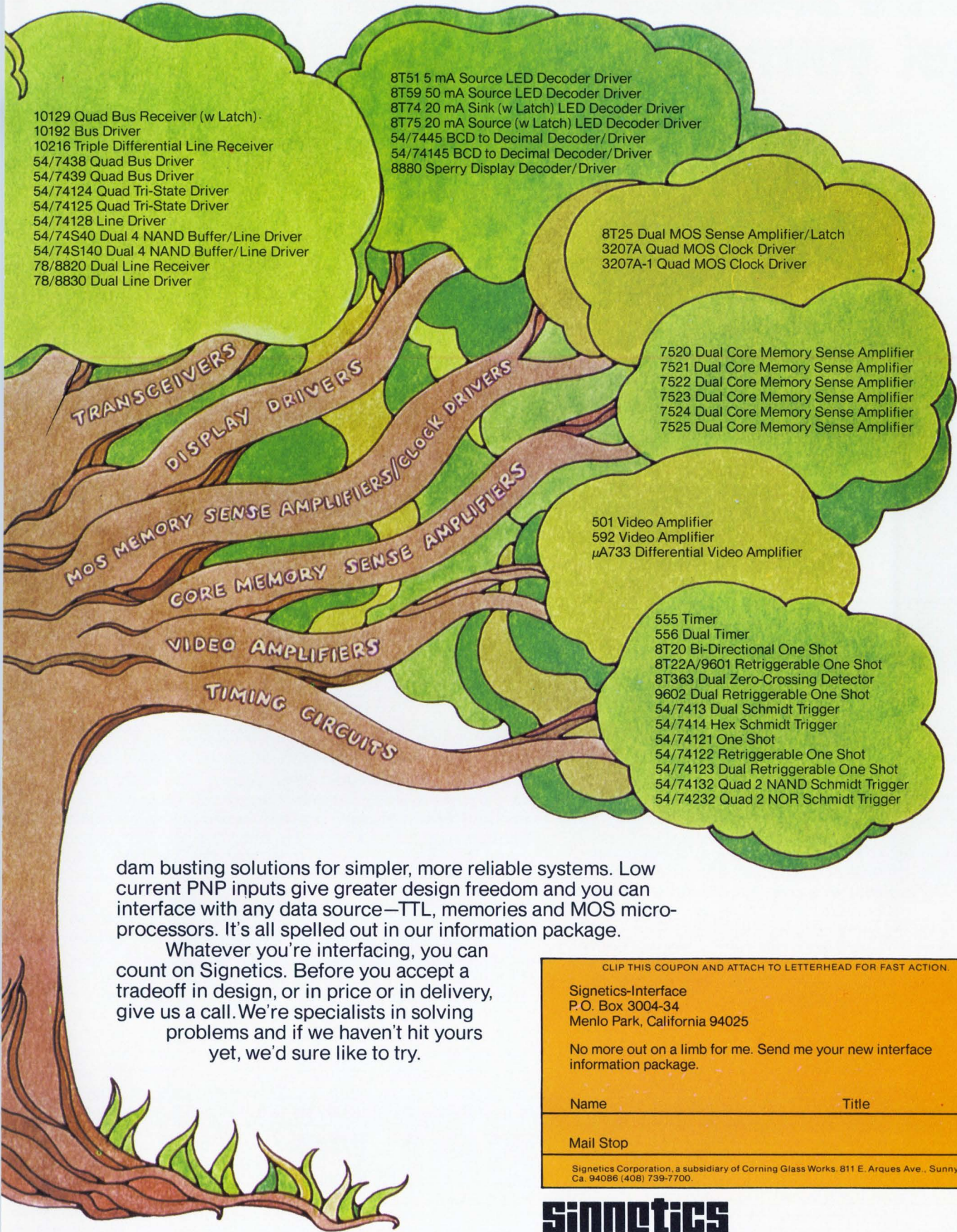
For a logical look at interface problems, consider Signetics. Interface devices in depth. Priced to move. Moving in carloads.

Beyond our host of industry standard interface circuits, Signetics' own family of dual high speed comparators is light years ahead. They've smashed the barriers of speed vs. input parameter tradeoffs and packed high speed TTL gates with a precision linear amplifier on a single monolithic chip. Our full spectrum of interface circuits covers A/D conversion, memory sensing, optical data coupling and ECL/TTL combinations with elegant solutions to a whole gamut of interface problems.

Signetics finds solutions to problems before others will even tackle them. Like our 8T23-8T24 combination for IBM channel-to-control interface, or the 8T26 which cuts out a bunch of circuitry in high speed, bi-directional, tri-state bus transceivers. Within the 8T family, there are built-in latches, tri-state outputs, built-in hysteresis—a slew of



# (BECAUSE OF THE TREE).



10129 Quad Bus Receiver (w Latch)  
 10192 Bus Driver  
 10216 Triple Differential Line Receiver  
 54/7438 Quad Bus Driver  
 54/7439 Quad Bus Driver  
 54/74124 Quad Tri-State Driver  
 54/74125 Quad Tri-State Driver  
 54/74128 Line Driver  
 54/74S40 Dual 4 NAND Buffer/Line Driver  
 54/74S140 Dual 4 NAND Buffer/Line Driver  
 78/8820 Dual Line Receiver  
 78/8830 Dual Line Driver

8T51 5 mA Source LED Decoder Driver  
 8T59 50 mA Source LED Decoder Driver  
 8T74 20 mA Sink (w Latch) LED Decoder Driver  
 8T75 20 mA Source (w Latch) LED Decoder Driver  
 54/7445 BCD to Decimal Decoder/Driver  
 54/74145 BCD to Decimal Decoder/Driver  
 8880 Sperry Display Decoder/Driver

8T25 Dual MOS Sense Amplifier/Latch  
 3207A Quad MOS Clock Driver  
 3207A-1 Quad MOS Clock Driver

7520 Dual Core Memory Sense Amplifier  
 7521 Dual Core Memory Sense Amplifier  
 7522 Dual Core Memory Sense Amplifier  
 7523 Dual Core Memory Sense Amplifier  
 7524 Dual Core Memory Sense Amplifier  
 7525 Dual Core Memory Sense Amplifier

501 Video Amplifier  
 592 Video Amplifier  
 $\mu$ A733 Differential Video Amplifier

555 Timer  
 556 Dual Timer  
 8T20 Bi-Directional One Shot  
 8T22A/9601 Retriggerable One Shot  
 8T363 Dual Zero-Crossing Detector  
 9602 Dual Retriggerable One Shot  
 54/7413 Dual Schmidt Trigger  
 54/7414 Hex Schmidt Trigger  
 54/74121 One Shot  
 54/74122 Retriggerable One Shot  
 54/74123 Dual Retriggerable One Shot  
 54/74132 Quad 2 NAND Schmidt Trigger  
 54/74232 Quad 2 NOR Schmidt Trigger

dam busting solutions for simpler, more reliable systems. Low current PNP inputs give greater design freedom and you can interface with any data source—TTL, memories and MOS micro-processors. It's all spelled out in our information package.

Whatever you're interfacing, you can count on Signetics. Before you accept a tradeoff in design, or in price or in delivery, give us a call. We're specialists in solving problems and if we haven't hit yours yet, we'd sure like to try.

CLIP THIS COUPON AND ATTACH TO LETTERHEAD FOR FAST ACTION.

Signetics-Interface  
 P.O. Box 3004-34  
 Menlo Park, California 94025

No more out on a limb for me. Send me your new interface information package.

Name

Title

Mail Stop

Signetics Corporation, a subsidiary of Corning Glass Works, 811 E. Arques Ave., Sunnyvale, Ca. 94086 (408) 739-7700.

**signetics**

INFORMATION RETRIEVAL NUMBER 142



# The Rolm 1602 has the power to get your program off the ground

For \$18,750  
the 1602 Ruggednova is the most powerful,  
yet lowest priced mil spec,  
16-bit processor with 8K of memory  
on the market



The 1602 is loaded with power features. 450 nanosecond semiconductor memory read cycle time. Memory expansion to 256K words. Dual Port memories. Floating point hardware. Stack processing. Double precision arithmetic. 32-bit instructions and powerful interrupt processing.

We could go into detail on how each of these features improves your system . . . but better yet here are five ways the 1602's power improves your overall program.

**1. Reduce programming costs.** The 1602 allows you to program in less time because you have more power per instruction. In addition to instruction power ROLM also provides a wide selection of documented software proven in over 8000 commercial and military installations.

**2. Reduce risks.** You don't have to worry about underestimating size of computer with the 1602. With its execution speed and expandability, there's plenty of computer to do the job. You can get out of speed binds with our semiconductor memory or custom microcode. And don't worry about memory binds with our external memory which is expandable up to 256K words.

**3. Reduce I/O processing problems.** With the 1602 power, the expanded interrupt structure, the DMA, and Dual Port memories you can handle more data on your computer system. To aid you in utilizing this I/O power, ROLM has available over 30 general purpose interfaces for the 1602. Your special interfaces can

even be placed right inside the 1602 with no time lost in designing an extra chassis or power supply.

**4. Reduce hardware costs.** A lot of the extra hardware normally needed can be eliminated since the 1602 has the power and capacity to do a wide range of tasks. You can reduce your costs by reducing the number of computers needed, not to mention the fact the 1602 is the least expensive full mil-spec machine available.

**5. Avoid qualification tests.** The powerful 1602 Ruggednova has already met Mil-E-5400 airborne environments, Class II; Mil-E-16400 shipboard environments, Class I; and Mil-S-901 for high impact shock. Its military name is AN/UYK-19(V). The 1602's performance is qualified and guaranteed after delivery with a 90-day warranty. This saves a lot of your time.

These are just a few of the ways the 1602 takes the risk out of selecting the right computer. If you would like those specific technical details we mentioned about the 1602, drop us a line . . . or, if your program needs to get off the ground faster, call:

**ROLM**  
CORPORATION

18922 Forge Drive  
Cupertino, Ca. 95014  
(408) 257-6440  
TWX 910-338-0247

Regional Sales Offices: Boston 617-237-5752; Cincinnati/Dayton 513-874-5406; Dallas 214-661-8905; Los Angeles 213-784-8500; New York 914-297-9533; Palo Alto 415-965-2224; Washington, D.C. 703-893-2696.

Domestic Representatives: Colorado 303-355-3521; Kansas 913-362-0919; Missouri 314-895-4100; Washington 206-624-9020.

An Equal Opportunity Employer



Take all the ideas you ever had about systems engineering.

Put them into a highly sophisticated technological environment.

And stir well.

At the Communication Systems Division of GTE Sylvania, your ideas are conceptual ingredients.

CSD is a highly integrated systems engineering and systems management proving ground.

A professional challenge.

An opportunity to assume an entirely new magnitude of involvement, in an atmosphere that recognizes innovative solutions and independent thinking.

It's your expertise.

Your talent and creativity.

Your ideas at work on some of the most advanced projects in state-of-the-art systems architecture and conceptual systems engineering.

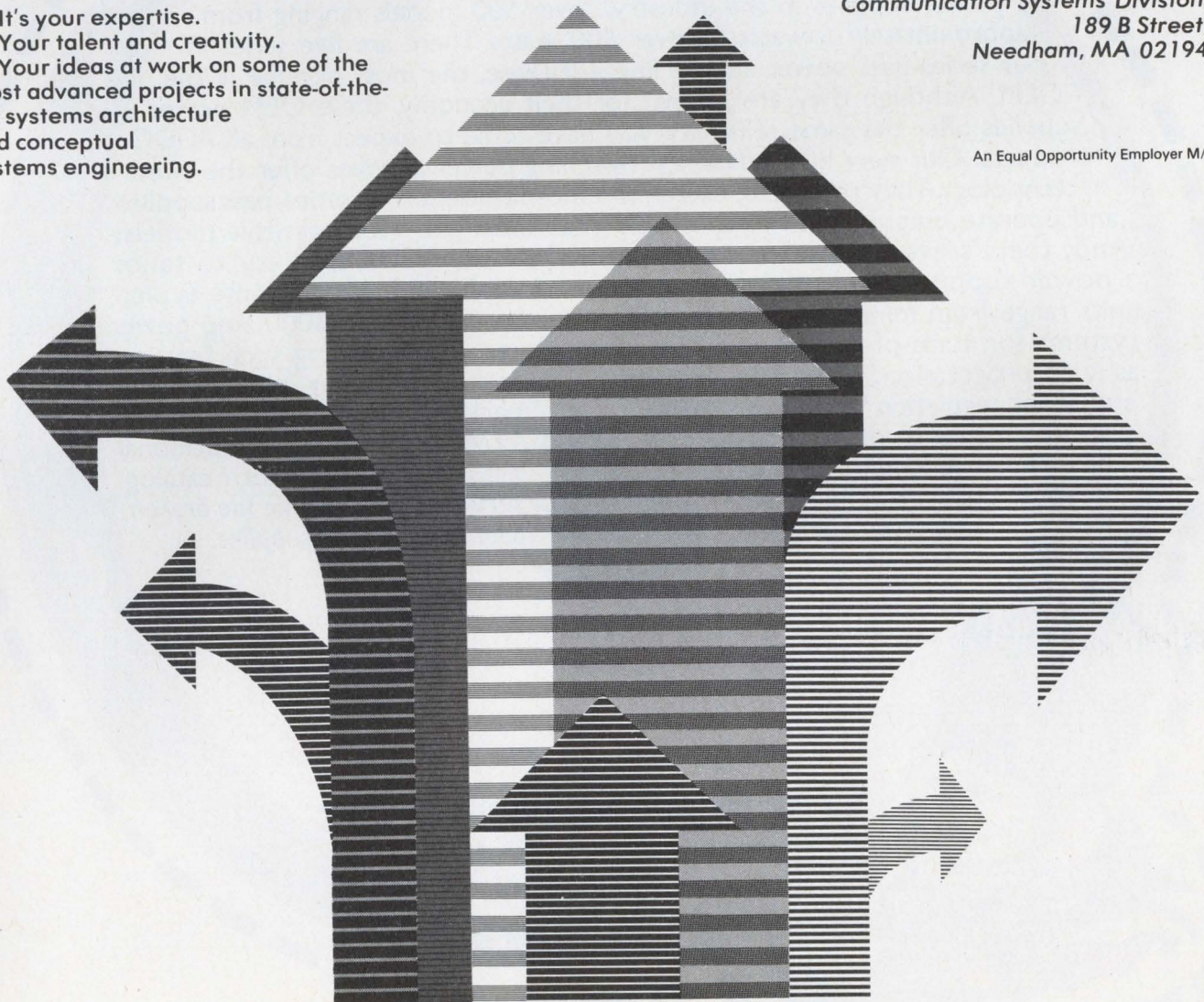
If you have a solid background in electronic systems engineering, and you'd enjoy following your solutions to their ultimate implementation, let us know about it.

The Communication Systems Division can offer you an outstanding opportunity to expand your professional horizons in the conceptual design and operations analysis of advanced command and control and communication systems.

# Your ideas at work

To investigate these opportunities, send your resume including salary history to James D. Gerraughty, GTE Sylvania, Communication Systems Division, 189 B Street, Needham, MA 02194

An Equal Opportunity Employer M/F



COMMUNICATION SYSTEMS DIVISION  
**GTE SYLVANIA**  
INCORPORATED

INFORMATION RETRIEVAL NUMBER 901



# EVEN THE BIGGIES HAVE TO BEAT THEIR OWN DRUM SOMETIMES.

It's about time we made some noise about the fact that we're one of the top three manufacturers of modular regulated DC power supplies. What does that mean to you? Plenty! ACDC Electronics provides one of the most extensive lines of standard power supplies in the industry...over 500 models ranging from approximately 6 watts to over 500 watts. There are five series in our series-pass power supply line. Of these, the most popular is the OEM. Although they are known for their economy, these OEM power supplies offer the same reliability you have come to expect from all ACDC products. Our new high efficiency switching power supplies offer the latest in technology. They're smaller, cooler, and more efficient than series-pass supplies and operate quieter and more reliably than most other competitive models. And, there's even more for us to "boom" about. ACDC's ability to tailor a power supply to specific applications is virtually unlimited. Some typical units range from miniature 400 Hz airborne power supplies to 3000 amp power systems for state-of-the-art computer complexes, incorporating such features as auto-progression, margining, sequencing, transistor switching, phase control and series regulation as well as special packaging configurations. Complete information is contained in our new 1974 catalog. To get your personal copy, just write to us on your letterhead, or, if our short form catalog service number. *Like the broken beat ACDC power supplies.*



Name \_\_\_\_\_

Company Name \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_

Zip code \_\_\_\_\_

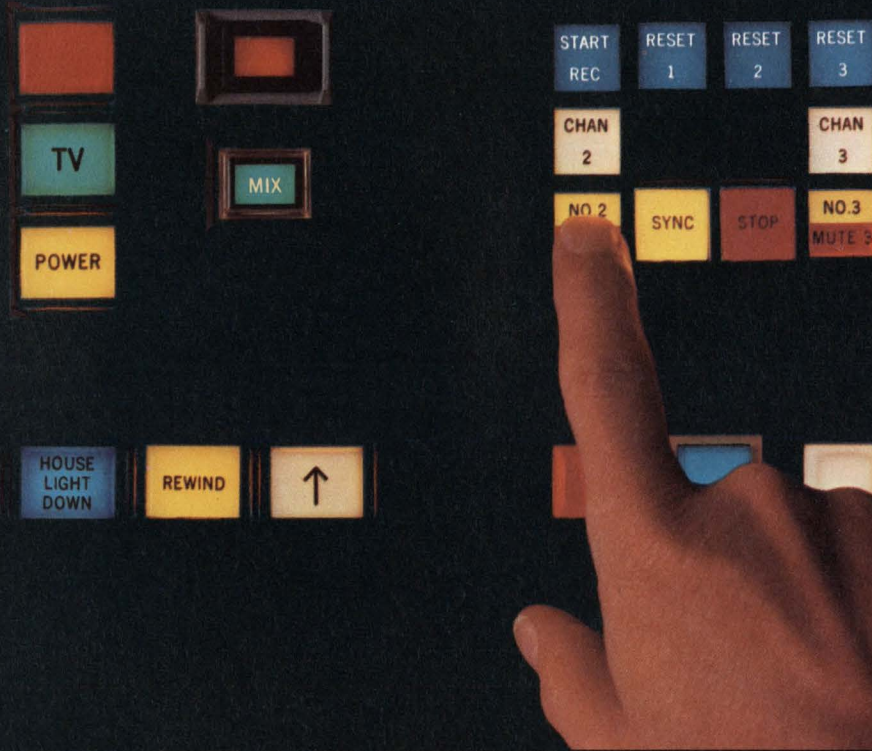
**acdc electronics inc**

Oceanside Industrial Center Oceanside, CA 92054  
(714) 757-1880





# Industrial designers like the way they look. Engineers like the way they work.



MAIN PHOTO:  
Series 3 (right) and Series 4 (left)

LOWER PHOTO:  
Series 4, (left) lowest cost, all three energy levels, snap-in mount.

Series 2, (back) with modular design, up to 4 lamps and 4 poles, military versions.

Series 1, (right) with bushing mount, panel seal, military versions.

Series 3, (front) the smallest in our line, with snap-in or matrix mount.

If you've got a particular idea about what a lighted push-button should look like, we've got four important numbers for you: Series 1, 2, 3 and 4.

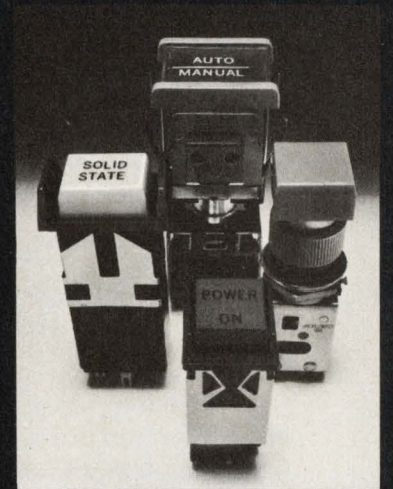
They represent one of the biggest selections of lighted pushbuttons in the world.

So you get to choose from a long list of options, depending upon the switch you select. Like buttons available in popular, highly consistent colors. Either transmitted or projected. Legending includes hot stamp, engraved or film insert, with an optional hidden legend available. Barriers and housings come in a choice of colors. Lighting is single or multiple lamp. Mounting either single unit, strip or matrix. You can also choose between round or square configurations, and most of them offer front-of-panel relamping without tools.

But your choice doesn't end at the front of the panel. In back of the button, there are three energy levels available—solid-state, low-energy and power. You can choose among solder, quick-connect, P.C. board mount or screw terminals. They're all U.L. and C.S.A. listed, with military-listed variations available. Circuitry can be single-pole, single-throw through four-pole, double-throw. With momentary or alternate action.

And, even though each of the four Series has its own particular advantages, they all have one thing in common: the kind of reliability you'd expect from the company that pioneered lighted pushbutton switches.

If you'd like more information on any or all of the MICRO SWITCH lighted pushbuttons, call toll-free 800/645-9200 (in N. Y. 516/294-0990, collect) for the name of your nearest Branch Office or Authorized Distributor.



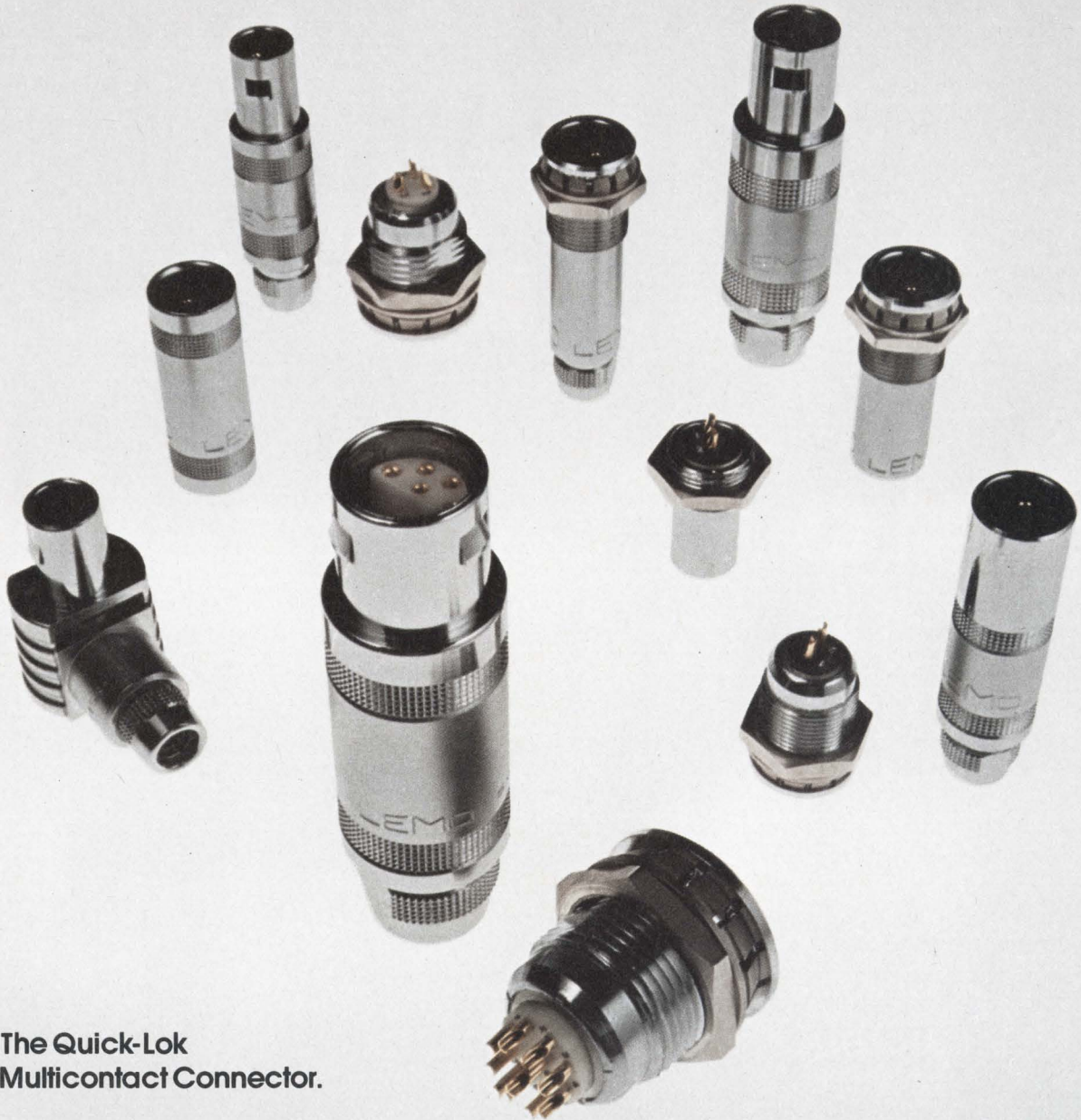
**MICRO SWITCH**

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL



# THE SWISS CONNECTION.\*



## The Quick-Lok Multicontact Connector.

To engage the connector, just push it straight in. To disengage it, pull straight out until the lock releases, then continue pulling to remove the plug from the receptacle. No twisting or turning is necessary.

The Quick-Lok feature;

Saves space because finger clearance is required on only two sides.

Reduces wear on the connector and cable because no twisting is necessary.

Grips firmly and remains locked until intentionally released.

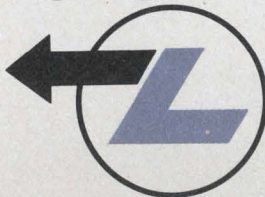
The Lemo multicontact connector is versatile. Miniature sizes are available with 2, 3, 4, 5, 6, 8 or 10 contacts. In addition to standard cable terminating plugs and panel mounting receptacles, adapters, couplers and right angle plugs are available.

With a satin chrome finish, Lemo connectors complement the clean, modern design of instruments, components and systems. They are ruggedly constructed of machined brass components.

A complete catalog is available on request.



\* Manufactured in Switzerland



**LEMO U.S.A. INC.**

2015 SECOND STREET • BERKELEY, CA 94710  
(415) 548-1966 • TELEX 335-393





## Fresh off the shelf. Ribbon cable from Hughes.

It could be as good an idea as penny candy: getting your ribbon cable from the same people who crack your tough flat conductor-cable problems.

We offer it by the foot, or as you like it. We not only make it, but we cheerfully cut it, strip it and terminate it for you.

Our new ribbon cable comes in widths from two to 100 conductors. The conductors are round (solid or stranded),

and have color-coded PVC insulation. You can get 22 to 28 AWG.

Of course, all our cable comes with Hughes quality built-in. And we handle your order with the helpful attitude of one of the most competitive companies in the cable business.

So write us soon. Hughes Connecting Devices, 500 Superior Ave., Newport Beach, Ca. 92663. Or call (714) 548-0671.



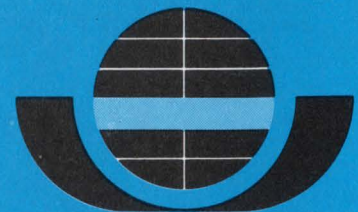
**HUGHES**  
HUGHES AIRCRAFT COMPANY  
CONNECTING DEVICES

**We crack the tough ones.**



# Centralab perspectives

FOR USERS OF ELECTRONIC COMPONENTS



CENTRALAB

Electronics Division  
GLOBE-UNION INC.

5757 NORTH GREEN BAY AVENUE  
MILWAUKEE, WISCONSIN 53201

## A new concept in thick film hybrid circuits lowers cost and broadens applications.

New resistor paints, automated production and laser trimming aren't the only reasons that the NEW PEC™ circuits from Centralab are the high quality performers engineers demand.

It's not surprising that the announcement of a breakthrough in thick film hybrid technology should come from Centralab. The product of a totally new concept in automated production, NEW PEC employs specially developed resistor paints that give these thick film circuits improved tolerance, better TCR, reduced noise and greater stability during load life. They offer unmatched reliability, through laser trimming and computerized pretest and final testing. Automation means increased production capacity for high volume orders and faster delivery. Complete processing time — from substrate to finished circuit — has been reduced from several days to a matter of hours. Yet, with all these improvements, NEW PEC is price competitive with discrete components.

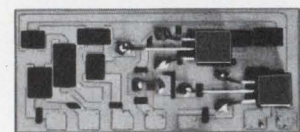
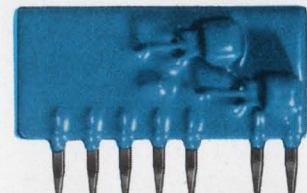
Ever since 1945, when Centralab pioneered thick film microcircuitry, they have continued to make major contributions to the technology and have been a leading supplier of thick film hybrid circuits. With the announcement of the NEW PEC system, they can now meet the increasing demands of present high-volume users and have extended the use of thick

film hybrids to a whole new range of applications.

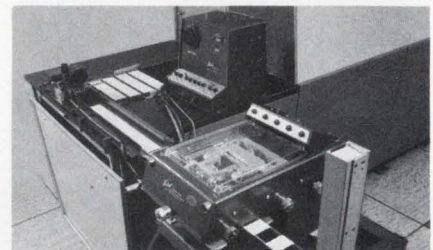
The automated production equipment recently developed by Centralab engineers brings a new degree of sophistication to the art of thick film hybrid microcircuitry. Advanced features like these can help you apply NEW PEC thick film hybrids:

- TCR reduced from  $-1700 \text{ ppm}/^{\circ}\text{C}$  to  $-375 \text{ ppm}/^{\circ}\text{C}$ .
- Resistor tolerance improved from  $\pm 10\%$  to  $\pm 5\%$ .
- Noise reduced from 15 db to 9 db.
- Resistor stability improved 35%.
- Alumina and steatite substrates for greater strength and better heat sinking for mounting active devices.
- Automatic screen printing insures precise metallization and resistor patterns.
- Mechanized component and lead attachment improves reliability 86%.
- Computer controlled laser pretest and adjustment. No problems of over-adjustment, abraded metallizing or contamination from sand abrasion.
- All circuits tested before and after encapsulation.

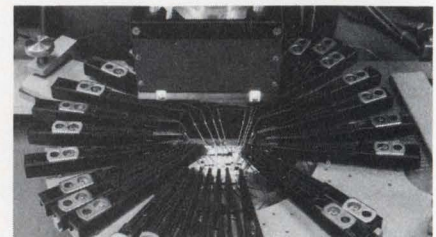
Centralab's NEW PEC opens new vistas for the user of thick film hybrids. For full details on how they can meet the needs of your application write Centralab for Catalog 1547.



Centralab's NEW PEC is low-cost, high-quality thick film circuitry for a wide range of applications. Automotive electronics, copiers, point-of-sale terminals, peripheral computer equipment, instrumentation and process control are just a few.



Screen printing is the first step in the NEW PEC automated process. Substrates are automatically fed through the printer where precise metallization patterns are deposited before firing.

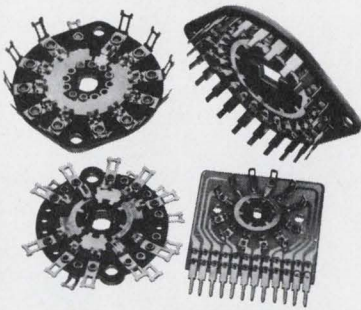


Computer controlled laser equipment provides pretest to insure proper screening and curing and precise adjustment of resistors. Resistor trimming is shown in this view of the laser head.



**Centralab**  
perspective:

**Rotary  
Switches.**



**Design them in  
for multi-circuit  
switching needs.**

When your best circuit design requires switching an array of many circuits, the benefits of rotary switches makes them the logical choice. Centralab, with the most complete line, gives you benefits like this:

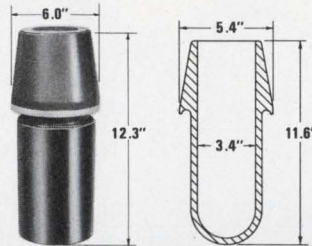
- Simultaneous switching of many circuits by varying the number of switching decks.
- Choice of index types — for 2 to 24 positions — 15° to 90° throw.
- Shorting and non-shorting contacts can be intermixed on the same section.
- Phenolic, ceramic, glass or diallyl phthalate insulation — to match your dielectric specifications.
- Optional electrostatic shielding.

Get the facts on total benefits. Write Centralab for Bulletin 1101SR.



**Centralab**  
perspective:

**Transmitter  
Capacitors**



*Ceramic  
dielectric  
insert.*

**Meet Specs For  
Extra Reliability  
and Save 50%.**

When selecting capacitors for transmitter equipment, Centralab can help. Example: one ceramic dielectric type can replace two vacuum types — increase reliability — yet reduce both weight and cost by 50% or more. The cup type shown, meets specs calling for 6000 pf, 10 kV and current ratings of 100 amps at 500 kHz.

Centralab's line of special capacitors includes header, feed-thru, tubular, slug and water-cooled types — plus custom designs to meet any spec.

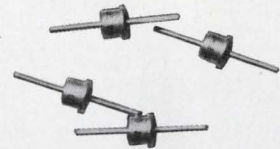
All it takes is a call to  
**Marty Hedrich at  
414/228-2033.**



**CENTRALAB**  
Electronics Division  
GLOBE-UNION INC.  
5757 NORTH GREEN BAY AVENUE  
MILWAUKEE, WISCONSIN 53201

**Centralab**  
perspective:

**CERAMOLITHIC®  
FILTERS HAVE  
EVOLVED WITH USE  
OF EVER HIGHER  
FREQUENCIES.**



MSI and LSI technology have been shrinking the world of electronics, dictating higher, faster frequencies/speeds. With active circuit elements in intimate relationship, electromagnetic fields are straying into unwanted places; sharp filtering has to be an important design consideration.

U.S. Capacitor Corporation, the world's leading innovator of monolithic ceramic capacitors and filters, has tracked circuit speed developments with one idea in mind: improved attenuation at increasingly higher frequencies, in state of the art sizes and at *affordable prices*. Ceramic Filter evolution happens at USCC/Centralab by basic research in dielectric materials and new manufacturing techniques.

Today's products of this evolution are CERAMOLITHIC® subminiature EMI/RFI filters like our 9900 series feed-thru's giving better than 70 db at 10GHZ in only a .110" x .156" diameter case size — for use in medical electronics and CATV. Write for our new 1974 filter catalog or call Don Thommen direct, (213) 843-4222.

USCC/Centralab  
2151 N. Lincoln Street  
Burbank, California 91504





**Centralab**  
perspectives



CENTRALAB  
Electronics Division  
GLOBE-UNION INC.  
5757 NORTH GREEN BAY AVENUE  
MILWAUKEE, WISCONSIN 53201

# spice

**VARIETY IN PUSHBUTTON SWITCH SELECTION.** That's how Centralab can help put a little more spice in your work-a-day life. Because nobody else can give you all the up-to-date features and functions that let you design the way you want to. Start with the basic module . . . then select the options you want, and every functional and appearance specification suddenly becomes reality.

Maybe you'll select Centralab pushbutton switches\* because they require so little space. That's important when you also consider that up to 29 modules can be ganged on a single bracket with horizontal or ver-

tical mounting, rear or back-to-back coupling.

Or, you may want the flexibility that 5 different center-to-center spacings offer you. You can have 10, 12.5, 15, 17.5 or 20 mm in non-lighted switches. Lighted pushbutton switches are available in 15 or 20 mm. For interlock and lockout functions, Centralab is your clear choice. We not only offer you momentary, push-push and interlocking action switches, but four types of lockout as well.

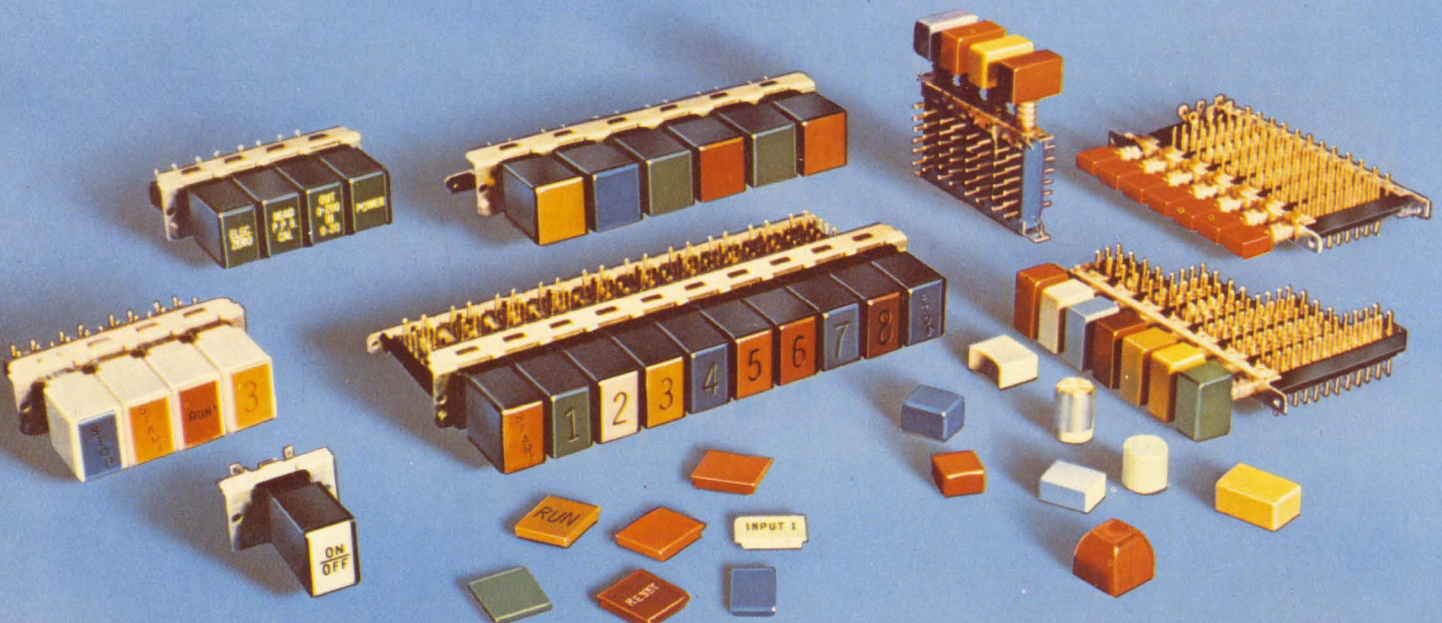
You'll find some of the brightest benefits in our lighted pushbutton switches. First, we supply both white and black lamp

housings with a variety of filters and lenses for the precise control of light output over a wide range of ambient light conditions. And the snap-in lens permits relamping through a front panel. Our shock-mounted filament lamps are designed for low maintenance and long life.

The lamp circuit can be integral or separate from the pushbutton switch circuit. Where it's integral, lamp and switch circuits are in the same terminal plane and can be flow soldered simultaneously for easier installation and service.

If you're looking for the boundless variety that means true design flexibility, we've got your kind of pushbutton switch. We'd like you to know about our epoxy sealed terminals, selective pin cutting, wrap-around support bracket, dust-seal covers, line switch and 25 button styles in 18 colors. And how we can furnish legends for buttons, filters or lenses. We've put it all in a new 24 page catalog that includes complete specifications, dimensional drawings and ordering data. It's yours for the asking. Just circle the information service card or write Centralab for Catalog 1550P. Put some spice in your life.

INFORMATION RETRIEVAL NUMBER 23



\*Isostat licensed



ACROSS THE DESK

(continued from page 16)

part; I know better.

The assumption was made that the reader would have sufficient technical competence to derive the voltage transfer function for the circuit in Fig. 2. The reader would have realized that  $|A|$  represented voltage gain in the frequency response plot, and that 4.4 dB was the static gain. Thus the conclusion is that you fall below that competence level.

I agree that the title in Point 7 is much better. Point 8 is vague. The noninverting terminal resistors in Fig. 1 were not discussed in the text; hence they were given no reference number. Thus Point 9 would not add to the article. Once the basic principal had been grasped, it should have been obvious that the feedback transfer impedance of  $A_2$  could be used to elevate the order of the filter from second to third—to the engineer who could derive common transfer functions. Your suspicions about the design procedure are well-founded. The correct calculations for  $R_4$  and  $R_5$  are:

$$R_4 = \frac{2}{\alpha_d \omega_d C} \left( \frac{\omega_n^2}{\omega_d^2} - 1 \right)$$

$$R_5 = \frac{2d}{\omega_d C} \left( \frac{\omega_n^2}{\omega_d^2} - 1 \right)$$

Robert J. Martin

Martin Marietta Aerospace  
P.O. Box 5837  
Orlando, Fla. 32805

**Abbrevs. Iv ths readr strnded & bewldrd**

Here is an example of abbreviations used in ED No. 1, Jan. 4, 1974:

MOS, ROM, LED, ECL, TTL, CRT, NMOS, PMOS, FET, MECL, DAC, eMOS, RAM, pROM, FIFO, UART V-ATE, CMOS/SOS-RAM, MSI, LSI, MCM, GSE, AGE, TSE, EMI, RFI, ELF, GAO, CAD.

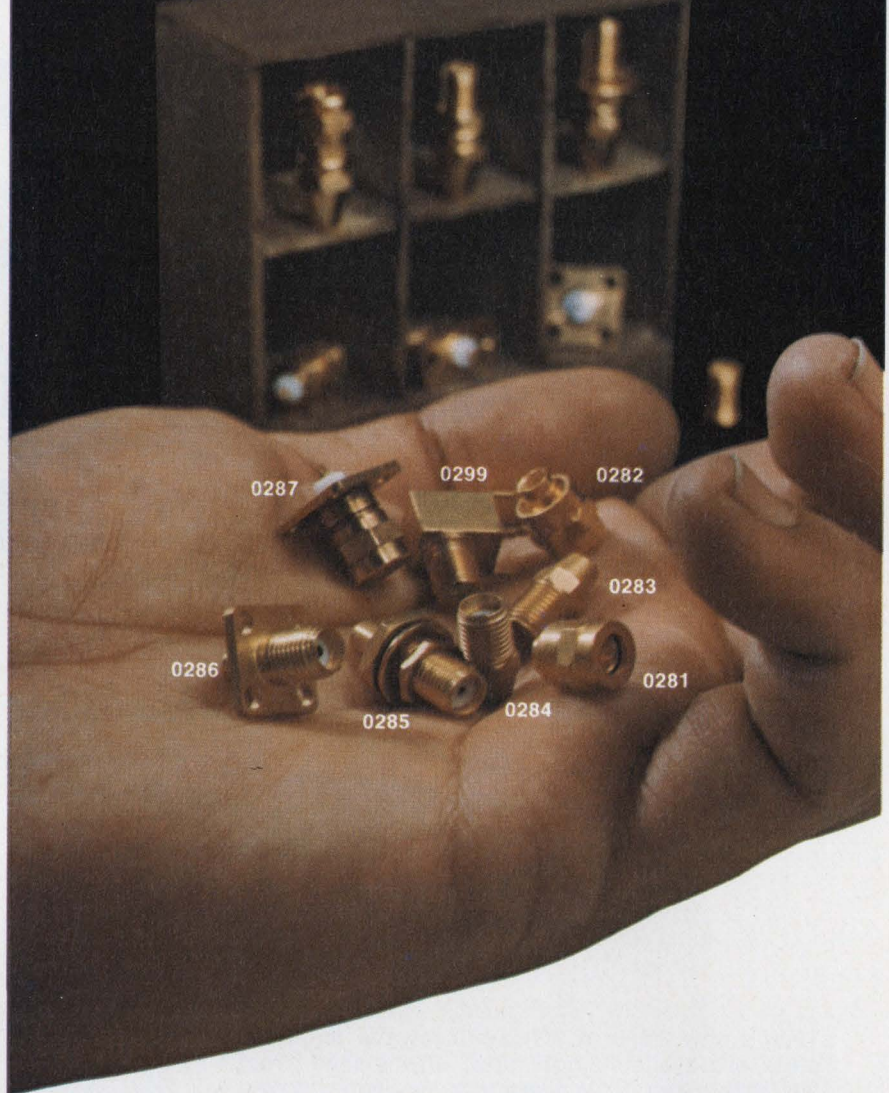
It's a jungle of words!

Vittorio Vallini

Via Rubio 79/A  
10137 Torino, Italy

A year ago we introduced 7 new JCM miniature RF coaxial connectors that "do the job for a fraction of SMA prices."

Here, by popular demand, are 8 more.



If you don't require all the electrical performance built into SMA type connectors, why pay for it? Up to 3 GHz for flexible cable assembly and even beyond 6 GHz for semi-rigid assembly, our new JCM series gives you the same electrical performance as the far more expensive SMA types. The series includes connectors for both panel and PC mounting. All are interchangeable and intermateable with the standard, expensive SMA connectors. So you can use them without making any changes... and without compromising required performance. There are JCM connectors to accept virtually any miniature size cable, so you don't have to stock a big variety. It's worth looking into, isn't it? All it costs is a stamp.

E. F. JOHNSON COMPANY / Waseca, Minnesota 56093

Dept. ED-7

Please check for technical information or test samples of our new low-cost series 142-0200-001 JCM connectors.

- Please send technical information.
- I desire test samples. Please call me at \_\_\_\_\_

NAME \_\_\_\_\_

FIRM \_\_\_\_\_

TITLE \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_

STATE \_\_\_\_\_

ZIP \_\_\_\_\_

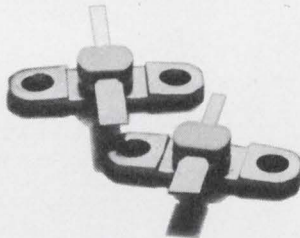


**E. F. JOHNSON COMPANY**

INFORMATION RETRIEVAL NUMBER 24



# Now you have an alternate source for 2GHz & 3GHz microwave transistors



TRW's new 2GHz & 3GHz microwave amplifier parts are available right now, off-the-shelf, from any authorized TRW distributor. So, soon as you qualify these parts, you are no longer at the mercy of a single-source manufacturer!

And here's some more news: our transistors are **not** simply "just as good" as the originals; they're better! Gold metalized to last longer. Metal migration failure is virtually non-existent. The 2GHz parts can also withstand infinite VSWR and overdrive. Yet TRW's gold metalized parts cost the same as ordinary aluminum ones (maybe less!).

These are practically drop-in parts. You can use them right now, in your present amplifiers—and, of course, in future designs. That means instant

improvement in the reliability of your amplifiers. Part for part:

	2GHz		3GHz	
	Aluminum	Gold	Aluminum	Gold
1W	MSC2001	TRW2001	MSC3001	TRW3001
3W	MSC2003	TRW2003	MSC3003	TRW3003
5W	MSC2005	TRW2005	MSC3005	TRW3005
10W	MSC2010	TRW2010	—	—

For details, call Don Comm, (213) 679-4561.

Or write TRW RF Semiconductors, an Electronic Components Division of TRW Inc., 14520 Aviation Boulevard, Lawndale, California 90260.



## TRW<sup>®</sup> RF SEMICONDUCTORS

These products are available through the following authorized distributors:

Almo Electronics  
Bell Industries  
Cramer Electronics Inc.

Electronics Marketing Corp.  
Elmar Electronics Inc.  
Hall-Mark Electronics Corp.

Pyttronic Industries Inc.  
Rochester Radio  
Semiconductor Concepts Inc.

R. V. Weatherford Co.  
Westates Electronics Corp.  
Wilshire Electronics



## Explosive bonding is used to connect microcircuits

Explosive bonding—an unusual approach to the problem of making connections in microelectronic circuitry—has been demonstrated to be practical by researchers at Western Electric Engineering Research Center in Princeton, N.J.

Ben H. Cranston, member of the research staff, reports that micro-scale bonds have been made safely and reliably through the controlled deposition and detonation of explosives.

Although explosive bonding has been used for many years for large-scale bonding of different metals, the investigation at Western Electric has successfully scaled down the process. The method offers the following advantages when microelectronic connections are made:

- Precious metals like gold are not needed in the process.
- Materials ordinarily difficult to join can be bonded together.
- The explosive bonds have greater strength than either of the parent materials.
- Changes in material properties, usually found because of the elevated temperatures common in other types of fusion bonding, are eliminated because the explosive bond can keep the materials below their melting points.
- Ultra-clean surfaces required for most solid-phase bonding systems, are usually not necessary.
- The bonding cycle is very short, and the highly localized application of explosive force does not affect the surrounding areas.
- Only a relatively simple setup is required, as contrasted with expensive equipment or tooling needed for other methods of microelectronics conductor bonding.

As Cranston explains the explosive-bonding process, the metals to be bonded are laid one over the other, with a thin layer of explosive charge on top of the upper

layer. The explosive is touched off by a hot tungsten filament at one edge of the upper layer.

The detonation propagates outward away from the initiation point, violently forcing the upper conductor down against the lower layer of material. At the point at which the upper and lower surfaces collide, a jet of material spurts out ahead and removes oxides, nitrides or adsorbed gases, thus providing a clean metal-to-metal bond.

Three types of bonds are possible with the explosive technique: A solid metal-to-metal bond, a bond formed by a layer of molten metal, or a bond that has an interlocking ripple due to small molten zones that were formed. The latter bond has the highest strength.

In fabricating bonds on microelectronic structures, the Western Electric researchers suspended the explosives in a special wet medium. The medium serves two purposes: It desensitizes the explosives for handling purposes, and it permits the explosives to be applied by use of screening techniques. An accurately controlled quantity of explosives is screened over the desired areas.

In some cases a buffer layer of material, like polyimide, was placed between the explosive and the metal to protect the surface and dampen the explosive force. Reliable bonds were formed by use of a buffer layer.

Materials bonded by Western Electric include copper to nickel, stainless steel to copper, and gold-plated copper to tantalum.

### 1-rpm video disc system shown to be feasible

The latest entry in the growing list of video disc players is an unorthodox 1-rpm system, demonstrated to be feasible by the Syd-

nor-Barent Scanner Corp. of Albuquerque, N.M. By contrast: most current video disc systems operate at 1500 to 1800 rpm.

The slow-speed system, invented by Dr. Iben Browning, President of Sydnor-Barent, substitutes optical technology for much of the electronics in other disc systems (ED No. 13, June 21, 1974, pp. 31 and 46). Whereas all other disc players impress some form of the TV signal on the disc, the Sydnor-Barent system uses a 12-in. clear plastic disc that—for a 90-min. black-and-white program—has 65,000 micro-sized images impressed on the disc in a spiral. These images are converted to a TV signal through the use of a conventional flying-spot scanner.

For a 45-min. color recording, a twin spiral of 130,000 images will be used. One image will contain the black-and-white picture, and its twin counterpart will contain the color image or an analog from which the color signals can be reconstructed.

While the average disc speed is 1 rpm, the images pass under an optical pickup head at a constant rate of about 5 mm/s.

Because of the exceptionally slow disc speed, the sound is impressed on the disc not as a conventional sound track, but as an optical transform or "voice print," according to Nels Winkless III, marketing director.

"Our objective with the new system," says Winkless, is a \$200 record player that has no precision instrumentation or servos. Also it must be a product that kids can work and which can't be damaged easily."

The disc is the one precision component in the system, he explains. The disc contains, in addition to the spiral of pictures on one face, an equal number of tiny lenses impressed on the opposite face of the disc. One lens is opposite each image. The images are enlarged and projected by the lenses into the flying-spot scanner. Resolution of these lenses, Winkless says, is better than that of a standard TV picture.

The disc will be somewhat thicker than a standard 12-in. record. The thickness governs the required separation between the images and lenses to keep the images in exact focus. But the tolerances required



are well within those of standard disc-pressing techniques. The optical-disc master is made by laser etching, says Winkless.

"We make a half-tone picture as a pattern of minute surface disturbances. In this case, light scatter—instead of light absorption—gives the image. From a metal master, clear plastic records can be pressed."

We have made experimental discs of polystyrene Winkless notes, "but we can use vinyl, which is what all the record makers use."

Because of the slow disc speed, the images pass the pickup head at only 12 frames per second—which raises motion and flicker problems.

But Winkless points out that motion becomes smooth at about 11 frames per second. And flicker is not objectionable with this system because there is no shutter. Instead as the disc rotates, the scene dissolves smoothly from frame to frame.

The reproduction of sounds at the disc rate of 5 mm/s was a problem, Winkless reports, because no conventional sound track would work. The solution was the use of sound spectrograms, otherwise known as voice prints.

## TI MOSFET paces TV tuner race

An n-channel, dual-gate MOSFET from Texas Instrument has joined the race to develop a new generation of vhf/uhf TV tuners with MOSFET front ends.

Other entrants are DMOS transistors (MFE 591) from Motorola, Phoenix, Ariz., and the SD 301 series from Signetics, Sunnyvale, Calif.

The TI device, the 3N225, lists highest performance of the lot. The MOSFET was introduced at the IEEE Spring Consumer Electronics Conference in Chicago.

Paul Davis, manager of the Evaluation/Application Laboratory for small-signal products at Texas Instruments, Dallas, stresses: "These transistors have superior gain and noise-figure performance at uhf (900 MHz) with a tenfold improvement in cross-modulation, compared with conventional bipolar tuner transistors."

Designed for the 30-to-900 MHz frequency band, the transistors ex-

hibit 25-dB gain in the low end of the band and taper off to 14 dB at 900 MHz. The typical noise figure is 5 dB, compared with 7 dB in conventional tuner transistors, and cross-modulation drops to 1% for 100 mV of undesired signal level, compared with 1% for 10 mV.

The TI transistors come in a plastic package and will sell for less than 50 cents in large quantities.

## Pulse echoes to measure size of metal cracks

It's already possible to "hear" subminiature cracks deep inside a foot-thick wall of a nuclear-reactor container. Microphones on the side of the container pick up the sound, amplify it and feed it into a computer. The computer processes the data and produces a map that shows the crack's position.

But how big is the crack? Up to a certain size cracks are permissible, but once that size is exceeded, the plant is legally required to repair them. To determine size now, cracks must be examined visually, a procedure that isn't easy when you're dealing with nuclear fuel.

A solution, however, may be at hand. Engineers at the University of Michigan's Dept. of Mechanical engineering are devising a system that, after locating the crack by standard acoustic emission procedures, measures the size of the crack by an ultrasonic pulse-echo system. The procedure entails the sending of an ultrasonic sound into the metal, then the analysis of its echo to determine the size of the aperture.

The examination can be made in approximately one day, depending on the number of personnel working on the project, according to Professor Julian R. Frederick, of the University of Michigan. A crew with a truck that contains computers, tape recorders, amplifiers and microphones is needed. During the procedure, the principle vessel, which is shaped like a giant thermos bottle, is examined one section at a time.

"Twenty to 30 microphones spaced from 4 to 6 ft apart are firmly attached to its sides," Prof. Frederick explains. "They generally cover an area 40 ft by 20 ft

with each test. The noise that the microphones pick up from the area is amplified and fed into a computer. As the computer processes the data, it produces a map that is read by a technician." With the present technique, the crack must be examined visually. With the new pulse-echo technique, the size of the crack will be shown on a computer readout. The Michigan engineers believe such a unit will be operational in the next two or three years.

## Life-cycle appliance costs still rising

Hidden costs of major consumer appliances, such as color television sets, are at least equal to the purchase price and threaten to increase sharply in the future, according to a two-year study of consumer durable products by the Massachusetts Institute of Technology and the Charles Draper Laboratory, Inc., Cambridge, Mass.

The life-cycle costs studied include those for maintenance and repairs, servicing, electrical operating energy and disposal.

Least understood, according to the report, are servicing costs. Due to improvements in product reliability, the need for service for color television has declined by 50% over the past eight years. But this possible savings in the life cycle of the product has been wiped out by increased servicing costs.

For color television sets, servicing costs amount to 34% of the total dollars spent on a set during its useful life. Purchase price accounts for 53% and electrical power, 12%. This means that the owner of a \$500 color TV can expect to spend about \$500 more during its usable life.

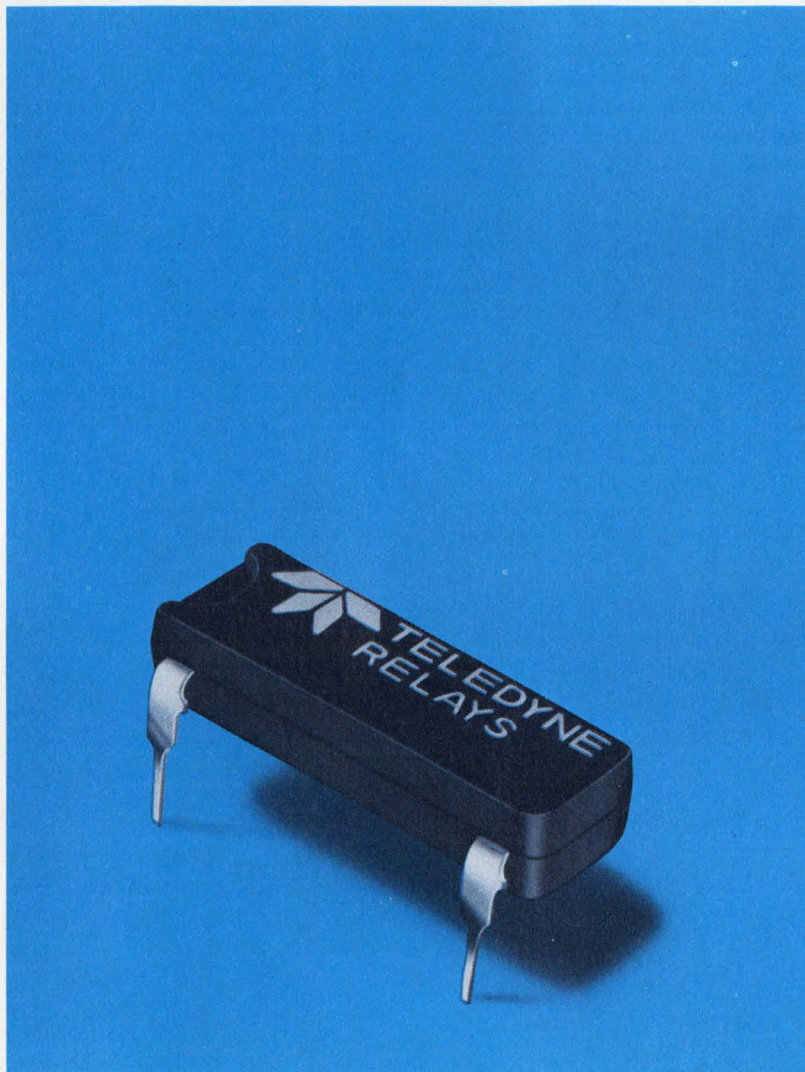
The solution, the report states, is not to make servicing more productive but to improve the initial design. TV set manufacturers have an incentive to heed this advice because of warranty costs and the intensity of competition.

Reliability is a particularly important sales attraction for color TV sets, the report points out, because so many people—60% of those polled—expect to be overcharged for TV repair service, and 34% expect trouble of some kind in getting the work done.



# SerenDIP-itous reminder

## A versatile family of solid state DIP relays



Serendipity is a gift for finding valuable or pleasant things you hadn't looked for. Teledyne, the world's largest maker of solid state relays makes serendipity for engineers — We make SERENDIP®s.

The SERENDIP® family includes four kinds of solid state DIP relays for different jobs. They up-grade, with all the advantages of solid-state — total input/output isolation, low-level logic input compatibility, fast response time, no "contact bounce" (drive IC's directly), and long life dependability. All this in low profile TO-116 DIP packs with equally low cost.

About those different jobs. The 640-1 features bi-polar output, AC or DC up to 50v/80Ma, with low ON resistance — 2 ohms typical. Use it for isolated line drivers and data couplers, A/D converters, modulators and demodulators.

The 641 is a small AC powerhouse — 1 AMP Triac output, 140 or 280 VAC with a 10 AMP surge rating. Try it for lamp or inductive load control — solenoids, motors, transformers, etc. And the 641 is now UL recognized.

The 643's are DC versions capable of switching up to 60v/400Ma or 250v/100Ma. They actually exceed current and voltage switching capabilities of opto-isolators. In communications, use them for keyer switching — or as telegraph relays.

Finally, the 644 is a low offset voltage unit that solves switching problems in instrumentation applications. Use it for low level transducer signal switching, series choppers, scanners, sample-and-hold, multiplexing, etc.

The SERENDIP® family — a pleasant reminder from Teledyne Relays. Ask your rep or distributor, or call us.

 **TELEDYNE RELAYS**

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

INFORMATION RETRIEVAL NUMBER 26



# A built-in heat pipe proposed to cool GHz power transistors

The use of a heat pipe directly on the chip may permit microwave power transistors to compete with klystrons and other gigahertz rf devices, according to Michael A. Merrigan, senior technical staff assistant at Hughes Aircraft, Fullerton, Calif.

Merrigan, a researcher who has demonstrated the feasibility of cooling rf power transistors with internal heat-pipe structures, points out that as the operating frequency of transistors increases into the microwave range, the transistor chip becomes small. This reduction severely limits the heat that can be dissipated and consequently the power output of the devices.

In Merrigan's investigation—

**Jim McDermott**  
Eastern Editor

performed for the Army Electronics Command, Ft. Monmouth, N.J.—the surface temperatures of the chip of a 2N5701 (35-W maximum rating) transistor operating at 76 MHz were reduced from 219 C at 29-W dissipation to 130 C at 42.5 W when the heat pipe was used.

With proper chip design, Merrigan is confident this technique can be extended to transistors operating in the 1-GHz region.

An advantage of the heat pipe, he says, is that it can be made of nonmetallic, dielectric materials and, as a result, can provide electrical isolation while maintaining high thermal conductance.

Another useful characteristic is the pipe's ability to carry off widely varying values of heat without variations in temperature. This insensitivity to local variations in input power is exploited in the

transistor heat pipe to reduce hot spots on the chip.

Application of heat-pipe cooling directly at the chip surfaces minimizes temperature irregularities over the chip surface and reduces the limiting thermal resistance—that of junction-to-case.

The heat-pipe approach was used in the Hughes investigation because of its high thermal conductance in dense high-power applications.

The basic pipe structure, Merrigan explains, consists of a sealed enclosure lined with a porous wick material that is wetted with a volatile liquid. No gas other than that of the pure vapor of the liquid is present. At normal vapor-flow velocity, the pressure is nearly uniform throughout the vapor space. The temperature along the wick surface then remains essentially constant at some equilibrium temperature.

The region of the heat pipe where heat is introduced is an evaporator; the cooling fluid is vaporized here. The section where the heat is removed is a condenser; the vapor is returned to fluid here. The flow of heat along the pipe is extremely rapid.

The working fluid chosen for the transistor heat pipe was 3M Co.'s fluorocarbon FC-77. It has a normal boiling point of 216 F, and because of its fluorinated structure, it is nonflammable and chemically inert. The fluid is essentially unaffected up to about 750 F.

Most important, the electrical insulating and dielectric characteristics of FC-77 are excellent, Merrigan reports. The liquid phase dielectric strength is about 500 V per mil, he says, and the dielectric constant less than 2.0 from 1 kc to 8.5 GHz.

Based upon the number of performance tests, Merrigan notes



Heat pipes for transistors are fabricated with Refrasil fiberglass wick structures. Here a 2N5701 transistor on a TO-60 header is in various stages of assembly. The sealed transistor is filled with 3M FC-77 fluid.



# The first modular instrumentation calculator.

## Just \$5945 as shown.

### It's our 31/53 Data Acquisition System with DM 501 and DC 503.

A powerful, yet inexpensive calculator combined with our 153 Instrumentation Interface and system software. You add the instrumentation modules you need. It's all there and it's portable. Now that's versatility!

With our 31 Calculator, you can read input from our DM 501 and/or DC 501, 502, 503 counters. You can log data selectively, calculate results and output data or trigger signals.

**Programming?** Little more than natural math. Go ahead, write your own. Also, our standard software gives you data logging (on the optional alphanumeric printer) and data capture on the 31 at operator selected intervals.

Dealing with complex variables? Then label 24 keys with personal functions on the user-definable overlay.

### Energy monitoring.

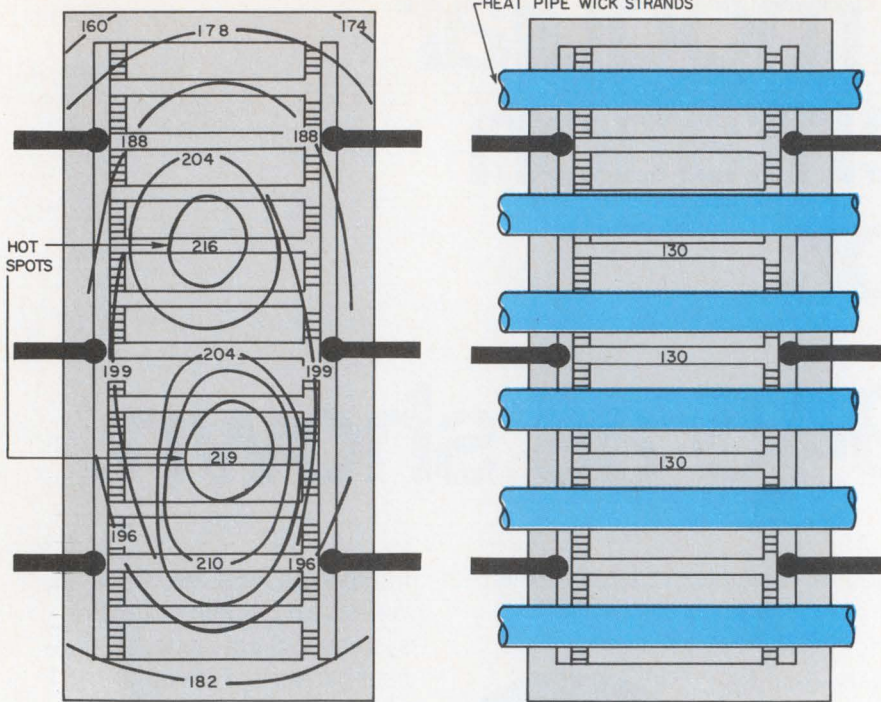
Quality control testing. Laboratory and production instrumentation. The applications go on, and so does our system's potential. Just add the main-

frames and modules you need. We have a graphic calculator system, too. Let our sales engineer fill you in. Pick up your phone and call our nearest center. Or write: IDD Calculators, P.O. Box 500, Beaverton, Oregon 97005.

**Our programmable calculators. Natural. Powerful. Significantly less expensive.**







**Thermal map of a 2N5701 transistor** (left) with 29-W input shows hot spots on the chip. With a heat pipe, the same transistor (right) has no hot spots at 40 W. In addition the chip temperature is reduced by 89 C.

that the wick material chosen was Refrasil glass fiber. The wick consisted of fiberglass stranded bundles 0.004-in. in diameter spaced 0.02 in. apart over the chip.

The open configuration was chosen, Merrigan explains, because of the high heat-flux density at the chip surface and the low thermal

conductivity of the wick material.

The remainder of the header was covered with a mat of glass fiber to provide fluid storage and fluid return.

The transistors used for the investigation were 2N5701's on TO-60 headers (see photograph). In fabricating the wick structure,

Merrigan placed wick strands across the chip surface and glued the ends with epoxy. To ensure good contact between the primary strands and the chip, additional strands were placed at right angles across the top of the primary bundles.

The inner surface of the transistor case was lined with a layer of glass fiber matting that projected slightly below the cap surface.

The remainder of the chip substrate on the header was covered with a pad of woven glass fiber for the condenser wick. The inner surface of the case cap was lined with another layer of glass fiber that made contact with the wick structure surrounding the chip. The cap was then welded in place on the header.

On the TO-60 cases the projecting connector pins on the cap were cut off near the top, and the FC-77 heat-pipe fluid was injected through the pin openings. The transistor was then heated to slightly above the atmospheric boiling point of the fluid (97 C), and the fluid was allowed to vent through the pin openings. The pins were crimped and solder sealed.

As the power to the heat pipe transistor increased, the junction-to-case thermal resistance decreased. Merrigan points out that this characteristic is consistent with usual heat pipe performance. Test data showed that the thermal resistance was cut by 80%. ■■

## Multiple-beam antenna could boost communication satellite capacity

Frequency reuse is the new marching cry in the communications industry. With this approach, the same portion of the crowded frequency spectrum can be used by several users simultaneously without interference.

A multiple-beam lens antenna that can produce up to six beams at the same frequency and can electronically aim those beams at any of 37 possible targets is under development at Philco-Ford,

Palo Alto, Calif. The antenna was described by William G. Scott, multiple-beam antenna section supervisor, during the Fifth Communications Satellite Systems Conference sponsored by the American Institute of Aeronautics and Astronautics in Los Angeles.

According to Scott, "It is a wide-band microwave constrained lens and feed array using printed-circuit technology for each lens element."

The antenna, he says, will produce pencil beams at the same frequency with sidelobes below -34

dB for all positions within an 18° conical field of view.

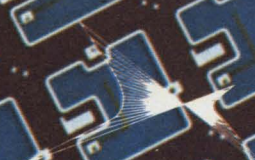
The sidelobes must be down at least 27 dB to make the system practical, Scott notes.

Such a multiple-beam antenna could greatly increase the capacity of communication satellites. The pencil beams could be aimed from a synchronous satellite at several different regions or cities. If the beams were sufficiently isolated from each other, all of these regions could communicate through the satellite on the same frequency band without interfering with each

**David N. Kaye**  
Senior Western Editor

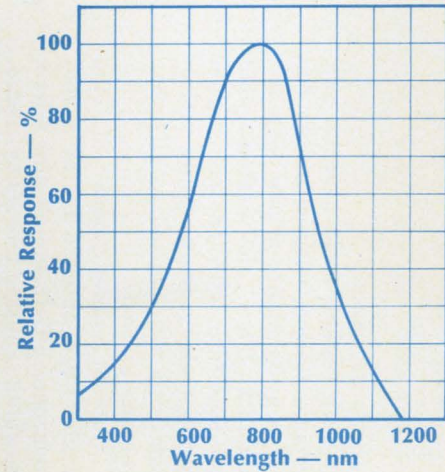
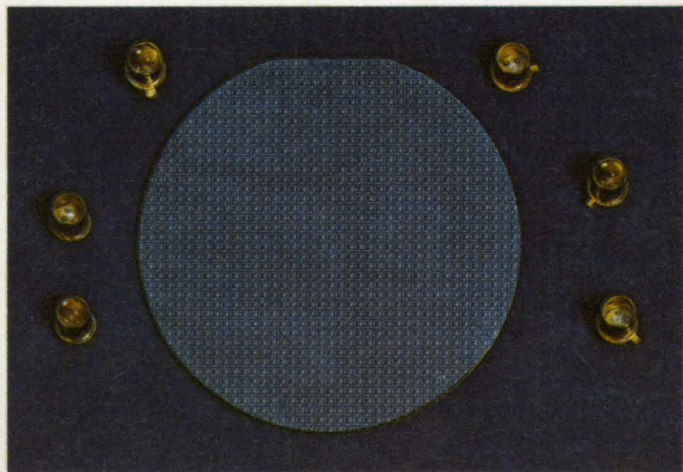


# vactec phototransistors



VACTEC, INC.  
2423 Northline Industrial Blvd.  
Maryland Heights, Mo. 63043  
Phone (314) 872-8300

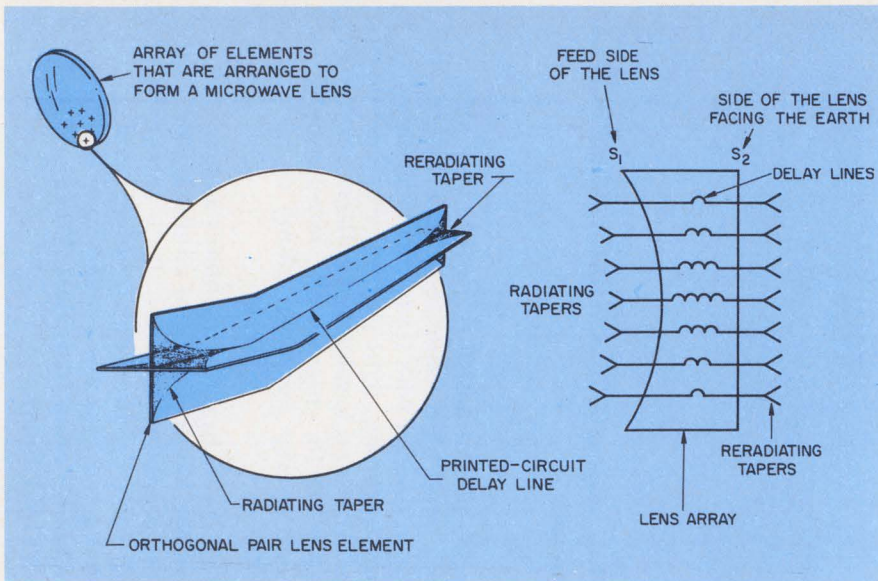
Vactec npn epitaxial large chip, high sensitivity phototransistor. An enlarged section of the wafer forms the colorful background.



Standard Vactec phototransistors provide very high sensitivity and good blue response. Liberal design flexibility is also offered with trade-off for some characteristics, including: light current; response time; spectral sensitivity; and breakdown voltage. Selection of packages are TO-18, co-axial, pill, non-hermetic TO-18 size and special arrays on 50-mil or 25-mil centers.

Custom design is practical for quantities as low as 10M per year. Masking charges are nominal. Our automatic test capability includes 100% sort (with light applied) for  $I_{CEO}$ , breakdown voltage and dark current. Vactec can also second-source practically anyone's phototransistors. Write for Bulletin VTTA-1 today.





The Philco-Ford lens array will contain 400 elements. Each is a delay line constructed of a pair of orthogonal printed-circuit boards. Tapers are used on each end as the radiating elements, and a meander line connects the tapers. The delay lines are phased so that when one side of the lens is illuminated by the feed array, the energy is shaped into a pencil beam that can be as narrow as 1/2 degree.

other's messages.

Each region would have its own ground station, with capability for two-way communications with the satellite. Thus one region could communicate with another region without the message being simultaneously transmitted to all other regions as well.

Current development of the Philco-Ford antenna is for a conventional 6-GHz uplink and 4-GHz downlink. With frequency reuse, all uplinks and all downlinks would be at the same frequency bands.

In the most common form of antenna, the antenna feed illuminates a reflector, which shapes the transmitted beam of energy. With any lens antenna, the feed illuminates one side of the lens array. The microwave energy is shaped by the lens—just as an optical lens shapes a beam of light—and retransmitted out the other side of the lens.

Scott describes the lens array as "a large number of radiating elements arranged in a circular grid to form a primary receiving array of small pickup antenna elements; a secondary reradiating array of elements, and a set of rf delay lines connecting, on a one-to-one basis, primary-to-secondary radiating elements."

The Philco-Ford lens array is

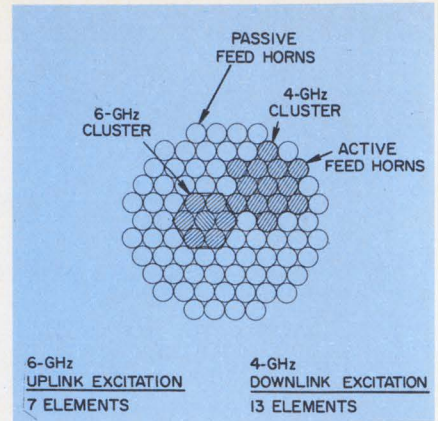
illuminated by feed horns arranged in a circular cluster. Each of the beams requires several feed horns. The feed horns needed for all of the beams illuminate the lens array simultaneously. The position of the feed horns generating each beam determines the direction of the pencil beam that comes out the other side of the lens array.

### Circular feedhorn cluster used

If single feed horns were used, the sidelobes of the antenna pattern would be too high for isolation of the multiple beams that are simultaneously generated, Scott notes. Philco-Ford solves the problem by using a circular cluster of feed horns to create each beam. The center horn is the primary feed, and the adjacent horns are phased so that phase cancellation of their signals brings the sidelobes at least 34 dB below the primary beam. At 6 GHz the feed cluster requires seven elements and at 4 GHz 13 elements to get sufficient isolation.

### Printed circuits in lens array

In the experimental antenna that Philco-Ford is constructing, the lens will be a circular array



A cluster of properly phased feed horns is necessary to keep the sidelobes at least 34 dB down from the main pencil beam. This allows several beams to be generated simultaneously but which are isolated from each other.

of 400 elements on approximately one-wavelength centers. It will weigh between 120 and 150 lb. The estimated aperture efficiency of the lens is 25 to 30%.

Scott points out that "in order to get low sidelobes, not only is the feed cluster necessary; it is also necessary to have very low phase error in the lens." Since the lens phase error is a function of the phase error of each of the lens elements, an inexpensive precision element was required. Each element is a microwave delay line. The phase of each element is proportional to the length of the delay line.

The elements are constructed as orthogonal pairs. Each pair is two printed-circuit boards in the shape of an orthogonal cross. The radiating ends of the boards are curving tapers, and the delay line structures are meander lines. The delay lines are transverse electromagnetic transmission lines, and the lens is said to be of the TEM type. A typical element is about 2 to 12 in. long. The shorter elements are at the center of the lens and the longer elements are placed around the perimeter.

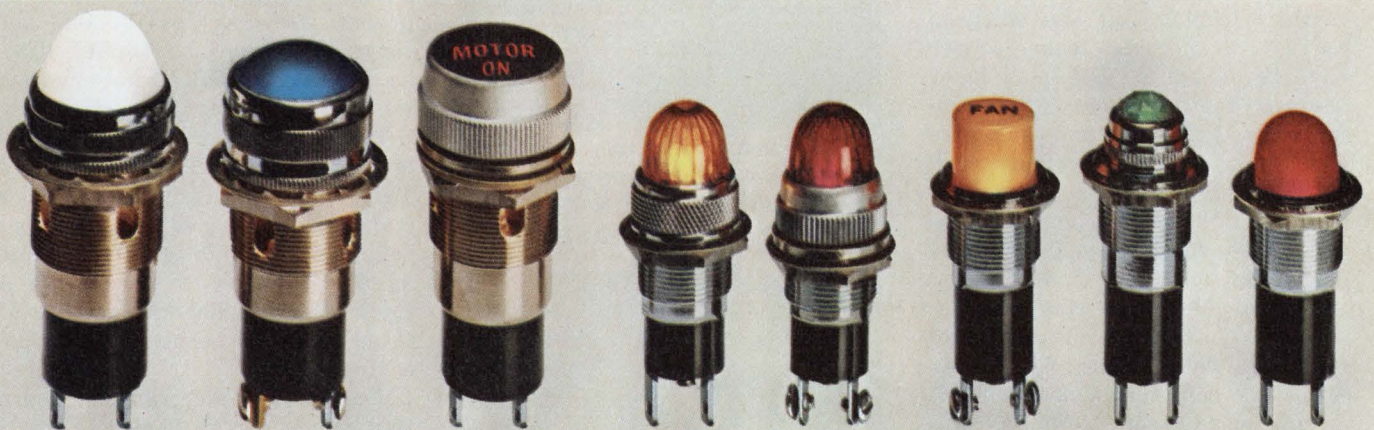
One surface of the lens is flat (outer surface), and the other is concave (feed side). The diameter of the lens will be about 5 ft and beamwidths as narrow as 1/2 degree will be feasible. The antenna is in the breadboard stage at present. ■■



# Dialight sees a need:

(**Need:** Single source supply for all indicator lights.)

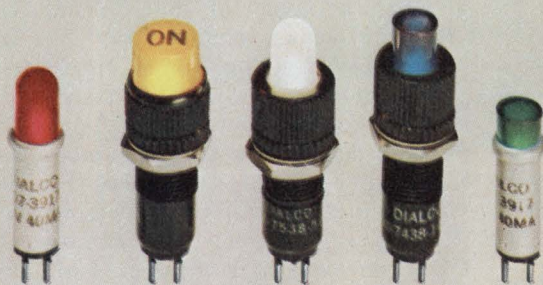
# See Dialight.



## INCANDESCENT OR NEON MINIATURE AND LARGE INDICATORS

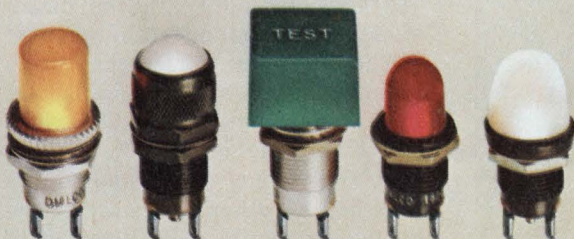
Designed to accommodate either incandescent (2-250V) or neon (105-250V) lamps for panel mounting in 11/16" or 1" clearance holes. Units meet or exceed MIL-L-3661 requirements; all are listed in Underwriter's Recognized Components Index. Wide selection of lens shapes, colors,

finishes and terminations. Many lenses may be hot stamped, engraved or offered with film legend discs. Oil-tight units with unique "O" ring construction make them oil, water and dust tight on the face of the panel. Available off the shelf for prompt delivery.



## LED, INCANDESCENT OR NEON ULTRA-MINIATURE DATALITES®

Meet or exceed MIL-L-3661. Replaceable plug-in cartridges for 1.35-125V operation. Indicators mount as close as 1/2" centers; available with red, green, amber, blue, white translucent, light yellow or colorless lenses in wide range of lens shapes, legends and finishes. Off-the-shelf.



## INCANDESCENT OR NEON SUB-MINIATURE INDICATORS

Meet or exceed MIL-L-3661. Mounts in 15/32", 1/2" or 17/32" clearance holes. Incandescent for 1.35-28V; neon has patented built-in current limiting resistor. Choice of cylindrical, faceted, convex, flat, square and round lens shapes, colors, finishes, legends. Off-the-shelf.

## DIALIGHT

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

SEND ME FREE INDICATOR LIGHT PRODUCT SELECTOR GUIDE.





# A super-thin copper foil for PCs uses up to 75% less of the metal

Like the U.S. Cavalry galloping to the rescue, the developers of micro-thin copper foil plan to help save the circuit-board industry from assault by copper shortages.

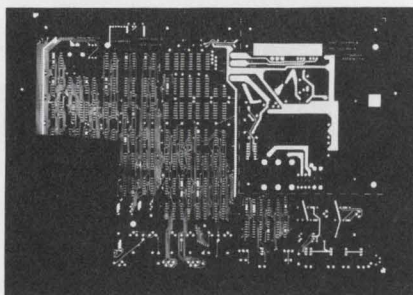
A peel-off process for manufacturing a copper foil 5  $\mu$  thick—a process that could mean copper savings of up to 75% plus labor savings for suppliers of micro-miniature PC boards and could give users denser circuitry—has been developed by Yates Industries, Bordentown, N.J. The company produces and supplies copper foil to electronics and other industries.

The announcement was made by Bernard C. Alzua, technical director of Cu-Tronics, Inc., Timonium, Md., a company that makes printed-circuit boards from laminates supplied by U.S. Polymeric, Stamford, Conn. Alzua has worked closely with Yates and has provided feedback on how the foil might best be used in the printed-circuit-board industry. Yates sends the processed copper foil to U.S. Polymeric, and that company laminates the foil to PC boards for such users as Cu-Tronics, Inc.

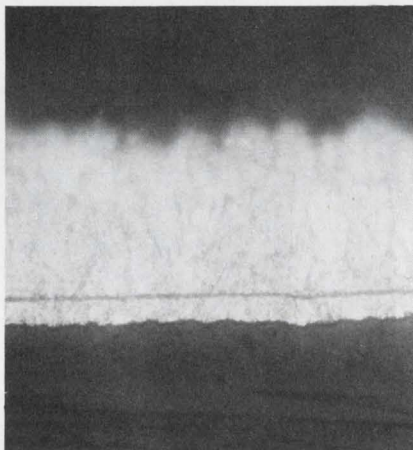
## Smaller width and lower spacing

In an interview, Alzua said that he had made several micro-miniature PC boards (Fig. 1) and that the most important result for designers was that minimum line width of 0.004 in. and spacings as low as 0.003 in. had been readily achieved. By contrast, conventional 1-oz. copper is 0.0014 in. thick, and the minimum line width is only 0.008 to 0.010 in. Alzua says he expects 0.002-in. line and 0.002-in. spacing in the future.

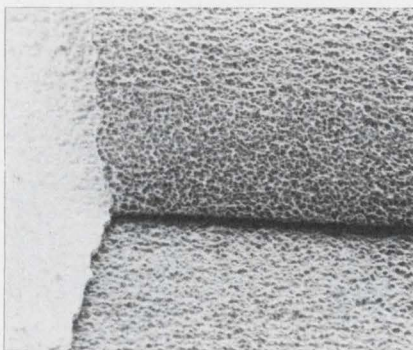
According to Alzua, electrode-



1. This actual size micro-miniature circuit design was made possible by the peel-off method of micro-thin copper.



2. Cross-section of the copper foil shows (top to bottom) carrier layer of copper, barrier line, and micro-thin layer of copper.



3. The thick layer of copper is peeled away leaving a five micron thick layer of copper.

posited copper foil 5  $\mu$  thick now can be smoothly laminated to the surface of a substrate, such as the epoxy glass series, polyester, phenolic and flexibles. This was impossible before the copper peel-off process was developed because the copper could not be applied flawlessly to the surface; what emerged was copper that was porous.

Use of micro-thin copper for circuit boards became practical when Yates electrolytically deposited a standard 2-oz. (.003 in.) copper foil, then laid in a barrier and built a second layer of copper 5  $\mu$  thick (Fig. 2). The combination of these two foils behave exactly like a single foil.

The bonding side of this micro-thin copper can be variously treated by the copper manufacturer to adhere to the type of substrate being used. Then the thick layer can be easily peeled off, leaving a 5- $\mu$  thick layer of fine, clean, virgin copper surface (Fig. 3). The copper peeling can be resold to a manufacturer who can recycle it.

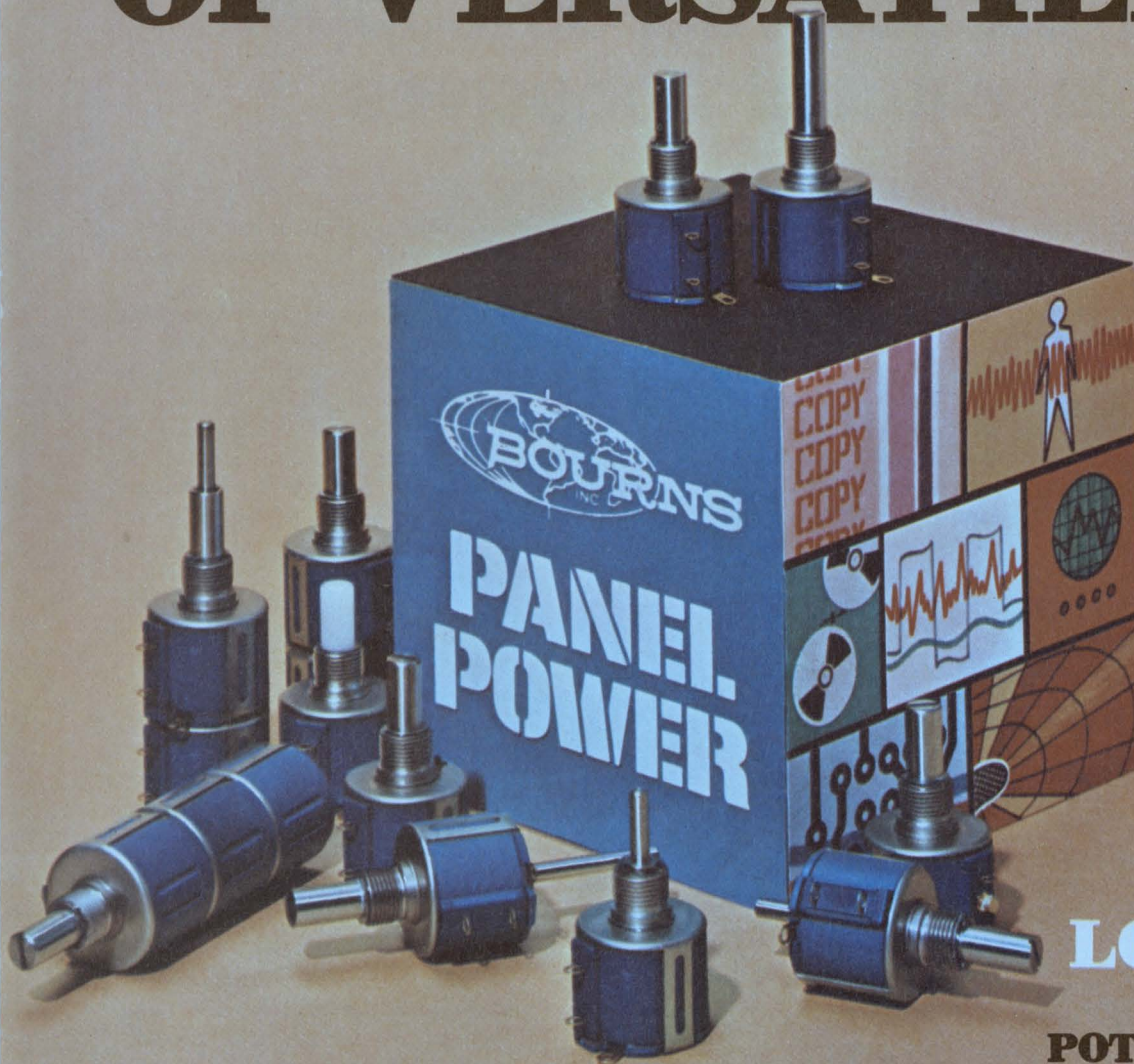
Apparently there are only a few disadvantages to using micro-thin copper. One is that micro-thin copper laminates may be from 25% to 40% higher in cost than the conventional 1 and 2-oz. laminates. Another is that someone has to peel off the top layer of copper manually or mechanically.

But, according to Alzua, the advantages far outweigh the disadvantages. Advantages that are of special interest to designers, and other users of circuit boards, are finer line control, smaller hole diameters, higher density of circuitry, no solder slivers and no pits and dents. Other advantages: no deburring of the hole after drilling, a reduction of 75% in etching time, etchant savings up to 80%, no undercut due to etching. ■■

Richard L. Turmail  
Associate Editor



# A MODEL OF VERSATILITY!



**BOURNS**  
**Model**  
**3540**  
**LOW-COST**  
**PRECISION**  
**POTENTIOMETERS**

## LOOK AT THE STANDARD OPTIONS

- Dual-section, common shaft
- Dual-section, concentric shaft
- 3-turns; 5-turns
- Extended shafts
- Rear shaft extension
- Flat on shaft
- High torque
- 1% T. R. tolerance
- .1% Independent linearity
- Center tap
- 1/4" dia. bushings,
- 1/8" dia. shaft

## LOOK AT THE FEATURES

- Small Size; 7/8" dia. x 3/4" long
- Linearity: 0.25%
- Rotational Life: 1,000,000 shaft revs.
- Non-cemented, all-mechanical assembly
- Molded-in, shaft-to-rotor construction
- Bourns exclusive SILVERWELD® Termination

## COMPETITIVELY PRICED

only \$3.97 for the basic, standard 3540 model in production quantities. All prices are in U.S. dollars; F.O.B., U.S.A.

## AVAILABILITY:

Contact your local Bourns representative, distributor, field sales office, or the factory direct for delivery and further details.





# One-step process bonds copper to ceramic without adhesives

A one-step process for attaching copper foil to ceramic substrates like aluminum oxide and beryllia uses no adhesives. The new method—called Direct Copper Bonding by its developer, General Electric—is reported to be simpler, less expensive and more reliable than present methods of ceramic IC assembly.

The process can replace gold in IC packages, GE says.

According to James F. Burgess,

staff member at GE's Research and Development Center, Schenectady, N.Y., other advantages include:

- The copper-ceramic bond routinely exceeds 20,000 psi.
- The electrical resistivity of the bonded pattern is essentially that of pure copper.
- Despite differences in the coefficients of expansion between copper and the ceramics, repeated thermal cycling from 77 K to 300 C

does not cause mechanical failure.

- Holes in the ceramic can be sealed hermetically.
- Thick-film conductor screening and firing steps are eliminated.
- Brazing and hard soldering do not cause bond failure.

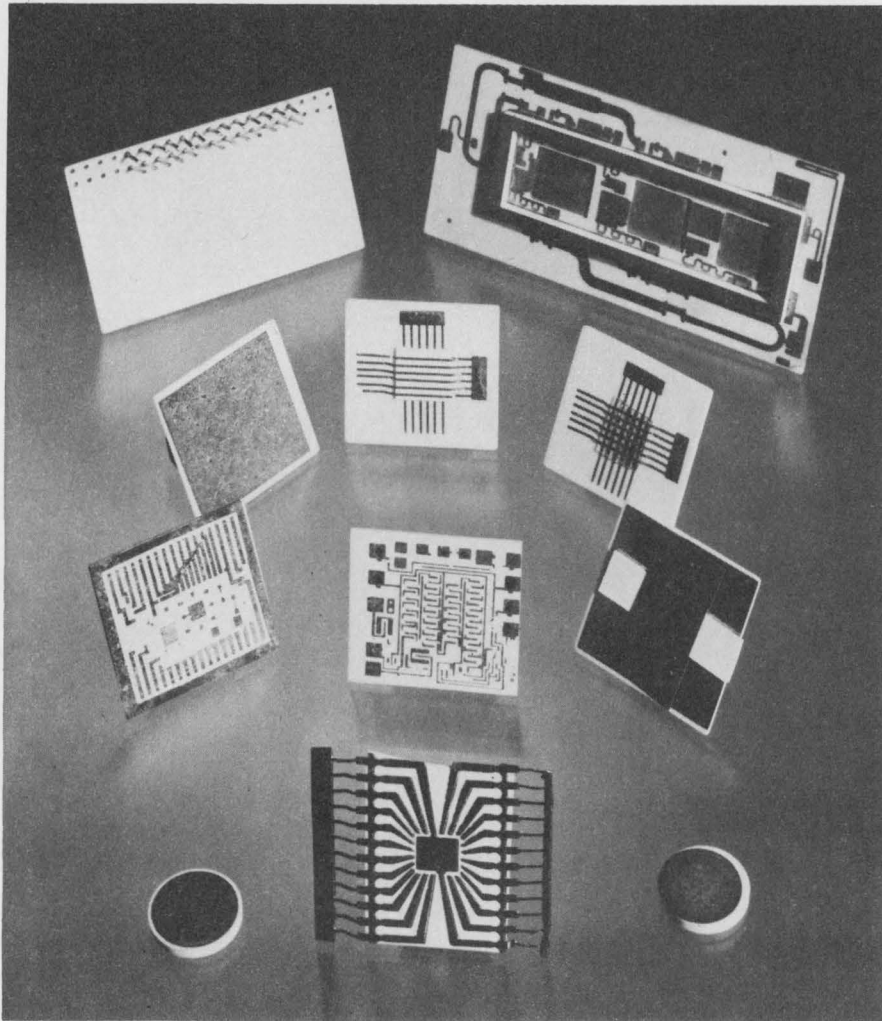
Burgess, who developed Direct Copper Bonding with Dr. C. A. Neugebauer and G. T. Flanagan, sees the process leading to improved heat-sinking of ceramic packages of all kinds. In addition, he says, it will be used in the fabrication of microwave IC packages and hybrid IC devices. Foils of 1 to 20 mils can readily be bonded, Burgess reports, but the process is also effective with copper sheets 1/4-in. or more thick.

## A eutectic is formed

The process creates a bond by heating copper in contact with a ceramic in a controlled, inert gas atmosphere that contains only a few hundredths of 1% of oxygen. The heat causes oxygen in the controlled atmosphere and the copper on the surfaces of the foil to form a eutectic—a mixture of copper and oxygen with a melting point that is lower than that of pure copper.

By careful regulation of the process temperature between the eutectic melting point of 1065 C and that of the copper (1083 C), the eutectic on the surface of the copper melts into intimate contact with the ceramic substrate. A strong bond is thus created without extensive diffusion of the two into each other.

Burgess points out that fabrication costs are considerably below those of conventional bonding methods because of the simplicity of the process and lower materials cost. ■■



A new direct-bonded copper process, by GE, was used to fabricate the conductor patterns on the ceramic packages. Copper heat sinks are also applied.



We stock more than 1,000 different types of coaxial connectors. From low-cost UHF types to the latest MIL-C-39012 designs. Sub-miniature SMA and SUB-Minax 27 Series, BNC, TNC and N Series.

But if that doesn't solve your problem, we've got more designs and options available than anyone else. Our vast file of engineering drawings and design variations



means that a call to us can literally put you in touch with as many as 90,000 different microwave interconnections. And if you still need something special, we'll custom-design it for you.

We mean business. Call your local Amphenol sales office, distributor or Amphenol RF division, Bunker Ramo Corporation, Danbury, Connecticut 06810. 203/743-9272.

**BUNKER RAMO** AMPHENOL

**One call will put you in touch  
with 90,000 different RF connectors.**





# Simplified waveform digitizer uses TV camera to capture the trace

After attempting for two years to obtain costly dual-gun scan converter tubes that would work satisfactorily in a waveform digitizer, researchers at Sandia Laboratories discarded that approach. Instead, they developed a digitizing system that costs less and simply takes a TV picture of a scope trace.

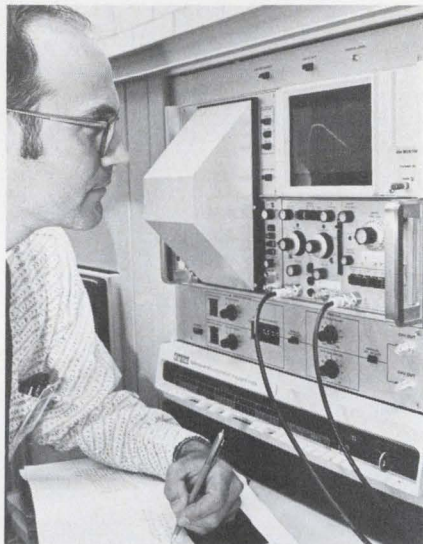
The TV camera output is then digitized and fed to a computer for analysis, as well as being displayed on a CRT in the digitized form. The system has several unusual features:

- It can be used with any commercial oscilloscope.
- Waveforms—whether fast transients or repetitive ones—can be digitized with an effective sampling rate of up to 25 GHz.
- A Polaroid camera can take photos of the trace being digitized.
- The system provides baseline—as well as waveform—digitizing, thereby freeing the operator of the need to adjust the oscilloscope trace position precisely.
- The system is available in two versions—for use in the laboratory and the field.

"In the original development, using dual-gun scan converter tubes, we obtained only two good ones out of 10," says Thomas L. Evans, a co-developer of the new system at Sandia in Albuquerque, N.M. "A major problem was dirt particles in the tube, which worked at 10 kV. The dirt caused voltage breakdown, and with 10 kV feeding into a chassis full of logic, we no longer had any logic."

The new system, Evans explains, consists of seven elements, a silicon-diode-array vidicon tube mounted in a commercial TV camera, an oscilloscope, mirror, beam splitter, logic chassis, display unit and Polaroid camera.

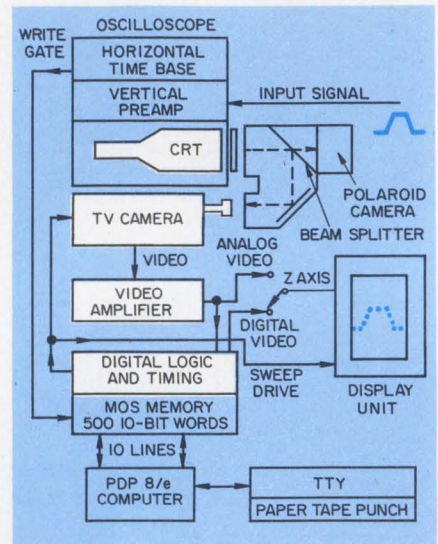
Light from the oscilloscope trace



The Sandia vidicon digitizer is checked by Thomas Evans, one of the developers. At top is the display, and below it the digitizer and computer.

is coupled to the target of the vidicon through a beam splitter and mirror (see figure). The vidicon tube converts the light image to an electrical signal that is fed to a logic chassis. In the logic section the signal is sampled and converted to a series of 500 words of 9 bits each. These digital words are stored in an MOS memory, from which the data can be extracted and viewed on the display unit. The data can also be sent to a minicomputer—in Sandia's case, a PDP 8/e—or other types of peripheral equipment.

For maximum accuracy, Evans points out, the vidicon digitizer is calibrated, with highly accurate amplitude and time signals, before the waveforms are digitized. These calibration signals are analyzed by the PDP computer. The computer uses the calibration factors to scale the data directly in engineering units and to correct for horizontal and vertical nonlinearities.



System configuration of the Sandia digitizer includes an MOS memory, whose contents are recirculated for display or computer entry.

The accuracy of the digitizer is limited only by its resolution, Evans points out. To verify this, Sandia measured pulse amplitudes independently with an oscilloscope differential-comparator amplifier. Pulse widths were measured with a time-interval counter. The digitizer always agreed within  $\pm 2$  digital counts (0.4% of full scale) of the scope and counter measurements.

Test results have demonstrated that single-shot transients can be digitized at sweep rates of 2 ns per division. Since 500 digital samples are obtained, this represents a sampling interval of 40 ps.

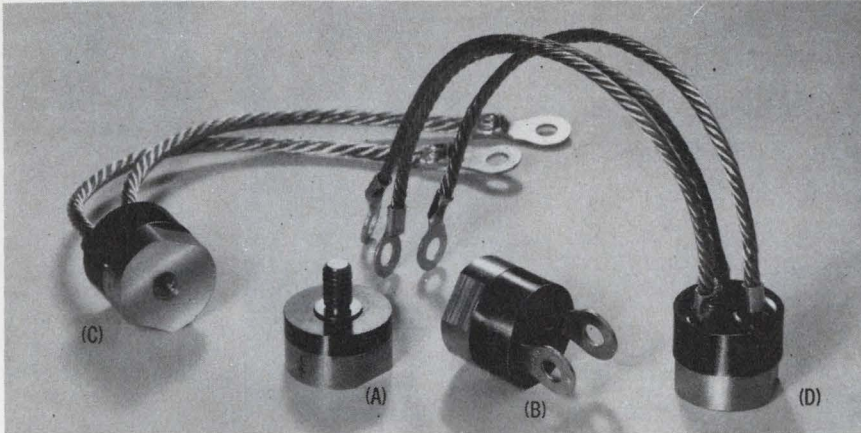
The compact field version includes the digitizer and an accessory case containing the TV camera, camera mount, digital cassette recorder and cables.

The field model also has an added static MOS memory that is compatible with either fast or slow peripheral devices. ■■



## FAST RECOVERY POWER RECTIFIERS

Reverse Recovery ( $T_{rr}$ ) 200ns and 2  $\mu$ s



## CUPAC 150

... the power house

CuPac 150 is specifically designed for high frequency-high power applications. CuPac 150 is capable of supplying up to 150 amperes with proper heat sinking. Available as half wave rectifier, doublers, center taps and three phase half wave bridge circuits.

Internally, CuPac 150 utilizes Semtech's Metoxilite rectifiers mounted on an (OFHC) oxygen-free hard copper insert base. Inherent rugged design and reliability enables the CuPac 150 to be used in stringent commercial, industrial, military and space applications.

Body Dimensions: 1.12" D x .70" H (+ stud)

FAST RECOVERY — ( $T_{rr}$ ) 200ns. (Fig. A)

Peak Inverse Voltage: 50, 100, 200 & 400V.

$V_F$  (max.) (@ 100A): 1.40V,  $T_j$  @ 25°C; 1.35V,  $T_j$  @ 100°C.

Reverse Current (max.) @ PIV: 25  $\mu$ A @ 25°C; 1 MA @ 100°C.

MEDIUM RECOVERY ( $T_{rr}$ ) 2  $\mu$ s.

PIV: 50, 100, 200, 400, & 600V.

$V_F$  (max.) (@ 100A): 1.22V,  $T_j$  @ 25°C; 1.17V,  $T_j$  @ 100°C.

Reverse Current (max.) @ PIV: 25  $\mu$ A @ 25°C; 1mA @ 100°C.

## CUPAC 150, LO- $V_F$

Peak Inverse Voltage: 30 & 50V.

Reverse Recovery: 85ns (typ.) & 100ns (max.)

### • 1/2 WAVE RECTIFIER

	@ 25°C	@ 100°C	@ 150°C
$V_F$ (typ.) @ 20A	.86V	.77V	.72V
$V_F$ (typ.) @ 60A	.95V	.88V	.85V
$V_F$ (typ.) @ 100A	1.02V	.97V	.93V

### • DOUBLERS & CENTER TAPS Figs. (B) & (C)

Body Dimensions: 1.12" D x .9" H (+ leads).

FAST RECOVERY ( $T_{rr}$ ) 200ns

PIV: 50, 100, 200 & 400V.

$V_F$  (max.) (@ 50A): 1.40V @ 25°C; 1.35V @ 100°C.

Reverse Current, per leg (max.):

13  $\mu$ A @ 25°C; 500  $\mu$ A @ 100°C.

MEDIUM RECOVERY ( $T_{rr}$ ) 2  $\mu$ s.

PIV: 50, 100, 200, 400 & 600V.

$V_F$  (max.) (@ 50A): 1.22V @ 25°C; 1.17V @ 100°C.

Reverse Current, per leg (max.):

13  $\mu$ A @ 100°C; 500  $\mu$ A @ 100°C.

### • 3 PHASE 1/2 WAVE BRIDGE Fig. (D)

Body Dimensions: 1.12" D x .9" H (+ leads).

FAST RECOVERY ( $T_{rr}$ ) 200ns

PIV, per leg: 50, 100, 200 & 400V.

$V_F$  (max.) @ 33A: 1.40V,  $T_j$  @ 25°C;

1.35V,  $T_j$  @ 100°C.

Reverse Current, Per Leg @ PIV:

10  $\mu$ A @ 25°C; 350  $\mu$ A @ 100°C.

MEDIUM RECOVERY ( $T_{rr}$ ) 2  $\mu$ s.

PIV, Per Leg: 50, 100, 200, 400 & 600V.

$V_F$  (max.) @ 33A: 1.22V,  $T_j$  @ 25°C;

1.17V,  $T_j$  @ 100°C.

Reverse Current, Per Leg @ PIV:

10  $\mu$ A @ 25°C; 350  $\mu$ A @ 100°C.

### • DOUBLERS & CENTER TAPS

	@ 25°C	@ 100°C	@ 150°C
$V_F$ (typ.) @ 10A	.86V	.77V	.72V
$V_F$ (typ.) @ 30A	.95V	.88V	.85V
$V_F$ (typ.) @ 50A	1.02V	.97V	.93V

### • 3 PHASE 1/2 WAVE BRIDGE

	@ 25°C	@ 100°C	@ 150°C
$V_F$ (typ.) @ 5A	.86V	.77V	.72V
$V_F$ (typ.) @ 15A	.95V	.88V	.85V
$V_F$ (typ.) @ 25A	1.02V	.97V	.93V

## NEW "STUD"

... Super stud rectifier



Semtech Corporation introduces the DO-5 Stud, a new series of high current silicon stud rectifiers for high frequency applications. Capable of supplying up to 50 amperes with proper heat sinking, the DO-5 Stud has been specifically designed for industrial, military and space applications.

Metoxilite rectifiers are used internally, the base is a DO-5 configuration and terminals offer easy soldering properties.

Body Dimensions: .69" D x .45" H.

FAST RECOVERY ( $T_{rr}$ ) 150ns

IR (@ PIV), Per Leg: 13  $\mu$ A @ 25°C; 500  $\mu$ A @ 100°C.

$V_F$  (max.) @ 50A: 1.40V @ 25°C; 1.35V @ 100°C.

MEDIUM RECOVERY ( $T_{rr}$ ) 2  $\mu$ s.

PIV: 100, 200, 300, 400, & 600V.

IR (@ PIV), Per Leg: 13  $\mu$ A @ 25°C; 500  $\mu$ A @ 100°C.

$V_F$  (max.) @ 50A: 1.22V @ 25°C; 1.17V @ 100°C.

## LO- $V_F$ "STUD"



... Low forward voltage drop.

LO- $V_F$  stud rectifier is specifically designed for high frequency, high power applications.

VERY FAST RECOVERY ( $T_{rr}$ ) 100 ns.

Peak Inverse Voltage: 30V.

	@ 25°C	@ 100°C	@ 150°C
$V_F$ (typ.) @ 10A	.86V	.77V	.72V
$V_F$ (typ.) @ 30A	.95V	.88V	.85V
$V_F$ (typ.) @ 50A	1.02V	.97V	.93V

"We're number 1 because we try harder"



**SEMTECH CORPORATION**

652 Mitchell Road, Newbury Park, California 91320  
(805) 498-2111, (213) 628-5392 / TWX: 910-336-1264

CHICAGO: (312) 352-3227

DALLAS: (214) 253-7644

FLORIDA: (305) 644-5404

NEW JERSEY: (201) 654-4884

SAN FRANCISCO: (415) 328-8025

EUROPEAN SALES: (Switzerland) (042) 232-242





...when one has a sure thing it is hard to resist showing off a little. Just as the royal flush is a guaranteed winner in poker, Futaba parts mean the same certainty for most major Japanese manufacturers. Precision manufacturing and reliability of performance are two reasons. Another great reason is constancy of supply. No matter how good parts are, this means nothing if they are not available when needed. With modern, high-capacity manufacturing facilities, this is where Futaba holds a real winning hand. Futaba parts—just ask for them.



Standard keyboard switches and key tops available from FUTABA stock for instant keyboard layout on your mounting plate.

**OTHER FUTABA PRODUCTS:**

- Press die sets.
- Mold bases for plastics.
- Material feeders for press work.
- Automatic stopping devices for automatic machinery.
- Radio control for hobby aircraft, race cars, etc.

**WE DON'T MEAN  
TO SHOW OUR HAND, BUT...**



**"FUTABA—THE BRIGHT PRODUCER"**

● For additional information, please contact:

**FUTABA INDUSTRIES U.S.A.**  
630 West Carob Street, Compton, California 90220, U.S.A.  
Phone: (213) 537-9610 Telex: 69-1227

**FUTABA ELECTRONIC INDUSTRIES LIMITED**  
Super Bldg., 1-11-5, Sotokanda, Chiyoda-ku, Tokyo, Japan. Phone: 255-5881  
Telex: J26532



# Still fighting snap, crackle and pop?



Noise has a way of showing up in circuits. Bendix has a way of preventing it. Filter connectors. Boasting some of the best attenuation curves available, Bendix filter connectors solve a wide range of low-pass filter problems. Small wonder Bendix is first choice in the fight against snap, crackle and pop.

These versatile connectors, production tooled, are available in a wide range of cylindrical and rectangular configurations designed to meet most any industrial, commercial and military application.



Configurations that can be intermateable with most MIL-Spec and popular commercial connectors and special designs for advanced state-of-the-art equipment. There's sure to be one that meets your attenuation and frequency requirements. You'll like what you hear when it comes to the price, too. And that goes for delivery as well.

Write for our new catalog. It's yours for the asking. The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.





# There's only one cermet film resistor with enough design improvements to set a new standard of quality.

Ultra thick solder coated wire leads are both weldable and solderable.

Capless design does away with problems associated with end cap construction.

Conformal coating provides outstanding insulation properties.

Alumina core is physically and thermally strong to resist fractures.

Crisp, clear, dual markings for easy identification.

We blended our extensive fixed resistor knowhow with 15 years of cermet experience to produce an outstanding cermet film resistor. And we've developed unique manufacturing techniques that let us provide consistent quality.

Available in preferred resistance values (E96 Series) from 10 ohm to 1 meg; higher values available on special order. 1/4 watt at 70°C; 1/8 watt at 125°C; 1% tolerance; 100 PPM. Size 0.250 L. by 0.090 D.

Available in tape reels if you prefer.

Approved to MIL-R-10509 for Style RN55; Characteristic D. Write Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204 for complete technical details on Type CC. International Division, Milwaukee, Wisconsin 53204. Canada: Allen-Bradley Canada Limited, Cambridge, Ontario. United Kingdom: Allen-Bradley Electronics, Limited, Jarrow, County Durham NE32 3EN.

**If you're really serious about cost, be serious about quality.**



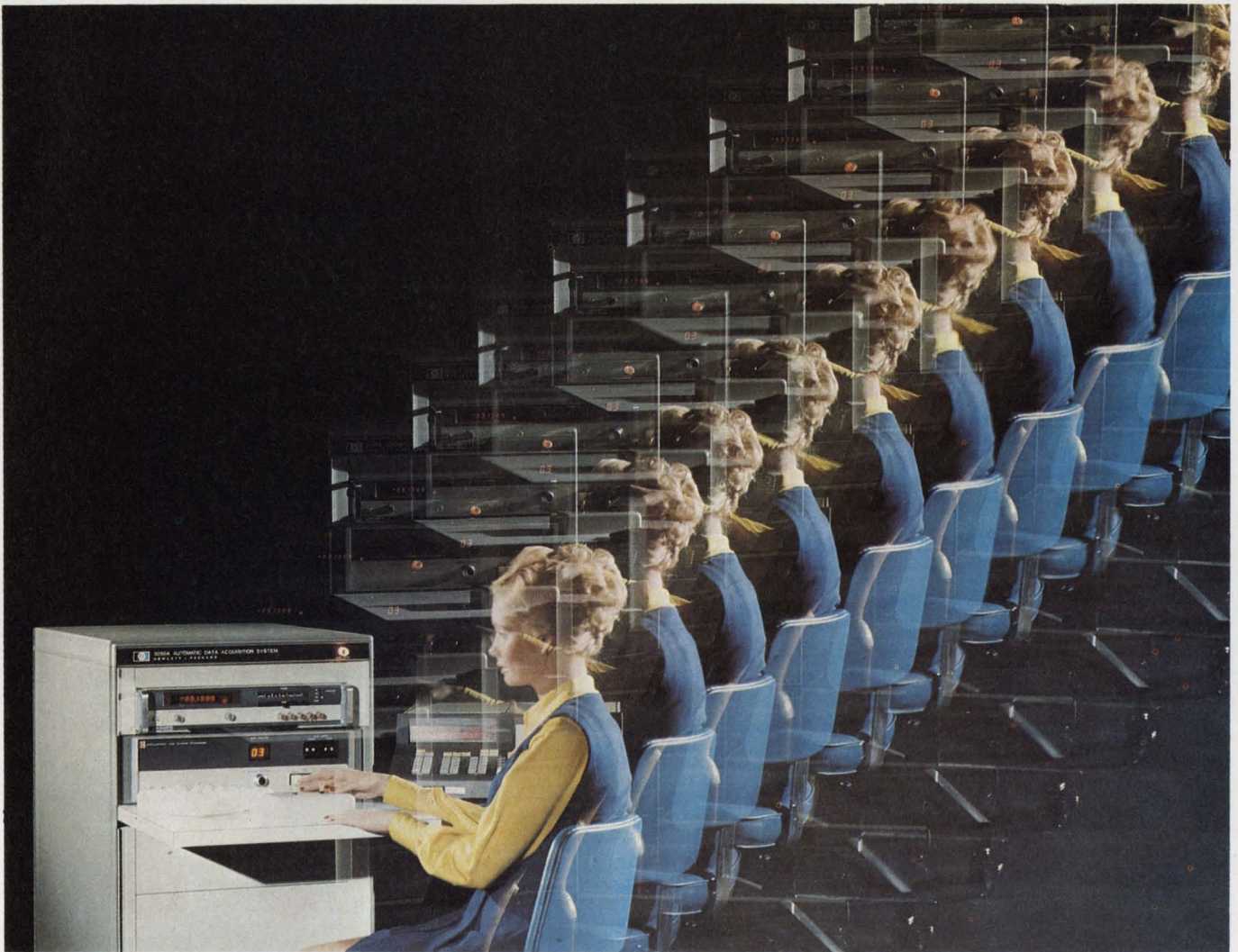
**ALLEN-BRADLEY**

Milwaukee, Wisconsin 53204

INFORMATION RETRIEVAL NUMBER 35

EC69





# Multiply your output...

...by adding one HP 3050A Automatic Data Acquisition System.

One 3050A can multiply your production output by as much as ten over manual test methods. Or, it can reduce testing time in R&D while boosting your testing capability. HP's 3050A eliminates most manual operations in AC V, DC V and Ohms Measurements. No more manual switching, no more visual monitoring or manual transcribing, no more data analysis... the unit's multi-channel scanner, DVM, and programmable calculator do all those things automatically. This system makes pass-fail decisions on the spot or prints out your test data, in the units you want, for rapid analysis. You get more efficient, more comprehensive testing while reducing testing errors.

Whether you have a manufac-

turing testing or an R&D application, easy-to-learn algebraic or BASIC programming language lets you program the system for your specific testing needs. You can select up to 100 individual channels, change ranges and functions on the DVM, analyze and store data, and print the results... all under calculator control.

Dry-reed relays and DVM resolution to  $1 \mu\text{V}$  lets you monitor low-level transducer outputs as well as large AC signals and DC levels to 200V. Computational power of the 9820A calculator controller (or optional 9821A and 9830A) allows you to do calculations and data analysis, thus eliminating data reduction tasks. You can convert measurements to engineering or scientific units, linearize and compensate transducer outputs, calcu-

late average values and standard deviation, perform design computations, and more... all automatically. And an optional page printer and X-Y plotter can save you hours preparing tabulated data and graphs.

Couple this capability with the system's operational simplicity—which lets you free skilled people for other tasks—and you can see why the 3050A is finding wide use in testing and data acquisition applications.

Contact your local HP field engineer for information on applying the 3050A to your testing situation. Or, write Hewlett-Packard.

HEWLETT  PACKARD

Sales and service from 172 offices in 65 countries.  
1501 Page Mill Road, Palo Alto, California 94306

INFORMATION RETRIEVAL NUMBER 36







# Reliability is a thousand relays when you need them.

These days, buying reliable relays isn't enough. They have to be available when you need them. And when you need a lot of relays you want a supplier who won't let you down. You can count on GTE Automatic Electric to supply the quantities you need, on the schedule we promise.

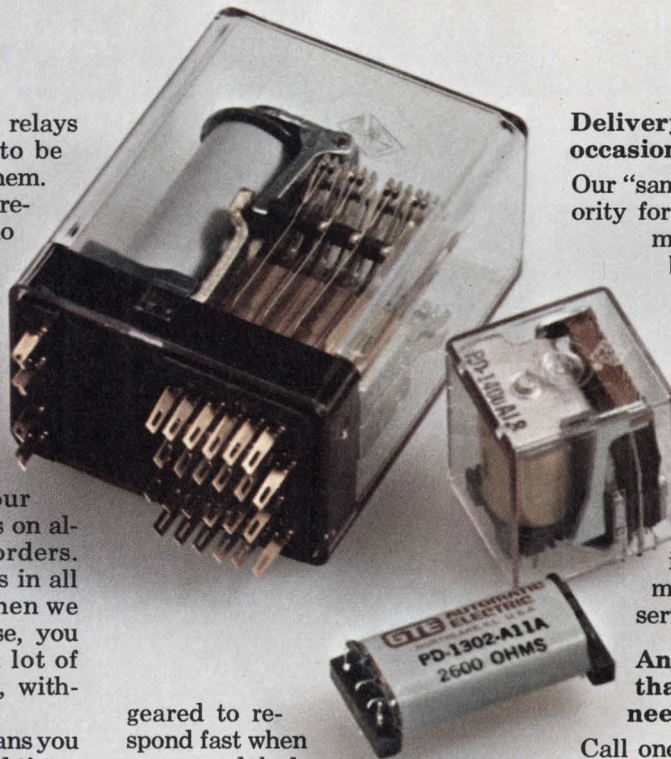
## We'll match our delivery record with anyone.

In the past year, we met our scheduled delivery promises on almost 100% of all relay orders. That's on all types of orders in all types of situations. So, when we give you a delivery promise, you can count on it without a lot of time-consuming expediting, without "check-up calls."

Don't think our record means you have to put up with long lead times either. We'll quote you shorter delivery schedules than just about anybody. And we'll make those schedules, too. On big orders — or little ones.

## Quick off-the-shelf delivery.

You can get over 200 kinds of relays from our stock, whether it's a little correed or a stepping switch with 400 contacts. So we can promise delivery of inventoried items in just a few days. Over one-third of our orders are "rush" and "off-the-shelf." That means we're really



geared to respond fast when you need help.

## How can we do it?

When everything else seems to be on allocation, how can GTE Automatic Electric be improving delivery times? Good question. The answer is improved manufacturing facilities to keep up with our increasing sales of high-quality relays. We take full advantage of high volume production equipment and techniques. And we have long-term commitments from our material suppliers. The more relays you need, the more you need us.

## Delivery programs for special occasions, too.

Our "sample service" gives top priority for prototypes or evaluation models. We ship custom-built samples in as little as two weeks. We also have a "programmed order plan" for trimming your bulging inventories. Just give us an annual order, and a delivery schedule. We produce and ship to meet your needs. And these delivery services are offered at no increase in price. We don't make you pay extra for service you deserve.

## An expensive relay is one that's not there when you need it.

Call one of our regional offices to set up a delivery program you can trust. You'll find our prices are more than just competitive.

Northlake, Illinois:  
312-562-7100 Ext. 324

North Hollywood, California:  
213-766-5203

Stamford, Connecticut:  
203-329-0981

Falls Church, Virginia:  
703-533-0636

GTE Automatic Electric,  
Northlake, Illinois 60164.

# **GTE** AUTOMATIC ELECTRIC





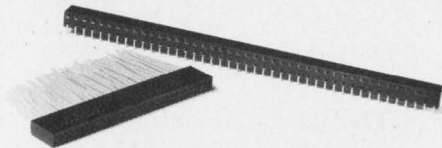
# “CANNON’S ADAPTA-CON CONNECTORS MADE A BELIEVER OUT OF MANAGEMENT, and a hero out of me.”

**“But it started with  
Bronx cheers.”**



“I kept my cool when they blew their collective top at the mention of my specifying Cannon. I knew they still connected Cannon with aerospace cost, not aerospace expertise.

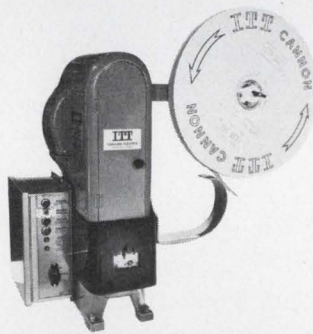
“So I laid out the facts and figures on Adapta-Con: Mates with 0.025" sq. posts; 0.100", 0.0125", 0.150" grid spacings; single or double row; low insertion force; low cost.



“But I told them that’s just the beginning. With Adapta-

Con we can use one connector type for all our equipment. For plugging to feed-through posts, back-panel tails, as I/O connectors, and jumpers. They’ll outlast most edgecard connectors. Want to hear more? I said. They did.

**“It puts a crimp in  
your costs, too.”**



“So I brought up Cannon’s automatic strip-and-crimp machine. It strips and crimps twisted pairs, jacketed cable and hard-coated wire, handles up to four gages at a single setting, and is faster and simpler to operate.

“They balked at capital expenditure, but brightened up when I explained we can lease it and more than make

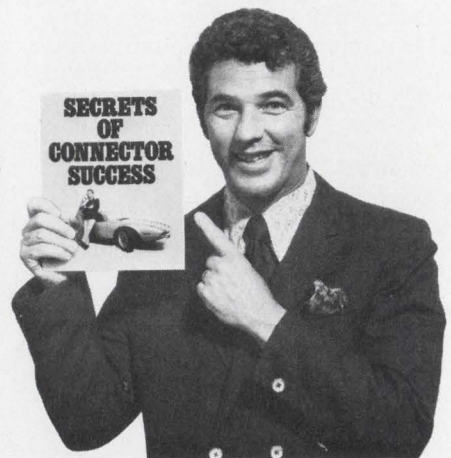
up the monthly charge by what we’ll save in just a week’s lower wire preparation costs.

“That cooled them off. And when Cannon delivered what it promised, on time, within cost, the cheers broke out. Real cheers this time.

“Want to know how I did it? It’s in this book. Send for it today. Cheers.”

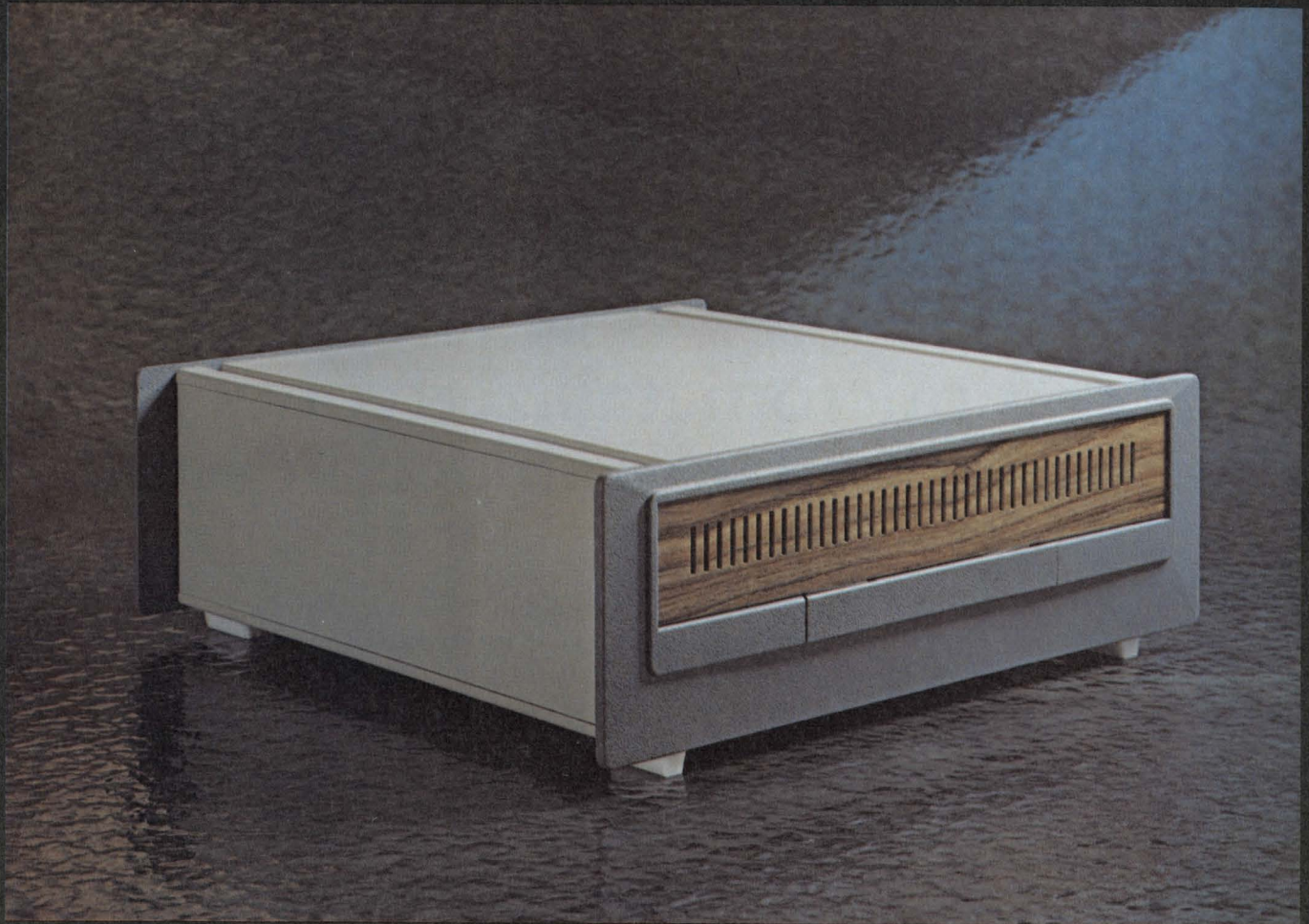
ITT Cannon Electric, International Telephone and Telegraph Corporation, 666 East Dyer Road, Santa Ana, CA 92702. (714) 557-4700.

**“Success starts here.”**



**CANNON ITT**





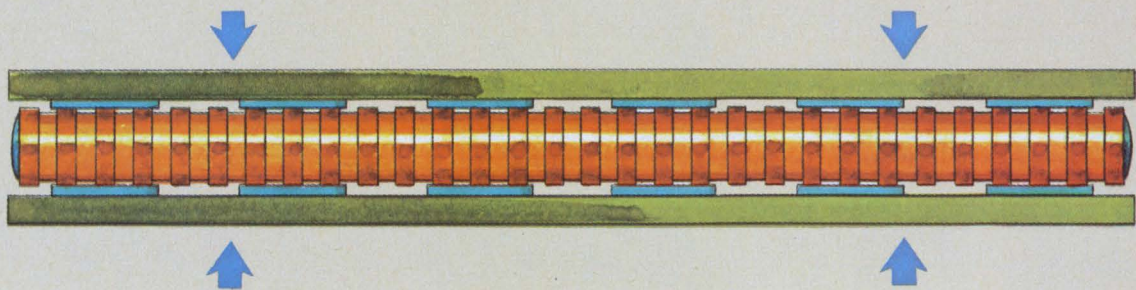
## ***The Optima Experience***

The Optima experience—it's colorful, stylish and now a great new way to package your electronics. We call it OptimaPAK. There is nothing like this case on the market today. Molded sculptured sides with handles neatly designed in... easily removed top and bottom panels and that's not all. The front and rear panels are part of a chassis assembly that slides right out of the front of the case or you may just want to mount it in a rack. We are eager to tell you all about OptimaPAK and share the Optima experience right now.

# **OPTIMA**pak

Write Optima Enclosures, a division of Scientific-Atlanta, Inc.  
2166 Mountain Industrial Blvd., Tucker, Georgia 30084 or call (404) 939-6340.



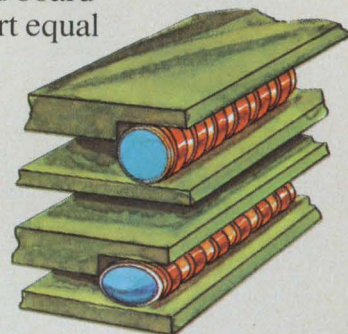


## Our new micrometallized connectors. We made them work under pressure.

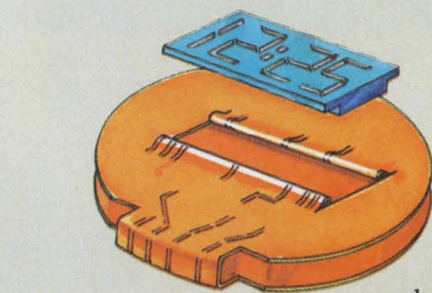
By combining micro-circuitry with an elastomer. Then the whole innovative package is placed between parallel planes of any hard board circuitry. So the elastomer can exert equal pressure along its entire length.



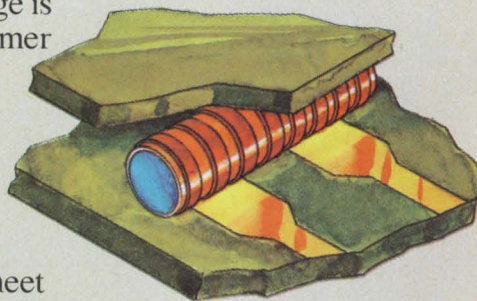
That's our extraordinary elastomer interconnection system. It's ideal for liquid-crystal displays in electronic watches. And for other products that demand advanced connection techniques.



Circuit paths are isolated from one another, and since we offer extremely fine resolution, multiple redundancy to the interconnected components is certain.



Another advantage is the fact that the elastomer rod can "float" within the micrometallized circuitry for unmatched resistance to shock and vibration. For easy handling and precise location, tabs and sprocket holes are available.



You can also be assured that AMP can meet your microelectronic interconnection needs: AMP Elastomate comes in a wide variety of cross-sections, lengths and circuit-path widths. But best of all, it doesn't take much pressure to make it work efficiently and economically for you. Just call (717) 564-0100. Or write AMP Incorporated, Harrisburg, Pa. 17105.

**AMP**  
INCORPORATED  
INFORMATION RETRIEVAL NUMBER 40



# washington report



Heather M. David  
Washington Bureau

## **U.S. may liberalize R&D requirements**

Federal contractors have for some time enjoyed a program that gives them funds based upon a percentage of their contract work, to pursue their own research interests. This money, particularly when given by the Defense Dept., must be used on research that is relevant to the interests of the Federal agency. However, this stipulation may be changed.

Industry, according to the General Accounting Office, would like to see the relevancy test dropped completely. If there must be a test, industry would prefer that the criteria be that the R&D be "in the national interest." The Defense Dept., the biggest supplier of such money, now appears to be considering switching to this position. In fiscal 1973, the Pentagon gave its contractors \$738-million to pursue independent R&D programs.

## **Congress boosts NASA programs**

Congress has told NASA to start work on an additional Earth Resources Technology Satellite (ERTS-C) and to accelerate a solar satellite power-station study. Both the House and Senate have approved the plan and have sent to the President an authorization bill that would add \$12-million to the Administration's request for funds for space application. The next hurdle NASA faces is convincing the Office of Management and Budget that the projects should be pursued.

## **FAA to require quality-control plans on electronics**

In a move that, if successful, could spread to other agencies, the Federal Aviation Administration has initiated a program that requires manufacturers of air-traffic-control equipment, navigation aids and related items to furnish detailed quality-control plans, along with their technical proposals, bidding on contracts. The FAA will check each contractor periodically to see that he is adhering to his plan. Failure to comply could mean termination of the contract, the agency says.

## **Senate rejects Pentagon trade veto power**

Legislation that would have made the Secretary of Defense the final judge of what technology could be traded with the Soviet bloc has been modified by the Senate in a vote on the military-procurement bill. The proposal, offered by Senator Henry M. Jackson (D-Wash.), was opposed by the Administration but backed by organized labor, the Senator says.

Jackson explains that his intent was to prevent transfer of high-tech-



nology items, such as wide-bodied jets, computers and integrated circuits, that Communist nations could use to strengthen their military capability. The Defense Dept., he says, is the best place to make such decisions. But the Senate voted for a modified version of the proposal, making the Secretary of Defense co-equal with the Secretary of Commerce and other high officials in giving such advice to the President.

However, it's not all over yet, the Senate Banking and Finance Committee will consider export-control legislation in the near future.

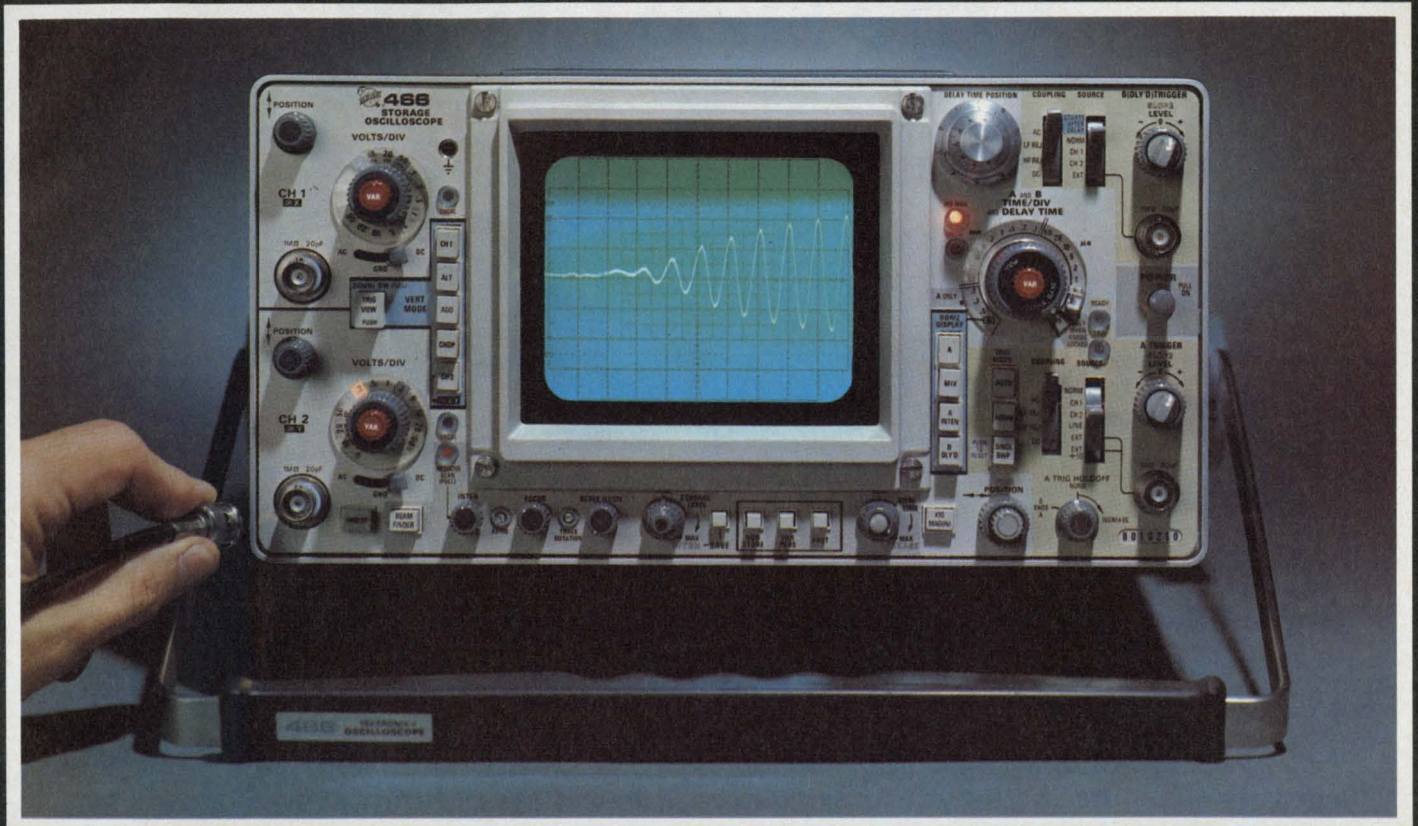
## **Design-to-cost: Real or public relations?**

The effectiveness of the Pentagon's much-ballyhooed "design-to-cost" program, aimed at bringing cost consideration into the design phase, particularly in electronic equipment, has been attacked in the Senate. "After three years," said Sen. Thomas Eagleton (D-Mo.), "design-to-cost has influenced the management of relatively few weapon systems. Despite the setting of cost goals and the bureaucratic machinery to enforce those goals, tradeoffs of excessive sophistication have not been made." He added: "Sadly we continue to prepare for combat from the inside of research laboratories, where the imagination of defense scientists far surpasses the practicality of the weapons they produce." Recent cost estimates of weapon systems, the Senator said, led him to conclude that ingrained resistance among the services had "transformed a good concept into little more than good public relations."

**Capital Capsules:** The Senate Antitrust and Monopoly Subcommittee has resumed hearings on the communications industry, focusing on allegations of anti-competitive practices by American Telephone & Telegraph. The hearings will deal with the interconnect area. . . . The Air Force's Avionics Laboratory, Wright-Patterson AFB, is seeking sources to perform exploratory microwave research and development in the area of high power microwave switches. The objective is to develop a high-power, high-speed, single-pole, double-throw microwave switch and its associated driver assembly. . . . Semiconductor industry reps have been told that a planned reclassification of silicon material as a chemical, rather than as a metal, will not alter the present exemption of silicon products from tariff regulations. WEMA got the news from the U.S. Tariff Commission. . . . The Air Force has successfully tested a fiber-optic data link for carrying flight-control signals inside an aircraft from the pilot's cockpit to the controls. Use of the fiber-optic data bus, developed by Hughes Aircraft, was the first for a fly-by-wire flight-control system. . . . Senator Birch Bayh (D-Ind.) has called once more for the termination of the phased-array, Sam-D air-defense system. He says the General Accounting Office has concluded that "even if the Sam-D technology works and even if the threat materializes," the missile will probably not be necessary if F-15 aircraft are available. . . . The Army Air Mobility R&D Laboratory, Fort Eustis, Va., is embarking on a program to demonstrate remotely-piloted-vehicle technology. It plans to award two contracts for a total of 50 aircraft with interchangeable sensors. . . . Comsat General Corp. has awarded a contract to Scientific Atlanta, Inc., for 100 shipboard antennas and associated terminal equipment as part of a major program to provide improved communications via satellite to commercial ships at sea. . . . The Defense Dept. has explained the \$7-billion cost growth reported by the General Accounting Office for 55 weapon systems. It cited the following: inflation (36%), engineering changes (25%), schedule changes (20%) and an accumulation of minor factors. The \$7-billion increase over only a six-month period ended Dec. 31, 1973, was in a large part due to such programs as the B-1 bomber, F-15 fighter, SSn688 submarine and Minuteman III missiles.



# Single-Shot Storage to 100 MHz



## for DESIGN

The 466 Portable offers the fastest stored writing rate of any Tektronix direct-view oscilloscope—1350 cm/ $\mu$ sec throughout its 100 MHz bandwidth. (5 divisions magnitude for single shot 100 MHz sine wave.) It provides up to a 5 nsec/division sweep rate through the X10 magnifier and vertical deflection sensitivity to 5 mV/division. You can view and retain fast rise, low repetition rate, single shot, or slow moving waveforms. Here are Tektronix's reliable trigger characteristics and CRT's that minimize residual image and burn problems. Now you can display phenomena that could never before be viewed with ease on an oscilloscope.

## for PRODUCTION

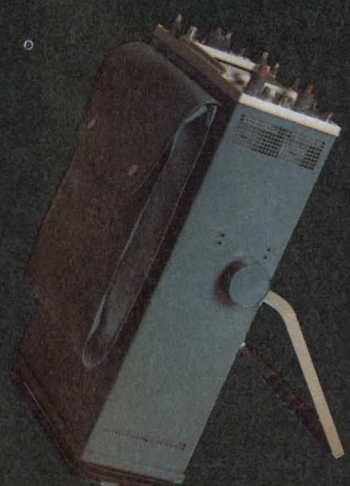
The 466's fast stored writing rate offers the production engineer unequalled capabilities. Stored waveforms are brighter—more visible in the high ambient light of assembly areas. Stored waveforms allow personnel to make faster, more accurate decisions and they permit study, comparison to a photo standard, and review by supervisors. Here is an oscilloscope that is essential in computer, aerospace, and many areas of communications. It is designed for minimum training of personnel. And on a dollar per MHz of bandwidth comparison, it is by far your best storage scope buy.

## for FIELD SERVICE

The 466 is the answer to field troubleshooting and calibrations that require the same exacting standards as those originally specified in the lab, production, or engineering. Weighing under 30 lbs., it carries easily. And the 13-position handle provides a versatile support stand. Take an instrument with Option 7 to a missile site or into an aircraft and power it with 12-24 VDC or the 1106 or 1105 battery pack. Its 1350 cm/ $\mu$ sec stored writing rate can make the Tektronix 466 your most valuable test instrument.

If the high writing speed of the 466 is not required, the 464 (which is otherwise identical) features 110 div./ $\mu$ sec. 466 Oscilloscope, \$3850. 464 Oscilloscope, \$3300.

Discover what the 466 can mean to you. For a demonstration or more information, contact your local Tektronix Field Engineer, or write Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005. In Europe write Tektronix Ltd., Guernsey, C.I., U.K.

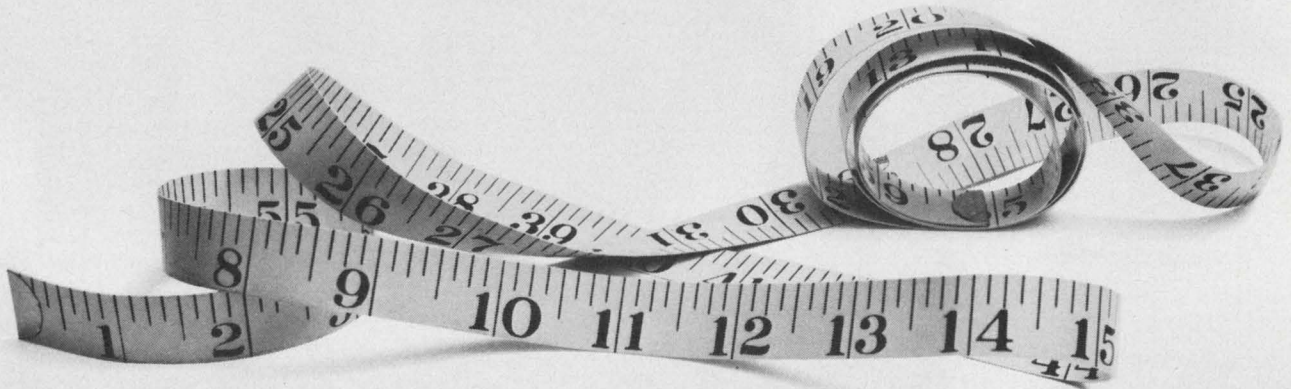


**TEKTRONIX®**

committed to  
technical excellence



# Introducing the Xerox custom-made SCU: One size fits all.



**And a perfect fit too.**

**Because our new SCU (System Control Unit) is very, very flexible.**

**So whatever controller or interface design you're planning for your digital systems, we can cover it. Handsomely.**

**Our SCU is a fully microprogrammable processor that allows direct control over hardware elements and operation sequences. It has no preset limited instruction sets. And different microprograms can make the SCU function with equally high efficiency in widely varying applications.**

**The SCU is much more than just a processor on a board. It's a complete micro-processor system that closely approaches the performance of custom hardware while avoiding most of the compromises imposed by conventional minicomputers.**

**And it's fast. Interrupt response as quickly as 350 nanoseconds, data transfer rates up to 2.85 million 16-bit words per second, complete arithmetic and logical operations in 350 nanoseconds. Plus 128 directly addressable input/output channels.**

**To show you how good the SCU is, you should know that we use it ourselves: in front-end communication processors, intelligent display systems—virtually all of our controller design applications! And it fits just fine.**

**If you'd like to try one on for size, call Xerox at (800) 421-6882. In California call (213) 679-4511, ext. 950. Or write Xerox Corporation, Dept. I 5-02, 701 S. Aviation Blvd., El Segundo, California 90245.**



# Three new Jermyn logic checkers

Our original Jermyn Logic Checker was such a resounding success that we've now brought out a whole new range, with an even better basic design.

The contact mechanism is better, to give a firm grip on the IC at all board angles.

The internal circuitry is better.

The viewing screen is better, divided into 16 segments to make pin identification nice and easy.

And the body is stronger, in high-impact glass-filled nylon.

There are three versions.

1. TTL. For positive logic TTL or DTL ICs, up to 16 pins, Vcc between +4.5V and +5.5V.
2. HTL. For positive logic HTL ICs, up to 16 pins, Vcc between +11V and +18V.
3. CMOS. Sensitive microamp version for CMOS devices up to 16 pins, Vcc between +8V and +18V.

If you've ever tried a Jermyn logic checker, you'll know just how useful it is.

If you haven't yet, you're in for a treat.

Just clip it over the logic IC, and it shows you the state of each pin, instantly, on a 16 LED display.

Lamp on = logic state 1.  
(Or open circuit, or Vcc supply, or unused pin.)

Lamp off = logic state 0.  
(Or ground.)

It doesn't matter which way round you clip it, because the checker locates the supply pins, takes its own power from them (very little, actually) and then checks the other pins.

And it doesn't matter where you clip it, on devices with less than 16 pins (8 or 14 for example).

With a little practice, you'll soon be able to check ten or more ICs a minute.

Compare that with fiddling about with probes and a CRO.

Price TTL \$85, HTL \$120, and CMOS \$165. Plus 75¢ post and packing.

Please add California Sales tax where appropriate.

Orders in today, we post today. Or ask for the leaflet.

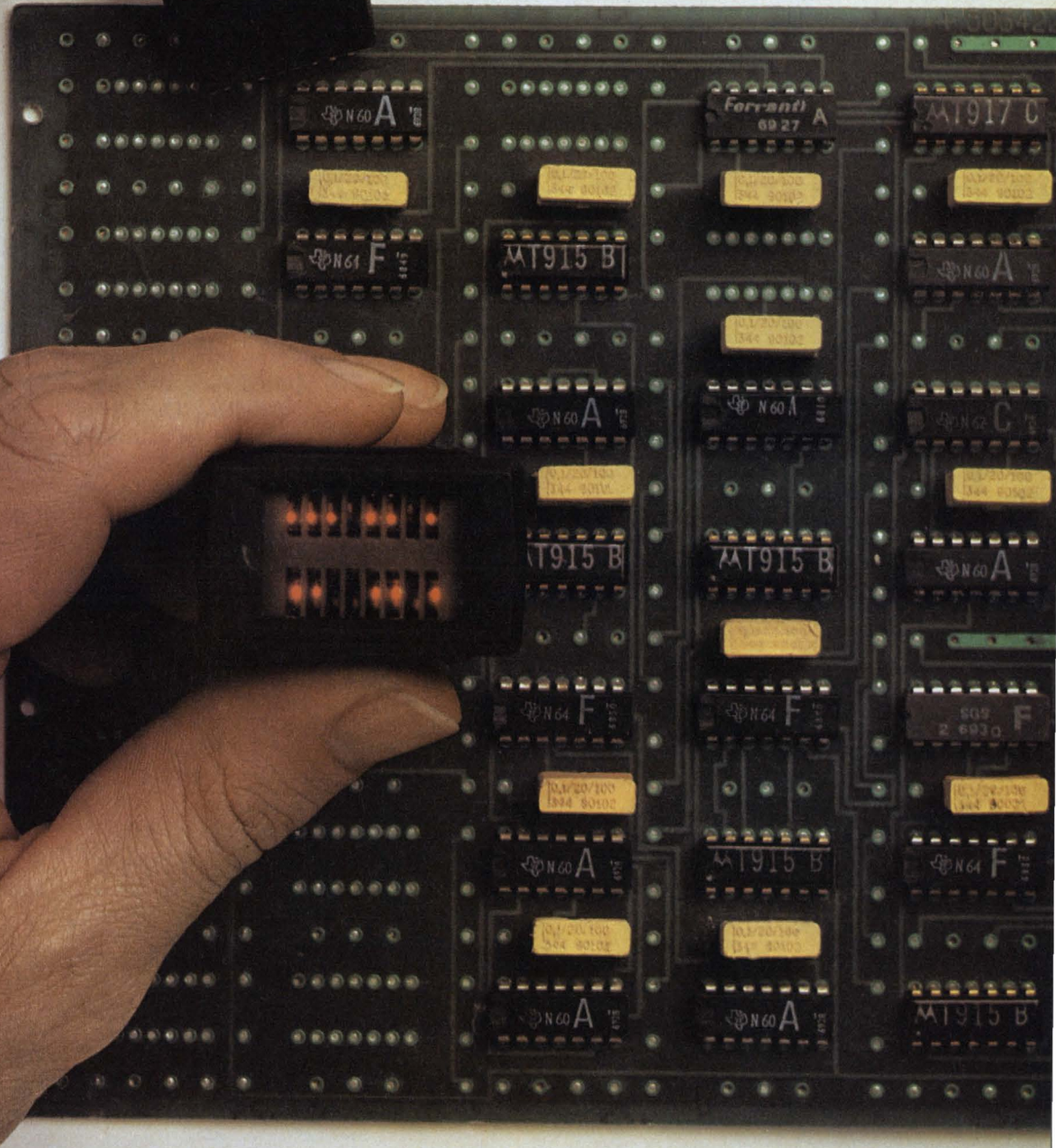
## Jermyn

712 Montgomery Street  
San Francisco CA94111  
Telephone (415) 362-7431  
or East Coast (914) 634-6151

Also at Sevenoaks (U.K.) (0732) 50144,  
Paris 744 29-71, Munich (089) 39 88 01



Instant logic-state display for TTL, HTL or CMOS ICs





FROM STOCK

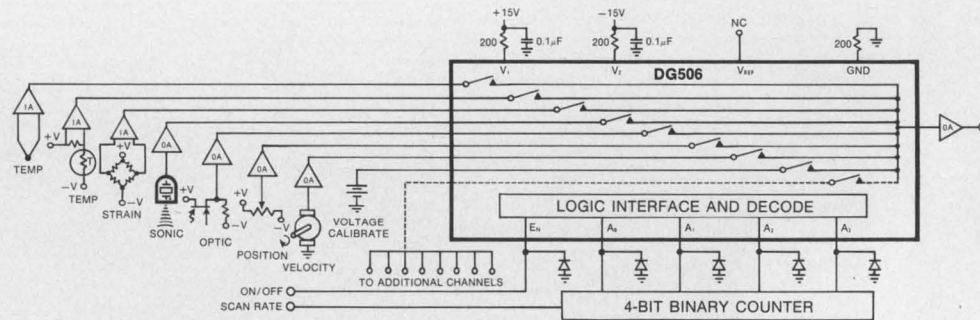
# The Deluxe MUX DG506

## 16-Channel CMOS Analog Multiplexer

No other device available has more switches per package or a greater dynamic analog signal range. The DG506 also includes a 4-line binary decode network which directly interfaces TTL, CMOS and DTL.

- $\pm 15V$  Supplies—same as your op amps.
- $\pm 15V$  Analog Signal Range—more than your op amps.
- 4-Line Binary Decode—selects one of 16 switches ON.

- Enable Control—disables all 16 switches, reduces standby power, lets you add more channels.
- Control Inputs Directly Interface TTL, CMOS, DTL.
- Break-Before-Make Switching—prevents dangerous channel shorting.
- Switching Time Less than  $1\mu s$ .
- Monolithic CMOS.



Typical Application: Sequential 16-Transducer Scanner (8 channels illustrated)

### Applications

- Process Control Systems
- Data Acquisition and Routing
- Telemetry Systems
- Analog Commutating Systems

Don't need 16 channels? The creators of the DG506 have extended this unique

family to offer the greatest selection of CMOS analog switches:

- DG200—Dual SPST
- DG201—Quad SPST
- DG507—8-Channel Differential MUX (16 switches)
- DG508—8-Channel MUX
- DG509—4-Channel Differential MUX (8 switches)

For further information

## write for data

IC Applications: (408) 246-8000, Ext. 120



Siliconix incorporated

2201 Laurelwood Road, Santa Clara, California 95054

INFORMATION RETRIEVAL NUMBER 44



## Growing old youthfully

In *As You Like It*, Shakespeare, one of the better modern playwrights, takes us through the seven ages of man. Starting with the memorable lines, "All the world's a stage,/And all the men and women merely players," he draws a picture of man from mewling and puking infancy to old age, with its "Second childishness and mere oblivion,/Sans teeth, sans eyes, sans taste, sans every thing."

Were he alive today, Shakespeare would no doubt draw a similar picture of the ages of a modern corporation—or engineer. He would picture vigorous, imaginative, hard-working youth, then the mellowed middle age and, finally, pathetic senility. Sceptically, we would look for exceptions. We'd find them, but they'd be rare.

Many of us who have worked for those younger companies would recall the excitement and challenge of building something from almost nothing. We would recall the thrill of out-smarting powerful competitors. We would forget the occasional bitter defeats and the 25-hour work days.

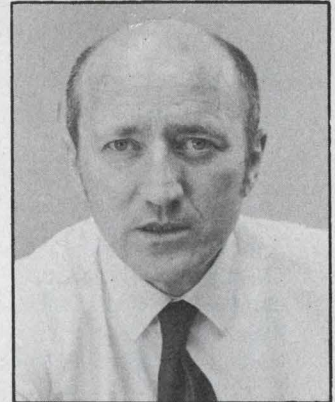
We might remember these companies as they arrive at middle age, when the arteries had not yet hardened—but were beginning to. We might recall the new luxuries. We didn't have to wire our own breadboards; we had technicians. We didn't have to make do with old second-hand test gear; we could buy brand-new modern equipment. And we enjoyed normal working hours. But something was missing—some spark. We had lost the fire, the excitement, the challenge, the feeling that we, as individuals, were very important.

As these companies grow older, they become engulfed in non-essential, non-productive routines. They are enmeshed in procedures, policies and tiers of managers. The attitude, "How do we get this job done quickly, effectively and profitably?" is replaced by "What's company policy?" and "What's the procedure?" We busy ourselves with filling out forms and operations manuals. And we become comfortable. Our hot young aggressive companies have become venerable institutions—"Sans teeth, sans eyes, sans taste, sans every thing."

Can we prevent this aging and decay? Or is that a hopeless search for a fountain of youth? I think there's hope. I recently visited a 35-year-old company with an enviable growth record and with sales exceeding half a billion dollars a year. The company kept its doors open all night so engineers could come in at any hour to try out an idea. And they did.

By our industry's standards, a 35-year-old company is very old, indeed. Yet the company, in some ways, was behaving like a youth. Perhaps that's the key.

It's probably impossible completely to escape the encumbrances of age and size. But maybe we can stall the onslaught of old age for a long time if we keep trying to emulate the vigor, enthusiasm and excitement of youthful companies—and engineers.



*George Rostky*

GEORGE ROSTKY  
Editor-in-Chief



**New! A 600-watt, 5V, 100 amps switching regulated power supply that has four outputs, measures just 3.9" x 7.5" x 16.12", weighs only 14 lbs., is 75% efficient and costs only \$493.\***

**And LH has 84 other equally exciting models to choose from** — all of them smaller, lighter, more efficient and priced lower than competitive switchers.

**250 to 1500 watts**

LH offers 7 standard wattage ratings — 250, 300, 500, 600, 1000, 1200 and 1500\*\* watts. This is the most comprehensive line of high-efficiency switchers available anywhere.

**4 outputs**

Standard LH switchers are available with single, dual, triple or quad DC outputs. Primary output is fully regulated. 2nd, 3rd and 4th outputs are semi-regulated, but may be fully regulated for \$30 per output.

**Low DC voltage, high power outputs**

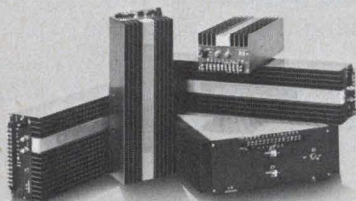
Primary voltages are at 5 VDC; 50, 100, 200 and 300\*\* amps. 2nd and 3rd voltages are standard  $\pm 12$ ,  $\pm 15$  and  $\pm 18$ V at 8 amps each; 4th voltage is 24V at 2 amps. Other voltages available.

**Input voltages externally selectable**

110/220 VAC, 47 to 440 Hz, can be selected by simply changing a jumper on the front terminal strip. DC input, 24 to 300 VDC, also available.

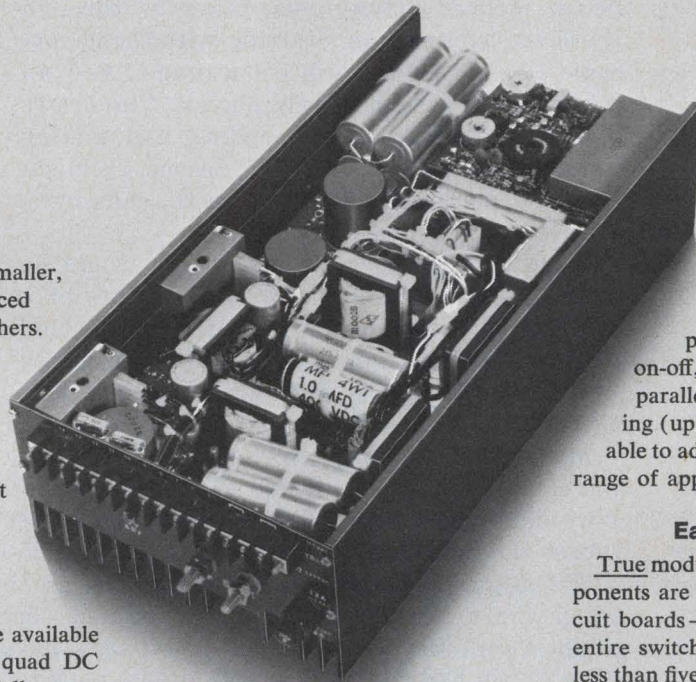
**6 case configurations**

All LH switchers use one basic



\*1000 pc. qty.

\*\*Available Sept. '74

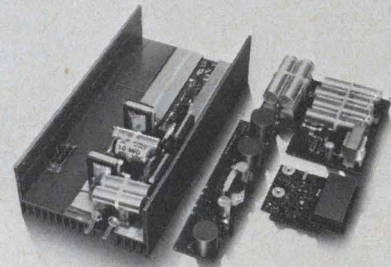


**A number of options**

Over-voltage protection, power fail detection, remote on-off, thermal cutoff, DC input, paralleling, master-slave paralleling (up to 10 units) — all are available to adapt LH switchers to a wide range of applications.

**Easy maintenance**

True modular construction — all components are mounted on just three circuit boards — make servicing easy. The entire switcher can be disassembled in less than five minutes.



*proven* design and package it in six different case shapes — wide and short or narrow and long — for customer convenience. With a nominal power density of 1.37 watt/cu. in., LH switchers pack more power into a smaller package than any other switchers you can buy.

**80% efficient**

On single output models, over 80% of the primary input power is delivered to the output terminal. On models with dual, triple and quad outputs, efficiency averages 75%.

**Lighter weights**

For example, LH's 250-watt single output model weighs only 7 lbs.; the 1200-watt, quad output unit, just 30 lbs.

**Priced as low as 63¢/watt**

Watt-for-watt, LH units are the lowest priced switching regulated power supplies you can buy. In 1 to 24 quantity, a 250-watt single output model sells for \$360; a 1200-watt quad goes for \$1245.

**Ask for full-line folder**

The LH rep in your area has a new six-page folder that fully describes the 85 standard LH switchers, and discusses possible options and modifications to meet specific requirements.

Ask him for a copy today.



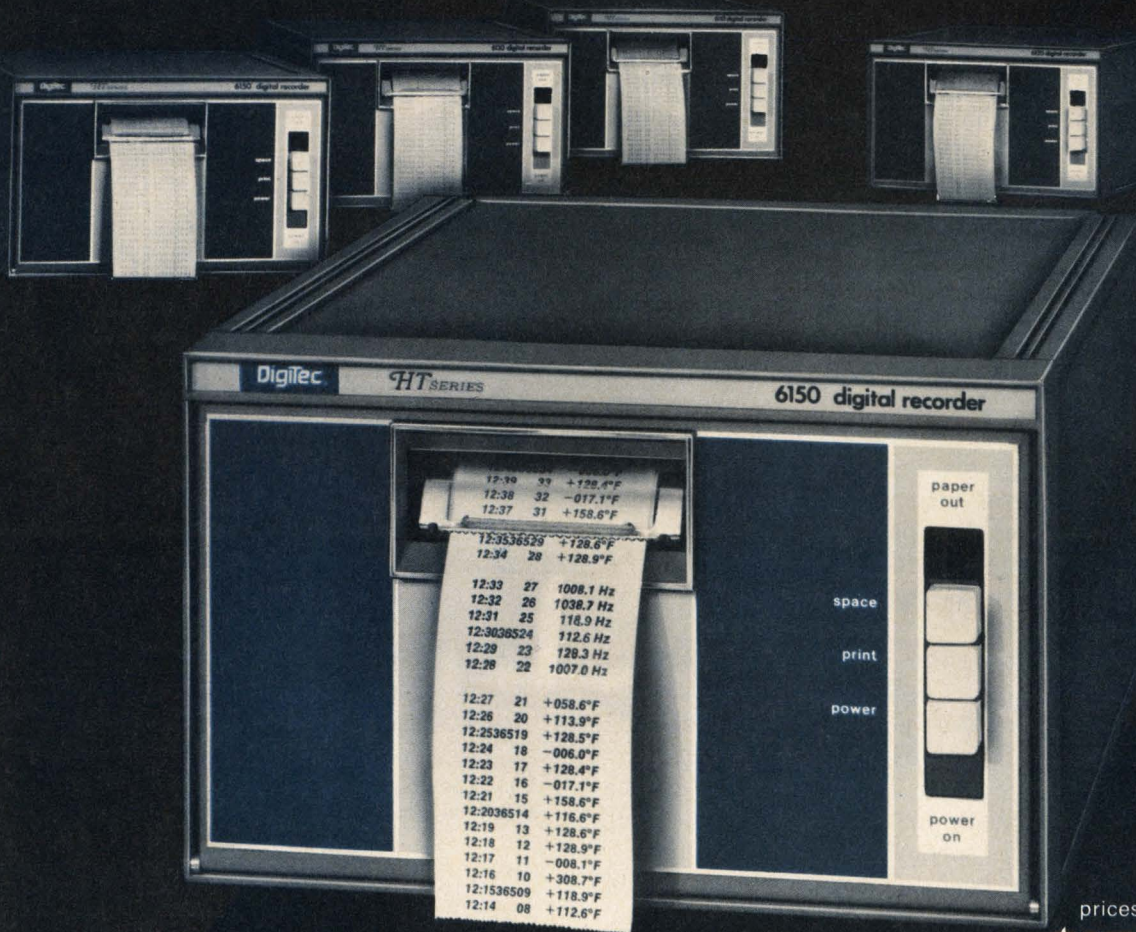
LH RESEARCH, INC., 2052 South Grand Avenue, Santa Ana, CA 92705 • (714) 546-5279



# DigiTec introduces the first in the **HT** SERIES *(a breakthrough in High Technology)* with five new Digital Recorders.

DigiTec's new HT Series (High Technology) is the culmination of a long term program to produce a complete line of digital instruments of the future for your needs. DigiTec has combined the state of the art with our own patented circuitry to offer truly innovative in-

strumentation. The HT Series, our proudest achievement, delivers instruments with the ultimate in reliability and performance. Reflecting the advanced technology contained within, all units utilize a new designer-styled, diecast enclosure.



6100 Series  
prices range from

**\$535.**

plus generous OEM discounts

Selected models in the 6100 series Digital Recorders offer combinations of: 10 or 18 column capacity / integral quartz clock, printing real or elapsed time and integral events or day counter.

All models feature: printing rate, 3 lines per second nominal / wide variety of parameter symbols / programmable floating decimal / "paper out" protection / programmable red or black print / TTL compatible, BCD input / programmable single or double spacing / systems output / automatic column blanking / front loading / rack mountable diecast enclosure / compact, half-rack size (5¼" h x 8½" w x 12½" d). Contact your nearest DigiTec representative for an immediate demonstration.

UNITED SYSTEMS CORPORATION  
918 Woodley Road, Dayton, Ohio 45403  
Ph. (513) 254-6251 Twx. (810) 459-1728  
a subsidiary of

**Monsanto**

INFORMATION RETRIEVAL NUMBER 241

**DigiTec**

FOR DEMONSTRATION, CIRCLE 242



# on Cooling electronic packages

Hot semi-conductors can fail. And semiconductor failure can be catastrophic. Satellites may go out of whack. Computers may falter. And 1974 cars may not start.

A key way to ensure and improve reliability is to keep the junction temperatures of the equipment's semiconductors at a safe operating value. It's generally accepted that the semiconductor failure rate is halved for each 10-C reduction in the junction temperature below maximum.

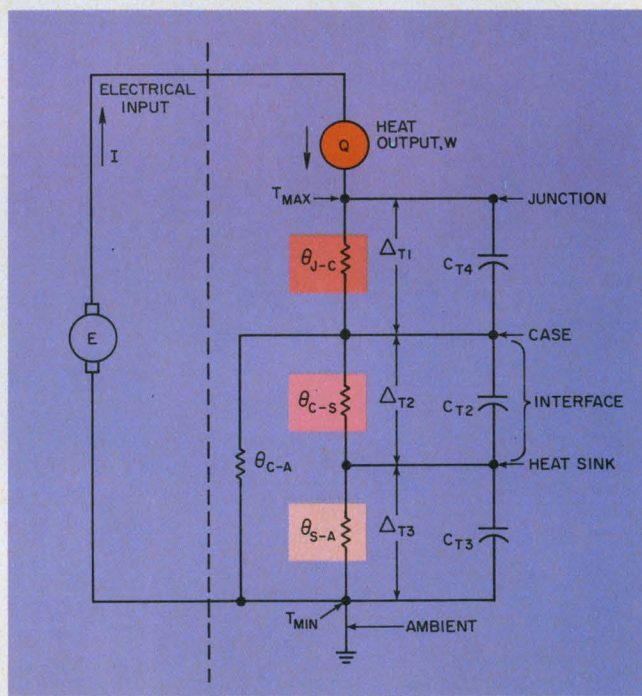
But how do you keep electronic components and packages cool? The problem is exacerbated by the trend to higher packaging densities.

Designers frequently neglect the selection of heat-transfer devices or systems because, first of all, the quantities, terms and concepts of heat-transfer technology are unfamiliar to some. And the specsmanship of heat-transfer device manufacturers—whether they package heat sinks, heat pipes, thermoelectric modules, fans and blowers, or heat exchangers—is compounded by the thermal jargon they use.

Thermal circuit design is becoming a crucial part of the electronic designer's bag of tricks, particularly when the penalty for neglecting thermal considerations early in the design can result in an add-on cooling kluge—and this can be costly in terms of both dollars and space. In some cases redesign from scratch may be necessary.

Fortunately the basic quantities in specifying heat-transfer devices and their related thermal circuits are analogous to electrical quantities. Thermal circuits can be evaluated on the basis of their electrical analogs.

For example, the flow of heat ( $Q$ ) from one point to another along a thermally conducting path—usually stated as power in watts—is com-



Understanding thermal circuits is easier with this electrical analog of a semiconductor and heat sink. Junction heat flows through the case and sink to the ambient.

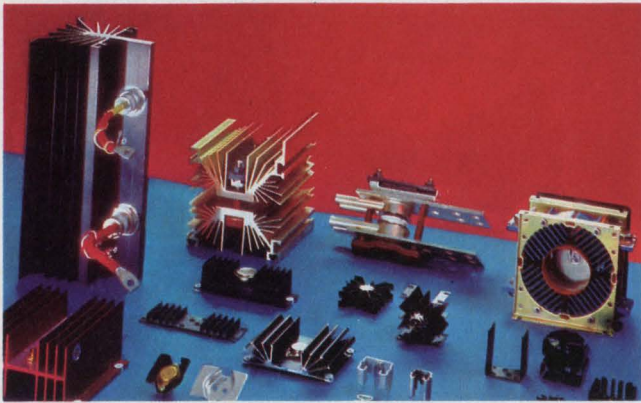
parable to electrical current flow. The temperature difference ( $\Delta T$ ) between any two points in this path corresponds to a voltage drop. Thermal resistance ( $\theta$ )—the quality that impedes the flow of heat from one point to another—is equivalent to electrical resistance. Thermal conductivity ( $k$ ) is analogous to electrical conductivity.

Whenever heat is applied abruptly to a thermal mass, the temperature does not rise instantaneously but requires some finite time—or lag—to do so. This characteristic is similar to that of a thermal capacitance and is so indicated in the

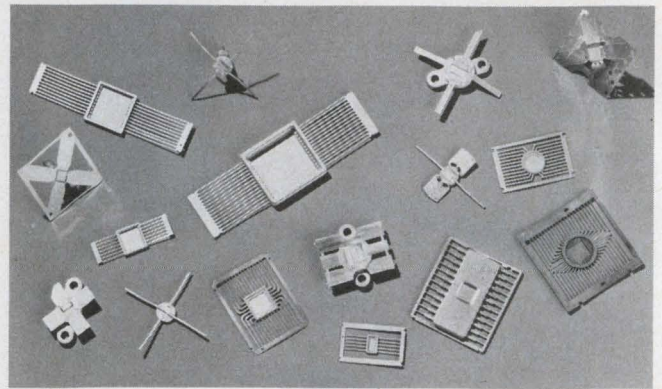








Convection cooling is used for all of the heat sinks here, by Wakefield, except for the liquid-cooled and fan-cooled units at upper right.



Excellent thermal conductivity of beryllia rapidly dissipates heat in these National Beryllia headers and packages for rf and microwave semiconductors and ICs.

the sink ( $\Theta_{S-A}$ ). This value is determined by the following: The amount of heat dissipated to the ambient air—either by radiation, convection or forced-air flow—plus that carried off by conduction to the chassis.

### Heat sinks in 3 major areas

The most widely used heat-transfer devices are heat sinks, which are produced in a seemingly endless number of designs. Thomas Coe, president of Wakefield Engineering, points to three major areas where these static cooling devices are found:

1. **In small, discrete components and integrated ceramic and DIP packages, usually mounted on circuit boards.** The devices are of small sizes and are usually produced in large quantities by sheet-metal-forming operations. The cooling device is frequently designed to fit a particular metal or plastic semiconductor case style. A problem encountered here is that the circuit designer doesn't leave enough airspace for adequate convection cooling. Or he doesn't orient the boards or devices for optimum airflow.

2. **In medium-power discrete components, usually in power supplies.** Here the cooling device is ordinarily designed to fit a class of semiconductors. Sometimes the heat-sinking device—most frequently made of aluminum extrusions—provides structural support. However, there is a tendency to expect too much structural support from these heat sinks, and that often results in extra machining and tolerances that make the price high.

3. **In high-power diodes and silicon-controlled rectifiers.** With these devices, the heat generated per component is much higher than in other applications. And the maximum operating temperatures of the junctions are lower, so that cooling requirements are tough. Ruggedness is required

for these heat-dissipating assemblies, since they are frequently used in compression modes. A basic problem is to provide the required cooling at a reasonable price and with practical designs. Sometimes, when a system is being developed, there is no practical means of providing the required cooling, so the system has to be derated or changed; the use of larger components or more components in parallel may be necessary.

### 'Thermal resistance': What is it?

Probably the most ambiguous term used by heat-sink manufacturers is "thermal resistance," says John E. Markley Jr., executive vice president of International Electronic Research Corp., better known as IERC.

Many manufacturers spec the thermal resistance from the interface side of the sink to the ambient temperature, he points out. Others list the thermal resistance from the semiconductor case to the ambient. Since the latter spec includes the thermal resistance of the interface, the two figures do not agree.

Knowledge of the complete thermal circuit between the semiconductor, its interface with the heat sink and the final transfer of heat to the ambient is as important as the electrical circuit in today's high-density packaging, Markley notes.

Facts needed to determine if a heat sink will perform as predicted by the specs include (1) Interface losses; (2) Whether the manufacturer's thermal tests were conducted in an open bench or in a test cabinet; (3) Whether the test was conducted on a thermal model or on the actual device, and (4) Whether or not thermal paste was used for the tests.

Many discrepancies in specs stem from the fact that most manufacturers use their own test methods, even though an industry standard exists. These standard procedures—used by



IERC and some others—are defined in the Electronic Industries Association Bulletin No. 5, "Recommended Test Procedure for Semiconductor Thermal Dissipating Devices," and its Amendment 5-1. Bulletin 5 details tests for metal-case semiconductors, while the amendment describes testing for plastic devices.

While many manufacturers rate their heat sinks by thermal resistance, this approach is valid, Markley says, only if all the test parameters are given.

From curves of the case rise above ambient vs power dissipation, the engineer can easily obtain thermal-resistance figures at any power level by dividing the case-temperature rise by the power dissipation.

Richard G. Vossler, marketing manager of Astrodyne, Wilmington, Mass., points out that many suppliers of heat sinks give a thermal resistance for the sink but do not state the power at which this thermal resistance applies or the ambient temperature. This can be deceptive.

For example, a three-inch-long heat sink with a black, anodized finish—like the Astrodyne 2517-0300-A10B—will have a thermal resistance of 1.96 C/W to 1.24 C/W, depending on whether it is operating at 10 W or 100 and if the ambient is 20 or 25 C.

William C. Jordan, vice president of engineering for Thermalloy, Inc., Dallas, Tex., notes that the designer can also be misled if the heat-sink manufacturer does the following:

- Fails to locate the thermocouples at the hottest point on the device case when data are reported for TO-5 and TO-3 heat sinks.

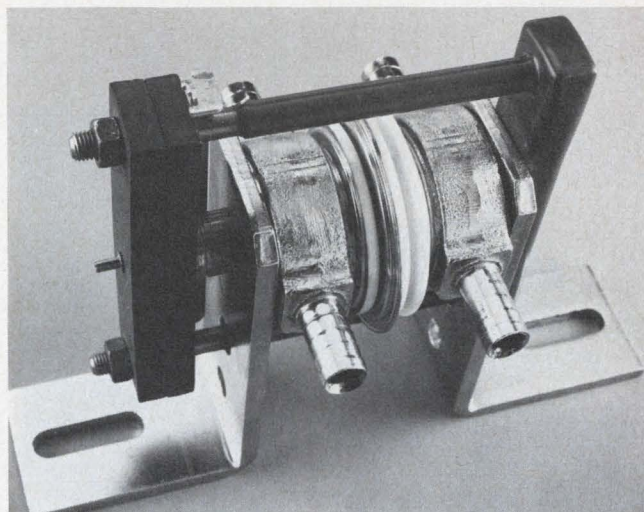
- Fails to specify the thermocouple location on DIP packages. The gradients in the package can be very large. (Thermalloy has measured as much as 25-C variation on plastic encapsulated cases when measuring from the middle to the end on a 14-pin DIP.)

- Uses large thermocouple leads or poor installation techniques when measuring heat-sink performance. For example, a large thermocouple with 24-gauge leads can draw off 10 to 20% of the power of low-power DIP packages.

- Uses highly polished surfaces for measuring interface performance data—a move that lowers the thermal resistance—yet does not indicate in his test data that his sinks are supplied with a nonpolished surface. This practice is reported to be widespread.

### Semiconductor failure can burn you

The figure most important to designers, Markley says, is the semiconductor-case temperature rise above ambient. Usually the user is forced to



**Thermal silicone grease**, by Dow Corning, improves the heat transfer across the interface between these liquid-cooling elements and a high-power Westinghouse silicon rectifier clamped under pressure between them. Cooling with distilled water permits a 1110-A rectifier to carry 1700 A. For dielectric separation between multiple rectifier units, silicone cooling fluids can be used.

rely on the thermal resistance of the junction-to-case and the reliability stated by device manufacturers. But their information is frequently unreliable.

"Semiconductor suppliers tend to grossly overstate the reliability and the power-handling capabilities of their devices," says Len Dietch, vice president of TV engineering for Zenith Radio, Chicago. "And this includes the power-handling capabilities of an IC which may be a small-signal processor.

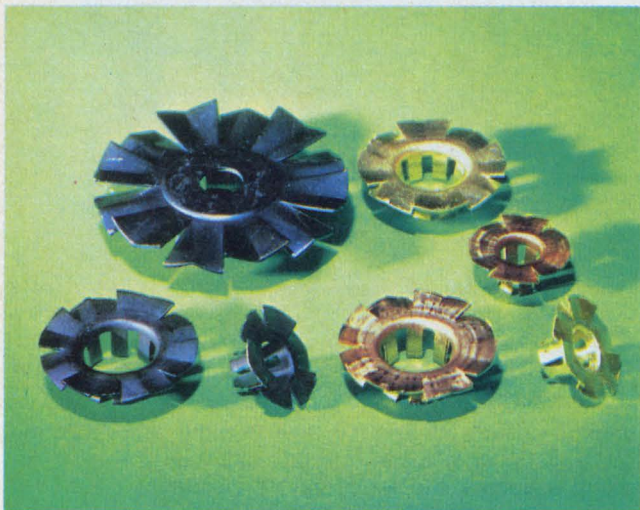
"We pay through the nose for semiconductor failures, because each service call under our year's warranty costs us \$20. And for a shop call, it's almost doubled. The alternative to failure of a semiconductor is to use the same device with a bigger heat sink, or a bigger device with a smaller heat sink—or some other combination that is more costly initially."

When semiconductors are mated with heat sinks, a critical thermal barrier between the device and the cooling element is the interface between the two. It is here that the highest thermal resistance is ordinarily present (see table). This resistance is a function of the following:

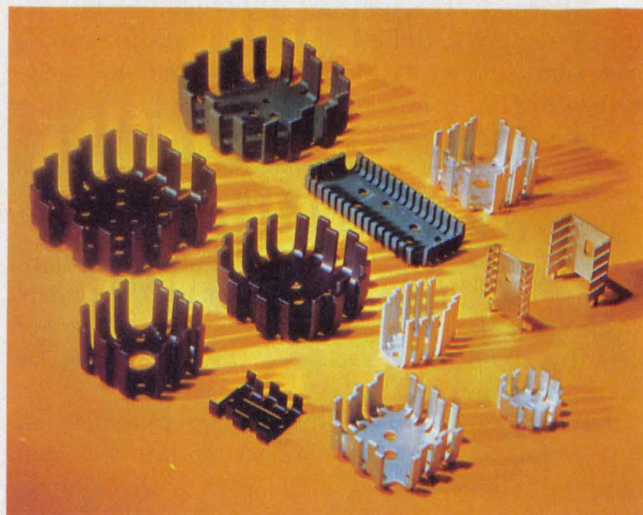
- The cross-sectional area.
- The surface finishes of both the device and the sink.
- The flatness of the surfaces.
- The pressure between the surfaces.
- The thermal conductivity of fillers, if used.

Allen W. Scott, manager of advanced development for the Varian Microwave Tube Div., Palo Alto, Calif., and author of a recent Wiley-Inter-





These staggered-fin, fan-top heat sinks, by IERC, have a low profile for close quarters and are designed for press-on installation. The staggered-finger units have



high efficiency and are smaller and lighter than some equivalent finned-extrusion designs that dissipate the same amount of heat.

science book, *Cooling of Electronic Equipment*, points out that unless care is taken to maximize the contact area, the temperature difference required to conduct heat across the interface can be as high as that needed to conduct it through several inches of aluminum heat sink.

To minimize this temperature difference, particularly for high-voltage applications, these procedures are advisable:

- Make the surface of the manufacturer's heat sink and semiconductor smoother where the two mate by abrasion, polishing or some other method.
- Apply large clamping forces, to bring the device into closer contact with the sink.
- If feasible, solder the device to the sink. Or bond it with an epoxy compound of high thermal conductivity.
- Use a thermal paste or heat-sink compound between the device and the heat sink. These compounds reduce the interface thermal resistance to a fraction of that of a dry surface.

The thermal pastes are usually grease-like silicones filled with heat-conductive metal oxides. These compounds resist drying out, melting or hardening even after long exposure to 200 C. Typical values of compound thermal conductivities range from 0.01 to 0.04 W/in. C—which is not very high. Consequently the compound must be applied in a thin layer.

Typical suppliers and their compounds are:

- Aavid Engineering—Ther-O-Link 1000.
- Emerson & Cuming—Ecotherm TC-4.
- Dow Corning—340 Compound.

- General Electric—G640 Compound.
- Jermyn—Thermoflow.
- Thermalloy—Thermacote.
- Trans-Tec—XL-500.
- Wakefield—Compound 120.

Robert Krasa, technical service and development engineer at Dow Corning, points out that some silicone sealants have the same heat-flow properties as the grease-like silicone compounds, with two added advantages. The sealants can bond a component in place, eliminating fasteners. Also, when cured, the sealants have no tendency to bleed or creep into areas where an insulating film is not wanted.

Krasa also notes that silicone fluids are used as dielectric coolants in large power devices, klystron tubes, communications transformers and capacitors. Unlike oil and other cooling fluids, they have little tendency to oxidize or gum up in long service at elevated temperatures. They flow freely at low temperatures.

#### Washers provide insulation

Frequently it's necessary to insulate semiconductors from their heat sink for electrical isolation. A variety of washers are available for this purpose, including epoxy-coated aluminum, hard-anodized aluminum, aluminum oxide ceramic, beryllium oxide (beryllia) ceramic, mica and high-temperature plastics like du Pont's Kapton and Mylar.

Beryllia washers—the most expensive—have the best thermal conductivity, the lowest thermal



resistance and the highest dielectric strength—on the order of 5000 V. Hard-anodized aluminum washers are second best. But whereas the anodized aluminum washer costs about 10 cents in quantity, the price of the beryllia equivalent is 50 or 60 cents.

The thermal conductivity of beryllia at room temperature is as good as or better than that of aluminum, says James Wade, market manager of the Electronic Product Div. of 3M, Chattanooga, Tenn. It depends upon the percentage of beryllium oxide in the ceramic. However, with an increase in temperature, the conductivity decreases.

Worth noting is the fact that thermal compounds are used with washers of all types.

Mica washers on the order of 2 to 8 mils thick and about 1000 V dielectric strength have been used for years. But according to Thermalloy's Jordan, they are being replaced—for nonthermal reasons—by amber-colored Kapton and green Mylar washers of the same thickness and about half the dielectric strength.

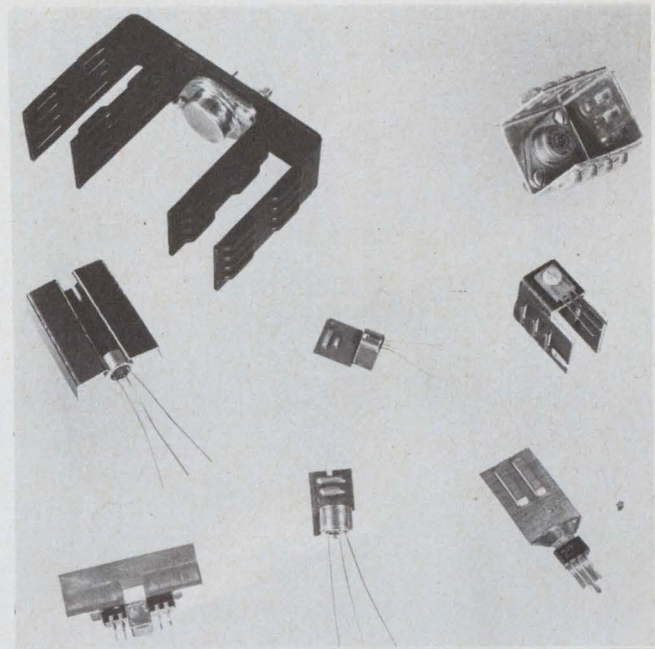
With the clear mica insulators, production workers may pick up two, stuck together, without realizing it. Experience has shown that when two washers are accidentally used, the thermal resistance is increased sufficiently to cause device failure. With the Kapton and the higher-temperature Mylar washers—which are becoming cost-competitive with mica—the shade of the color provides an instant clue to a double washer.

One approach to the problem of heat-sink insulation without use of mica or other washers is a proprietary coating system—Insulube 448—made by IERC. It is applied by spray during manufacture of the heat dissipator. The recommended thickness for application of the coating is  $0.003 \pm 0.001$  in. Its dielectric strength is 1000 V dc per mil with an insulation resistance of 50 G $\Omega$  at 500 V dc.

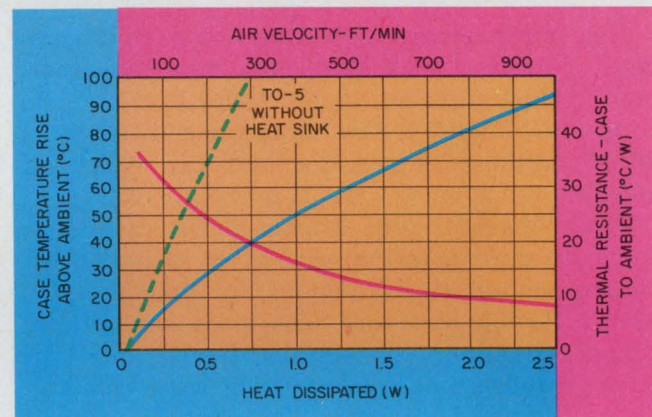
For thermal bonding of semiconductors and other components to heat sinks or chassis, thermally conductive epoxies are available from heat-sink suppliers. These have thermal resistivities on the order of 25 to 30 C/W.

### Heat pipes for confined areas

Where the packing density of electronics is high, there may not be sufficient space within the rows of PC boards or other confines to use a heat sink. Or the air where the hot components are placed may be at an excessive ambient temperature. One solution is to use heat pipes—devices that absorb heat from a component in a restricted area and pipe it off, to be dissipated at a heat sink in a cooler ambient.



Low-cost heat sinks for consumer products, by Staver, range from devices for 500-mW plastic transistors (bottom center) to 12-W power transistors (top left).

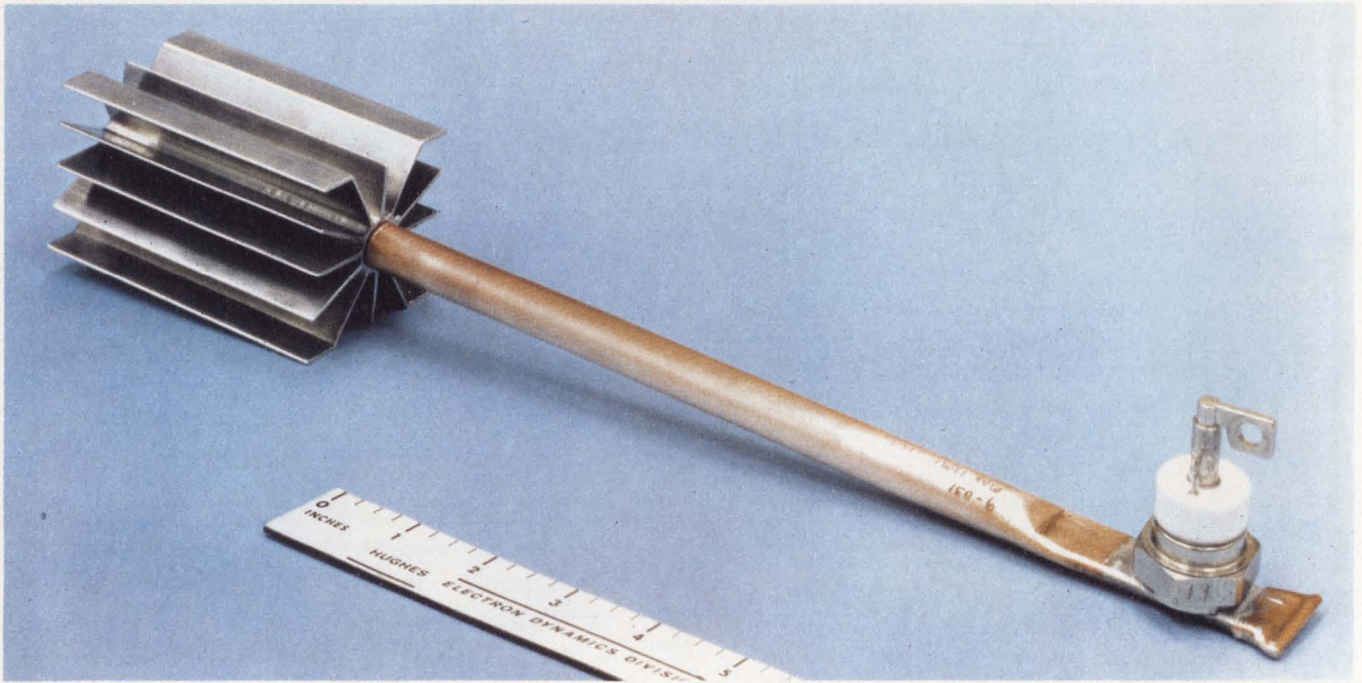


Heat-sink thermal data are typically presented in terms of thermal resistance for air cooling and rise above ambient for convection cooling.

### Interface thermal resistance (in °C/watt) for a TO-3 case

Semiconductor to mounting surface (no insulator, dry)	.05 - .20
Semiconductor to mounting surface (no insulator, with thermal compound)	.005 - .10
Beryllium oxide (BeO) wafer between semiconductor and mounting surface	.10 - .40
Hard anodized aluminum wafer between semiconductor and mounting surface	.35 - .70
2 mil. Thermalfilm plastic insulator between semiconductor and mounting surface	.55 - .80





The high-frequency SCR on this Hughes heat pipe dissipates 100 W, which is rapidly carried away by the thin-wall heat pipe to the aluminum fins for convective

cooling. The major advantage here is that the cooling takes place away from the source of heat. The heat pipe distributes the heat evenly along the length of the fins.

Heat pipes, according to Ron Kemp, chief engineer of Jermy, San Francisco, have high thermal conductivity—about 400 times that of solid copper. A pipe of 1/8-in. diameter can transport 20 W, while a 1/2-in.-dia unit can carry off 500 W.

While the heat pipe usually comes in tubular form, it can assume a variety of other hollow shapes—square or rectangular, for example—and even a flexible structure. The pipes are made of copper, aluminum or stainless steel, and they have an inner lining—a wick—of some capillary

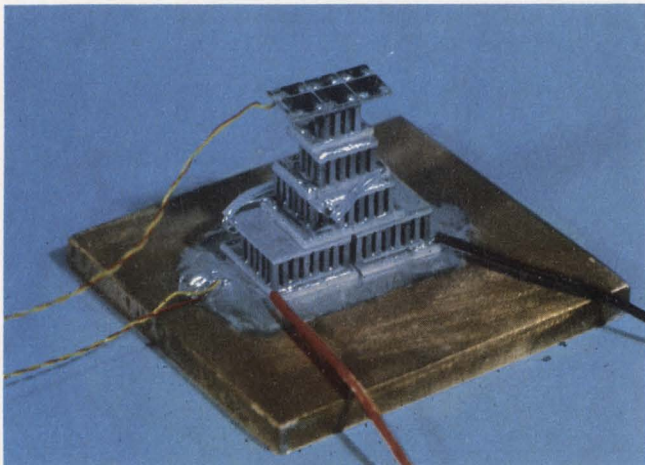
material. The wicks come in a variety of configurations.

A small amount of fluid—such as of water, ammonia or other dielectric—is sealed in the pipe in a partial vacuum. The heat pipe's operating temperature is dictated by its working fluid. It can operate as low as  $-170\text{ C}$  or as high as  $400\text{ C}$  for electronic applications.

T. A. Hummel, thermal products marketing manager for Hughes Aircraft Co., Electron Dynamics Div., Torrance, Calif., describes the operating cycle this way:

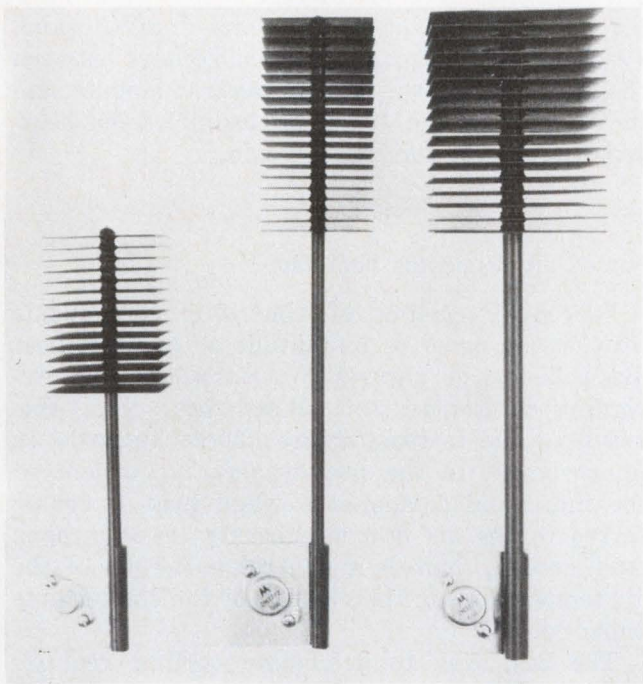
The heat from the component or source being cooled vaporizes the working fluid in one end—the vaporizer region—of the heat pipe. The hot vapor moves to the cooler end—the condenser region—where the vapor gives up the thermal energy as the heat of condensation and returns to a fluid state. The condensed working fluid then is fed back to the evaporator section by the capillary action of the wick.

The performance of heat pipes varies with their orientation relative to gravity, notes Richard Vossler, marketing manager of Astrodyne, Inc., Wilmington, Mass. Heat pipes are rated at 100% of their effective transfer capacity when operated in the horizontal plane, he says. But as the condenser and heat-sink end are raised above the evaporator end, the heat-transfer capacity increases. With the pipe in a vertical position, the heat transfer can be two or three times that of its rated performance.



Thermoelectric cooler by Borg-Warner has unusually high efficiency, pumping 33.5 mW of thermal load at a temperature of 193 K, with use of but 2.06-W input.





**Finned heat pipes** by Jermyn are used to conduct heat away from TO-66 and TO-3 power transistors. In still air the pipes dissipate (left to right) 20, 30 and 40 W.

Hummel of Hughes points out that small heat pipes for electronic applications have been designed to operate against gravity—in any position—by use of thick, homogeneous wicks. But they have relatively high thermal resistance—on the order of 0.33 C/W for a 1/4-in. unit, 0.28 C/W for a 1/2-in. pipe and about 0.7 C/W for a 1-in. dissipator.

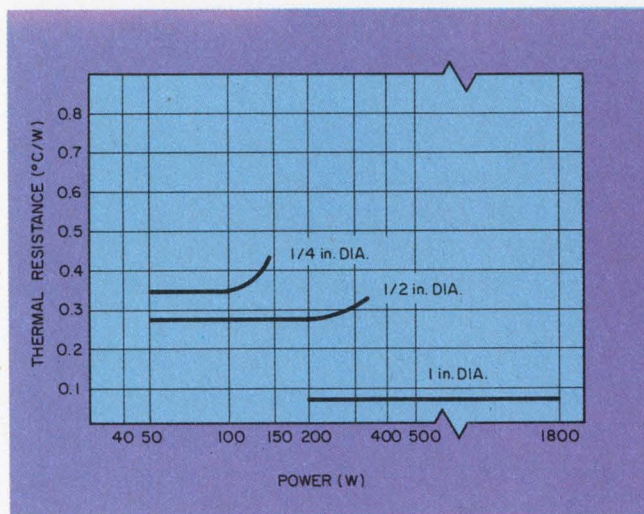
This thermal resistance, Hummel notes, must be considered in all applications.

#### Thermoelectric modules can cool or heat

There are three basic areas where thermoelectric modules can be used to advantage:

- 1. In cooling a small heat load to a low temperature.** A good example is the cooling of infrared detectors from  $-70\text{ C}$  ( $203\text{ K}$ ) to  $-128\text{ C}$  ( $145\text{ K}$ ). The mass to be cooled is small, and the power dissipated by the mass is small. The detector-module combination is mounted in a vacuum enclosure to reduce ambient heat loads and to prevent water or other gases from condensing on the detector. Operating temperatures can be achieved within a few seconds to minutes. To lower the module temperature, power input must be increased. Typically, 3 to 6 W are required for operation at  $-80\text{ C}$  and 50 to 80 W for  $-128\text{ C}$ .

- 2. In cooling a component or a small package to 5 to 10 C.** A typical example is cooling a parametric amplifier or oscillator, to decrease noise.

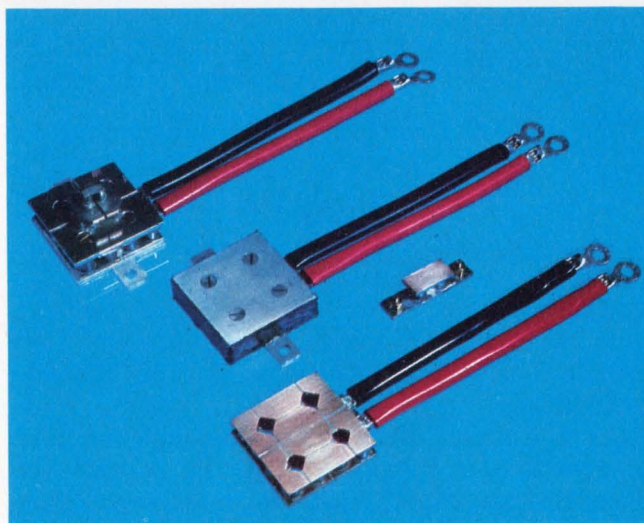


Heat pipes developed for electronics applications, by Hughes, can be used in any position. But their thermal resistance is higher than standard units.

- 3. In temperature-stabilizing a component, a package or an entire system at 25 C.** An illustration here is stabilizing an IR system. If the ambient rises above 25 C, the thermoelectric module operates in the cooling mode. If the temperature decreases, the thermoelectric module heats. Thus the optics and other temperature-sensitive components are stabilized. The heat load may vary from a few watts to 100 W.

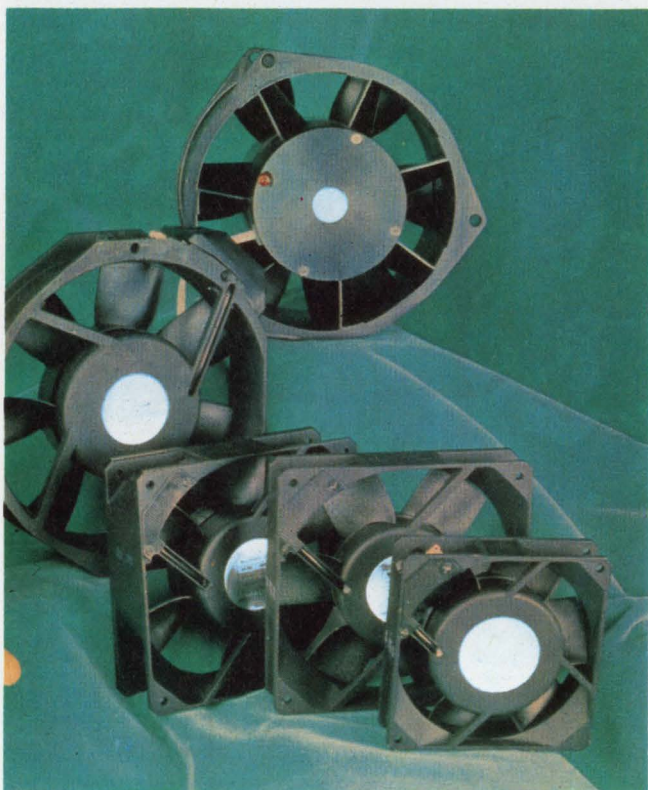
The major tradeoffs when a thermoelectric module is chosen for an application are in voltage, current and cost. A module will pump a specified quantity of heat over a defined temperature differential for a given amount of power.

Several combinations of modules have vary-



Thermoelectric cooling modules, like these from Ohio Semitronics, can be built up from single thermoelectric couples into multicouple and multistage devices for greater cooling.





Most fans used in cooling computers range from 3-1/8 to 6-in. dia., like these Amphenol units. They deliver from 17 to 260 cfm of air.

ing voltages and currents for the same amount of total power.

For lowest cost, the designer should select as large a current as practical and build the voltage to the required power level. However, if the required voltage is 3, 6 or 12 V, the number of thermoelements are well established, as shown in this table:

Power (W)	Current (A)	Voltage (V)	No. of Elements	Cost (\$)
10	1	10	100	100
10	2	5	50	50
10	10	1	10	10

A designer can be misled if he fails to consider the thermal resistance of the hot junction and the consequent problems involved in getting that heat dissipated, says Dr. Warren E. Bulman, Ohio Semitronics, Columbus. He points out that module performance depends on the hot-side temperature.

As an example, Bulman cites a module intended to give a 70-C difference, with the hot side, or base, held at 25 C. With the base temperature elevated to 75 C, a temperature difference of 100 C can be obtained.

Two common problems in customer-assembled systems, according to Dean R. Hoppens, market-

ing manager of Nuclear Systems, Inc., Garland, Tex., are (1) Inadequate thermal contact between the cool side of the thermoelectric module and its component, and (2) Poor design of the heat-removal system for the hot side.

### Forced air dissipates heat fast

Forced-air cooling of electronic components provides an order of magnitude or more of heat dissipation over natural convection cooling. According to Rotron, Inc., Woodstock, N.Y., this result is due to two factors: First, there is an improvement in the heat-transfer coefficient of the individual components when heat is transferred to the air flowing directly around them. And, second, there is a general reduction of the air temperature in the vicinity of the components being cooled.

The best way to determine cooling requirements accurately, says Rotron, is to make an actual test of the equipment. Because of the complex nature of flow paths in electronic equipment, standard pressure-drop calculations do not generally provide useful answers. For designers who do not have equipment to perform the tests, manufacturers like Rotron do the testing at their laboratories at no charge.

For each type of air mover, there is a range of "specific speed" for which its efficiency is highest. Specific speed is defined by the following formula:

$$N_s = N \sqrt{(\text{cfm}) / \Delta P^{3/4}},$$

where N is shaft rpm, cfm is the cubic feet of air delivered per minute and  $\Delta P$  is the pressure drop in inches of water.

Evaluation of this formula shows that air-moving devices with high specific speeds are most efficient when delivering high flows against low static pressures. Conversely air movers best suited for transporting air at high pressure and low volume have low specific speeds. The figure gives the specific speeds for a variety of common air-moving devices.

For example, the specific speed for a 60-Hz, 3300-rpm motor to move 125 cfm of air at a pressure drop of 1 in. of water would be:

$$N_s = \frac{3300 \sqrt{125}}{(1.0)^{3/4}} = 37,000.$$

With a specific speed of 37,000, reference to the figure indicates that the application can be satisfied with a squirrel cage or centraxial blower.

If the same flow and pressure requirements were specified for a military application, where 400-Hz power is available and if shaft speed of 11,000 rpm were selected, the specific speed



would be 122,000. Tubeaxial or vaneaxial fans are well-suited for this application.

### Fans and blowers cool computers

Major application areas for cooling fans are in the computer industry, says Lawrence F. Edwards, product manager for Amphenol, Broadview, Ill. They are used in mainframes, for both large-scale machines and minicomputers, and also peripheral gear, like CRT terminals, printers, point-of-sale terminals and modems. Other applications are in test and control equipment.

Fan specifications are, for the most part, comparable among manufacturers. However, the airflow measurements of one or two manufacturers overstate the air delivery at low static pressure, because they use the pipe method of measurement. The fan blows air through a pipe that is about the same size as the fan's diameter. As a result, a significant velocity pressure component is present, which gives a boost to airflow.

Most manufacturers use the chamber method, in which a fan blows air into a chamber that is many times larger than the fan's diameter. Consequently the velocity pressure component is near zero.

The noise spectrum of different fans can be compared by examination of manufacturer data and curves. But this may be misleading, because the same absolute sound pressure is not used by all manufacturers.

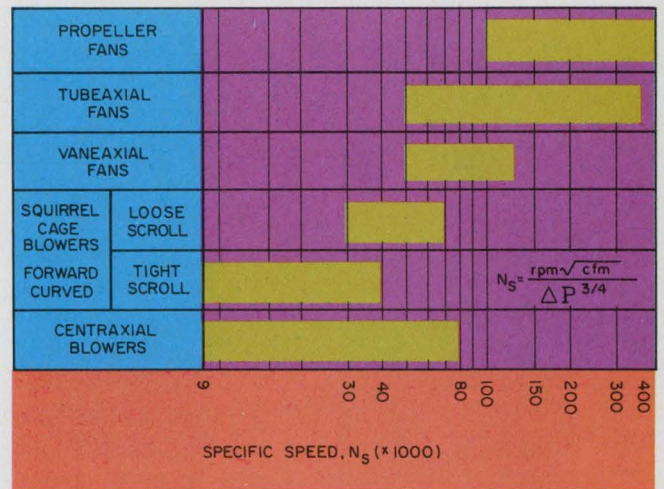
Be wary of published life data, Amphenol's Edwards cautions. Often the life data for a fan do not specify whether it is for a long-life ball-bearing fan or low-cost sleeve bearing model; it can make a drastic difference.

It probably takes up to 10 years of testing accurately at 20 C to determine the life of a fan, Edwards says. But in 10 years the fan's design may change radically. Motor-life guarantees are usually more sales talk than practical, Edwards notes. The designer must pay the cost of a defective fan's removal, its reinstallation and its shipping; under these conditions the user usually finds it is more expensive to exercise the warranty than it is to replace the fan from his own stock.

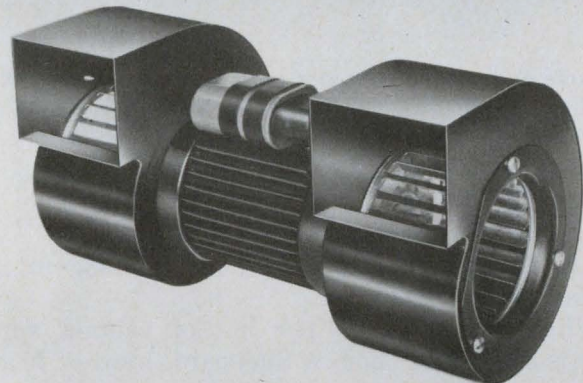
There are three major tradeoffs in fan selection:

1. **The initial purchase price vs long-term cost.** Longer fan life results in lower maintenance costs and less downtime, which can more than offset the difference in the purchase price of a longer-lived fan. This is especially important when the manufacturer leases the equipment and bears the cost of upkeep.

2. **Cooling performance vs noise.** A lower noise



A figure of merit for applying a fan or blower—specific speed,  $N_s$ —is based on the shaft speed, the air volume moved and the pressure drop required.



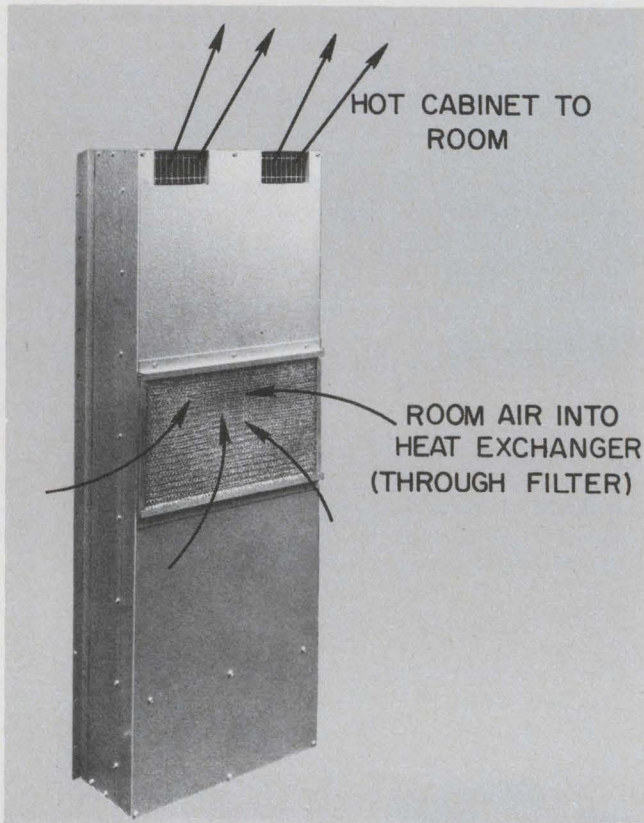
Designed for cooling ducted or tightly packed electronics packages, this Rotron duplex centrifugal blower is produced in six models, with capacities from 100 to 600 cfm.

level is achieved when the rpm of the fan is reduced. However, the amount of airflow is directly proportional to speed. And, more important, the static pressure generated is a function of the square of the speed. As a result, noise reduction is paid for with a drastic reduction in cooling capacity.

3. **Structure vs noise.** Obstructions to airflow on the intake side, including the supporting struts of the fan itself, increase noise. Minimum obstructions should therefore be sought.

When high packaging density produces relatively high dissipation per board, or where the electronics must be protected from adverse environments—like those in an aircraft or in industrial plants—the use of closed cabinets and





Adverse environments require sealed cabinets with built-in cooling systems. This heat exchanger, by Kooltronic, cools the air inside the cabinet.

either integral or separate heat exchangers is necessary.

When about 0.1 W per in.<sup>2</sup> of cabinet surface is exceeded, Thomas Sheppard, head of heat

transfer at Bendix, Teterboro, N.J., suggests the use of a cold-wall cooling technique that Bendix has used for airborne computers. With this, the walls of the cabinet are doubled, and the space between them is filled with radiator-type cooling fins.

Filtered air is forced under pressure through inside walls, Sheppard explains, as well as through the walls of the enclosure sealing the electronics. While the seal is not hermetic, it prevents dust, dirt, moisture and water from contaminating the PC board components, Sheppard notes.

In essence, a heat exchanger is built into the wall of the box, he says, and large computer manufacturers like IBM are adopting this technique.

For on-line process-control equipment in harsh industrial environments, sealed electronic cabinets and closed-cycle cooling are required. Here a heat exchanger is incorporated into one side of the cabinet, explains William G. Stewart, vice president of engineering for Kooltronic, Inc., Princeton, N.J. It may be an air-to-air or air-to-water exchanger, with the air inside the cabinet continually cooled and recycled internally. Or it may be a specially packaged air-conditioning system.

Integration of this type of cooling system into an electronic cabinet requires close collaboration between the electronic designer and the system supplier, Stewart points out. Such collaboration should generally begin in the conceptual stage, he says, to integrate the cooling unit into the electronic system at minimum cost, space and noise. ■■

## Need more information?

The companies and products cited in this report have, of necessity received only brief mention. They've been selected for their illustrative qualities. The product lines marketed by these and other companies are identified below. The code to these products is: FB—fans and blowers; HE—heat exchangers; HP—heat pipes; HS—heat sinks; HW—heat washers; TG—thermal grease; TE—thermoelectric coolers; TS—thermal sealants; LC—liquid coolants.

Aerotronic Assocs., Inc., Riverside Dr., Contoocook, N.J. 03229. (603) 746-3141. (M.R. Longley). (HE) **Circle No. 400**  
 Agnew-Higgins, Inc., Box 857, Garden Grove, Calif. 92642. (714) 893-1301. (M. L. Burleson). (FB) **Circle No. 401**  
 AHAM, P.O. Box 909, Azusa, Calif. 91702. (213) 334-5135. (Harold Sullivan). (HS) **Circle No. 402**  
 Alpha Components Corp., 115 Eucalyptus Dr., El Segundo, Calif. 90245. (213) 322-7780. (J. T. Cataldo). (HS,FB) **Circle No. 403**  
 Amco Engineering Co., 7333 W. Ainslie St., Chicago, Ill. 60656. (312) 867-8500. (F. A. Johnson) (FB) **Circle No. 404**

Ametek/Lamb Elec., 627 Lake St., Kent, Ohio 44240. (216) 673-3451. (R. O. Swift). (FB) **Circle No. 405**  
 Ampheno! Component Marketing Services, 2875 S. 25th Ave., Broadview, Ill. 60153. (312) 345-4260. (L. F. Edwards). (FB) **Circle No. 406**  
 Ashland Electronic Products, 32-02 Queens Blvd., L.I.C., N.Y. 11101. (212) 392-4010. (J. R. Lukasik). (FB) **Circle No. 407**  
 Astrodyne, Inc., 353 Middlesex Ave., Wilmington, Mass. 01887. (617) 658-9191. (Dick Vossler). (HE,HS,HP) **Circle No. 408**  
 Bailey Instruments, Inc., 515 Victor St., Saddle Brook, N.J. 07662. (201) 845-7252. (R. J. Bailey). (TE) **Circle No. 409**  
 Barber-Colman Co., Motor Div., Dept. S., 12116 Rock St., Rockford, Ill. 61101. (815) 877-0241. (M. Scheider). (FB) **Circle No. 410**  
 Bemco, Inc., 9908 San Fernando Rd., Pacoima, Calif. 91331. (213) 899-5296. (J. Riddle). (HE) **Circle No. 411**  
 Birnbach Co., Inc., 177 Hanse Ave., Freeport, N.Y. 11520. (516) 223-8400. (N. Frost). (HS) **Circle No. 412**  
 Bud Radio, 4605 E. 355th St., Willoughby, Ohio 44094. (216) 946-3200. (M. Blumberg). (FB) **Circle No. 413**  
 CEA, Div. Berkleonics, Inc., 1 Aerovista Park, San Luis Obispo, Calif. 93401. (800) 592-5910. (F. W. Davis). (HS,HE) **Circle No. 414**  
 Cabtron Systems, Inc., 200 Anets Dr., Northbrook, Ill. 60062. (312) 498-6090. (D. V. Fury). (FB) **Circle No. 415**  
 Cambridge Thermionic, 445 Concord Ave., Cambridge, Mass. 02138. (617) 491-5400. (W. G. Nowlin). (TE) **Circle No. 416**  
 Chem Aero, Inc., 231 E. Lomita Blvd., Wilmington, Calif. 90744. (213) 775-2581. (E. Swanson). (HE) **Circle No. 417**  
 Chemical Etching Equip. & Supply, 7629 Crawford Ct., Alexandria, Va. 22310. (703) 971-2646. (R. E. Hunt). (FB) **Circle No. 418**



Cinch-Monadnock, Oper. of TRW Electronic Comps., Div. TRW Inc., 18300 E. Valley Blvd., Box 1222, City of Industry, Calif. 91747. (213) 964-6581. (G. Holmes). (HS)

Circle No. 419

Clements Mfg. Co., 6656 S. Narragansett Ave., Chicago, Ill. 60638. (312) 767-7900. (J. B. Handy). (FB)

Circle No. 420

Commercial Chemicals, 3M Co., M.J. Shaver Bldg., 2245 S.E., St. Paul, Minn. 55101 (LC)

Circle No. 399

Cordover, Carl & Co., 104 Liberty Ave., Mineola, N.Y. 11501. (516) 747-5150. (J. Cordover). (HS)

Circle No. 421

Corning Glass Works, Tech. Prods. Div., Corning, N.Y. 14830. (607) 962-4444. (W. M. Baldwin). (HE)

Circle No. 422

Daburn Electronics & Cable Corp., 2360A Hoffman St., Bronx, N.Y. 10458. (212) 295-0050. (HS)

Circle No. 423

Delbert Blinn Co., Box 2007, Pomona, Calif. 91766. (714) 623-1257. (H. A. Manning). (HS)

Circle No. 424

Delco Electronics Div., 700 E. Firmin St., Kokomo, Ind. 46901. (317) 459-2175. (A. B. Goodspeed). (HS)

Circle No. 425

Dow Corning Corp., Midland, Mich. 48640. (517) 636-8510. (Robert Krasa). (TG, TS, LC)

Circle No. 426

du Pont Co., 1007 Market St., Wilmington, Del. 19898. (302) 774-2421. (R. M. Glaping). (HE, LC)

Circle No. 430

Dynatherm Corp., 1 Industry Lane, Cockeysville, Md. 21030. (301) 666-9151. (HP)

Circle No. 427

E-Tronics, 16774 Schoenborn, Sepulveda, Calif. 91343. (213) 787-5581. (F. Black). (HS)

Circle No. 428

Eastern Industries, 100 Skiff St., Hamden, Conn. 06514. (203) 248-3841. (HS, HE, FB)

Circle No. 429

Eimac, Div. Varian Assocs., 301 Industrial Way, San Carlos, Calif. 94070. (415) 592-1221. (J. R. Quinn). (HE)

Circle No. 431

Electro Impulse, Inc., Box 870, Red Bank, N.J. 07701. (201) 741-0404. (M. Rubin). (HE)

Circle No. 432

Electronic Enclosures, Div. Wyle Labs., Box 90978, Los Angeles, Calif. 90009. (213) 679-0181. (A. Blinder). (FB)

Circle No. 433

Electronic Products Div., 3M Co., Cherokee Blvd. & Mfrs. Rd., Chattanooga, Tenn. 37405. (615) 265-3411. (HS,HW)

Circle No. 434

Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. 02021. (617) 828-3300. (W. R. Cuming). (TG)

Circle No. 435

Equipto Enclosure Systems, Div. Equipto Electronics, 435 Woodlawn Ave., Aurora, Ill. 60507. (312) 897-4691. (Carl W. Peterson). (FB)

Circle No. 436

Fansteel Inc., One Tantalum Pl., N. Chicago, Ill. 60064. (312) 689-4900. (D. V. Caldwell). (HS)

Circle No. 437

Fischer Special Mfg. Co., 446 Morgan St., Cincinnati, Ohio 45206. (513) 961-1280. (J. Conner). (HS)

Circle No. 438

General Electric Silicone Prod. Dept., Waterford, N.Y. 12188. (518) 237-3330. (TG, TS, LC)

Circle No. 439

Hammond Mfg. Co. (U.S.) Inc., 1051 Clinton St., Buffalo, N.Y. 14240. (519) 822-2960. (R. F. Hammond). (FB)

Circle No. 440

Howard Inds., Div. MSL Inds., Inc., Box 287, Milford, Ill. 60653. (815) 889-4105. (E. W. Kleinschmidt). (FB)

Circle No. 441

Hughes Electron Dynamics Div., 3100 Lomita Blvd., Torrance, Calif. 90509. (213) 534-2121. (T. A. Hummel). (HP)

Circle No. 442

Humphrey, Inc., 9212 Balboa Ave., San Diego, Calif. 92123. (714) 565-6631. (H. H. Kries). (FB)

Circle No. 443

Hunter Tools, 9674 Telstar Ave., El Monte, Calif. 91731. (213) 686-0411. (T. Neff). (HS)

Circle No. 444

IMC Magnetics Corp., Corporate Offices, 570 Main St., Westbury, N.Y. 11591. (516) 334-7070. (E. Egan). (HE,FB)

Circle No. 445

IMC Magnetics Corp., New Hampshire Div., Rte. 16B, Rochester, N.H. 03867. (603) 332-5300. (K. E. Friese). (FB)

Circle No. 446

Inland Electronics Prods. Corp., 35 E. Glenarm, Pasadena, Calif. 91105. (213) 682-1521. (W. August). (HS)

Circle No. 447

International Electronic Research, 135 W. Magnolia Blvd., Burbank, Calif. 91508. (213) 849-2481. (J. Markley). (HE,HS,HW,TG)

Circle No. 448

International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245. (213) 678-6281. (F. Schulze). (HS)

Circle No. 449

Janitrol Aero Div., 4200 Surface Rd., Columbus, Ohio 43228. (614) 276-3561. (R. W. Schilling). (HE)

Circle No. 450

Jerymn, 712 Montgomery, San Francisco, Calif. 94111. (415) 362-7431. (HS,HP,TG,HW)

Circle No. 451

Johnson Corp., 805 Wood St., Three Rivers, Mich. 49093. (616) 278-1715. (R. W. Gotschall). (HE)

Circle No. 452

Kewanee Science Equipment Corp., 4012 Logan St., Adrian, Mich. 49221. (313) 263-5731. (R. E. Bateman). (FB)

Circle No. 453

Kooltronics, Inc., P.O. Box 504, Princeton, N.J. 08540. (609) 799-1466. (George Vogel). (HE)

Circle No. 454

Labconco Corp., 8811 Prospect, Kansas City, Mo. 64132. (816) 363-6330. (J. N. McConnell). (FB)

Circle No. 455

Lear Siegler, Inc., Romec Div., 241 S. Abbe Rd., Elyria, Ohio 44035. (216) 323-3211. (D. J. Meister). (HE)

Circle No. 456

Master Appliance Corp., 1745 Flett Ave., Racine, Wis. 53403. (414) 633-7791. (F. N. Pfeil). (HE)

Circle No. 457

Mauratron, Inc., 2741 Satsuma, Dallas, Tex. 75229. (J. E. Sykes).

Circle No. 458

McLean Engineering Labs, 70 Washington Rd., Princeton Jctn., N.J. 08550. (609) 799-0100. (W. B. Eckenhoff). (HE,FB)

Circle No. 459

Melcor-Materials Electronic Products, 990 Spruce St., Trenton, N.J. 08638. (609) 393-4178. (M. Levine). (TE)

Circle No. 460

Molon Motors & Coil, 3737 Industrial Ave., Rolling Meadows, Ill. 60008. (312) 259-3750. (T. J. Bujewski). (FB)

Circle No. 461

3M Co., Electro Prods. Div., 3M Center, St. Paul, Minn. 55101. (612) 733-1110. (TE)

Circle No. 488

Nanotron Relay Co., Sub. Veradyne Corp., 330 N. Victory, Burbank, Calif. 91502. (213) 849-3123. (J. Ashford). (HS)

Circle No. 462

National Beryllia Corp., Greenwood Ave., Haskell, N.J. 07420. (201) 839-1600. (Roy Durnwirth). (HS,HW)

Circle No. 463

Norelcom Inds., Inc., 200 Allen Blvd., Farmingdale, N.Y. 11735. (516) 249-7245. (R. E. Thaw). (FB)

Circle No. 464

Nuclear Systems, 2613 Industrial Lane, Garland, Tex. 75041. (214) 278-3545. (Dean Hoppins). (TE)

Circle No. 465

Ohio Semitronics, 1205 Chesapeake Ave., Columbus, Ohio 43212. (614) 486-9561. (A. Leatherman). (TE)

Circle No. 466

Optima Enclosures, Div. Scientific Atlanta, 2166 Mountain Ind'l Blvd., Tucker, Ga. 30084. (404) 939-6340. (P. Stokes). (FB)

Circle No. 467

Pamotor, Inc., 770 Airport Blvd., Burlingame, Calif. 94010. (415) 347-1203. (C. Port). (HE,FB)

Circle No. 468

Perfection Mica Co., Magnetic Shield Div., 740 Thomas Dr., Bensenville, Ill. 60106. (312) 766-7800. (R. F. Gans). (HS)

Circle No. 469

Plessey Ceramic Div., Plessey N.J. Inc., 8th & Harrison Sts., Frenchtown, N.J. 08825. (201) 996-2121. (J. D. Fredericks). (HS,TW)

Circle No. 470

Precision Dipbraze Tor., 14715 Arminta St., Van Nuys, Calif. 91402. (213) 786-6524. (S. Hines). (HE,HS)

Circle No. 471

Premier Metal Prods. Co., Div. of Sunshine Mining Co., 337 Manida St., Bronx, N.Y. 10474. (212) 991-6600. (A. Bozza). (FB)

Circle No. 472

Ripley Co., Inc., 1 Factory St., Middletown, Conn. 06457. (203) 346-6677. (R. S. Clark). (FB)

Circle No. 473

Rotron, Inc., Hasbrouck Lane, Woodstock, N.Y. 12498. (914) 679-2401. (J. O. Hill). (HE,FB)

Circle No. 474

Rotating Comps., Instr. Systems Corp., 770 Park Ave., Huntington, N.Y. 11743. (516) 423-6200. (A. L. Boada). (FB)

Circle No. 475

SWS Silicones, Sutton Rd., Adrian, Mich. 49221. (313) 263-5711. (R. C. Flewelling). (HS)

Circle No. 476

Santa Barbara Research Center, 75 Coromar Dr., Goleta, Calif. 93017. (805) 968-3511. (H. C. Wilcox). (HE,TE)

Circle No. 477

Shigoto Inds., Ltd., 350 Fifth Ave., New York, N.Y. 10001. (212) 695-0200. (E. Kramer). (TE)

Circle No. 478

Smith, Herman H., Inc., 812 Snediker Ave., Brooklyn, N.Y. 11207. (212) 272-9400. (S. Fleischman). (HS)

Circle No. 479

Standard Environmental Systems, Inc., 392 Minnisink Rd., Totowa, N.J. 07512. (201) 256-2200. (D. E. Wilson). (HE)

Circle No. 480

Stantron, Wyco Metal Prods., Box 9158 V.C., No. Hollywood, Calif. 91609. (213) 875-0800. (L. Turner). (FB)

Circle No. 481

Staver Co., Inc., 41 N. Saxon Ave., Bay Shore, N.Y. 11706. (516) 666-8000. (J. B. Lazarus). (HS)

Circle No. 482

TRW/Globe Motors, 2275 Stanley Ave., Dayton, Ohio 45404. (513) 228-3171. (J. D. Bourque). (FB)

Circle No. 483

Technipower Inc., Benrus Ctr., Ridgefield, Conn. 06877. (203) 438-0333. (A. R. Saenz). (HE)

Circle No. 484

Telectro Systems Corp., 96-18 43rd Ave., Corona, N.Y. 11368. (212) 651-8900. (H. Sussman). (FB)

Circle No. 485

Tenney Engineering Inc., 11000 Springfield Rd., Union, N.J. 07083. (201) 686-7870. (R. S. Schiffman). (TE)

Circle No. 486

Thermalloy Co., Inc., 2021 W. Valley View Lane, Dallas, Tex. 75234. (214) 243-4321. (Robert Alpert). (HE,HS,HW,TG)

Circle No. 487

Titchener, E. H. & Co., 8 Titchener Pl., Binghamton, N.Y. 13902. (607) 772-1161. (R. D. Lindridge). (FB)

Circle No. 489

Torin Corp., Kennedy Dr., Torrington, Conn. 06790. (203) 482-4422. (E. Myers). (HE,FB)

Circle No. 490

Trans-Tec Corp., Box 1022, Columbus, Neb. 68601. (402) 564-2748. (S. Zwick). (HE,HS)

Circle No. 491

Triac Electronic Systems, Box 550, Forest Hills, N.Y. 11375. (212) 687-0620. (M. Walpow). (TE,HE)

Circle No. 492

Union Carbide Carbon Prods. Div., 270 Park Ave., N.Y., N.Y. 10017. (212) 551-2345. (HE)

Circle No. 493

Vemaline Prods. Co., 455 W. Main St., Wyckoff, N.J. 07481. (201) 891-3200. (C. J. Dawkins). (HS)

Circle No. 494

Vent-Rak, Div. General Devices Co., 525 S. Webster Ave., Indianapolis, Ind. 46219. (317) 359-5407. (H. L. Crouch). (FB)

Circle No. 495

Wakefield Engineering Inc., Components Div., Teal & Audubon Rds., Wakefield, Mass. 01880. (617) 245-5900. (D. Hegarty). (HS,HE,HP,HW,TG)

Circle No. 496

Waterbury Pressed Metal Co., Parts Div., 407 Brookside Rd., Waterbury, Conn. 06714. (203) 756-8891. (W. H. Armstrong). (HS)

Circle No. 497

Xcelite, Inc., 770 Bank St., Orchard Park, N.Y. 14127. (716) 662-4461. (F. Davis). (HS)

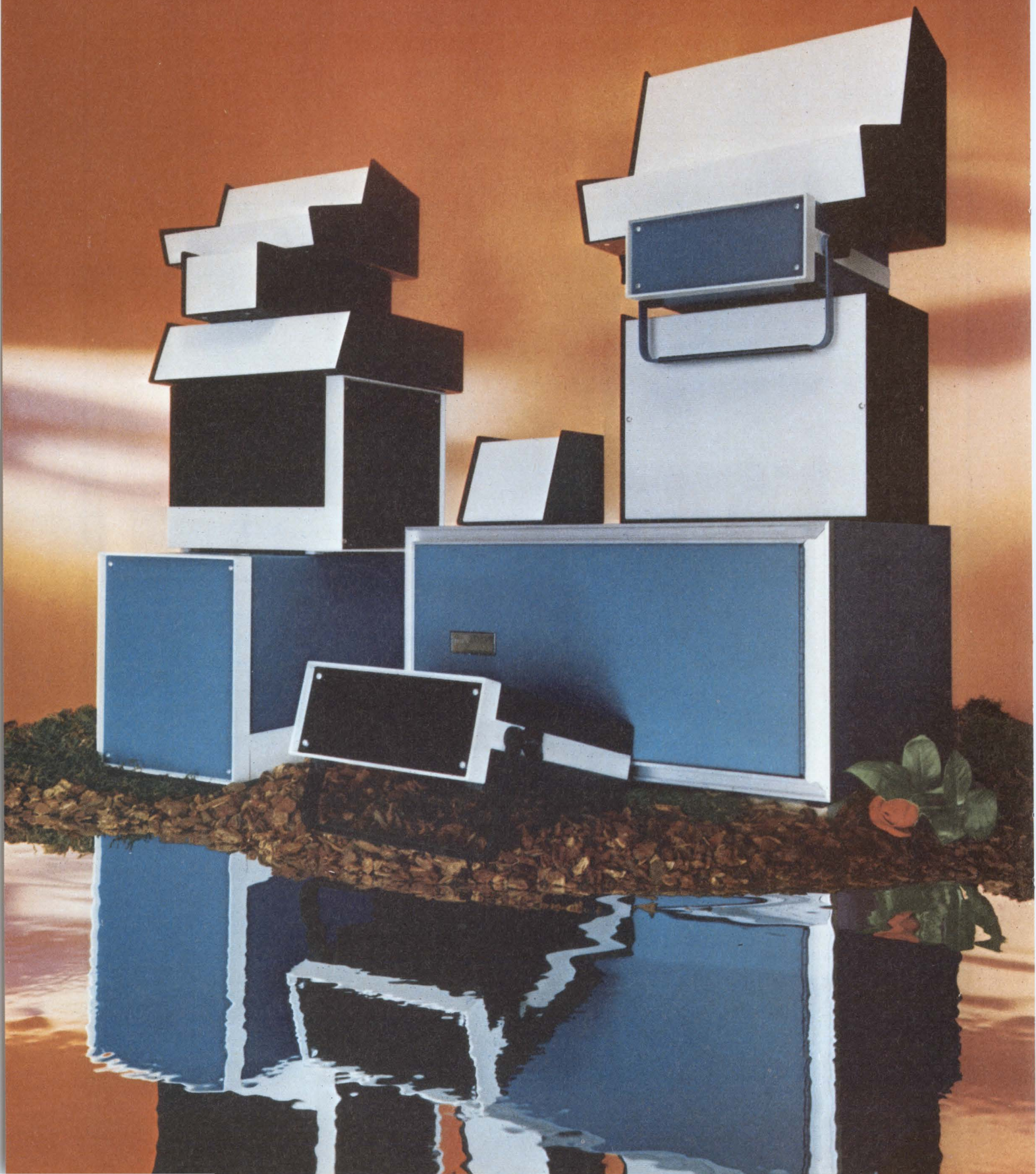
Circle No. 498

Zero Mfg. Co., Zero West Div., 777 Front St., Burbank, Calif. 91503. (213) 846-4191. (M. S. Huffman). (FB)

Circle No. 499



# CONTEMPORARY HOUSING.





# Whichever one you need, you'll get the most for your money from BUD.

When you need housings for small equipment, devices and instruments, go to the authority, Bud.

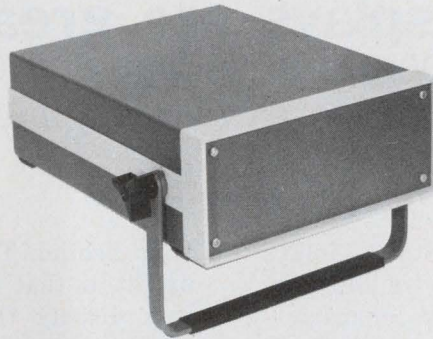
You'll find the cabinet you need. You'll find the right size and configuration. You'll find the design, engineering and construction you want.

It adds up to one thing: Value... getting the most for your dollar.

And whatever cabinet you want, you get. Now! Every cabinet Bud makes is an off-the-shelf item. Every one is immediately available from over 300 Bud Distributors.

No one in the industry offers you as much as Bud, whether it's product line, service, availability or value.

For the name of the Bud Distributor or Representative in your area, call (800)645-9200, toll free.



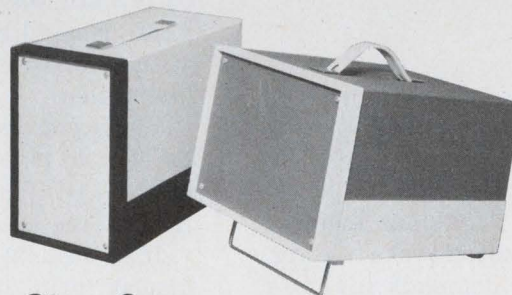
## The all-new TR Series.

These new, versatile instrument enclosures may look custom made, but they're off-the-shelf items at your Bud Distributor. Four sizes, plus four accessory chassis. Good looking! Functional! Quality construction! The body is .050 aluminum; front panel, .090 aluminum. Top and bottom can be removed quickly for easy access to dust-free interiors. Carrying handle is used as tilting bail. Front panel, self-adhesive rubber feet and handle bail are included with each unit. Finished in mar-resistant, durable, easy-to-clean Nextel; offered in two color combinations: Blue (BLN) and white, or brown (BRN) and white.



## The Stylist... new from Bud.

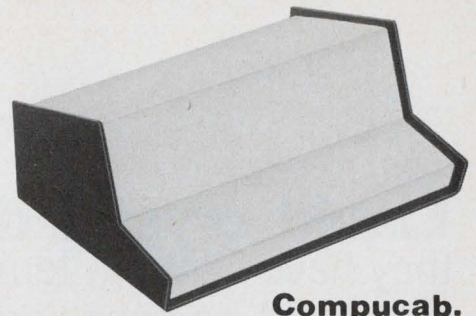
The Stylist, Bud's new line of cabinets, comes in six sizes. Clear inside depth of each is 14 3/16"; overall width, 20 13/16"; overall depth, 15 1/4". A 19" wide door is optional. An etched aluminum extrusion framing the front panel complements the appearance of your products. Square corner design is a construction plus: Full-width flanges along top and bottom add strength at each corner; no tilt, no sway when cabinet is loaded. Load carrying capacity, 500 pounds. Cabinet's 16 gauge cold rolled steel structure is based on stressed skin concept; it's self supporting, no internal framework. Finishes: Royal blue (RB) and gray hammertone (HG).



## ShowCase.

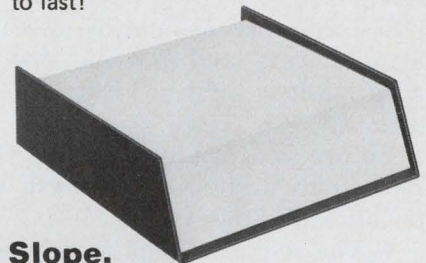
Use it as a desk top instrument case, in systems, in racks or as a portable enclosure. However it's used, the ShowCase adds an extra touch of quality to your products. As for extra value... front and rear panels plus bail are included!

ShowCase comes in two color combinations: Black and white, royal blue and white. And, as always, Bud gives you a wide selection of sizes: Ten in all!



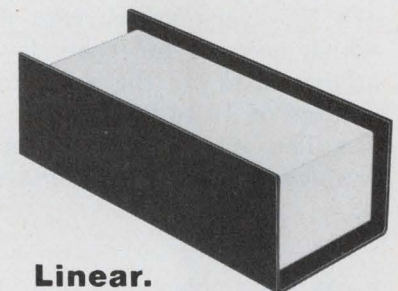
## CompuCab.

The keyboard design of the CompuCab gives it a custom-made look, yet it's a standard Bud cabinet. It houses varied types of instruments; offers maximum visibility; no fasteners visible on panel area. All aluminum construction. Built to last!



## Slope.

Here's a small cabinet that offers maximum visibility of panel mounted components. Base is black textured; one-piece, white cover is easily detached for quick access to interior. All aluminum; no fasteners exposed on the visible surfaces. Designed for today. Tomorrow.



## Linear.

Practical. Economical. Designed, engineered and built to give you the value you look for. One-piece white enamel cover is easily detached from black enamel base for convenient access to interior. All aluminum; no fasteners mar panel areas. Always in stock!

# BUD

**"The Housing Authority"**

BUD RADIO, INC.  
4605 E. 355th St. Willoughby, Ohio 44094  
216/946-3200 TWX 810-427-2604



# Liquid crystal displays are great—but . . .

they have lighting, temperature, voltage and drive limitations that must be considered before you design with LCDs.

For digital readouts, liquid-crystal displays (LCDs) have a lot to offer: They're inexpensive, have low-power electrical drive characteristics that are compatible with those of MOS-logic drivers and provide good contrast, even with outdoor lighting. But LCDs also have limitations.

Before you can incorporate them successfully into your designs, you must consider characteristics like these:

- The so-called display may require additional artificial light. Unlike other displays, LCDs don't generate their own self-lighted characters.

- The sensitivity of LCDs results in a narrow operating temperature range, generally from 0 to 105 C. LCDs draw varying amounts of current, depending on the temperature. And their characteristics can be altered by storage temperatures.

- The very low-current demands of LCDs—which account for their low power needs—are accompanied by the need for a relatively high voltage of 15 to 20 V.

- The operation of LCDs requires a low ac-frequency drive that contains no superimposed dc.

## Break the ambient-only rule

Both modes of the liquid-crystal display—dynamic-scattering and twisted-nematic—are intended to work primarily with ambient illumination. The display reflects light that has bounced off its energized structure back to the viewer. But if the user's application demands night or low-ambient performance, back-lighting is required.

The transmissive-mode LCD is chosen, for instance, when a calculator is designed for use in areas lighted to less than 10 foot candles. A lamp, rated at a half watt per half-inch of height, can illuminate a dynamic-scattering LCD

from behind. The resulting light level can be as bright as that for a gas-discharge or light-emitting display that operates in normal ambient conditions.

No additional power is drawn by the LCD, even if the ambient light level increases. Both reflective and transmissive modes are immune to high ambient washout.

Power for artificial illumination can be independent of the display, and does not have to be switched with it. The selected source usually is based on available power. The user can add color easily to a back-lighted LCD with a colored light source.

## Back-light displays

Several back-lighting schemes are outlined in the accompanying figure. Schemes A, B and E make use of light spillage, a desirable feature when a keyboard or writing surface is lighted. Back-lighting adds about a dollar or two to the cost of an 8 or 12-digit display.

It's simpler to back-light a twisted-nematic than a dynamic-scattering LCD, since the twisted nematic has less directional sensitivity. Flood lighting is all right for back-lighting, when used with a diffuser that helps to even out the illumination.

When you design the product package, there's no need to place fillers, grids or the like in front of the LCD. Integrate the display so it becomes part of the external package.

If nomenclature is desired on the face of the display, print it directly on the LCD rather than on an intermediate glass surface. This eliminates two potentially troublesome reflecting surfaces.

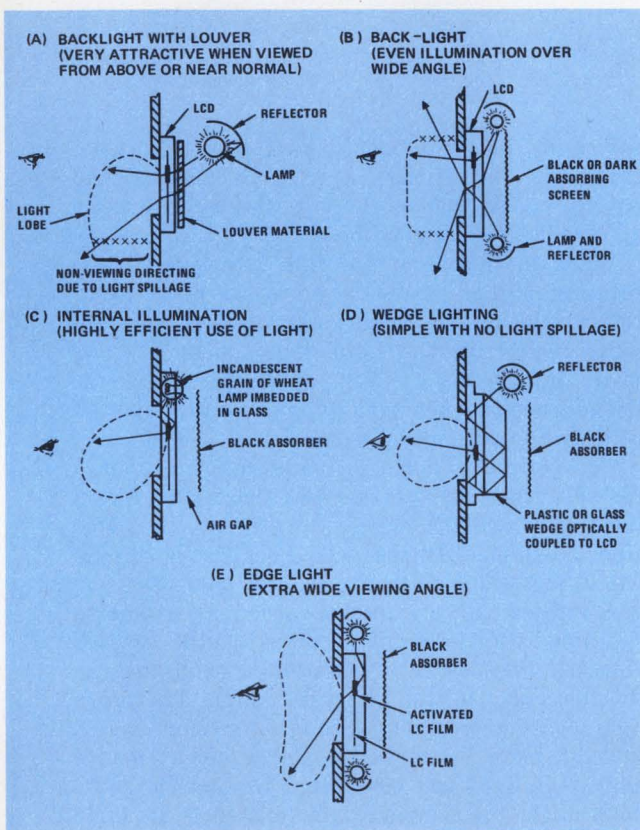
The best way to combat LCD reflecting problems is to put a shallow etch, or frosting, on the front glass surface. This breaks up the image of any reflection and renders it less distracting. If etched glass is not available, laminate a piece of commercially etched picture-frame glass to the front of the display. Use a transparent epoxy resin to simplify optical coupling between both pieces of glass.

All liquid-crystal displays can be made im-

---

Larry E. Tannas, Jr., Group Leader of Display Techniques, Electronic Research Div., Rockwell International, 3370 Miraloma Ave., Anaheim, Calif. 92803.





Five basic lighting techniques are used to back-light a dynamic-scattering, transmissive-mode LCD. One scheme (A) gives limited light spill when viewed from above or nearly head-on. Another (B) uses two lamp/reflectors to spread light over a wide angle. A third (C) uses light very efficiently. The fourth (D), called wedge-lighting, eliminates light spillage. And the fifth (E) offers the user an extra-wide viewing angle.

immune to washout—transmissive as well as reflective. For example, scattering centers in a dynamic transmissive-mode LCD help trap light. The centers, through internal reflections, reduce washout within the glass confines.

#### Light-traps keep half

If the efficiency of the LCD is high, a small percentage of the ambient light is internally trapped. But, of the portion trapped, only half the light can return out of the front side.

The liquid-crystal material does not back-scatter, and the display has immunity to high point light sources, like a spotlight, the sun or a window. But it is not so immune to continuous light sources, such as an open bright sky or a very large illuminated area. The loss of immunity is largely due to glare.

When glare, caused by first surface reflection, is directed toward the viewer, the display may wash out. This can be eliminated if the first surface is made to reflect a dark image. In one outdoor application, a user tilted an LCD-equipped traffic sign slightly forward, so that the first surface reflection was from the ground, not from the sky.

#### Electrical interface and characteristics

Liquid-crystal displays are high-impedance devices. High impedance, which lowers power requirements, also offers the user a choice of connector-assembly methods and styles—a feature not always offered with other displays.

Connector contact resistance of several hundred ohms does not affect the brightness of the LCD. One reason is that the transparent conductor on the LCD connector edge is usually either indium or tin oxide, both very hard and abrasive-resistant materials.

A pointed connector pin, which penetrates a connector edge that contains these materials, completes the physical interface. When 10 or more insertions are desired, or a high-vibration environment is expected, use gold-pressure contacts.

The connector edge should then be silk-screen-printed with gold to mate with the gold pin. Where screenable silver has been printed, wire can be bonded directly to the glass edge via indium-gold alloy solder. The user can also weld beam leads ultrasonically onto gold or silver pads printed on the glass.

At room temperature dc resistivity is typically  $10^9$  to  $10^{10}$   $\Omega/\text{cm}$ , depending on whether a dynamic-scattering or twisted-nematic LCD is used. Cell requirements range from 50 to 5  $\mu\text{W}$ , respectively, for a half-inch-high display.



## The ABCs of liquid-crystal displays

A liquid-crystal display (LCD) is passive; it does not emit light regardless of the mode of operation. The two basic types of LCDs are dynamic-scattering and twisted-nematic (or field-effect). In turn, each can be obtained in either a reflective or transmissive mode. The major features of these four LCDs are shown in the accompanying table.

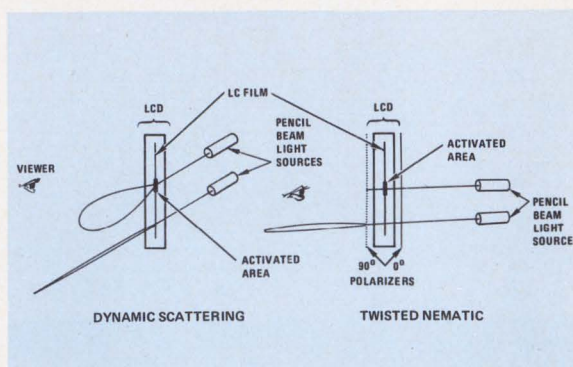
For all types, light falling upon the display is refracted or rotated by the thin film of the LC material. The display area is electrically controlled to produce a contrast over the unexcited area.

In dynamic-scattering (left-hand figure), many small domains of liquid crystal are formed with the application of the electric field. Multiple refractions at the boundaries of the domains cause the ballooning of a pencil beam of light, so an off-axis viewer sees a definite contrast. The unactivated area remains transparent, while the activated area appears frosty and opaque, and takes on the color of the light source.

The pencil beam that goes through the unactivated area can be seen only if the viewer looks down the beam itself. The lobe on the left side represents a polar diagram of light intensity, with a  $\pm 10^\circ$  half-power angle typically. Note that light is only forward-scattered. To obtain the reflective mode, simply place a mirror on the left side. The mirror permits the light source and viewer to be on the same side of the display. This can be detrimental if the viewer sees the image of the light source or cluttering images.

Light rotates in the twisted-nematic mode (right-hand figure) as opposed to being refracted in the dynamic-scattering mode. The LC material in the twisted-nematic cell aligns parallel to the inner surface. With the two surfaces rotated  $90^\circ$  during cell construction, polarized light rotates the same amount.

When unactivated, the pencil beam is first



polarized, then rotated  $90^\circ$  by the liquid-crystal film; the light passes through the second polarizer. A viewer on the left who looks directly at the display sees the beam.

When the liquid-crystal film is activated, the rotating ability is destroyed by a breakup of the crystal order. The second polarizer now absorbs nearly all the light incident on it, and gives this area a black appearance. Inverse images can be achieved when both planes of polarization are made parallel.

The reflective mode is achieved by use of a reflector in place of the left polarizer. Again the viewer and the light source are on the same side. No image can be seen here (as with dynamic scattering) because of the polarizers.

A limited viewing angle, caused by excessive rotation, is an inherent property of the twisted nematic. The degree of rotation depends on the thickness of the liquid-crystal film. Therefore light passing obliquely through the film passes through more LC material. For a large enough angle, the light can be rotated beyond the optimum angle for complete transmittance. Reliable display interpretation should be expected at  $\pm 30^\circ$  to the normal, although half of the light is absorbed at the first polarizer.

Dynamic scatter		Twisted nematic	
Reflective	Transmissive	Reflective	Transmissive
Efficient use of ambient light good down to moonlight	Widest viewing angle	Most efficient use of ambient light	Narrower viewing angle
Viewing angle sensitive to location of ambient light	Lowest cost	No background image clutter as diffusive reflector can be used	Readable in total darkness with back light
Background cluttered by image of viewer and surroundings (desirable on a woman's watch)	Readable in total darkness with back light	Narrower viewing angle	No light spillage
Aesthetically interesting characteristics can be incorporated in colored dichroic mirror	Changeable color by changing back-light color	Lowest power	Changeable color by changing back-light color
	Back light (or front light) desirable in some form at all times		Back light in some form desirable at all times



The material resistivity of the LCD changes by almost three orders of magnitude over the operating temperature range. The dielectric constant, approximately 5, also varies by 50%.

Dynamic scattering displays usually specify 20 V ac. The display responds best to a square-wave drive, with a frequency in the range of from 20 to 200 Hz. The lower frequencies are used to excite the LCD when temperatures are low. However, the display won't respond to excitation frequencies above a so-called critical frequency—in this case, 400 Hz.

The LCD cell is black-boxed to simulate a leaky capacitor. This capacitor time constant is 1 ms at room temperature. Since an LCD presents a capacitive load to the drive electronics, power loss varies with drive frequency. Typical values of power loss are 1  $\mu$ W for dynamic-scatter and twisted-nematic, referenced to a half-inch-high character.

Response time is also a function of temperature—about 200 ms at room temperature. This parameter changes by two orders of magnitude over the operating range. But display speed cannot be increased significantly by use of faster drive electronics.

Material viscosity represents a limiting factor of LCD response speed. The lower the ambient temperature that surrounds the display, the slower the display's speed.

#### LCD temperature range—a 'nematic' band

Most dynamic-scattering displays use a mixture of materials called butylanilines, doped for conductivity with a proprietary ionic material. This combination gives the display an operating range of approximately -15 to 55 C.

Depending on ambient temperature, a complete reversal of LCD characteristics can occur. The effects are similar to the melting and freezing of water. The useful operating temperature range is limited to a band called the nematic range. Above this, the material becomes an isotropic liquid and ceases to exhibit anisotropic (liquid-crystal) properties.

Below the nematic range the material becomes a solid, and, once again, it shows isotropic properties. Ordinarily you don't have to worry about temperature-induced expansion. The material closely matches that of the surrounding glass envelope.

At present, users as well as manufacturers face nematic-band problems. One possible solution widens the nematic band so the lower limit of the operating range falls below room temperature. Eastman Kodak, for example, uses this technique for a dynamic-scattering material that achieves a range of 0 to 105 C.

The user must know how to evaluate a

good LCD and how to spot potentially defective ones. A malfunctioning display can be detected by one of the following characteristics:

- *A slippery feeling or peculiar odor.* This means that the liquid-crystal material is leaking out of the glass sandwich. Bubbles develop in a few hours of operation, and sooner or later they void a segment.

- *Irregular dark and light areas when a display on standby is viewed through cross-polarizers.* This indicates poor alignment of the liquid-crystal molecules relative to the glass walls. Hair-like lines, frosty surface or other irregularities show poor alignment and can lead to a visually disturbing appearance.

- *Excessively slow ON or OFF response.* This indicates an excessively thick liquid-crystal space, which normally remains stable unless caused by contamination.

- *Low resistance.* This shows excessive doping or contamination of liquid-crystal material. The display should be rejected immediately, since this defect causes shortening of display life.

#### Characteristics of good LCDs

Properly functioning displays meet the following criteria:

- *Wide operating temperature.* A net operating band of at least 65 C should be expected from any LCD. The low end of the nematic band must approach 0 C. Check to make sure the response time is not too slow at the lower temperature and that current consumption is not excessive at the higher temperature.

- *A low critical frequency.* This increases proportionately with temperature, and it is the upper frequency at which the display stops dynamic scattering. Excessive conductivity is one cause of a high critical frequency. For the dynamic-scattering mode, the critical frequency must be above the drive frequency at the lowest operating temperature. At room temperature, the critical frequency should be about 500 Hz and consistent ( $\pm 50$  Hz) from one display to another. Character-to-character consistency also should be  $\pm 50$  Hz within each display.

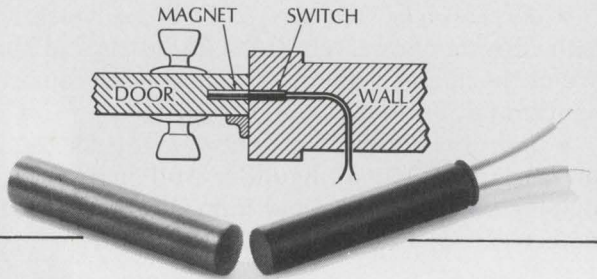
- *Wide storage temperature.* The liquid-crystal envelope must survive the storage temperature. Alignment of the display material can change, depending on storage history, at the lower temperature extremes. This is a particularly important parameter with twisted-nematic LCDs, since reliable hermetic seals have been developed only recently. The seal may leak at storage temperature extremes because of a mismatch in the thermal expansion of sealing materials. Storage temperatures of -50 to 100 C should be used.

- *Consistent upper and lower transition tem-*



## Magnetically activated proximity switches for faster, easier, residential alarm system installations

- Low cost, concealed.
- Easily installed with 1/4" drill.
- Types for closed and open loop systems.
- Draws microamp current. 6V or 12V DC operation.
- Fully protected against environment.
- Completely concealed in door and jamb. Tamperproof.
- Quick deliveries. Small quantities in one week.



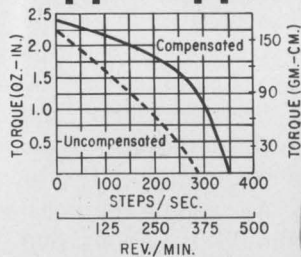
Write or call for information.

PRICE ELECTRIC RELAYS

### NORTH AMERICAN PHILIPS CONTROLS CORP.

Frederick, Md. 21701 • (301) 663-5141  
INFORMATION RETRIEVAL NUMBER 48

## Discover new performance and economy for your stepper applications.



### 4-phase PM logic motors for under \$9ea.\*

Get information today on our new low cost 82401 Series reversible permanent magnet logic stepper motor. It will achieve an optimum cost vs. performance ratio for you. End uses include analytical instrumentation and computer peripheral applications such as printer drives, X-Y plotter drives and chart drives.

Coil design assures low wattage operation.....3.5 watts for both 5 vdc and 12 vdc models. Stable stepping operation is achieved by using a permanent magnet construction. Maximum pull-in/out torque is 2.4 oz-in. with a compensation network. Also a maximum pull-in rate of 350 steps/sec and pull-out rate of 480 steps/sec can be attained. Basic step angle is 7.5°, but integral gearing can be furnished to provide a variety of stepping angles and torques.

\*In 500 quantities.

Send for information today!

A. W. HAYDON CO. PRODUCTS

### NORTH AMERICAN PHILIPS CONTROLS CORP.

Cheshire, Conn. 06410 • (203) 272-0301

INFORMATION RETRIEVAL NUMBER 49

## Who makes LCDs?

The following manufacturers offer liquid-crystal displays. Readers may consult these vendors for full product-line information by circling the appropriate information retrieval number:

- AEG Telefunken, Fachbereich Rohren, D-79 Ulm, Soflinger Strasse 100, West Germany. **CIRCLE NO. 500**
- American Microsystems Inc., 3800 Homestead Rd., Santa Clara, Calif. 95051. **CIRCLE NO. 501**
- ElectroVac, A-1194 Rampengasse 5, Vienna, Austria. **CIRCLE NO. 502**
- Hamlin Inc., Lake and Grove Sts., Lake Mills, Wis. 53551. **CIRCLE NO. 503**
- IEE (Industrial Electronic Engineers), 7740 Lemona Ave., Van Nuys, Calif. 91405. **CIRCLE NO. 504**
- Integrated Display Systems, Inc., Montgomeryville, Pa. 18936. **CIRCLE NO. 505**
- ISE International Corp., Shinbashi Kokusai Bldg., No. 2.7.7, Higashishinbashi, Minato-Ku, Tokyo, Japan. **CIRCLE NO. 506**
- ILIXCO (International Liquid Crystal Co.), 26101 Miles Rd., Cleveland, Ohio. **CIRCLE NO. 507**
- Liquid Crystal Inc., 208 Route 206, South Somerville, N.J. 08876. **CIRCLE NO. 508**
- Optel, Box 2215, Princeton, N.J. 08540. **CIRCLE NO. 509**
- Orega-Cifte, 50., Rue J. P. Timband, 92-Courbevois, France. **CIRCLE NO. 510**
- RCA Solid State Div., Somerville, N.J. 08876. **CIRCLE NO. 511**
- Rockwell International Corp., Microelectronics Div., P.O. Box 3669, Anaheim, Calif. 92803. **CIRCLE NO. 512**
- Toshiba Ltd., Tokyo, Japan. **CIRCLE NO. 513**
- Transparent Conductors Inc., 26 Coromar Dr., P. O. Box 549, Goleta, Calif. 93017. **CIRCLE NO. 514**

perature. A variation of 1 C in upper transition temperature indicates a change in material purity, type or doping level. The transition temperature should be constant from batch to batch, and constant with time on any one batch. Failure is evident when the display temperature band narrows by 10% after an initial operation period of 100 hours.

■ *Wide scattering lobe.* An LCD's scattering lobe depends on the type of material, dopant and operating voltage used. If off-axis view is important, specify a wide-lobe LCD. Scattering lobe can be increased if the ac drive voltage is raised.

■ *Speed of response.* If the response speed rises above 200 ms, it becomes noticeable and may be objectionable. The response is proportional to the square of the display-film thickness. A high drive voltage causes the display to turn on quickly, but also to extinguish slowly. The opposite is true for a low-drive voltage.

■ *Material color.* The display should be transparent or have only a slight but bright yellow tinge. Reject displays with a dull yellow or brownish tinge, since this invariably indicates contamination.

■ *Voltage.* Display performance should be relatively insensitive to normal supply-voltage fluctuations. However, a 200% overvoltage may cause damage and shorten display life, if applied for more than a few minutes. ■■

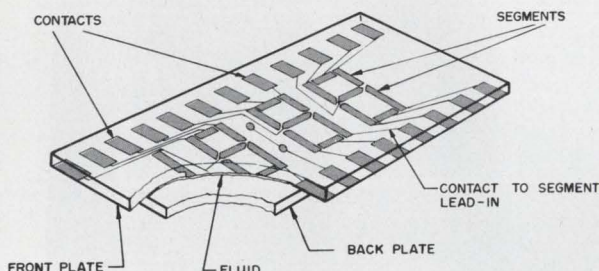


# The case for Liquid Crystal Displays

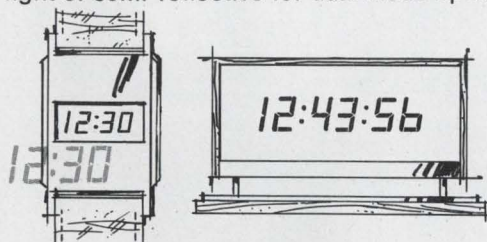
**Liquid crystal displays;** light emitting diodes; incandescent and fluorescent displays and "Nixie" tubes are popping up frequently in circuit designs as the trend to digital readout continues. Each has a purpose and the design engineer should become familiar with all types. We make liquid crystal displays.

## The display of the future?

Our display is a sandwich of two plates, joined and hermetically sealed at the perimeters. A space of about .0005" separates the plates, and this is filled with a nematic liquid crystal solution.



When the liquid is not electrically excited, its long, cigar-shaped molecules are parallel to one another in a position perpendicular to the plates. Thus, the liquid appears transparent. Applying an electric current creates ion activity which leads to turbulence and causes the liquid to scatter incident light. The visual effect is that of a frosted glass. LCD's can be made completely transmissive for back-lighting, reflective for ambient light or semi-reflective for dual mode operation.



Producing an image — digital or other — simply requires a conductive surface the shape of the desired image on the glass plate toward the viewer. Current flowing from the conductive image on the front plate through the crystal liquid to the common-ground back plate causes the liquid to change from clear to a frosted appearance in the current-carrying area.

These images are almost always in the form of seven segments that make up the numerals 1 through 0. Energizing the proper segments produces the desired numerals. Lead-ins connect the segments to external contacts on the sandwich (display).

## Consider the advantages.

Liquid crystal displays have a number of distinct advantages. Simplicity is the reason for several of these. The elements are few and passive — very little can go wrong with an LCD and this means reliability and long life.

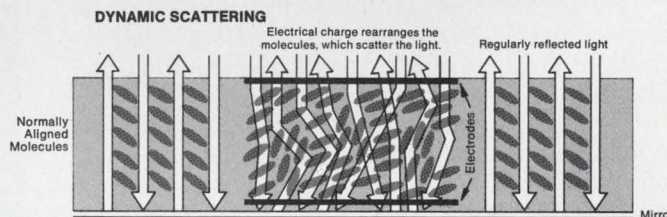
Simplicity means low cost, too — lower than that of most comparable displays. Packaging costs are low because LCD's can be driven directly by MOS and C/MOS circuits. In our dynamic scattering displays very narrow character widths are possible and still provide a good viewing angle — 60 degrees in many cases.

Low power consumption makes the LCD a logical choice where power limitations rule out other display types. Watch type LCD's use only 30  $\mu$ W, for example, with all segments energized at 15 volts.

LCD's offer the greatest flexibility of any display type. Several standard displays are immediately available from Hamlin's stock. Special displays with virtually any type of image can be produced with surprisingly low preparation or "tooling" cost. Because of the LCD's simplicity, lead time on specials is only a matter of weeks.

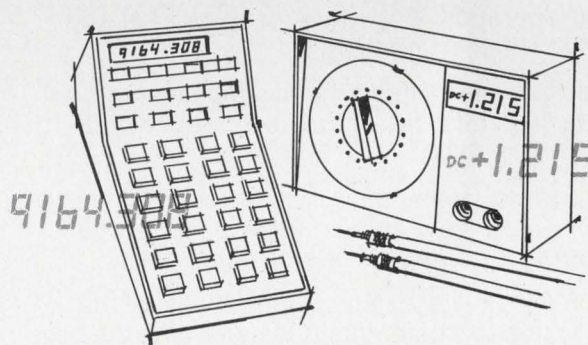
## A few limitations.

LCD's have limitations, too. Operating temperature range is one. Liquid crystals slow down and may even cease to function at temperatures below 0°C. Above 50-60°C, crystals go into solution and will not function normally.



Extremes do not damage LCD's. Once the temperature returns to normal, operation is automatically resumed.

LCD's do not generate light, and they are somewhat difficult to read under low ambient light conditions. (Side or back lighting can remedy this.) Visibility under medium to high ambient light conditions is excellent.



In the majority of display applications, MOS and C/MOS compatibility, reliability, flexibility and low power requirement are important considerations. No other display type can match the liquid crystal display on these jobs. They could become the display of the future. And that's the case for the LCD. For specification and application data, write Hamlin, Inc., Lake Mills, Wisconsin 53551. Or call, 414/648-2361. (Evaluation samples are available at moderate cost.)

**HAMLIN**  
INCORPORATED

INFORMATION RETRIEVAL NUMBER 50



# ENTER ↑

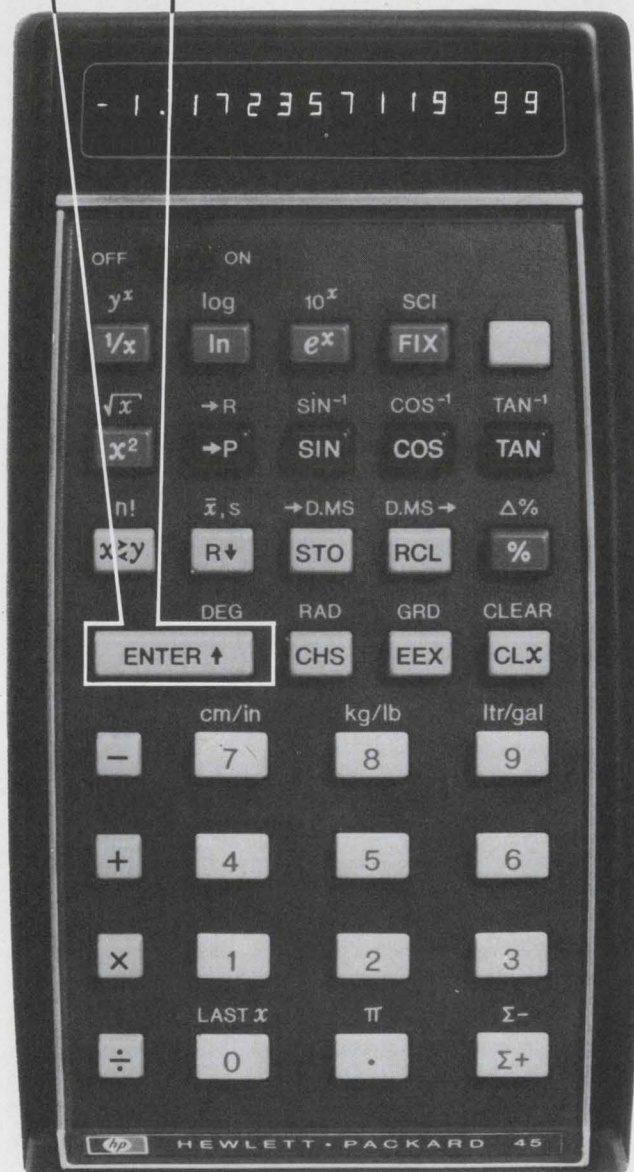
## This is your key to unprecedented calculating power. Only Hewlett-Packard offers it.

In 1928 a Polish mathematician, Dr. Jan Lukasiewicz, invented a parenthesis-free but unambiguous language. As it's evolved over the years it's come to be known as Reverse Polish Notation (RPN), and it's become a standard language of computer science.

Today, it's the only language that allows you to "speak" with total consistency to a pocket-sized calculator. And the only pocket-sized calculators that use it are Hewlett-Packard's.

**ENTER** ↑ is the key to RPN because it enables you to load data into a 4-Register Operational Stack with the following consequences:

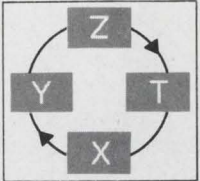
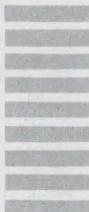

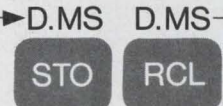
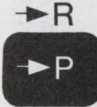

1. You can *a/ways* enter data the same way, i.e. from left to right, the natural way to read any expression.
2. You can *a/ways* proceed through your problem the same way. Once you've entered a number you ask: "Can I operate?" If yes, you perform the operation. If no, you press **ENTER** ↑ and key in the next number.
3. You can see *a/ll* intermediate data anytime, so you can check the progress of your calculations *as you go*.
4. You almost never have to re-enter intermediate answers—a real time-saver, especially when your data have eight or nine digits each.
5. You don't have to think your problem all the way through beforehand to determine the best method of approach.
6. You can easily recover from errors since each operation is performed sequentially, immediately after pressing the appropriate key, and all data stored in the calculator can be easily reviewed.
7. You can communicate with your calculator efficiently, consistently and without ambiguity. You always proceed one way, no matter what the problem.





## The HP-45 uses RPN.

That's one reason it's the most powerful pre-programmed pocket-sized scientific calculator. Here are 8 others:

1. It's pre-programmed to handle 44 arithmetic, trigonometric and logarithmic functions and data manipulation operations beyond the basic four (+, -, ×, ÷).
2.  It offers a 4-Register Operational Stack that saves intermediate answers and automatically retrieves them when they are required in the calculation.
3.  It lets you store up to nine separate constants in its nine Addressable Memory Registers.
4. It gives you a "Last X" Register for error correction or multiple operations on the same number. If you get stuck midway through a problem, you can use the "Last X" Register to unravel what you've done.
5.  It displays up to 10 significant digits in either fixed-decimal or scientific notation and automatically positions the decimal point throughout its 200-decade range.
6.  It converts angles from decimal degrees, radians or grads to degrees/minutes/seconds and back again.
7.  It converts polar coordinates to rectangular coordinates... or vice-versa. In seconds.
8.  Its Gold "Shift" Key doubles the functions of 24 keys which increases the HP-45's capability without increasing its size.

## The HP-35 uses RPN too.

If the HP-45 is the world's most powerful pre-programmed pocket-sized scientific calculator, the HP-35 is runner-up. It handles 22 functions, has a 4-Register Stack, one Addressable Memory Register and also displays up to 10 digits in either fixed-decimal or scientific notation.

\*Domestic U.S.A. prices, not including applicable state and local taxes.

## New low prices.

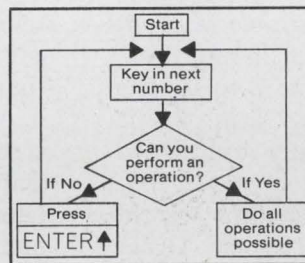


HP-45: \$325\*

HP-35: \$225\*

Now the exceptional value of these exceptional instruments is even more apparent, because we've cut their prices by \$70\*. You can now own the world's most powerful pocket-sized pre-programmed scientific calculator, the HP-45, for only \$325\*. The HP-35 now costs just \$225\*.

### Send for our booklet "ENTER vs. EQUALS."



It demonstrates the superiority of Dr. Lukasiewicz's language by comparing it to other calculators' systems on a problem-by-problem basis, and it explains the algorithm shown above which lets you evaluate any expression on a calculator that uses RPN and an Operational Stack. This booklet is

must reading for anyone seriously interested in owning a powerful pocket-sized calculator.

### The coupon gets you detailed specifications of either the HP-45 or the HP-35 plus the booklet.

Just check what you want and send it along. We'll get your information back to you by return mail.

**Hewlett-Packard makes the most advanced pocket-sized computer calculators in the world.**



Sales and service from 172 offices in 65 countries.  
Dept. 232H, 19310 Pruneridge Ave., Cupertino, CA 95014. 614/17

Hewlett-Packard  
Dept. 232H  
19310 Pruneridge Avenue  
Cupertino, CA 95014  
Please send the booklet, "ENTER vs. EQUALS:"  
 Detailed specifications on your HP-35.  
 Detailed specifications on your HP-45.  
 HP-35(s) at \$225\* each plus state and local taxes.  
(Check enclosed.)  
 HP-45(s) at \$325\* each plus state and local taxes.  
(Check enclosed.)

Name \_\_\_\_\_  
Company \_\_\_\_\_  
Street \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_



## Why not use hybrids? For small size, long-term reliability, true hermetic sealing and adaptability to the latest technologies, they're a good choice.

Most PC-board circuits that use discrete components can be replaced by a microcircuit hybrid package. Hybrid packages need three to 10 times less circuit area.

The largest hybrid substrate available is about 6 in.<sup>2</sup>, but the usual one is between 0.25 and 2 in.<sup>2</sup>. Therefore, with a reduction factor of 8 to 10, the circuitry on a densely packed 3 × 5-in. PC is about the maximum that is usually hybridized into a single package.

But small size and corresponding light weight are not the only reasons for going hybrid. Other advantages include these:

- Reliability and long-term stability.
- Excellent matching of components, especially resistors, for temperature tracking.
- Hermetic sealing in metal and ceramic packages.
- Production by volume processes.
- Moderate costs for medium-volume quantities (1000-10,000).

### Hybrids are versatile

A hybrid is an integrated circuit that uses a versatile mix of technologies—a composite of thick and thin-film passive components, a wide range of interconnecting and packaging technologies and both discrete semiconductors and monolithic ICs. By this combination of almost all the major technologies, wide flexibility and high density in circuit configurations are possible. A hybrid circuit can use the most advanced monolithic ICs and the best active and passive discrete components. Thus hybrids can provide a wide performance spectrum for both analog and digital applications.

The long-time stabilities of film resistors are excellent—far exceeding those of carbon-composition resistors. The temperature coefficients of film resistors, especially thin films, are also superior to carbon types. When resistance ratios are used, 5 ppm/°C tracking is routinely attained,

even for thick films. Low-cost, automatic, resistor trimming can also produce initial tolerances of better than 0.1%.

Functional, or dynamic, trimming eliminates trim potentiometers and trim capacitors in circuits that require accurate adjustments to better than 0.05%.

And for many capacitors of less than 100 pF, screen-printed devices are economical and stable. Capacitors to 0.01 μF can also be produced in film form, but for the higher values, chips are more economical. Chip capacitors come in a wide range of types and sizes for use in a hybrid. For example, types like K1200, NPO and tantalum have capacitances from 10-pF to 10-μF.

### Both thick and thin films are used

Most resistors are applied by thick-film methods. However, for extra high stability, wide resistivity range and superior ratio matching, the thin-film resistor might be the better choice.

Thick films offer low cost and perhaps quicker delivery, because the hybrid maker generally makes his own thick-film resistors, but he may have to go outside for thin-film chip resistors. Thick-film resistors use a screen-printed cermet material, composed of precious metals, their oxides and suitable glasses. And thin-film resistors are usually sputtered or vapor deposited tantalum-nitride, nickel-chromium or chromium cobalt.

Connections between components are also made with film techniques. Thick-film conductors are printed, precious-metal alloys of gold, platinum, palladium and silver. And thin-film conductors are generally deposits of almost pure gold.

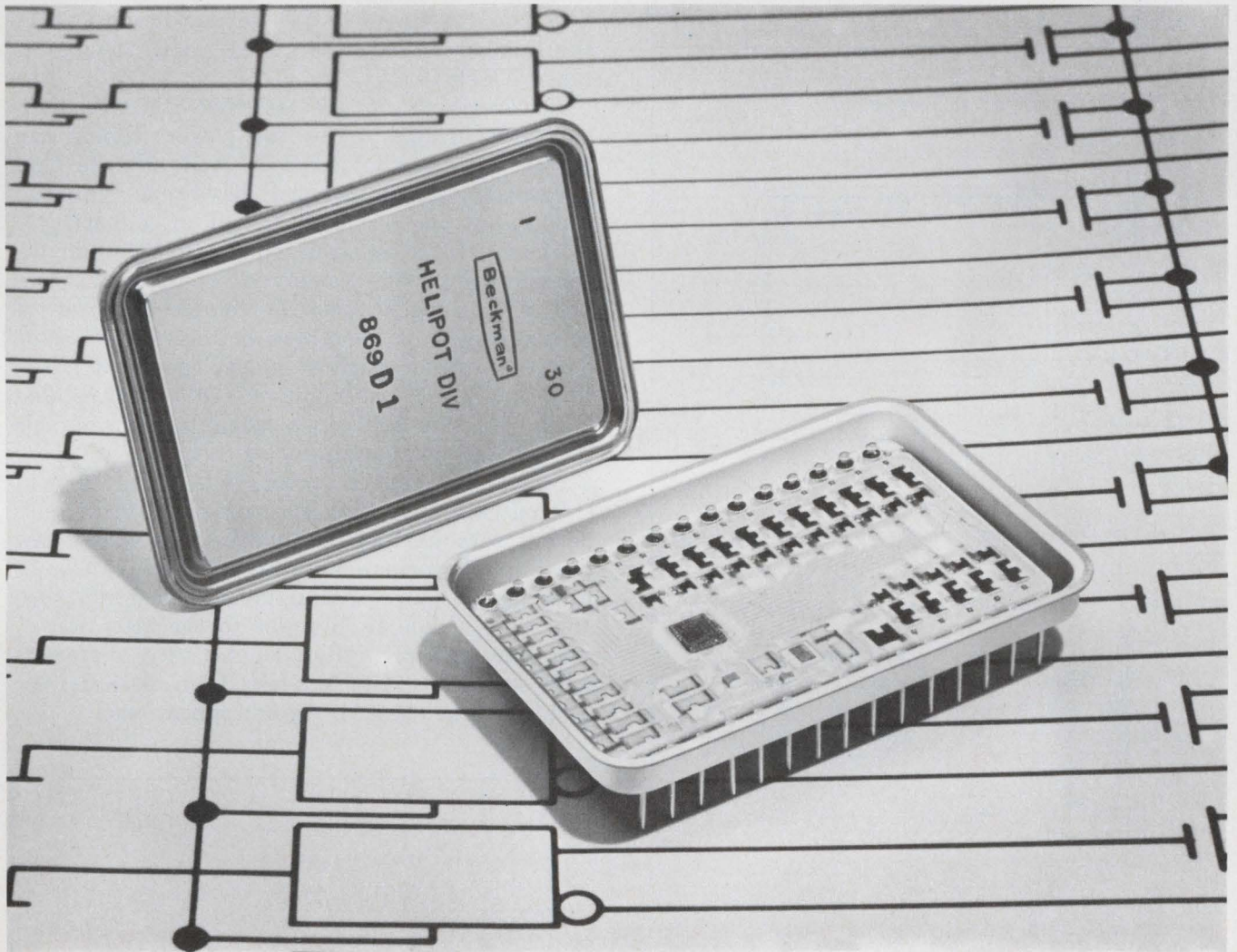
About 85% of the hybrids use thick-film technology, with the screen-printed resistors and conductors applied on a substrate of alumina (generally 96% Al<sub>2</sub>O<sub>3</sub>). The remaining 15% of the hybrids use thin-film technology, where resistors and conductors are deposited on glass, alumina or silicon substrates. Semiconductor devices and chip capacitors are then added.

Active devices are usually mounted in die, or

---

Frank Ruegg, Chief Engineer, Microcircuits Engineering, Beckman Instruments, Inc., Fullerton, Calif. 92634.





These hybrid d/a converter packages combine many technologies. They include: MSI, bipolar and MOS ICs, linear ICs, thick and thin-film resistor networks and

discrete chip devices. The newest and most advanced devices can be combined by hybrid methods and enclosed in high-density packages.

chip, form. Special capacitors ( $0.1 \mu\text{F}$  and up) and resistors also come in chip form. They are often connected to the deposited circuit by thermocompression or ultrasonic bonding methods. These processes are commonly called chip-and-wire construction. Chips are held to the substrate surface by remelting of the interface (eutectic bonding) or by use of epoxy or low-temperature

cermets as adhesives. Both chip-bonding and wire-connecting are generally manual operations.

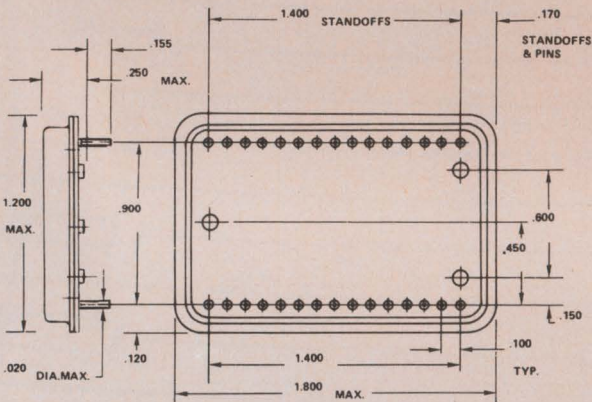
A number of chip forms have been developed to replace the chip-and-wire approach and to improve reliability. These include beam-lead and flip-chip devices.

Inductors and transformers are difficult to include within the hybrid and they generally are

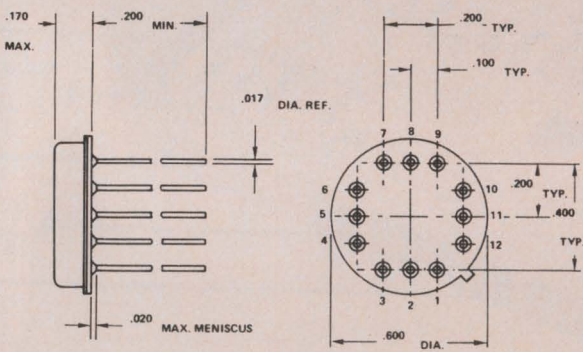


**Table 1. Some hybrid housings**

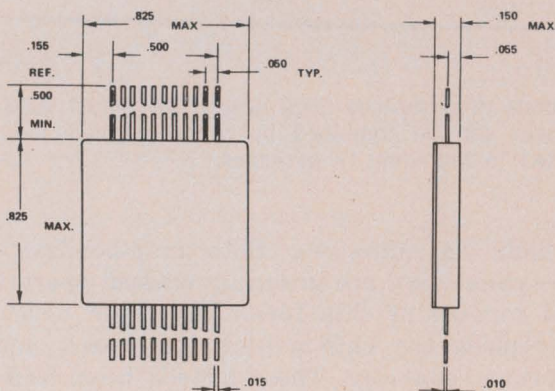
Package Type	Method of Seal	Number of Terminals	Available Substrate Area (Sq. in)	$\Theta_{CA}$ ( $^{\circ}\text{C}/\text{W}$ )	Power Rating (W)	Outline Drawing
Metal pin packages	Cold weld	10	0.465	60	2	A
		20	0.850	30	4	
30		1.250	20	6.5		
	Cap weld	12	0.104	80	1.5	B
Metal ribbon-lead packages	Stitch weld	12	0.340	90	1.4	C
		22	0.465	55	2.3	
Dual in-line packages	Epoxy	14 16	0.086 0.098	80 80	1.5 1.5	D



(a)



(b)



(c)

designed out or mounted outside the package. Some low-inductance coils are now made in chip form, especially for high-frequency circuits. These coils can provide usable inductances with respectable Qs, and in sizes that are compatible with hybrid dimensions.

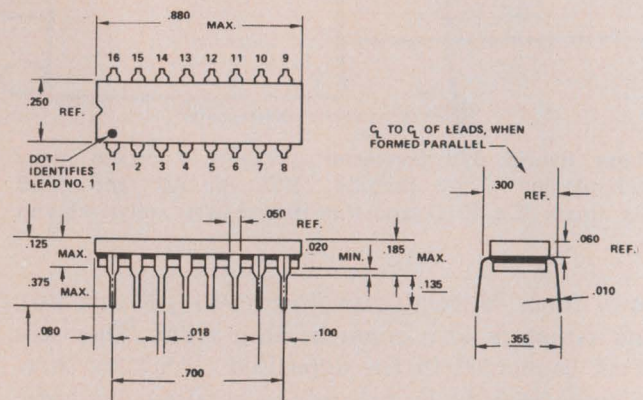
**Resistors are the primary element**

Of all the components, resistors are the primary circuit elements of hybrid technology. Resistors can be made inexpensively and in high density. Thus resistor-dependent circuits such as DACs are favored for hybrid packaging, where the number of capacitors and active devices is relatively small.

Power circuits of greater than 5 W are difficult to hybridize, unless the power devices can be left outside the package. And circuits that need many I/O pins or that have many internal connections can also be difficult to convert.

Though thick and thin-film assembly can accommodate a wide variety of component types and values, no process is completely void of restrictions. It is sometimes better to leave some devices—large capacitors, large power transistors and diodes, specially selected devices and large inductive devices—in discrete form outside the microcircuit package.

Conductors and crossovers must also be considered carefully. Fine-line screening techniques permit very narrow line widths, but Ohm's law prevails. High-current paths and low-impedance lines may require special layout considerations, and these should be brought to the attention of the manufacturer. High-conductivity materials with line resistivity of less than 0.01  $\Omega$  per square can be used for these applications.



(d)



Crossovers may affect the design because the bottom and top conductors form a small capacitor—of typically less than 2 pF. Insulating glass between the two conductors has a dielectric constant of approximately 8, and the actual capacitance value depends on the total area of the crossover. In most applications the placing of the crossover can be controlled so capacitance does not interfere with circuit performance, but the manufacturer should be told about circuits that are particularly sensitive to capacitive coupling. Critical circuit areas can be guarded by conductor patterns in addition to control of crossover design.

Hybrid housings are extremely varied; they range from simple leadless, polymer-coated assemblies to sophisticated multipin, hermetically sealed metal packages. The substrate can be a major portion of the housing, with a simple lid for mechanical protection, or it can be completely enclosed in an all-metal package. Many hybrids are made in all-ceramic packages, with polymer or glass seals. And hybrids can also be assembled simply as potted modules.

#### What to tell the manufacturer

Though many hybrid manufacturers are equipped to design and evaluate circuits, it's best if the customer supplies a working, properly toleranced design. Hybridization is primarily a packaging job, and this is what the manufacturers do best.

The circuit performance requirements must be precisely defined. Performance can be evaluated by either black-box specifications or a toleranced schematic. But the most meaningful description of circuit performance is a combination

of the schematic diagram and a description of significant input/output parameters and their desired tolerances.

Black-box specs alone require engineering design and development by the hybrid manufacturer, and this will increase costs. A schematic diagram alone, even though the components are toleranced, does not always tell which performance parameters are critical.

The items normally categorized as black-box specifications are these:

- Power-supply voltage and current levels.
- Input parameters, such as voltage range, input impedance and input current.
- Output characteristics, such as output impedance, voltage range, slew rate and output current.
- Transfer characteristics, such as gain settings or logic truth tables.
- Maximum ratings, such as worst-case-voltage conditions, temperature-range limits, etc. Note that each category may provide vital information not included in the schematic diagram.

Tell the hybrid manufacturer everything that may affect circuit performance. He can then take advantage of the special characteristics of some microcircuit manufacturing techniques. For instance:

- Resistors can use the same film material for close temperature tracking.
- Resistors can be functionally trimmed in the operating mode to eliminate the need for subsequent calibration procedures.
- Minimized conductor lengths can reduce capacitive/inductive effects.

Passive component tolerancing should include the initial tolerance, power and voltage rating and any other parameter that will have a direct effect on circuit performance. The data might include such items as voltage coefficient, power factor, temperature coefficient, noise and high-frequency characteristics.

Semiconductor specifications should include the closest generic type, JEDEC number or the semi manufacturer's part number. It is not likely that all of these numbers will be directly available in chip form. But the hybrid manufacturer can generally come close to obtaining suitable substitutes. He normally purchases semiconductor devices to wafer-probed specifications and then lot-qualifies each type to other key parameters. However, it is not usually feasible to probe ac or temperature dependent parameters in this way. When such parameters are critical to circuit performance, the hybrid manufacturer must use semiconductor lots that have been selected by the semiconductor maker for the temperature or ac parameters.

**Table 2. Component unit areas**

Component type	Units per component
Resistors (cermet, thick film) General purpose (up to 100 mW) . . . .	1.0 Units
Capacitors	
Screened (cermet-270 pF) . . . . .	1.0 Units
Chip capacitors 0.1" x 0.1" . . . . .	2.0 Units
Diodes, passivated chip	
Signal switching . . . . .	0.5 Units
Zener/reference . . . . .	0.5 Units
Schottky/hot carrier . . . . .	0.5 Units
Transistors, passivated chip	
Bipolar small signal . . . . .	0.5 Units
Bipolar medium power . . . . .	1.0 Units
JFET . . . . .	0.5 Units
Integrated circuits, passivated	
Linear (741, 710, 107, etc.) . . . . .	2.0 Units
Digital (7400, etc.) . . . . .	4.0 Units
MOS arrays (3101, etc.) . . . . .	0.5 Units/Lead
MSI devices (74145, etc.) . . . . .	0.5 Units/Lead



# IEE-IRIS<sup>TM</sup>

## TRANSILLUMINATED STATUS INDICATORS & ANNUNCIATORS



- **BIG, BOLD, BRIGHT** Display with easy-to-read, single plane viewing
  - Choice of 1/2", 3/4", or 2" high, 7-bar digital or 9-bar hexadecimal characters
- Up to twelve discrete messages per module; five optional, standard screen colors
- Unlimited message versatility — any graphics or symbols reproducible on film
- Long life, low power, subminiature incandescent lamps
- Simple, plug-in installation with no external hardware
- Low cost per message with optimum versatility

From the very beginnings of information display, IEE has been a leader in the innovative design, successful introduction, reliable manufacture, condensed packaging, and effective application of high quality, display devices and integrated systems for commercial, industrial and military use. Based on two decades of experience, and a dedication to quality, IEE today offers:

- the world's most diversified selection of display products
- the design, human factors, and

systems integration expertise to fulfill your most sophisticated requirements.

- The pricing, product availability, and productive capacity to meet your most demanding schedules

- and the ingenuity and sincere desire to help solve your most complex display problems. Information Display is OUR business; why not contact the experts for YOUR solutions? Call or write today for information regarding introductory offers on prototype evaluation quantities of many of IEE's display products.



**the Olympus of displays**

Industrial Electronics Engineers, Inc.  
7740 Lomona Ave., Van Nuys, Calif. 91405  
Phone: (213) 787-0311

European Office: 6707 Schifferstadt, Eichendorff-Allee 19, Germany.

The hybrid manufacturer often has his own repertoire of semiconductor devices. If possible, the design should use these devices.

### Housing the hybrid

The first step in selecting a hybrid package is to count the pins. The pin count may have more impact on package selection than the amount of circuitry. The next step can be defined only after these questions are answered:

- What size substrate is needed?
- Is the circuit complex, so that it requires partitioning into more than one package? Can the circuit be divided into individually testable functions?
- What style package should be used?
- Are there special mechanical and environmental requirements?

Try to use a package considered standard by the manufacturer and avoid costly, all-metal packages if true hermeticity isn't needed.

Table 1 lists some common standard package styles with their pin capacities, available substrate areas, power dissipation and thermal resistances.

You can estimate the substrate area you need, as follows:

Assume one unit of area is 0.015 in.<sup>2</sup> This is the area of a resistor. A component density of 0.015 in.<sup>2</sup>/unit is moderate and can be readily achieved, provided pin assignments are not fixed before the layout is designed. Assign a number of units to each component by consulting Table 2, and total the number of units for the circuit. Determine the substrate area:

$$A_s = (0.015 \text{ in.}^2) \cdot (U_t),$$

where  $U_t$  = total units. A package choice based on available substrate area can then be chosen from a listing such as Table 1. But the unit system is strictly a short-cut method. Common sense must be applied liberally.

### Temperature is another constraint

Temperature rise is another important packaging constraint. The rise,  $T_R$ , is a function of the total power dissipation,  $P_T$ , of all internal circuit elements:

$$T_R = T_C - T_A = (P_T) (\theta_{CA}),$$

where  $T_C$  = case temperature,  $T_A$  = ambient temperature and  $\theta_{CA}$  = case-to-ambient thermal resistance.

An approximate value of  $\theta_{CA}$  for a package in free air and with minimum heat conduction through pins is 35°C/W/in.<sup>2</sup>. For example, a circuit that dissipates 1 W, rises approximately 35 C above ambient in a 1-in.<sup>2</sup> package, or 70 C above ambient in a 1/2-in.<sup>2</sup> package. This general rule



is a conservative first approximation.

Though the case temperature may be safe, individual component temperatures may exceed safe limits. The maximum allowable junction temperature for silicon devices depends on the application, and in some cases it is limited by system specifications. The general rule is never to allow a junction to exceed 200 C. High-reliability applications often further limit temperature to 150 C.

### Hybrid costs: \$5000 and up

Hybrid manufacturers generally prefer making many (10,000 pieces) low-cost simple units to a few (1000) high-cost, complex ones. They're interested in jobs where the gross will exceed roughly \$5000, if business is slow, and perhaps \$20,000 when the backlog is long.

They generally charge for layout, tooling and fixturing. This is a one-time charge, and it can range from a few hundred dollars to several thousand.

Drawings and the 10 to 20 prototypes generally required to test the design take a minimum of six weeks. Special parts may add as much as eight weeks. And burn-in requirements and load-life testing can extend the delivery time even further.

### Monolithics are another way

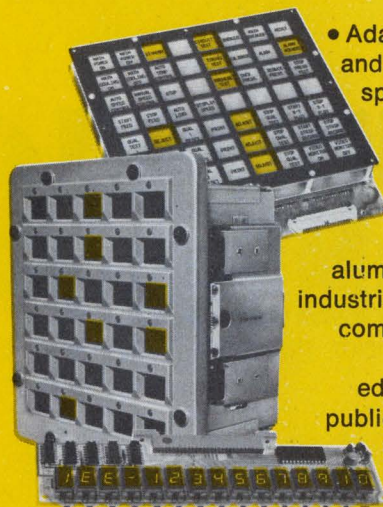
Monolithic technology in many cases offers most of the advantages of hybridization and the end product is even smaller in size. The main difference is an initial high tooling cost and the need to run a minimum of 100,000 units. If the circuit is primarily digital and the quantity large enough, the custom monolithic approach can offer a cost advantage. Monolithic tooling and start-up costs are roughly an order of magnitude greater than hybrid costs—typically \$20,000 to \$100,000—though parts costs in large volumes are significantly less.

Custom analog MSI or LSI monolithic designs are particularly difficult to execute, because the monolithic approach does not allow the experimenting and prototyping that hybrids allow at modest cost.

Hybrids provide greater circuit flexibility, less problems with parasitics and they have the potential for greater precision, long-term stability and greater freedom in component selection. And hybrids can usually handle higher-power circuitry than monolithics.

In addition to the above, the yield factors for custom monolithic devices are difficult to determine in advance. This is an important consideration in a packaging choice. ■■

# IEE-SYSTEMS



- Adaptable to all applications and environments
- Airborne, space, surface, subsurface, field and military command center applications
- Process control, petrochemical, hydroelectric, paper, textile, aluminum, and manufacturing industrial usages
- Point-of-Sale, communications, accounting, computer, public health, educational, transportation, public services, governmental, medical & hotel facilities, and service industry commercial installations
- Multi-functional capabilities: information display; status indication; switching; automatic control; operator cueing & decision assistance; POS customer data
- The ideal solution to the system designer's display requirements

From the very beginnings of information display, IEE has been a leader in the innovative design, successful introduction, reliable manufacture, condensed packaging, and effective application of high quality, display devices and integrated systems for commercial, industrial and military use. Based on two decades of experience, and a dedication to quality, IEE today offers: • the world's most diversified selection of display products • the design, human factors, and

systems integration expertise to fulfill your most sophisticated requirements. • the pricing, product availability, and productive capacity to meet your most demanding schedules • and the ingenuity and sincere desire to help solve your most complex display problems. Information Display is OUR business; why not contact the experts for YOUR solutions? Call or write today for information regarding introductory offers on prototype evaluation quantities of many of IEE's display products.



**the Olympus  
of displays**

Industrial Electronics  
Engineers, Inc.  
7740 Lemona Ave., Van Nuys, Calif. 91405  
Phone: (213) 787-0311

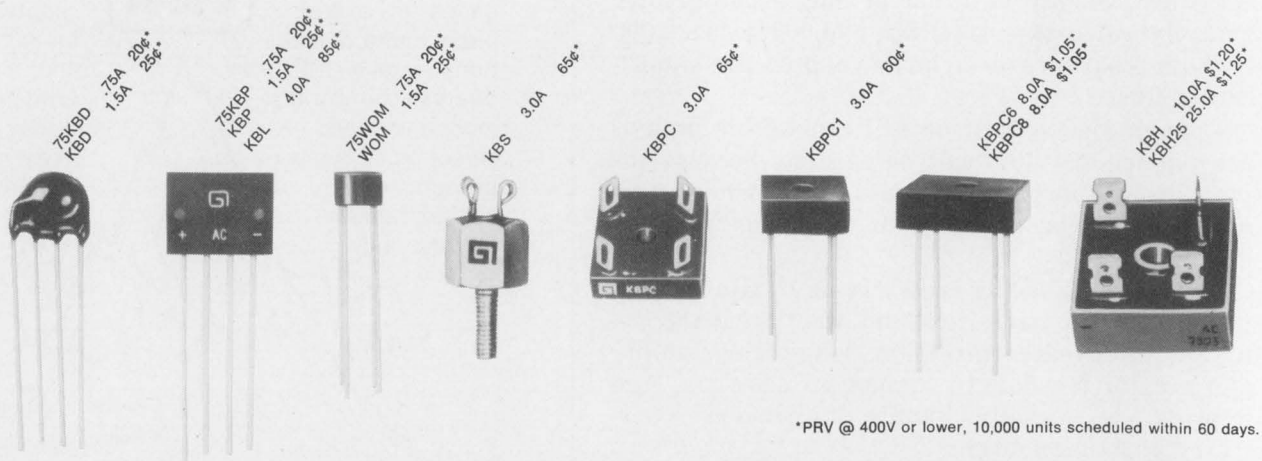
European Office: 6707 Schifferstadt, Eichendorff-Allee 19, Germany.



# CHECK IT

WHICH BRIDGE RECTIFIER MANUFACTURER GIVES YOU THE MOST FOR YOUR MONEY?

- 1—Which is the first and only company using flame-retarding materials (classified 94V-0) in the construction of all its rectifiers and bridge rectifiers? .....
- 2—Who can replace 4 rectifiers with a bridge rectifier at no additional cost? .....
- 3—Who has bridge rectifiers ranging from ¾A to 25A? .....
- 4—Who delivers bridge rectifiers within 30 days A.R.O.? .....
- 5—Whose bridge rectifiers contain patented glass passivated rectifiers? .....
- 6—Whose AQL is lower using a bridge rectifier instead of 4 rectifiers? .....
- 7—Which company should be checked for the lowest priced bridges, anywhere? .....







**GENERAL  
INSTRUMENT**

**MOTOROLA**

**VARO**

**UNITRODE**

**SEMTECH**

**DIODES INC.**

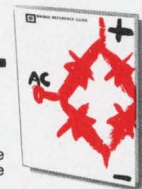
..... <input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
..... <input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

# GI'S GOT IT!

Fill out coupon and mail. Or call toll-free 800-645-1247 (In New York State call 516-733-3235)

General Instrument Corporation  
Semiconductor Components Division  
600 W. John St., Hicksville, N.Y. 11802

- |                                     |                                     |                                     |   |
|-------------------------------------|-------------------------------------|-------------------------------------|---|
| <input type="checkbox"/> 75KBD .75A | <input type="checkbox"/> 75WOM .75A | <input type="checkbox"/> KBPC1 3.0A | <input type="checkbox"/> KBH 10.0A              |
| <input type="checkbox"/> KBD 1.5A   | <input type="checkbox"/> WOM 1.5A   | <input type="checkbox"/> KBL 4.0A   | <input type="checkbox"/> KBH25 25.0A            |
| <input type="checkbox"/> 75KBP .75A | <input type="checkbox"/> KBS 3.0A   | <input type="checkbox"/> KBPC6 8.0A | <input type="checkbox"/> Bridge Reference Guide |
| <input type="checkbox"/> KBP 1.5A   | <input type="checkbox"/> KBPC 3.0A  | <input type="checkbox"/> KBPC8 8.0A |   |



Check! I want the most for my money.  
Please send me complete information on  
General Instrument's bridge rectifiers (those  
I've checked):

NAME \_\_\_\_\_ TITLE \_\_\_\_\_  
 COMPANY \_\_\_\_\_ ADDRESS \_\_\_\_\_  
 CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

**GENERAL INSTRUMENT CORPORATION  
SEMICONDUCTOR COMPONENTS**



INFORMATION RETRIEVAL NUMBER 54



# Improve ROM systems with pROMs.

Here are two ways to use programmable ROMs to change words and increase memory size after a masked-ROM system is designed.

With two design techniques that use programmable ROMs—the pROM patch and the pROM wire scrambler—you can alter a masked-ROM system after you're committed to masks.

The pROM-patch method changes words and handles increased address fields in ROM. The pROM wire-scrambler technique expands memory size simply and by a factor of two through the use of memories that have the same pinout and model number of the PC-board ROMs.

System designers usually wait for the last minute to order masked ROMs. They know that custom ROM masks cost \$300 to \$750 each and cannot be changed. Moreover vendors typically quote an 8-to-12-week delivery and require a minimum order. The result of a scrapped mask and work-in-progress can often be a \$20,000 error and a four-month delay.

Typically pin-compatible pROMs are used for prototype and first production systems. Programmable ROMs permit rapid design changes in the field. But their higher cost—three-to-five times that of ROMs—tends to make designers want to switch to ROMs as soon as possible.

## A ROM/pROM compromise: The pROM patch

An example of the pROM patch appears in Fig. 1. Below the  $512 \times 8$ -bit ROM, consisting of two  $512 \times 4$ -bit ROM ICs, are two pROM circuits and a TTL gate not found or required in conventional  $512 \times 8$ -bit ROM systems. The additional  $512 \times 4$ -bit and  $32 \times 8$ -bit pROMs allow word changes.

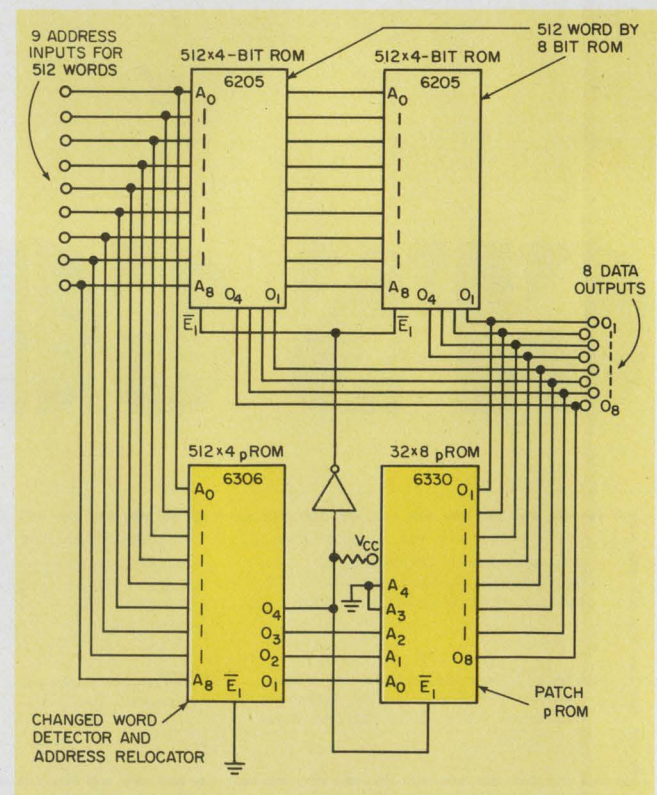
The masked ROMs can be soldered into the board, since their contents don't change. The pROMs must be placed in sockets to simplify their removal for programming in conventional equipment.

The  $512 \times 4$ -bit pROM is programmed to detect the word that must be changed and to point to an address in the  $32 \times 8$ -bit pROM that contains the corrected data. Output  $O_4$  of the

larger ROM goes low only when its input detects a changed word. Then the masked ROMs are disabled and the  $32 \times 8$ -bit pROM is enabled. Outputs  $O_2$ ,  $O_3$  and  $O_4$  of the larger pROM are programmed to point to word 0 of the  $32 \times 8$ -bit pROM for the first design change. Subsequent changes use the remaining words.

The smaller pROM contains the patch data. Its output is OR-tied onto the data-out bus of the masked ROMs. Patch data appear on the bus when the enable signals of the  $512 \times 4$ -bit ROMs go high, and the enable signal of the  $32 \times 8$ -bit pROM goes low.

Tables A and B illustrate a design situation that could benefit from a patch technique. ROM-word 71, part of a microprogrammed timing



1. A patch pROM and changed-word detector provide a  $512 \times 8$ -bit ROM system with the flexibility to change any eight of the 512 words before or after system shipment. The memory model numbers refer to circuits offered by Monolithic Memories.

Joseph J. McDowell, Systems and Applications Manager, Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, Calif. 94086



generator, fails to pass final tests before customer shipment. To correct the error, the  $512 \times 4$ -bit pROM is removed from the socket and programmed to have "LLL" stored in word 71. The  $32 \times 8$ -bit pROM is then removed from its socket and programmed to have the new data "HLLLHLL" in word 0. The patch corrects the design error.

After shipment, the customer wants to add a tape-reader option. This requires a one-word patch to disable the teletypewriter and enable the high-speed reader. This time word 74 is changed via a patch stored in word 1 of the  $32 \times 8$ -bit pROM. A serviceman in the field makes the change at the customer's facility.

Later, ROM technology makes possible higher speeds. The patch is now used to accommodate these higher speed ROMs. Shortly after that, the higher-speed ROM is found to have excessive noise sensitivity; two additional patches are installed in the field to overcome the problem.

The patch technique in the example saves six mask changes and considerable documentation change. It also permits rapid changes in the field

without PC-board rework to remove the soldered-in ROMs.

### Patch handles increased address fields

Still another variation of the patch technique permits the handling of address fields that are larger than the number of words in a changed-word detector (Fig. 2). A 4-to-1 multiplexer helps to reorganize the  $512 \times 8$ -bit pROM to look like a  $2048 \times 1$ -bit changed-word detector. The multiplexer trades off four outputs— $O_1$  to  $O_4$ —for two inputs— $A_9$  and  $A_{10}$ . Outputs  $O_5$  to  $O_8$  of the pROM point to an address in a second patch pROM (not shown) where the correct data are stored. Up to 16 changed words can be handled, since outputs  $O_5$  to  $O_8$  are wired to inputs  $A_0$  to  $A_3$  of the patch pROM.

To avoid ambiguous words, addresses  $A_9$  and  $A_{10}$  are wired into the patch pROM as address inputs  $A_4$  and  $A_5$ . Without this connection, the changed-word detector would not be able to tell at outputs  $O_5$  to  $O_8$ , for example, whether the changed word is 511, 1023, 1535 or 2047, since

Engineering change #	ROM word (decimal) requiring change	Patch pROM word (decimal)	Reason for change
1	71	0	Design error
2	74	1	Tape reader option
3	24	2	Higher-speed unit
4	349	3	Customer requests field changes
5	495	4	
6	5	5	

(a)

6306 Decimal address	6306 Contents				6330 Decimal address	6330 Contents							
	$O_4$	$O_3$	$O_2$	$O_1$		$O_8$	$O_7$	$O_6$	$O_5$	$O_4$	$O_3$	$O_2$	$O_1$
5	L	H	L	L	4	L	H	H	H	L	H	L	L
24	L	L	H	L	2	H	L	H	L	L	L	H	H
71	L	L	L	L	0	H	L	L	L	L	H	L	L
74	L	L	L	H	1	L	H	L	L	L	H	H	H
349	L	L	H	H	3	L	L	H	H	H	H	L	L
495	L	H	L	L	4	L	L	L	H	L	H	L	L
ALL OTHER WORDS	H	H	H	H	7	H	H	H	H	H	H	H	H

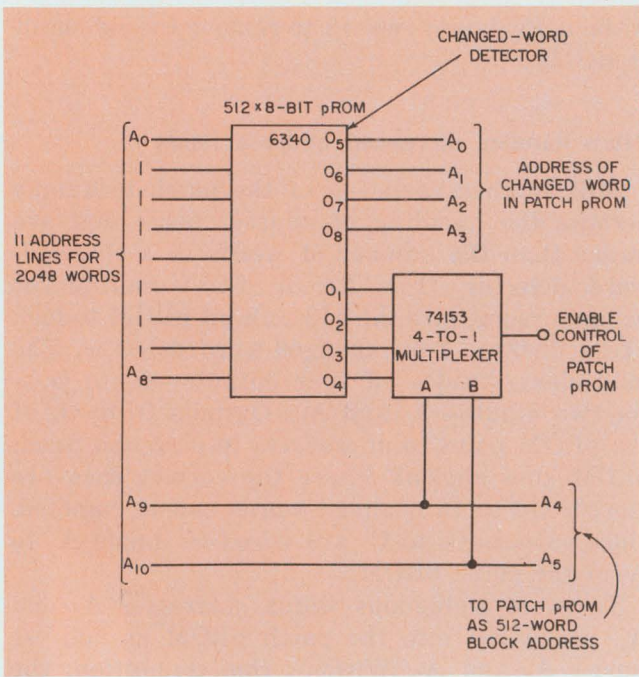
- Note: 1. L = TTL LOW  $\approx 0$  V  
 H = TTL HIGH  $\approx 3$  V  
 2. Unprogrammed words have high outputs  
 3. The pROMs are activated when enable  $\bar{E}_1$  goes low.

(b)

**A typical record of engineering changes** (A) that the patch method can handle. The truth table (B) gives the required programming of the 6306 pROM. The

6306 must detect the changed word and point to an address in the 6330 patch pROM, which is programmed with the corrected data.





2. A 512 x 8-bit pROM can be reorganized to appear as a 2048 x 1-bit changed-address detector with the aid of the multiplexer. The configuration also provides enable control and changed-word address for a patch pROM. Up to 16 changed words can be detected in each of the four 512-word blocks.

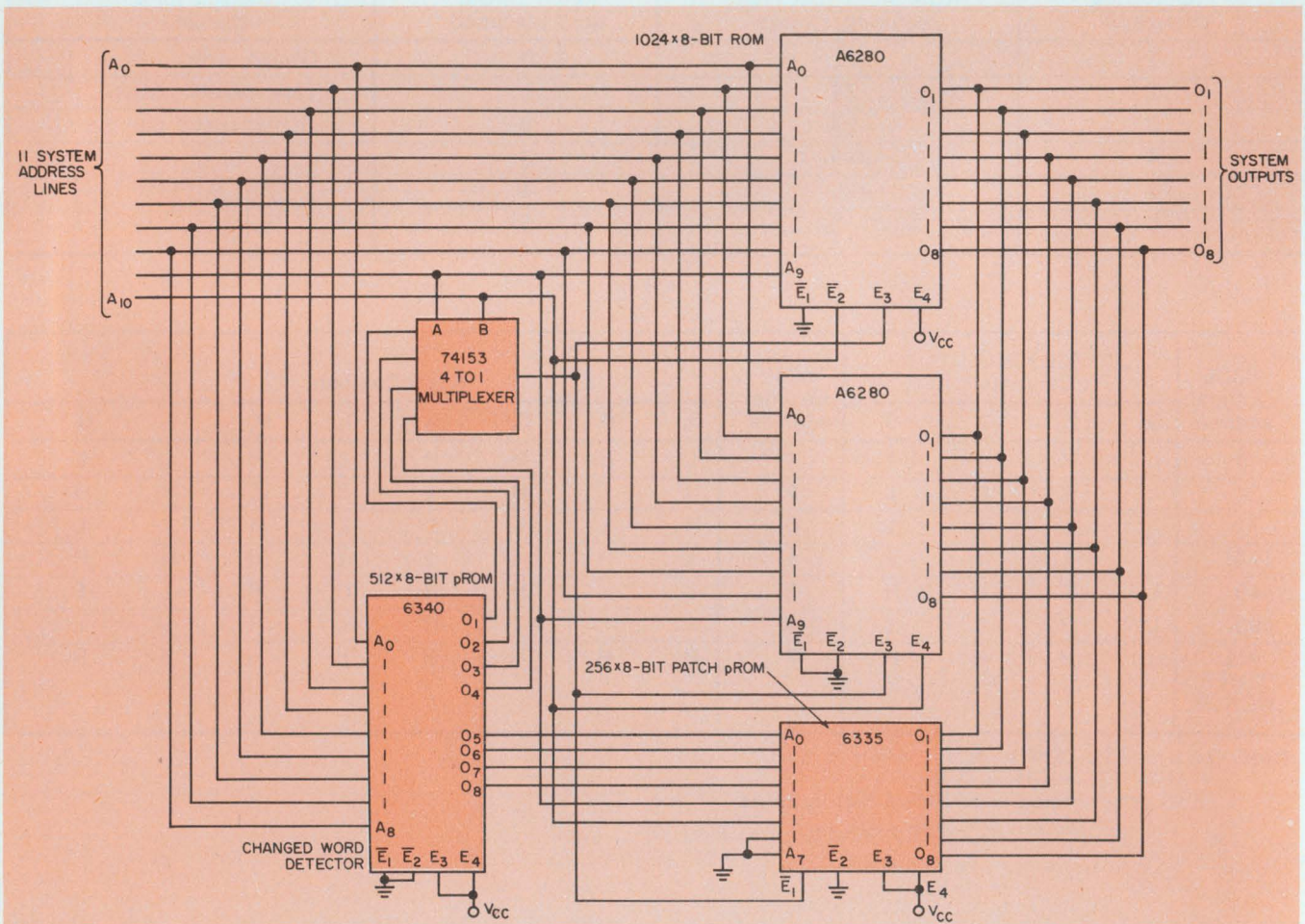
the detector is a 512-word device. Also, if word 511 is changed, you would not be able to change word 1023, 1535 or 2047, since only the low-order address bits— $A_0$  to  $A_8$ —go into the 512 x 8-bit pROM.

This technique doesn't allow 64 random changes, as might be expected from a six-address-input patch pROM. But the technique does permit a maximum of 16 words to be changed in each of the four blocks of 512 words.

A complete 2048 x 8-bit ROM system can have 16 words patched in each block of 512 words (Fig. 3). Two 1024 x 8-bit ROMs are used to make the 2048 x 8-bit ROM. Their outputs are wire-ORed, and system address  $A_{10}$  and the ROM's low and high active enables select a block of 1024 words.

When  $A_{10}$  is low, indicating the first 1024 words, and a changed word is not detected, the upper ROM activates; it has  $\bar{E}_1$  and  $\bar{E}_2$  low and  $E_3$  and  $E_4$  high, which constitute the enabling requirements. When  $A_{10}$  is high, indicating the last 1024 words, the lower ROM activates through  $E_3$ , and the upper ROM deactivates on the change of  $\bar{E}_2$  to a high.

When a changed word is detected, the multiplexer output goes low and disables both ROMs



3. This 2048 x 8-bit ROM system permits altering of 16 words in each block of 512 words. Memory ICs

are enabled when  $\bar{E}_1$  and  $\bar{E}_2$  go low and  $E_3$  and  $E_4$  go high. The ROM system uses two 1024 x 8-bit ICs.



when  $E_3$  goes low. The  $256 \times 8$ -bit patch pROM, however, becomes enabled through  $E_1$ , and it gates the patch data onto the output bus. Only 64 words of the 256 words in the patch pROM can be used. Hence  $A_6$  and  $A_7$  are grounded. It's possible to have a system that uses the spare words in the patch pROM to permit an additional level of patches. For that case, change the conditions on  $A_6$  and  $A_7$  to place the patch pROM into another of the four blocks of 64 words each.

A larger number of patch words can be obtained by use of multiple pROMs in the changed-word detector. And a larger number of patched outputs can be obtained by several patch pROMs driven in parallel.

### Expand memory size with pROMs

The second design technique—wire scrambling—simplifies doubling of a memory's size at any time during development or after the system is shipped. Like-numbered ROMs and pROMs can be used, because they are generally pin-compatible, the key requirement of the technique.

Newer bipolar  $256 \times 4$ -bit ROMs and pROMs and  $512 \times 4$ -bit pROMs are pin-compatible. The only difference between the pinouts of the  $256 \times$

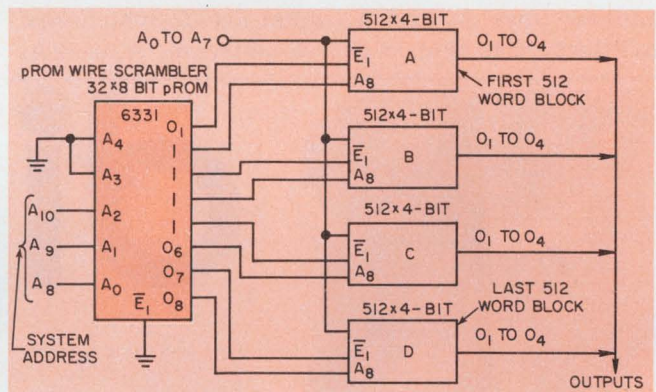
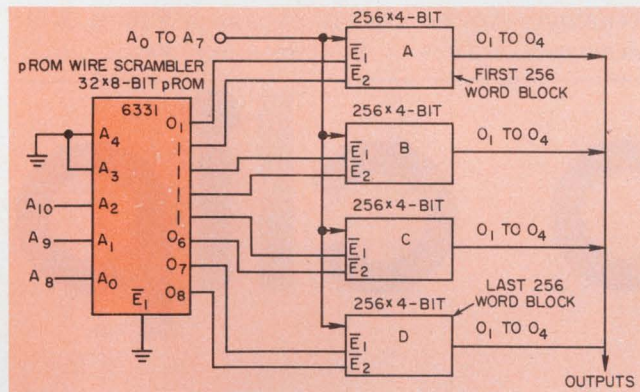
4 and  $512 \times 4$ -bit ICs is that the  $256 \times 4$ -bit circuit has two enables and the other has one. The  $512 \times 4$ -bit memories trade off the second enable for the required higher-order address line,  $A_8$ . Examples include Monolithic Memories' 6301 and 6306 memories, which are, respectively, pin-compatible  $256 \times 4$ -bit and  $512 \times 4$ -bit pROMs.

Many designers, aware of the pin-compatible feature among ROMs and pROMs, bring enable lines out to the board connector. This permits the signal to be used as a chip enable or a higher-order address line reserved for expansion.

This approach has several disadvantages: First, in larger memory systems that have several rows of packages on the board—say, 10 rows of 10 packages each—10 chip-enable lines (one per row) must be brought to the card connector. Hence 10 pins and board area are wasted. Second, the decoder that selects one of the rows to be activated must be placed off the printed-circuit board to avoid use of an elaborate on-board jumper system.

Finally the card-connector pins that convert a chip enable to an address must be rewired to double the memory size. The rewiring makes field changes costly and time-consuming.

The situation is further aggravated when you



6331 Address			6331 Content							
$A_2$	$A_1$	$A_0$	$O_8$	$O_7$	$O_6$	$O_5$	$O_4$	$O_3$	$O_2$	$O_1$
L	L	L	H	H	H	H	H	H	L	L
L	L	H	H	H	H	H	L	L	H	H
L	H	L	H	H	L	L	H	H	H	H
L	H	H	L	L	H	H	H	H	H	H
H	L	L	H	H	H	H	H	H	H	H
H	L	H	H	H	H	H	H	H	H	H
H	H	L	H	H	H	H	H	H	H	H
H	H	H	H	H	H	H	H	H	H	H

L = TTL LOW  $\approx 0$  V  
H = TTL HIGH  $\approx 3$  V

4. A  $32 \times 8$ -bit pROM wire scrambler handles the scrambling of address and enable signals for a  $1024 \times 4$ -bit system. Memories A through D can be ROMs or pROMs, and they are enabled when signals at  $\bar{E}_1$  and  $\bar{E}_2$  are low. The scrambler selects one of four rows.

6331 Address			6331 Content							
$A_2$	$A_1$	$A_0$	$O_8$	$O_7$	$O_6$	$O_5$	$O_4$	$O_3$	$O_2$	$O_1$
L	L	L	L	H	L	H	L	H	L	L
L	L	H	H	H	H	H	H	H	H	L
L	H	L	L	H	L	H	L	L	L	H
L	H	H	H	H	H	H	H	H	L	H
H	L	L	L	H	L	L	L	H	L	H
H	L	H	H	H	H	L	H	H	H	H
H	H	L	L	L	L	H	L	H	L	H
H	H	H	H	L	H	H	H	H	H	H

L = TTL LOW  $\approx 0$  V  
H = TTL HIGH  $\approx 3$  V

5. This  $2048 \times 4$ -bit system uses memories with the same pinout as that of the  $1024 \times 4$ -bit system of Fig. 4. But the pROM scrambler is programmed differently, and address  $A_8$  replaces enable line  $E_2$ . The scrambler maintains the phase of address  $A_8$ .



expand from a  $256 \times 8$ -bit to a  $1024 \times 8$ -bit system. Address and chip-enable must be scrambled.

A solution is to use a pROM wire scrambler, as in Figs. 4 and 5. The two figures differ only in that Fig. 5 shows a  $2048 \times 4$ -bit system, while Fig. 4 shows a  $1024 \times 4$ -bit system. The tradeoff of address and enable lines is handled by different programming of the  $32 \times 8$ -bit pROM. Both systems use memories having the same pinouts, and they don't require board-conductor rewiring or the accessibility of enable lines at the card connector.

Of course, the pROM should be in a socket, since it may be removed and replaced by another pROM, programmed differently to expand the system.

In the  $1024 \times 4$ -bit system of Fig. 4, eight words of the  $32 \times 8$ -bit pROM are programmed to form a 1-of-4 decoder. Unlike a TTL decoder, however, this puts out two low-level signals to select a row, since we must have both  $\overline{E}_1$  and  $\overline{E}_2$  low to select a row. In addition the pROM is programmed to ignore input  $A_{10}$  when it is high, because the maximum memory size with a  $256 \times 4$ -bit device is  $1024 \times 4$ -bits.

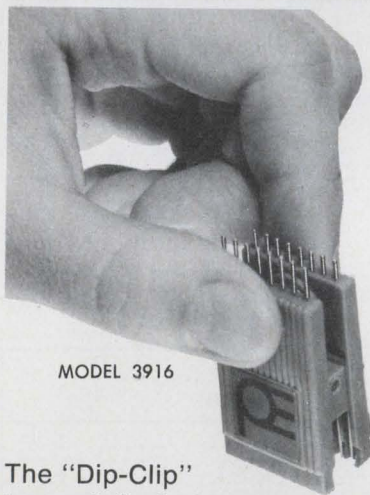
In Fig. 5 we also want to perform a 1-of-4 row select. But because the rows contain 512 words, address lines  $A_9$  and  $A_{10}$  must decide which row to select. Note that in Fig. 4, addresses  $A_8$  and  $A_9$

make the row-select decision.

Also in Fig. 5, the pROM must change enable  $\overline{E}_2$  of Fig. 4 into address input  $A_8$ . This is accomplished by programming of outputs  $O_2$ ,  $O_4$ ,  $O_6$  and  $O_8$  (wired to address  $A_8$  of the  $512 \times 4$ -bit ICs) to agree in sense with input address  $A_8$  (wired to pROM-address  $A_0$ ). In the address/content table, whenever  $A_0$  goes low (L), outputs  $O_2$ ,  $O_4$ ,  $O_6$  and  $O_8$  go low. And whenever  $A_0$  goes high (H), outputs  $O_2$ ,  $O_4$ ,  $O_6$  and  $O_8$  go high. System address  $A_8$  therefore becomes "wired through" the pROM, preserving its input phase. Addresses  $A_9$  and  $A_{10}$  are decoded in the pROM to form a 1-of-4 decoder on outputs  $O_1$ ,  $O_3$ ,  $O_5$  and  $O_7$ ; address  $A_8$  is ignored in this function.

The pROM scrambler has a disadvantage: increased access time. In the  $2048 \times 4$ -bit system (Fig. 5), for example, the pROM access time adds to the  $A_8$  address path, which also includes the  $512 \times 4$ -bit ROMs. However, the pROM shown features an access of less than 50 ns, and it buffers the address input, which otherwise would usually require two TTL inverters to preserve the phase of the address. Hence the net speed loss is not severe. Moreover the pROM has three-state outputs that can easily drive a row of 10 ICs.

The same wire-through and scrambler-decoder techniques can be used to expand a  $256 \times 8$ -bit memory to a  $1024 \times 8$ -bit memory. ■■

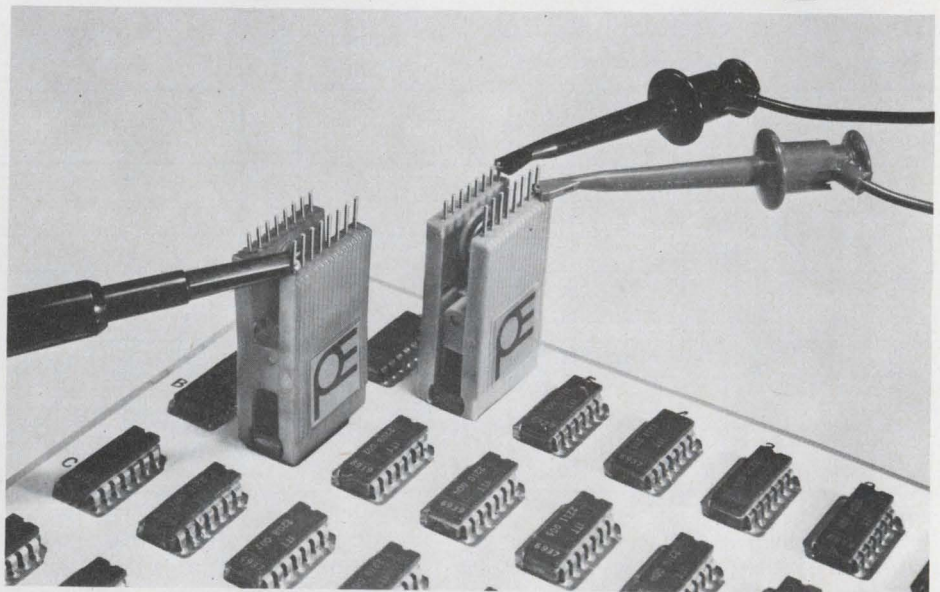


MODEL 3916

The "Dip-Clip" is specially designed to allow the attachment of test probes to 14 or 16 lead DIPs. The unique patented design greatly reduces the possibility of accidental shorting while testing live circuits. Numerous test probes may be quickly connected for hands-free testing.

# dip clip

T.M.



**POMONA ELECTRONICS**

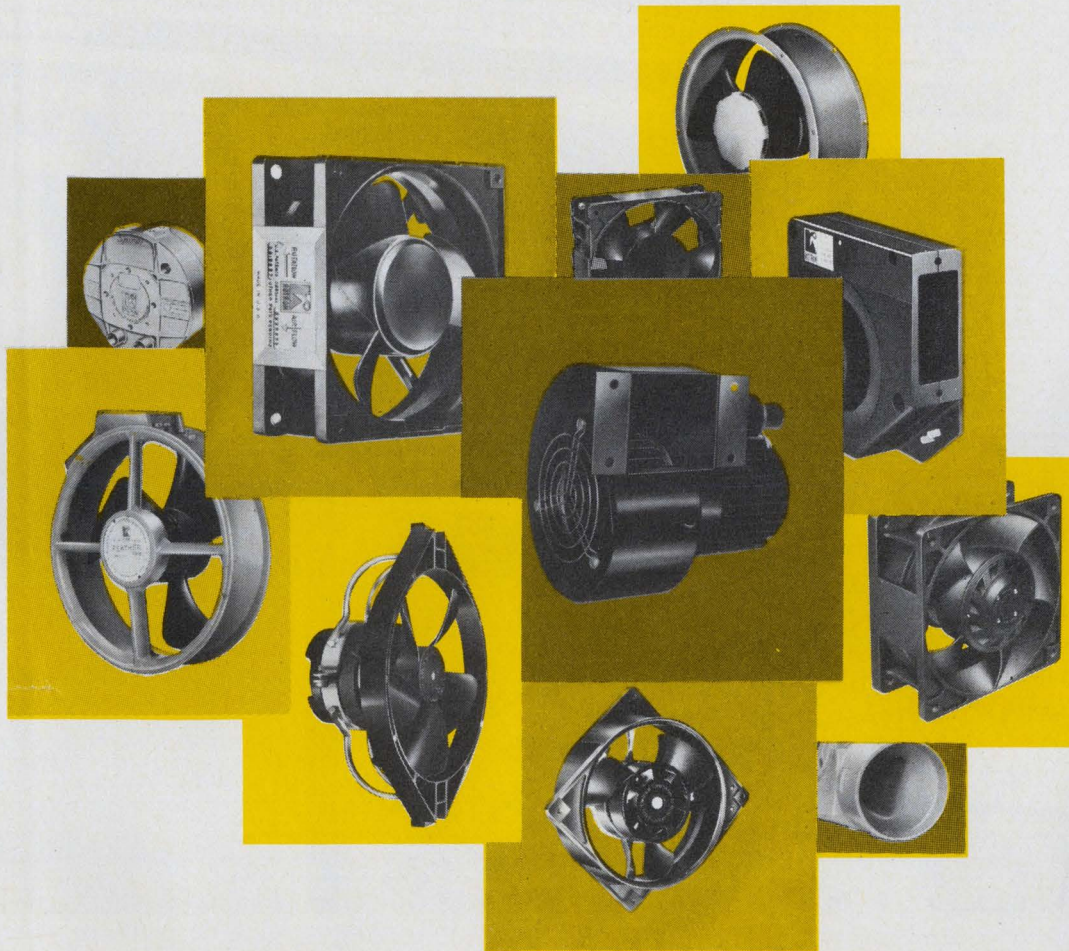
A Subsidiary of ITT

1500 E. Ninth St., Pomona, Calif. 91766 • Telephone: (714) 623-3463

INFORMATION RETRIEVAL NUMBER 55



# Which air movers for your system?



## Rotron® has the answer.

There are at least three major reasons why you can rely on Rotron to provide the best possible answer to your air moving need.

1. Rotron makes the widest selection of fans and blowers in the industry.
2. Rotron has a reputation for producing only the finest air movers. It's a reputation well earned, and one Rotron intends to keep.
3. Rotron offers you this superior selection and quality at hard-nosed competitive prices.

What's more, Rotron field application engineers will be glad to work directly with you where custom solutions may be required. You get the benefit of more than 20 years experience in developing specific answers to specific air moving problems.

Finally, Rotron products are available through a large, nationwide network of stocking distributors, to meet your needs in fast off-the-shelf delivery time.

Next time an air moving question arises, check Rotron. You'll like the answer. Get more information by writing or phoning Rotron today.

*Why settle for less when the best costs no more?*



**ROTRON INC.**, Woodstock, N. Y. 12498 ☐ 914 • 679-2401 ☐ TWX 510-247-9033

Pacific Div., Burbank, Cal. 91506, 213•849-7871 • Rotron B.V., Breda, Netherlands, Tel.: 79311, Telex: 844-54074

INFORMATION RETRIEVAL NUMBER 56





# What's the Difference?

## 3-1/2 digit multimeter with 6 to 13 times the accuracy of a typical analog meter

The industry's most popular bench-type VOM, compared above to our Model 282 Digital Multimeter, has 3% full scale DC accuracy. On the 50-volt scale, that's an accuracy of  $\pm 1.5$  volts, or an accuracy of reading of 7.5% at about 20 volts. The 282's accuracy of reading is  $0.5\% \pm 1$  least significant digit, or  $\pm 0.11$  volt. Divide those two figures—1.5 by 0.11—and you find that the 282 has 13.6 times the accuracy at that reading.

Even at readings close to 50 volts, where the analog multimeter is most accurate, Model 282 remains more than six times as accurate as the analog multimeter.

As for ease of reading . . . the picture above shows Model 282 and the analog meter full size. Put it where you'd normally set up your multimeter and see for

yourself how much more easily you can read the 282's bright digital display.

And there's more—automatic polarity, clear out-of-range indication, automatically positioned decimal point, 100% overrange capability, complete overload protection, 10 megohms input impedance and a three-position handle that doubles as a stand for tilt-up viewing. Plus a Model PR-21 probe with switchable 100K ohm isolation resistor to prevent capacitive loading while measuring DC in RF circuits.

And all for almost an analog price! Now in stock at your local distributor or write Dynascan.

**MODEL**  
**282**  
**\$200**



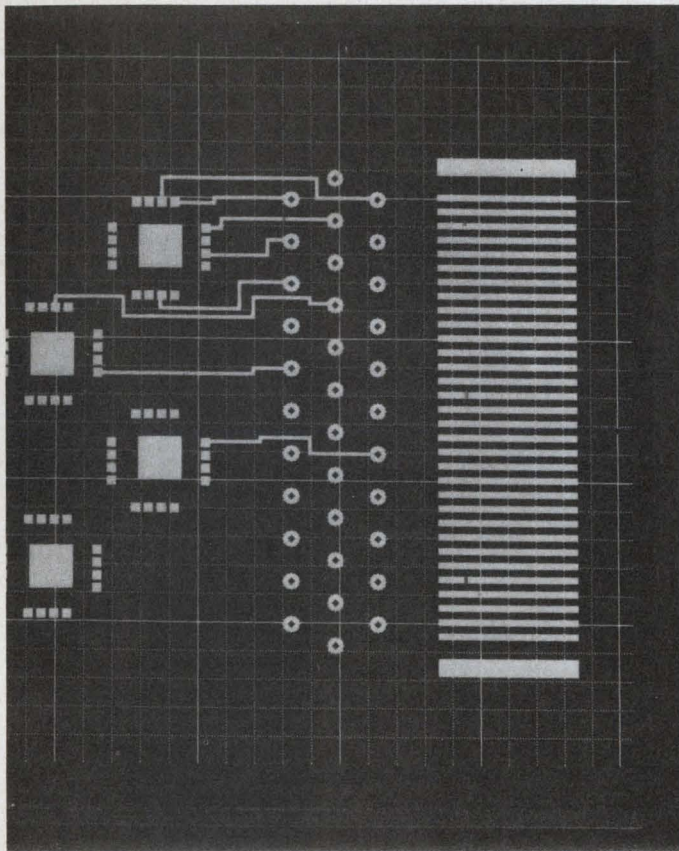
**B&K** PRODUCTS OF  
**DYNASCAN**

1801 W. Belle Plaine Ave. • Chicago, IL 60613 • Phone (312) 327-7270

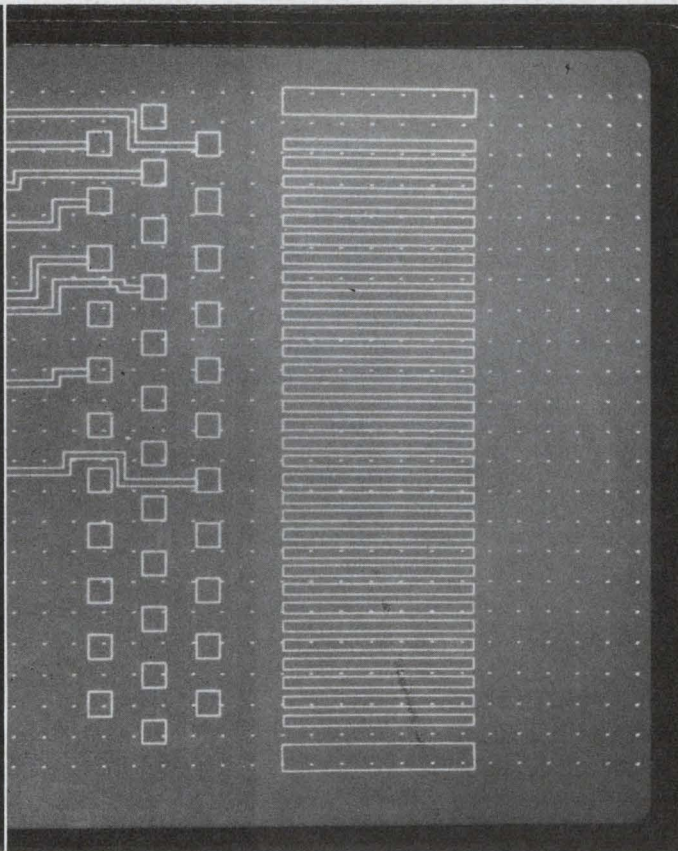
INFORMATION RETRIEVAL NUMBER 57



# Digivue® - a better way to look at it.



Unretouched time exposure of data displayed on a Digivue unit. Note high contrast picture, precise graphics.



Unretouched time exposure of same data displayed on a CRT. Note lack of contrast in CRT image.

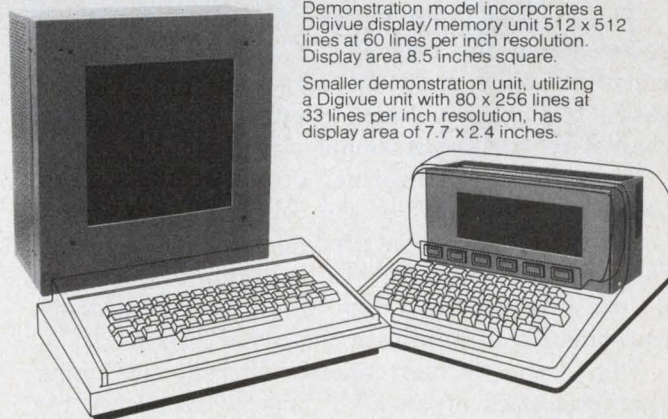
When your customers spend a lot of time looking at data displays and computer terminals, the advantages of Digivue plasma display units over CRT's become clear.

Very simply, Digivue display/memory units are better to look at. Digivue units present a flicker-free high contrast display for more precise readings and reduced chance of eye fatigue.

And Digivue units make it easier to use what's on the screen. Inherent memory is a feature of every unit. Digivue images appear on a thin, flat panel - which allows you to design compact components. The 512-60 models offer hard copy and rear projection capabilities, too. All of which gives *you* a product with more features to sell.

Sure, Digivue display/memory units currently cost more than CRT's. But they're worth a lot more to your customer, because they do a lot more.

For an informative booklet about Digivue display/memory units call (419) 242-6543, Ext. 66-415, or write Electro/Optical Display Business Operations, Owens-Illinois, Inc., P.O. Box 1035, Toledo, Ohio 43666.



Demonstration model incorporates a Digivue display/memory unit 512 x 512 lines at 60 lines per inch resolution. Display area 8.5 inches square.

Smaller demonstration unit, utilizing a Digivue unit with 80 x 256 lines at 33 lines per inch resolution, has display area of 7.7 x 2.4 inches.

**OWENS-ILLINOIS**  
Toledo, Ohio



# Squeeze more from power supplies.

Efficiency rises when a forward-loop switching regulator is designed around a saturating magnetic core.

High efficiency and fast regulation are two goals every power-supply designer aims for. But how do you attain these goals practically and inexpensively?

A good way is with a forward-loop switching regulator built around a square-loop magnetic core. A current transformer is used to drive the base of the main transistor.

Besides low losses, the technique offers other benefits: Switching frequency can go as high as 20 kHz, resulting in inaudible operation and in a considerable reduction of both magnetics size and capacitor values. Moreover efficiency improves over that of 60-Hz supplies, the forward-loop regulator is easily stabilized and complicated control circuitry isn't needed.

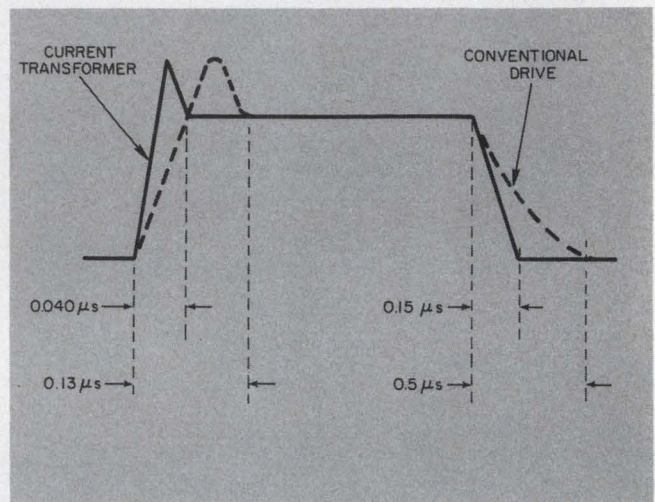
The key to high efficiency—possibly the highest attainable in 250-to-500-W supplies—lies in the constant volt-second characteristics of the saturating core, in which the product of "on" time and the difference between input and output voltage is maintained constant.

## Saturating core keeps output steady

Thus if the input voltage  $E_{in}$  increases,  $t_{on}$  is reduced and the product  $(E_{in} - E_{out})t_{on}$  remains constant. Note that the forward loop compensates for input-voltage changes more rapidly than does the conventional closed-loop design.

The current transformer provides a base drive that is proportional to the collector current and varies according to a predetermined ratio of  $I_c$  to  $I_b$ . If, for example, the load changes, and requires less current, then the base drive drops equivalently to minimize the drive losses.

Fig. 1 shows the collector-current switching characteristics of an SVT 300-10 transistor for both the conventional and the current-transformer approach. Switching loss with a conventional, or voltage source, base drive is 20 W at a power output of 350 W. By contrast, the cur-



1. About three times faster switching occurs when the switching regulator pass transistor is driven with a current transformer, rather than a conventional base drive. As a result, switching losses drop drastically.

rent-transformer base drive reduces switching losses to 8 W.

Operation of the square-loop core for forward-loop regulation can be illustrated by a self-saturating dc-to-ac inverter (Fig. 2). When the circuit oscillates and  $Q_1$  conducts, the supply voltage is dropped across the transformer primary winding  $N_1$ , as indicated by the equation:

$$E_{in} = N_1 \frac{d\phi}{dt} \times 10^{-8},$$

where  $d\phi/dt$  is the rate of flux change in  $T_1$ .

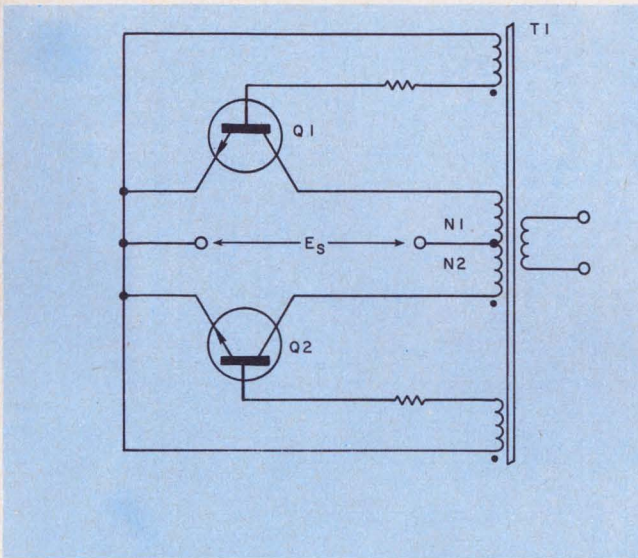
When the core approaches saturation, the induced voltage and, consequently, the base drive, are reduced. Because transistor  $Q_1$  is turned off, the induced voltages across windings  $N_1$  and  $N_2$  are reversed. This, in turn, causes a reversal of bias, and transistor  $Q_2$  turns on as  $Q_1$  turns off. Then this cycle repeats.

A square-loop core used as a forward-loop regulator functions similarly, except that  $E_s$  differs for  $t_{on}$  and  $t_{off}$  (Fig. 3). In the figure, when  $Q_1$  is on

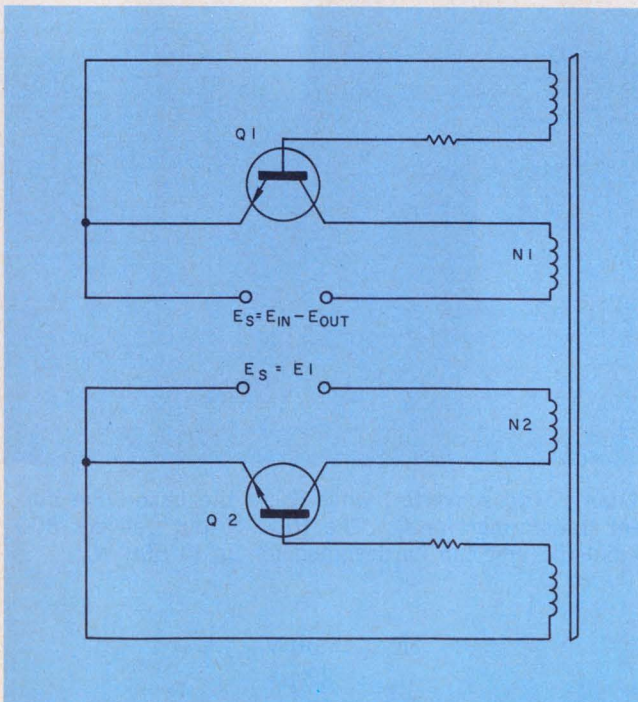
$$(E_{in} - E_{out})t_{on} = N_1 d\phi \times 10^{-8}.$$

When  $E_{in}$  changes,  $t_{on}$  also changes and maintains the product of  $(E_{in} - E_{out})$  and  $t_{on}$  constant. When  $Q_2$  is on

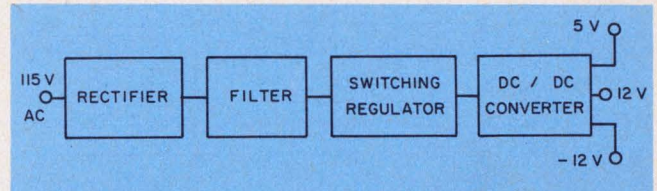




2. Self-saturating, square-loop-core inverter forms the basis of a forward-loop regulator.



3. Operation of the regulator can be visualized more clearly when windings  $N_1$  and  $N_2$  are separated, and the circuit equations are written for alternate conduction of  $Q_1$  and  $Q_2$ .



4. Functional elements of the forward-loop supply: The rectifier and filter are conventional designs. The converter switches at 20 kHz and delivers output voltages of +5 and  $\pm 12$  V.

$$E_1 \times t_{on} = N_2 d\phi \times 10^{-8}$$

This type of control reduces the 120-Hz line ripple by 33 dB.

#### Design includes dc/dc converter

The elements of a 300-W forward-regulated supply are shown in Fig. 4, and the complete schematic is given in Fig. 5. The rectifier and filter are conventional designs, with the filter rated at 100 V dc, 4 A.

The design, which includes a dc-to-dc converter, can operate from a 115-V, 60 or 400-Hz ac line. The switching regulator provides a 50-V output with input voltage variations from 80 to 160 V, and the dc-to-dc converter produces +5 and  $\pm 12$  V dc from the 50-V output.

This supply has many applications; for instance, computer peripherals, minicomputers and avionics equipment. And of course, the bulky 400-Hz transformer so common in avionics equipment is eliminated.

From the basic switching-regulator equations,

$$E_{out} = E_{in} \frac{t_{on}}{t_{on} + t_{off}}$$

$$E_{out} t_{off} = (E_{in} - E_{out}) t_{on}$$

$$E_1 t_{off} = (E_{in} - E_{out}) t_{on},$$

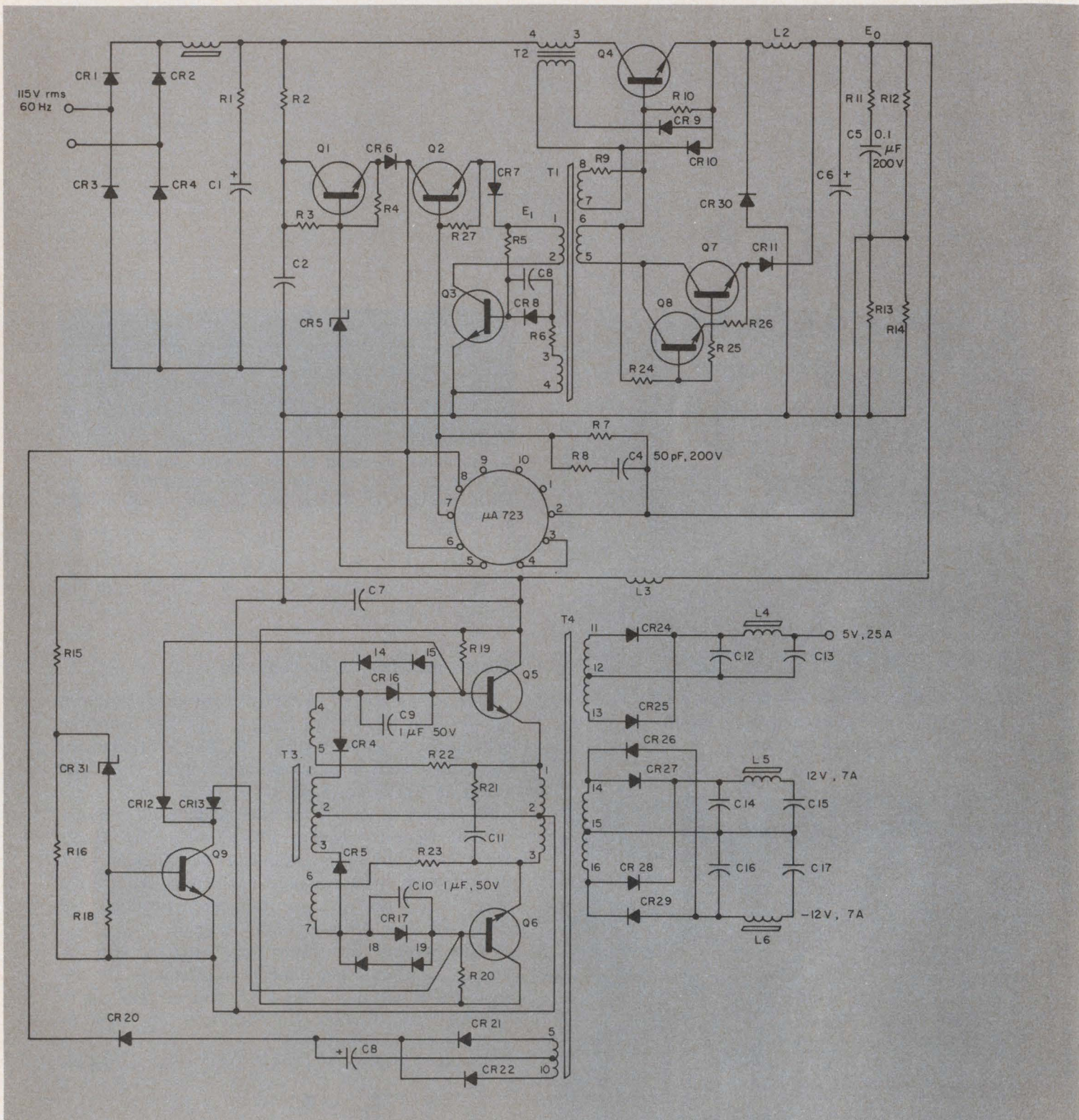
where  $E_1 = kE_{out}$ , and  $k$  is a constant. If the product of  $(E_{in} - E_{out}) t_{on}$  is maintained constant, and  $t_{off}$  is also constant, then the output remains constant. Operation of the regulator is as follows:

When  $Q_1$  is on and  $Q_2$  is off (or vice versa), the voltage across winding 6-5 is

$$E_{in} - V_{CE(sat)} + V_{BE} - E_{out}.$$

When  $Q_1$  saturates





5. Schematic of the complete supply. Square-loop transformer  $T_1$  switches at 20 kHz as transistors  $Q_3$  and  $Q_4$  conduct alternately. Transformers  $T_3$  and  $T_4$  form part

of the dc/dc converter, while  $T_2$  is the base-drive current transformer for  $Q_4$ . The triple-output delivers 300 W but the unit can be designed for up to 500 W.

$$E_{in} - V_{CE(sat)} + V_{BE} \approx E_{in}$$

Transformer  $T_1$  (winding 5-6) is designed to support the volt-second value and also to meet the minimum 20-kHz switching frequency.

Other design criteria are:

$$E_{in}(\text{minimum}) = 80 \text{ to } 160 \text{ V}$$

$$E_{out} = 50 \text{ V}$$

$$t_{on} = 32 \mu\text{s}$$

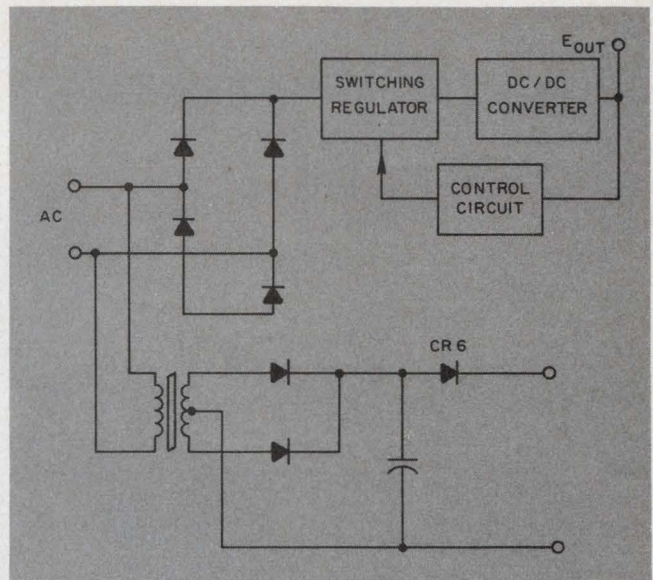
$$t_{off} = 18 \mu\text{s}$$

Transformer  $T_1$  is designed first; then the value of  $E_1$  is chosen to meet the  $t_{on}$  and  $t_{off}$  requirements. When  $T_1$  saturates,  $Q_4$  turns off and



## Component values

SYMBOL	PART NO.	DESCRIPTION
<b>TRANSISTORS</b>		
Q1, 2, 3, 7, 9	2N5326	80 V, 5 A
Q4, 5, 6	SVT300-10	300 V, 10 A
Q8	2N4305	80 V, 5A
<b>DIODES</b>		
CR1-4	1N3211	300 V, 15 A
CR5	1N5077	30 V ZENER
CR6-22	DSR5101	100 V, 5 A
CR24, 25	SD-51	Schottky 35V — 60 A
CR26-29	SVD100-12	100 V, 12 A
CR30	SV300-12	300 V, 12 A
CR31	LVA 68A	6.8 V ZENER
<b>CAPACITORS</b>		
C1	350 $\mu$ F, 250 V dc	
C2	0.1 $\mu$ F, 200 V dc	
C3	0.1 $\mu$ F, 50 V	
C4	50 pF, 200 V	
C5	0.1 $\mu$ F, 200 V	
C6	100 $\mu$ F, 75 V dc	
C7	5 $\mu$ F, 100 V dc	
C8	22 $\mu$ F, 50 V dc	
C9, 10	1 $\mu$ F, 50 V dc	
C11	0.002 $\mu$ F, 200 V	
C12	1 $\mu$ F, 50 V dc	
C13	1000 $\mu$ F, 10 V dc	
C14, 16	1 $\mu$ F, 50 V dc	
C15, C17	1000 $\mu$ F, 20 V dc	
<b>RESISTORS</b>		
R1	0.33, 5 W	
R2	2.5 k, 3 W	
R3	20 k, 1/2 W	
R4	10 k, 1/4 W	
R5	30 k, 1/4 W	
R6	2 k, 1/4 W	
R7	154 k, 1/8 W 1%	
R8	51 k, 1/4 W	
R9	300, 1 W	
R10	100, 1/2 W	
R11	4.22 k, 1/8 W 1%	
R12	21.5 k, 1/8 W 1%	
R13	5.11 k, 1/8 W 1%	
R14	S.I.T. 1/8 W 1%	
R15	10 k, 1 W	
R16	3 k, 1/2 W	
R18	10 k, 1/4 W	
R19, 20	10 k, 1 W	
R21	51, 1 W	
R22, 23	7.5, 5 W	
R24	10 k, 1/2 W	
R25	2 k, 1/4 W	
R26	600, 1/4 W	
R27	2 k, 1/4 W	
<b>TRANSFORMERS</b>		
T1—CORE	52000 — 1/2 D	MAGNETICS INC.
WINDING—1 — 2	50 Turns, #30	
3 — 4	25 Turns, #30	
5 — 6	130 Turns, #30	
7 — 8	25 Turns, #30	
T2—CORE	52402 — 1 D	MAGNETICS INC.
WINDING—1 — 2	40 Turns, #24	
3 — 4	4 Turns, #18	
T3—CORE	5200 — 1/2 D	
WINDING—1 — 2	180 Turns, #28	
2 — 3	Bifilar wound	
T4—CORE	52029 — 1 D	
WINDING—1 — 2	50 Turns, #18	
2 — 3	Bifilar wound	
4 — 5	5 Turns, #28	
6 — 7	Bifilar	
8 — 9	36 Turns, #32	
9 — 10	Bifilar	
11 — 12	7 Turns, #16 (Dual)	
12 — 13	Bifilar	
14 — 15	12 Turns, #16	
15 — 16	Bifilar	
<b>INDUCTORS</b>		
L1 = 6 mH @ 4.5 A		
CORE # E 1 625 SQ	— 120 Turns — #20	
L2 = 1.0 mH @ 7.5 A		
CORE # E 1 375 SQ	— 60 Turns — #18	
L3 = 130 $\mu$ H @ 7.5 A		
CORE # 55120 — A2	— 70 Turns — #20	
L4 = 25 $\mu$ H @ 25.0 A		
L5, 6 = 100 $\mu$ H @ 8.0 A		



6. For better regulation at the 5-V output, the loop can be closed from the 5-V terminal instead of the 50-V point. When this is done, a modified start circuit keeps the output and input isolated.

$Q_3$  turns on in response to the regenerative characteristics of the core. Then  $t_{off}$  is determined by  $E_1$  and winding 1-2 of transformer  $T_1$ .

### Current transformer drives base

To complete the switching-regulator design, winding 8-7 is used to initiate turn-on of  $Q_4$ , and winding 3-4—along with  $R_5$ —turns  $Q_3$  on and maintains it in the on state. Base drive is provided through the current transformer. During  $t_{off}$  the voltage across winding 8-7 resets the current transformer.

The output voltage is sensed and amplified via the  $\mu$ A 723 IC voltage regulator which, in turn, varies  $E_1$ . Capacitors  $C_5$  and  $C_4$  are selected for loop stability.

Frequency of the dc-to-dc converter (20 kHz) is controlled by saturating transformer  $T_3$ . The main transformer connects between the emitters of transistors  $Q_5$  and  $Q_6$ . This connection turns the converter off, should the switching regulator short through the network composed of  $R_{15}$ ,  $R_{16}$ ,  $CR_{31}$ ,  $Q_9$ ,  $CR_{12}$ , and  $CR_{13}$ . This approach protects the power-supply load from overvoltage caused by the short. Rectification of the 5-V output is accomplished by Schottky diodes  $CR_{24}$  and  $CR_{25}$ , which have a forward drop at 25 A of about 0.5 V.

For certain logic circuits—those in which better regulation is required—the regulator loop can be closed if the output is sensed in any of the usual ways. Regulation to within 1% can be achieved. To retain isolation between the output voltage and the input line when the loop is closed, a modified start circuit can be implemented (Fig. 6). ■■



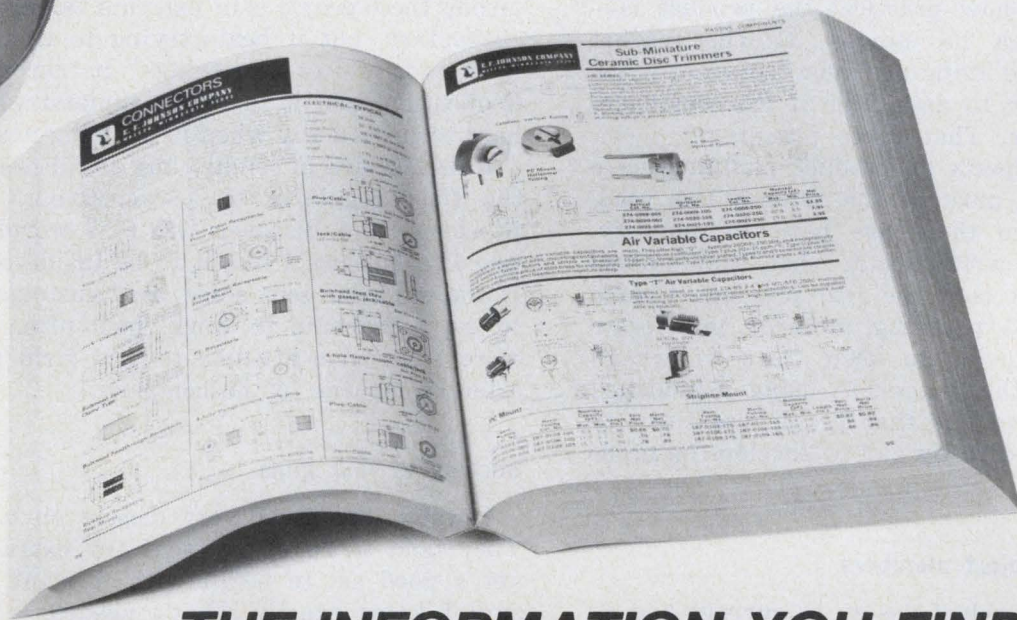
# CUT



# Electronic Design's



# DOWN YOUR DETECTIVE WORK



**THE INFORMATION YOU FIND HERE  
WILL SAVE YOU TIME AND MONEY**

When you see *Electronic Design's* GOLD BOOK you'll wonder how you ever got along without it. You don't have to be a super-sleuth to find out who makes what or where to find it.

For example, there are over 500 pages on Semiconductors; almost 300 pages on Power Supplies; 300 catalog pages on instruments; 150 pages on Switches—approx. 3,500 pages of directory data and technical material in all.

And the Directories — they're the most complete and comprehensive, the most thorough and useful reference sources ever compiled. Almost 7,500 manufacturers are listed with *complete* address, zip and phone. In most cases (where applicable) you also get 800 (toll-free) numbers, Telex, TWX, cable address, facsimile equipment with make and number, plus QPL and FSC designations, financial data and names of key officers.

6,400 distributors are listed — with both alphabetic and geographic access — in the *Distributors Directory*.

See how often *Electronic Design's* GOLD BOOK will answer your questions before you even pick up the phone. Keep the manufacturer's tech pages in front of you when you call — it can speed the discussion and help you communicate your needs quickly and easily.

# GOLD BOOK

COMING JULY, 1974



## **Don't be a slave to a project schedule,** advises this manager, who believes that it's far more important to review a product constantly to test how practical it is.

They say there never has been a project completed on time and within budget. So what? No designer I know can develop his best product if his main concern is the schedule. His main concern should be how practical the product is—NOW, not when he started it. The market changes and the designer must constantly re-view his product to determine if it's worth developing further. That takes planning.

Some vital aspects of product planning have been ignored in most of the articles I've read, probably because these are hard to quantify. People tend to write about what they understand, even if it isn't the real problem. Charts and reports and planning methods proliferate and they're valuable to keep track of what's going on. But the danger in using established methods exclusively is that people use them to meet milestones directly and to develop the product indirectly.

### **Cross-fertilize project members**

To keep my product design as current and as practical as possible during a project, I do the following at Sigma:

- Interface engineers with other disciplines.
- Review the specs constantly.
- Stick to my initial design approach most of the time.
- Solve the most difficult technical design problem first.

It's wrong to insulate engineering in a company. I've worked with a number of companies in many fields, and it seems to me that in a world that's increasingly technological the engineer knows some things that he should share. There should be cross-fertilization between engineering and sales, particularly when they're developing new products. New products are risky, and any input that can be shared by these two disciplines is vital to the success of the project.

---

**Tom Beling**, Vice President, Engineering, Sigma, Braintree, Mass. 02185.

Here the salesmen sit next to the design engineer. We even moved their desks together. The industrial engineers and applications engineers are also there. We feel that regular interface among these people is of extreme value. It sounds elementary, but it beats trying to communicate by memo. It does two things: It increases communication, and it increases understanding. It's hard to curse a guy when he's sitting next to you.

I also believe in sending my engineers out into the field regularly to see customers, explore problems, and discover the real world, as opposed to how we'd like it to be inside of Sigma. If the engineer sees some poor customer trying to get a machine to work, he'll often adopt a more responsive attitude toward field problems after he returns to the company.

### **Sticking to your guns**

I watch the specs very closely on a project. They tend to be vague, so I try extra hard to get a good set to begin with. I want to make sure I know exactly what's needed.

I'll start out with a certain set of specs at the beginning of a project, but before it's finished, I'll usually end up with a completely different set. What happens is that I can't meet the specs, or I exceed them in some areas, or I find some aren't needed at all. Every time the specs are changed, I review the product again to determine if it's still practical.

All along the way you've got to ask production people what they think of the specs: Are they practical? From a company point of view, product design is the relatively cheap part of product introduction. After the product is designed, you have to make a decision on whether to go into the pilot run, production, sales and the whole business. All that usually costs more than the design itself.

Then there's the "should-I-start-with-a-new-approach" question.

You're working on a project and run into obstacles; if you don't, the project probably isn't worth doing. But when you do stub your toe, you always have this question: Do I push ahead



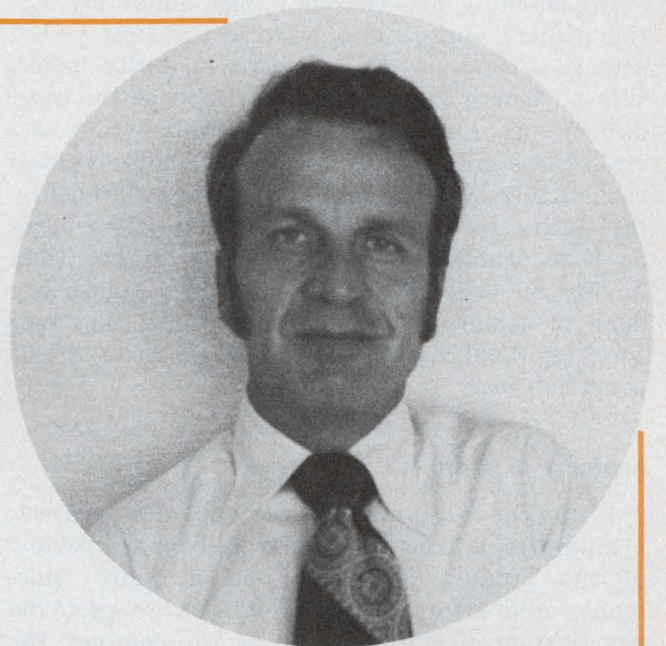
## Tom Beling and Sigma Instruments

Tom Beling's career has the unmistakable mark of success; after serving in the U.S. Army Signal Corps for two years, he made a habit of steady advancement.

Between the time he was a designer of various portions of airborne radar at Farnsworth Electronics and Sigma's Vice President of Engineering, Beling worked as a systems engineer on Doppler Radar at Raytheon, as a division manager in instrumentation and audio research at United Research, Inc., and as vice president of engineering at Acton Labs.

In the middle of his career he attended Harvard Business School and earned an MBA to go along with the BSEE and MSEE he'd earned earlier at the University of Illinois.

Sigma Instruments, his present employer, was founded in 1938 to make sensitive relays, an area in which the company is still a leader. Other switching products now include general purpose relays, reed relays, and outdoor lighting controls, as well as hybrid and solid state relays. Electronic controls for electric utilities were added in the 1950's, and a line of digital step-



ping motors and associated electronics has been developed in the past few years. Beling is responsible for the design and development of all products at Sigma.

Beling's extracurricular activities include membership in IEEE and ARRL, published articles, and six patents. Special interests are camping and photography. He has probably had a lot of practice taking pictures since he and his wife have four children ranging in age from 11 to 18.

or do I start over with this new approach I just thought of? It doesn't matter what kind of project you're doing. After you do it, you think, "Man, if only I'd done such and such, I might be better off." It's very difficult to see the problems in a new approach, as opposed to the problems you already know about in the old approach.

I know of no solution to this problem. You can try to use good judgment and call the ap-

propriate people together to review the situation carefully. But then you still have to face the decision alone. My philosophy is: I had a plan and I expected troubles . . . now what's really wrong with that plan? Sometimes that really sobers me up. But 70% of the time I'm better off sticking to my first approach.

I never base the decision on how much money has been spent; there's no way I'm going to get



it back. I've tried both ways often enough, and most of the time I've found that if I try the second approach, the first approach starts looking pretty good again.

The ability to develop this kind of expertise and judgment is more important than trying to quantify and control something that is less susceptible to control the more difficult it gets. In our company we take only a few projects that are a gamble, and we don't cry very hard if we don't win.

Occasionally one reason I may doubt my initial project approach is because the first task I attack is finding the critical feasibility point. When I look at a project, I look first at the most difficult technical problems—there may be several. I assimilate that as quickly, honestly and realistically as I can, and try not to be blinded by my desire for it to work. I put all my energy on that problem at the beginning, rather than having an orderly project, where the tasks are done in sequence. I waste some time, but over the long haul I find out what products aren't practical early in the game.

### Anatomy of a project

From the beginning to the end of a project, I maintain a constant and cold-blooded review of the product, to avoid putting more time, money and effort into it if it isn't going to be practical or if it's going to be too complex for the customer to use.

After I get a good set of specs, I contact everyone in my department who I think would be able to contribute an idea. Because of the nature of our company, I have people who do various kinds of engineering—electromechanical, relay, mechanical, electronic. I ask them how they would solve it, and I give them a day or two to mull it over.

I'll get diverse ideas for the solution, from which I'll try to synthesize an approach. Engineers in some companies work on the problems in cubicles. Other engineers find it difficult to use the expertise they have because they are in competition with other departments or divisions in the same company.

I like to "blue sky" the solution a bit. I don't want to have a preconceived notion of it. I'm not afraid of not knowing some phase of technology. I'll ask questions to find out about it; but we all pick and choose the better ideas, and I act as the catalyst. I never fault a project member for making a wrong decision, unless he has plowed forward after he has been proved wrong.

At this point we've spent about 5% of our budget, and we've decided that the design is

technologically feasible. So we start forming detailed plans and charts. If we keep checking spec modifications (where we are and what we can do) and cost modifications, we can estimate what the cost is going to be and what we can sell it for. We're comparing cost and price constantly, playing them off the specs.

Maybe we'll get in the middle of the project and find that the cost is so high it'll be an engineering monument to finish. And maybe, even though the costs appear to be high, the product might look promising enough for us to press ahead and try to drop costs out later.

### Testing theory against the project

Let me give you an example of how my theory worked on a project we had a couple of years ago.

The customer supplied the specs, and we supplied an overly enthusiastic idea of what could be done with the cost. Neither one of us knew what he was doing; we were breaking new ground. The customer gave us an optimistic set of specs to meet the requirement when we gave him an optimistic projection.

Soon it became apparent that a lot of things had to be done to the product other than the specs we'd received. Our plans were thrown out of kilter. We spent four or five times the amount of money that we'd estimated. But as we went along, we saw the product taking a positive shape.

Sometimes the engineer can come up with a product that's so good it's worthwhile even at twice the budget. Cost should never be the engineer's chief worry. He could develop a product at half the budget and never sell the first one.

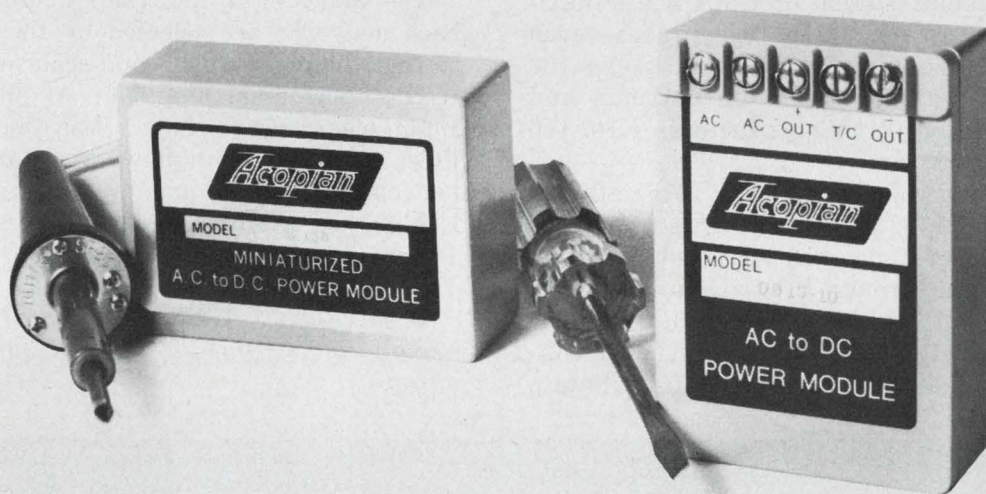
Timing is important, too. An engineer could have invented the digital computer 200 years ago, and it wouldn't have done him any good. He might have been remembered as a genius, but he'd never be remembered as a millionaire.

When we had finished the product for our customer, we found that it performed more functions than we'd asked it to, opening up new markets for the customer. So, at the moment, it appears that this device, which cost us so much, is going to be a big winner, selling at about three times the original estimated price.

I've been 25% to 50% more successful with this project method than with any other I've used, but it was enough to make a PERT man blanch in horror. What we were doing along the way was holding back and seeing what we had and asking ourselves, "What can the product do now?" "Is there anything else it could do?" It took a lot of hard work and liaison with this particular customer to get the answers we had to have. ■■



# ±15 VOLT POWER MINI'S FOR OP AMPS



ALL MODELS U.L. RECOGNIZED

## PC-BOARD MOUNTING

OUTPUT CURRENT MA	SIZE INCHES	PRICE	MODEL
25	2.3 x 1.8 x 1.00	\$24	D15-03
50	2.3 x 1.8 x 1.00	39	D15-05
100	3.5 x 2.5 x 1.00	49	D15-10A
200	3.5 x 2.5 x 1.00	69	D15-20
300	3.5 x 2.5 x 1.25	105	D15-30
500	3.5 x 2.5 x 2.00	130	D15-50

## CHASSIS MOUNTING

OUTPUT CURRENT MA	SIZE INCHES	PRICE	MODEL
100	3.5 x 2.5 x 1.38	\$55	DB15-10
150	3.5 x 2.5 x 1.38	65	DB15-15
200	3.5 x 2.5 x 1.38	75	DB15-20
300	3.5 x 2.5 x 1.63	105	DB15-30
350	3.5 x 2.5 x 1.63	110	DB15-35
500	3.5 x 2.5 x 2.38	135	DB15-50

Line/load regulation,  $\pm 0.1\%$  or better; ripple, 1 mv; input, 105-125 VAC. Other single and multiple output models from 1 to 75 volts, to 2.5 amps. Liberal quantity discounts. Three-day shipment guaranteed.

Complete details on these plus a comprehensive line of other power supplies and systems are included in the Acopian 74-75 catalog. Request a copy.



Corp., Easton, Pa. 18042. Telephone (215) 258-5441.

INFORMATION RETRIEVAL NUMBER 60



## Low power at ohmmeter's probes allows safe usage on most sensitive components

Ordinary ohmmeters can damage tunnel diodes, MOSFETs and many transistors. The more sensitive components can be harmed even by so-called micro-power ohmmeters. However, the power used at the probes of the ohmmeter in the figure is so low that the ohmmeter can be used on the most sensitive components.

The circuit imposes only maximum voltage of 10 mV, a maximum current of 1 mA and a maximum power of 2.5  $\mu$ W to the test probes—even on the lowest resistance scale. On the  $\times 10$ ,  $\times 100$  and  $\times 1000$  scales, the maximum currents and powers are reduced further by factors of 10, 100 and 1000, respectively.

In the circuit, a voltage of 10 mV is maintained between point "A" and ground. This voltage is also across one of four selected fixed resistors, designated  $R_f$  ( $R_1$  through  $R_4$ ), which is in series with the unknown junction resistance  $R_x$ . Variable resistor  $R_v$  at the input to op-amp  $A_1$  sets the voltage level that point "A" is forced to maintain

via the circuit's negative feedback.  $R_v$  also serves as the ohmmeter's zero-set control.

With point "A" at 10 mV, the current through resistors  $R_f$  and  $R_x$  is

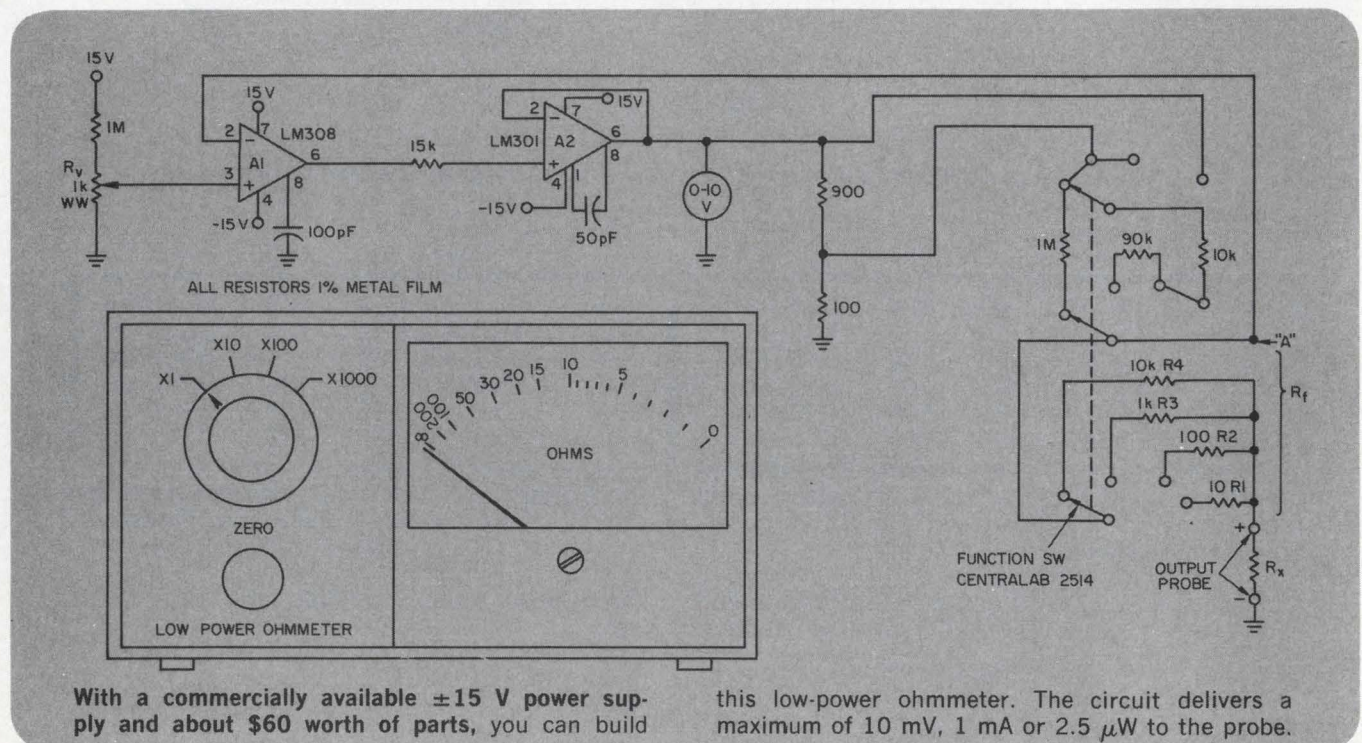
$$I = 10 \text{ mV} / (R_f + R_x).$$

The current is supplied by the output of  $A_2$ , whose output voltage is proportional to this current, or  $1 / (R_f + R_x)$ .

The values of  $R_f$  and the resistors in the feedback networks are selected by the range switch so that the meter reads mid-scale when  $R_x = R_f$ .

The operational amplifier  $A_1$  should have an input bias current that is less than  $10^{-7}$  A that flows through the unknown resistance at the upper end of the ohmmeter's useful range. The LM308 has a rated bias current of only  $7 \times 10^{-9}$  A, which meets the criterion amply.

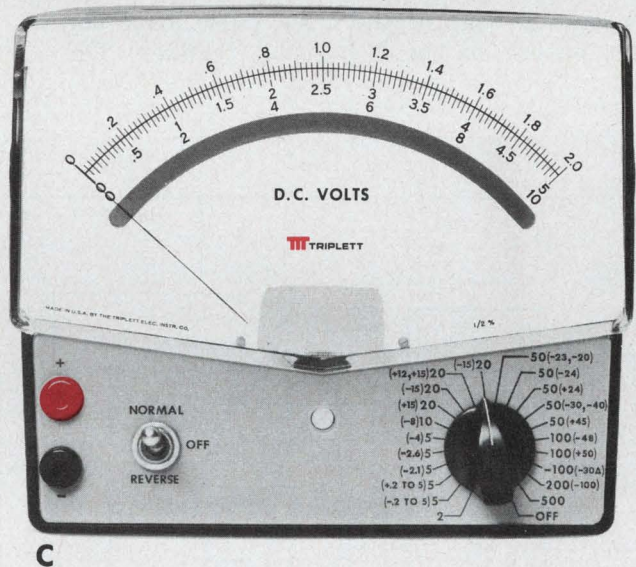
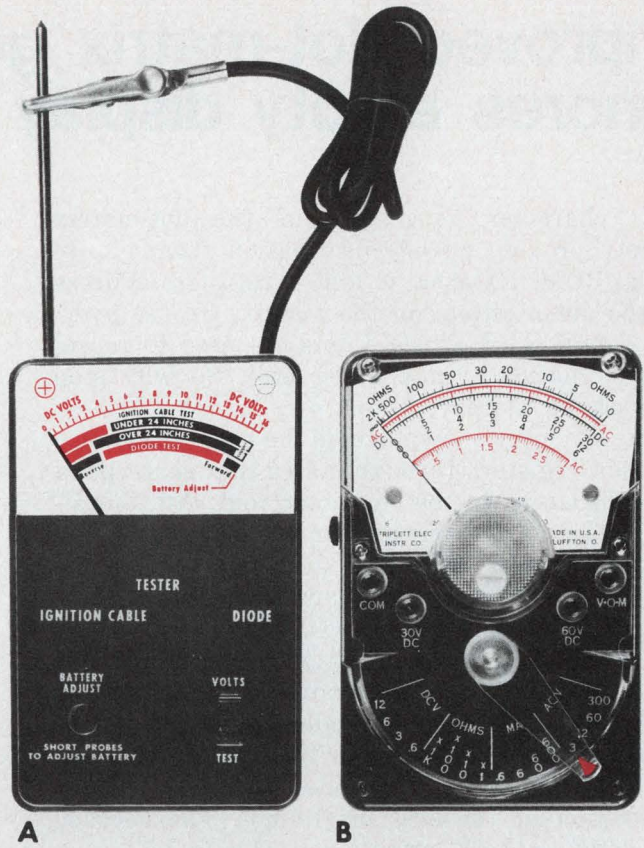
*B. D. Wallace, Instrumentation Program, University of California, Santa Barbara, Calif. 93106.*  
CIRCLE NO. 311





If you need  
a tester  
with **special**  
scales, ranges,  
accessories  
or any  
combination...

Buy a  
**Triplett tester**  
custom-designed  
for you



Triplett, manufacturer of the World's most complete line of V-O-M's, is ready, willing and able to design and manufacture special testers of virtually any size, style or type to meet your specifications.

Tester A (above) was designed to give auto mechanics a simple, rugged tester for "go/no go" tests that would otherwise be measured in electrical units unfamiliar to them.

Tester B is a modification of a

standard Triplett tester incorporating only the specific ranges needed by the field service engineers for whom it was designed.

Tester C has special ranges and special input connectors and cables to permit a single-point connection for trouble-shooting and servicing all the circuits of a complex business machine.

Several other buyers of standard Triplett test equipment request their company name on the dial to personalize their testers.

If you think a custom tester may solve some problems for you, contact your Triplett representative. He'll put you in touch with the Tester Designers and Engineers at Triplett who'll help you analyze the problem and suggest the optimum cost/result solution. Triplett Corporation, Bluffton, Ohio 45817

**TRIPLETT**  
BLUFFTON, OHIO 45817

Manufacturers of the World's  
most complete line of V-O-M's

INFORMATION RETRIEVAL NUMBER 61



# Improved dot-matrix generator ignores empty display positions

IC character generators of the dot-matrix variety provide on/off information from an integral ROM. External X and Y registers address all the dot positions in the matrix. On the average only a third of these dots are used to represent a character in a given font. So why step through all states?

The circuitry shown avoids the need to advance position registers through states that correspond to blank areas in the character font. All Y-position addresses correspond to active dots.

When the ASCII code is first presented to the character generator, the unit outputs the first column on lines O<sub>1</sub> through O<sub>7</sub>. To follow the circuit operation, assume initially that the input causes O<sub>3</sub> and O<sub>6</sub> to be activated and that the S-R latch is cleared. Then encoder gates G<sub>6</sub> and G<sub>3</sub> provide inputs to the priority encoder. The encoder ignores G<sub>3</sub> but it encodes G<sub>6</sub> for the correct Y position of the first bright dot. The decoder connected to the Y outputs activates line 6.

The leading edge of the clock pulse loads the encoder output to the Y-position register. The

clock pulse also generates the intensity signal and its trailing edge strobes decoder gate G<sub>13</sub> to set bit Q<sub>6</sub> of the latch. With Q<sub>6</sub> high, gate G<sub>6</sub> is disabled, and only line 3 remains active at the priority encoder.

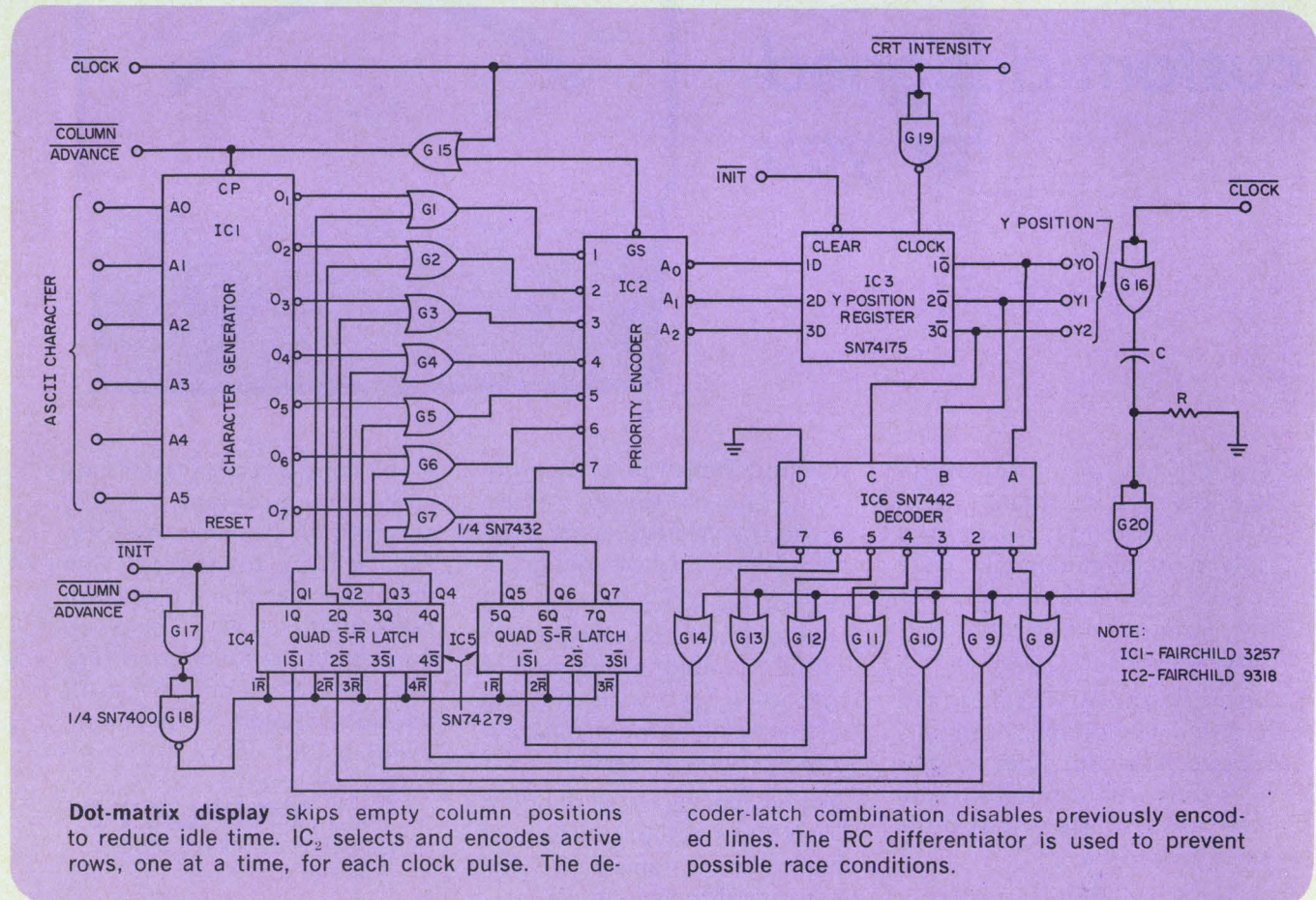
The next clock pulse outputs the dot as before; however, no more lines remain active at the priority encoder. Since all encoder inputs are inactive, the unit will generate signal GS to open gate G<sub>15</sub>. The next clock pulse clears the latch and advances the character generator by one column. The circuit is now ready to output the next row of dots. An X position register (not shown) selects the display column.

The whole circuit is suitable for fabrication as a single IC. Use of a 7-bit S-R latch to store column information Q<sub>1</sub> through Q<sub>7</sub> would eliminate the need for gates G<sub>1</sub> and G<sub>7</sub>.

*Kruno Culjat, Senior Engineer, General Atomic Co., P.O. Box 81608, San Diego, Calif. 92138.*

*(This article was written when the author was employed by Ortec Inc., Oak Ridge, Tenn.)*

CIRCLE No. 312



**Dot-matrix display** skips empty column positions to reduce idle time. IC<sub>2</sub> selects and encodes active rows, one at a time, for each clock pulse. The de-

coder-latch combination disables previously encoded lines. The RC differentiator is used to prevent possible race conditions.



**Inselek can now provide total custom LSI design and fabrication, at a price competitive with bulk CMOS, and do it in less time than our competition.**

**The Classical Design Story—**

A typical approach to custom LSI circuits employs either MOS or bipolar technologies. MOS offers low cost and low power, but lacks a high switching speed. Bipolar has the speed, but it's expensive to make and power dissipation is high. This leaves you with a formidable design decision. Will it be MOS or bipolar? Either way it's a compromise.

**The No Compromise Way—**

Inselek now offers you a custom SOS/CMOS approach where you never have to compromise. Using our proven technology you'll receive all the inherent benefits of both MOS and bipolar, and obtain comparable development costs as well. Here's what we'll do for you. Inselek will either design and fabricate a custom SOS/CMOS IC for you, or produce integrated circuits from your own design (in either ceramic or plastic packages), or, if you prefer, we'll provide you with only the wafers. Any way you choose you come out a winner.

**Getting Started—**

Before you commit to any process, get all the facts first. Compare costs, reliability and technologies. For details on the Inselek "No Compromise Way" circle the reader service number or write:

**Inselek, Inc.**, 743 Alexander Road, Princeton, N.J. 08540.  
Telephone: (609) 452-2222.

You'll find we may not be very modest, but we're easy to do business with.

# Inselek customizes the SOS/CMOS IC.



SALES OFFICES IN  
CONCORD, MASS. (617) 369-5298 AND  
LOS ANGELES, CALIF. (213) 889-2788

DISTRIBUTORS:  
WEST COAST— WESTATES (213) 341-4411 NEW ENGLAND— GREEN SHAW (617) 969-8900 MID-ATLANTIC— WILSHIRE ELECTRONICS (609) 786-8990

INFORMATION RETRIEVAL NUMBER 62



# Combinatorial logic circuit calculates the absolute difference of numbers

The absolute magnitude of the difference between two positive binary numbers,

$$Z = |X - Y|,$$

can be calculated with two SN74283 binary adders, two SN7486 EXCLUSIVE-ORs and one inverter. Many applications in digital design, such as in d/a converters, require this operation.

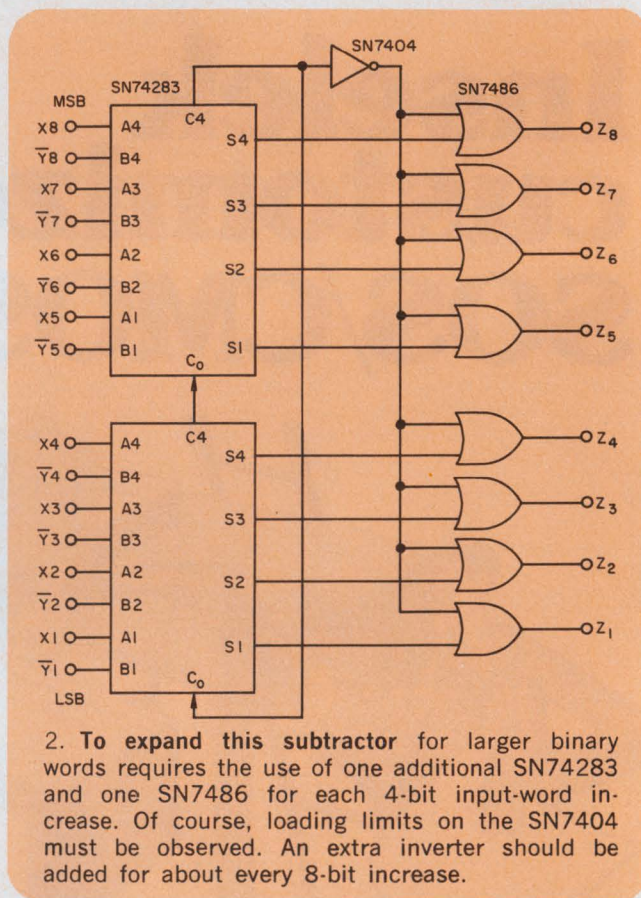
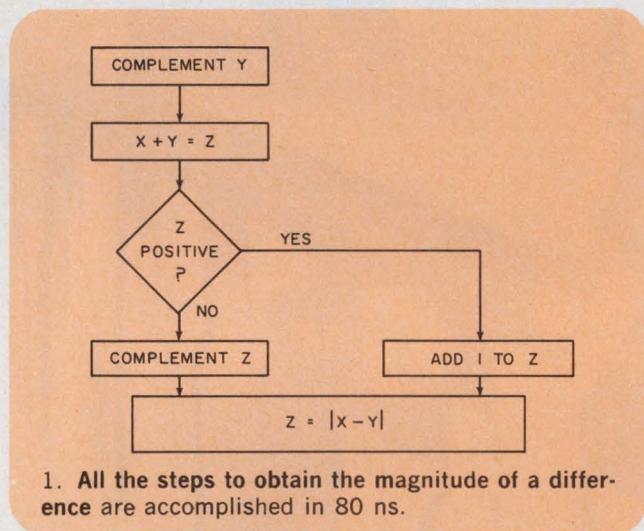
A flow chart of the required steps is shown in Fig. 1. Many computers perform these operations sequentially, but the simple combinatorial circuit in Fig. 2 does it for two 8-bit binary numbers, in less than 80 ns. When the ONE's complement, or inversion, of Y is added to X and a carry is obtained, the result is positive, and the carry must be added to the result to get the correct answer. This process is called the end-around-carry method—the equivalent of use of a TWO's complement of Y.

When no carry comes out of the highest-order

adder, the SN7404 inverter applies a ONE to the EXCLUSIVE-ORs, and all the inputs are inverted in their outputs. Though the circuit shows only an 8-bit implementation, its extension to larger numbers is explained in Fig. 2.

*Paul Jacobs, Principal Engineer, Raytheon Co., 6380 Hollister Ave., Goleta, Calif. 93017.*

CIRCLE NO. 313



## IFD Winner of March 1, 1974

**Jerald Graeme, Manager, Monolithic Engineering, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706.** His idea "Bootstrapped RC Differentiator Performs Accurately Without Phase Inversion" has been voted the Most Valuable of Issue Award.

**Vote for the Best Idea in this issue** by circling the number for your selection on the Information Retrieval Card at the back of this issue.

**SEND US YOUR IDEAS FOR DESIGN.** You may win a grand total of \$1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive \$20 for each published idea, \$30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of \$1000.





# STRIKE

# GOLD

**...every time you  
actuate a  
Cherry  
Keyboard Switch**

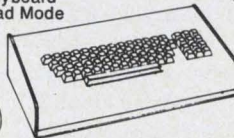
Cherry's unique gold "crosspoint" contacts eliminate the two main causes of contact failure—(1) formation of insulating chemical film on contact surfaces, (2) mechanical interference of foreign particles on contacts.

This proven design concept (gold prisms at right angles to each other) provides high force per unit of contact area to enhance reliability. Tested to 50,000,000 operations and beyond, the gold crosspoint contact keyboard switch is available individually, with or without two-shot molded keycaps, or as part of a fully encoded electronic data entry keyboard.

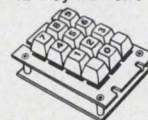
**FOR A FREE SAMPLE SWITCH** and all the facts on Cherry keyboard switches, plus standard and custom keyboards, PHONE 312-689-7700 . . . or circle reader service number below.



Model B70-54AA Keyboard  
53-Key Special Quad Mode



Model B65-1712 Keyboard  
12-Key Numeric



Electronic Desk Top  
Calculators



# CHERRY



**CHERRY ELECTRICAL PRODUCTS CORP.**  
3609 Sunset Avenue, Waukegan, Illinois 60085

**Cherry Worldwide:** (Subsidiaries) Hirose Cherry Precision Co., Ltd., Tokyo • Cherry Mikroschalter GmbH, Bayreuth, Germany  
• Cherry Electrical Products (U.K.) Ltd., St. Albans, Herts • (Licensee) G.W. Engineering Pty. Ltd., Sydney



INFORMATION RETRIEVAL NUMBER 63



## Photodetector combines slim pulse with high gain

A photodetector tube that measures light pulses of only a few picoseconds and has high gain has been designed at the Philips Electronics and Applied Physics Laboratories at Limeil Brevannes in France. Such a device is needed in plasma research and in the measurement of laser signals.

The tube is basically a cathode ray with a photocathode in place of the normal cathode. The tube also contains an electron gun, an electron focusing system, a deflection unit, a microchannel plate and a fluorescent screen.

A light signal focused on the cathode is converted into an electron current proportional to the intensity of the illumination. The electron beam is accelerated and

intensified by the tube's electron optical system. The resultant fluorescent-screen display has a light output proportional to the flux received at the photocathode. A control electrode in the electron gun synchronizes gating of the tube with an external signal.

Spiral scanning is applied to electrostatic deflection plates for observation of light phenomena. The scanning is produced by two 200-MHz, amplitude-modulated sinusoidal voltages. The spot speed is 2 cm/ns with a 200-V, peak-to-peak sweep voltage. The accelerating voltage is 2 kV. The time resolution of the tube is 10 ps. With a trialkaline photocathode, the photon gain is more than 10,000 for a wavelength of 0.5  $\mu\text{m}$ .

CIRCLE NO. 315

## Coil plus a/d converter monitors phone dialing

A monitor that can reveal the use of company telephones for personal calls has been produced by Telstop SA in Luxembourg.

An inductive coil picks up dialing signals from the telephone cord, and the signals are recorded on a magnetic-tape cassette. An a/d conversion system produces a paper printout of the numbers called.

The device cannot be used for wiretapping, since it picks up only the dialing signals. However, it must be approved by telecommunications authorities wherever it is used.

CIRCLE NO. 316

## Photomultiplier gain soars to 15,000

Image intensifiers that have a gain of 15,000 and can operate in a gated mode are being built by Philips Eindhoven in the Netherlands.

Small channel photomultipliers, about 12  $\mu\text{m}$  in diameter and 5-mm long, are fused side-by-side. This produces a thick plate with a sensitivity of  $10^{-5}$  LUX. The image amplifiers are gated to enhance an image and to suppress light that is backscattered by fog or smoke.

The method—called Milkrokanal, or channel photomultiplier technology—employs a long laser pulse to

illuminate the subject. But the gate opens only for a brief period at the precise time that light from the subject returns to the camera. Unwanted light, such as that reflected from suspended particles or even a curtain, arrives when the gate closes and is prevented from obscuring the image.

CIRCLE NO. 317

## Higher sensitivity noted in varactor-diode amp

A parametric varactor-diode amplifier operates at room temperature with a sensitivity that the developer—Ferranti of England—says was attainable previously only through use of cryogenic techniques. It amplifies within the 7.25-to-7.75-GHz band.

The operating bandwidth is 500 MHz. Effective input-noise temperature is 100 K at 7.5 GHz. Ferranti says that improved semiconductor fabrication methods and a higher-than-usual pumping frequency—50 to 60 GHz, compared with 40 GHz—give the increased performance. Raising the operating frequency increases the ratio of pump-to-signal frequency. Therefore, Ferranti says, better noise performance can be obtained from a varactor diode.

CIRCLE NO. 318

## System widens capability for patient monitoring

A new system for computer-assisted monitoring of patients not only checks physiological variables against norms but also analyzes them in relation to one another and to previously measured values.

Up to 32 patients can be monitored at one time. Patient data are updated every 30 seconds, and data can be stored up to 16 days.

The system, developed by Siemens of West Germany and called Simon, includes provision for immediate computer access to any information concerning individual patients. Hospital personnel communicate with a Siemens 404 computer and peripheral equipment, with video monitors and keyboards. The 404 includes control unit, operator console typewriter, tape reader, tape punch, data store and magnetic disc recorder.

CIRCLE NO. 319



# If anybody can hand you the ready-made P/C connector you need,

## we can.

That's because we have more of them on the shelf than anybody else we know. We have them from .050 contact centers through .156, from 6 to 210 contacts, with full bellows, semi-bellows and cantilever designs, with gold saving AuTAc™ plating, low insertion force contacts, in micro miniatures, dual and single read-outs . . . and on and on and on.

We've been at this 23 years. And — because we don't compromise on quality

when we make our connectors — we don't like to see your P/C designs compromised by a make-do connector. So, we have a lot of them.

They're all cataloged in our latest 44-page brochure. Send for your free copy so you'll have it when you need it.

Or, if you need help right now, just pick up your phone and call Customer Service. (213) 341-4330.

**Ok. Send me:**  Details on your line of P/C connectors.  
 and, come to think of it, your low cost circular connectors, too.

Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_

Zip \_\_\_\_\_



# Viking

## CONNECTORS

Viking Industries, Inc./21001 Nordhoff St./Chatsworth, Calif. 91311



INFORMATION RETRIEVAL NUMBER 64



# Navy Standard Hardware Program packaging made easy and profitable

If you're supplying equipment to Navy Standard Hardware Program guidelines, our ingenious new SHP Packaging System will make coming up with the packaging absolutely simplistic and halve your packaging costs at the same time.

## No sweat SHP

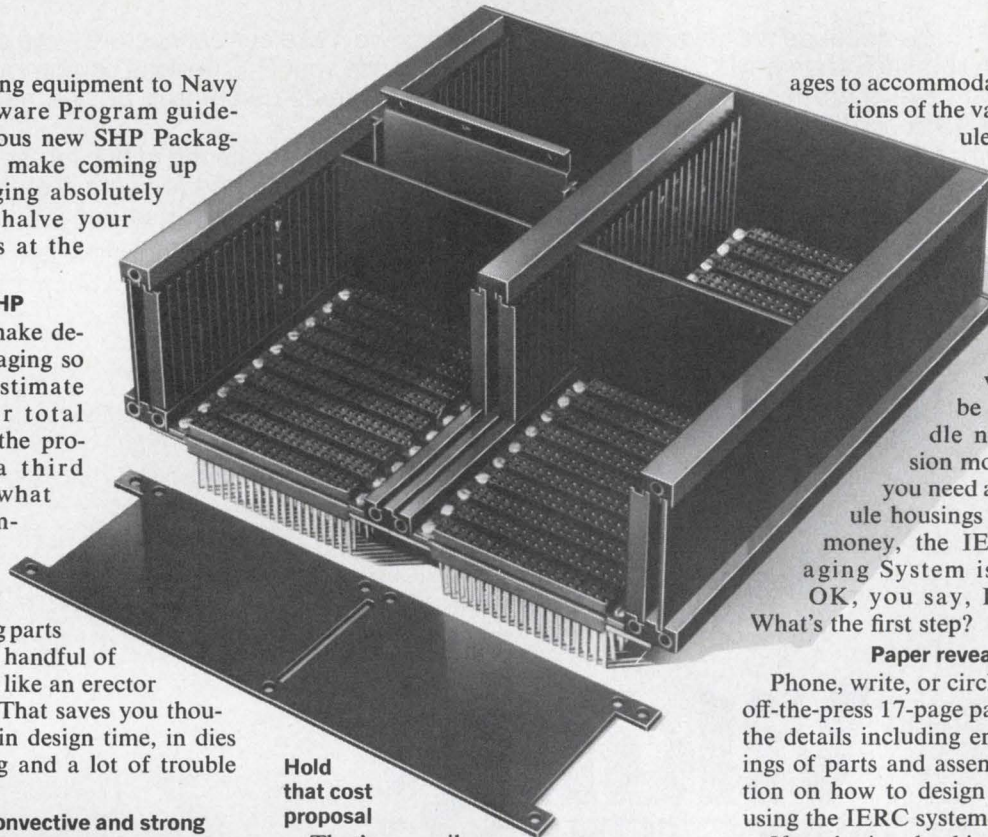
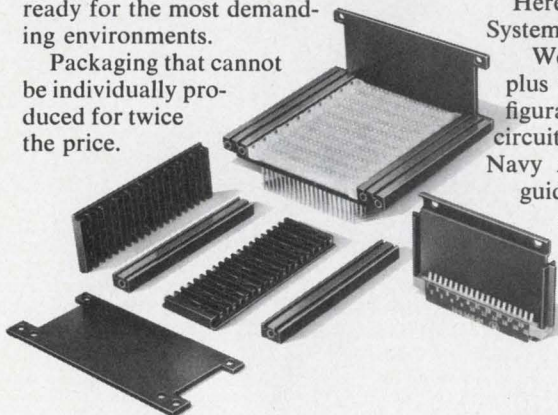
First off, we make designing the packaging so effortless we estimate you'll cut your total design load for the procurement by a third because that's what our first customers are experiencing.

Production consists of putting parts together — just a handful of different kinds — like an erector set. Only easier. That saves you thousands of dollars in design time, in dies and other tooling and a lot of trouble to boot.

## Conductive, convective and strong

And when you get finished you'll have packaging for your circuitry with the high order of thermal efficiency you'd expect from industry's leading manufacturer of circuit heat dissipating devices. Plus mechanical integrity that's ready for the most demanding environments.

Packaging that cannot be individually produced for twice the price.



## Hold that cost proposal

That's a pencil-sharpening fact you can ill afford to ignore if you're in the middle of preparing a proposal in response to an RFP that calls out SHP — or if you ever expect to bid an SHP program.

Here's how our new SHP Packaging System works:

We've designed six basic parts — plus a few specials for unusual configurations — with which you can build circuit module housings conforming to Navy Avionics Facility, Indianapolis, guidelines and dimensions for any of the common SHP-defined circuit modules using nothing but a screwdriver.

**Ad infinitum**  
You can build these pack-

ages to accommodate any combinations of the various SHP modules, and the potential dimensions of the packaging in span and depth are for practical purposes limitless.

In fact, our system is so versatile it can be adjusted to handle non-SHP-dimension modules as well. If you need any kind of module housings and like to save money, the IERC SHP Packaging System is for you, too. OK, you say, I'm interested. What's the first step?

## Paper reveals all

Phone, write, or circle to get our hot-off-the-press 17-page paper that gives all the details including engineering drawings of parts and assemblies and a section on how to design SHP packaging using the IERC system.

If you're involved in SHP or ever expect to be, get involved with the IERC SHP Packaging System today.

Ask about our SHP module plates including our revolutionary Metal Core Circuit Board plates for extremely high power densities, too. International Electronic Research Corporation, a subsidiary of Dynamics Corporation of America, 135 West Magnolia Blvd., Burbank, Calif. 91502. (213) 849-2481.

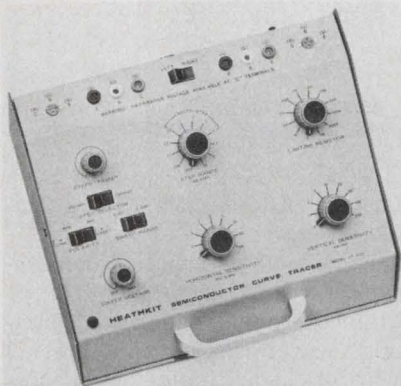


**Heat Sinks/Dissipators**



## new products

### Build your own curve tracer



Heath Co., Benton Harbor, Mich. 49022. \$89.95 (kit); stock.

Used with an oscilloscope, the IT-1121 semiconductor curve tracer accurately displays operating parameters of virtually all types of semiconductors, such as bipolar transistors, diodes, SCRs, triacs, FETs, etc. Extra leads are provided for tests of larger devices or for in-circuit tests. All major controls are stepped in a 1, 2, 5 sequence for maximum parameter resolution.

CIRCLE NO. 250

### DPM changes range and function with plug-ins

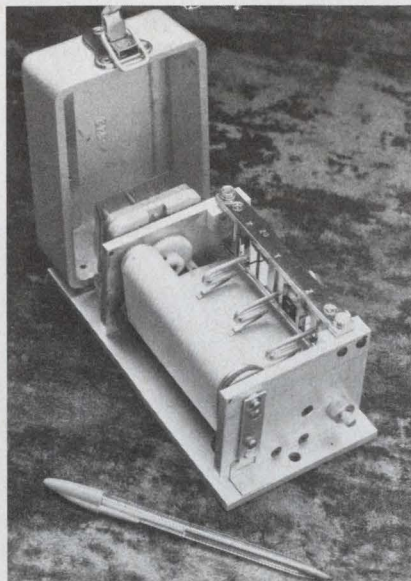


Newport Laboratories, 630 E. Young St., Santa Ana, Calif. 92705. (714) 540-4919. \$145; 4 wks.

Model 257 line-powered, 3-1/2-digit panel meter offers selection of full-scale range and function (dc volts or dc current) by substitution of a plug-in 16-pin DIP range-change module. Full-scale ranges from 19.99 mV (10  $\mu$ V per count resolution) to 199.9 V, and from 1.999  $\mu$ A to 1.999 A. Input impedance on the lower ranges is 1 G $\Omega$  and input bias current is as low as 0.1 nA.

CIRCLE NO. 251

### Chart recorder runs six months by itself



Impact-O-Graph Corp., 181 Northfield Rd., Bedford, Ohio 44146. (216) 439-6116. \$580; stock.

Model M chart recorder gives up to six months of recording without attention. Chart speeds available are 1/8, 1/4, 1/2, and 1 in./h. The 1/8 in./h rate provides six months of recording on a 45-ft roll of 4-in.-wide pressure-sensitive paper. The unit is driven by a battery-powered electronic clock. The battery is rated for more than one year's operation before replacement.

CIRCLE NO. 252

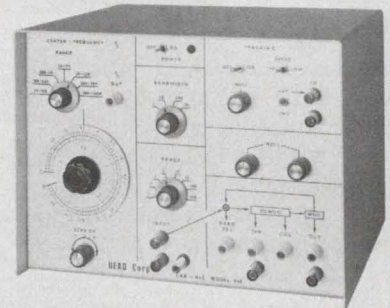
### 3-in. scope boasts bag of service tricks

RCA Electronic Instruments, 415 S. Fifth St., Harrison, N.J. 07029. (201) 485-3900. \$229 (optional price).

This 3-in. portable service scope, the WO-33B, also includes a built-in Quicktracer transistor-diode tester circuit complete with special probe (similar to the RCA WC-528B); a vectorscope function for color TV; and a "ringing" test function to check flyback transformers, yokes, coils and other inductances. Scope specs include a bw of 5 MHz and a max. sensitivity of 10 nV pk-pk/in.

CIRCLE NO. 253

### Test instrument wears many hats

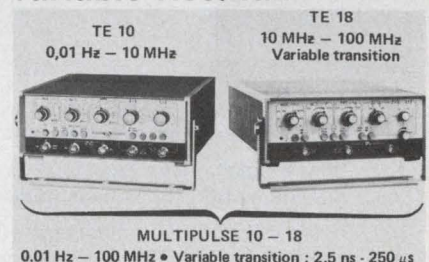


UFAD Corp., 700 36th St. S.E., Grand Rapids, Mich. 49508. (616) 241-6000. \$2275; 45 days.

Model 850, the "LAB-ALL," is a multifunction test/measurement instrument. Used with a multimeter, the "LAB-ALL" becomes a bandpass or band reject tracking filter, tunable notch filter, distortion analyzer, wave analyzer, and phase-sensitive voltmeter. With a scope the 850 becomes a servo analyzer, network analyzer and phase angle voltmeter. With a scope and function generator, the unit becomes a nonreal-time spectrum analyzer. The 850 measures phase, frequency, and amplitude of all signals having harmonic components between 30 Hz and 100 kHz. Accuracies range from  $\pm 0.25\%$  to  $\pm 2\%$ , depending upon function.

CIRCLE NO. 254

### 100-MHz pulser offers variable rise/fall



MULTIPULSE is a new series of fully compatible pulse generators. Tekelec-Airtronic, Cite des Bruyeres, Rue Carle Vernet, B.P.°2, N°376. France. (1) 626-02-35.

TE 18 pulse generator covers 10 to 100 MHz and features adjustable rise and fall times. Other specs include variable pulse width and delay of 5 to 50 ns, variable amplitude of 200 mV to 5 V into a 50- $\Omega$  load, variable rise and fall time of 2.5 ns to 250  $\mu$ s.

CIRCLE NO. 255



## INSTRUMENTATION

### High-power pulse gen sells for \$1190

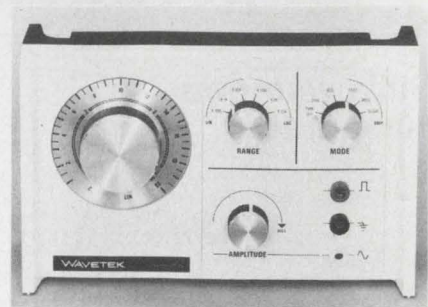
Velonex, 560 Robert Ave., Santa Clara, Calif. 95050. (408) 244-7370. \$1190; stock to 30 days.

The Model 340 high-power pulse generator provides 5-kW peak power at 1% duty factor with pulse output of 1000 V at 5 A. The unit's

fully recessed plug-in feature allows impedance matching between the pulse generator and load for any impedance between 0.1 and 20,000  $\Omega$ . Standard plug-in units also allow voltage isolation, polarity inversion and varying rise and fall time. Pulse widths range from 100 ns to 1 ms and rep rates from 1 shot to 100,000 pps. Amplitude is continuously adjustable from less than 100 to 1000 V.

CIRCLE NO. 256

### Compact function gen works on batteries

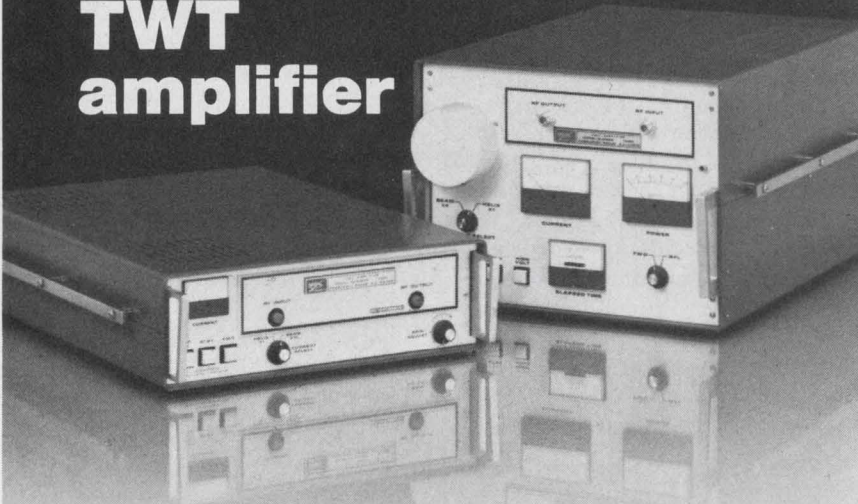


Wavetek, 9045 Balboa Ave., San Diego, Calif. 92123. (714) 279-2200. \$149.95; stock.

The Model 30 function generator features 2-Hz to 200-kHz simultaneous sine, square and triangle waveforms with internal linear or logarithmic sweep. External capacitors can be added for unlimited frequency down ranging. Sweep mode and voltage-control mode give a frequency change of 1000:1. Full voltage control requires only 0 to 1 V, either dc for programming discrete frequencies or ac for FM operation. This hand-sized battery-operated generator weighs less than 1-1/2 lb.

CIRCLE NO. 257

## There's still nothing like vacuum tubes for an exceptional TWT amplifier



Sure our amplifier uses solid state components—everywhere, in fact, except in the high voltage regulator and the TWT itself.

Why a vacuum tube regulator? Because of the greater reliability with this inherently high voltage component.

It qualifies our TWT amplifier especially for antenna pattern measurement, EMI susceptibility testing and r-f power instrument calibration.

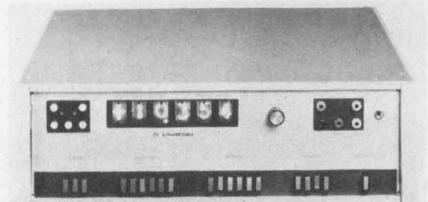
But we utilize contemporary concepts when they add to reliable performance. Our modular construction and plug-in boards will accommodate a variety of TWTs for example.

And we can and do add VSWR protection, harmonic filtering and variable output, where required.

Octave band width 10, 20, 100 and 200 watts TWTAs from 1 GHz to 18 GHz. For detailed specifications write MCL, Inc., 10 North Beach Avenue, La Grange, Illinois 60525. Or call (312) 354-4350.



### DMM samples, holds and controls remotely



California Instruments, 5150 Convoy St., San Diego, Calif. 92111. (714) 279-8620. \$1740; 30 days.

Model 6653A is a four-digit, 10%-overrange multimeter designed to perform in data-acquisition systems. The unit offers such standard or optional capabilities as successive-approximation logic, three filter modes to provide optimum speed vs rejection and true-rms conversion. Functions include six ranges of dc V from 0.001 mV to 100 V, three ranges of dc/dc ratios from 0.0001:1 to 110:1, four ranges of true-rms ac V (50 Hz to 100 kHz) from 0.0001 to 1100 V and five ranges of resistance. Long-term accuracy is to  $\pm 0.01\%$  of fs  $\pm 0.01\%$  of reading.

CIRCLE NO. 258



# You can't get this from Augat.



The blank card you see above has 120 connector contacts and 22 built-in test points. It will accept a fantastic variety of sockets, microboards, and discrete components.

It is our 3-D Dual-in-Line Socket Card. You can buy it blank and install only the sockets you need. Or you can buy it with sockets

already installed in a variety of standard configurations.

You get what you need, and you pay for no more. And it will liberate your design ideas as no Augat board can.

**Try us. We'll see you through.**

## EECO

1441 East Chestnut Avenue  
Santa Ana, California 92701  
Phone 714/835-6000  
Also from G. S. Marshall Company nationwide.

**FREE SOCKET BOARD AND PACKAGING  
HARDWARE CATALOG!**

We'll send it to you if you'll send us the information below.

Name \_\_\_\_\_

Position \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_



# MORE POWER MORE BANDWIDTH

Our Model 503L is an ultra-wideband RF power amplifier whose wide range of frequency coverage and power output provides 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 minimum distortion.

Constant forward power is continuously available regardless of the output load impedance match, making the 503L ideal for driving highly reactive loads.

Unconditional stability and instantaneous failsafe provisions in the unit provide absolute protection from damage due to transients and overloads.

This low cost instrument, covers the frequency range of 1.6 to 540 MHz with a linear power output of 3 watts . . . and there's no tuning. Priced at \$995.\*

#### Applications include:

- Laboratory instrumentation
- Communication systems
- Laser modulation
- RFI/EMI testing
- Spectroscopy

\*USA and Canada



For further information or a demonstration contact

**ENI, 3000 Winton Road South,  
Rochester, New York, 14623.  
Call 716-473-6900.  
Or TELEX 97-8283 ENI ROC.**

# ENI

The world's leader  
in solid-state power amplifiers.

## INTEGRATED CIRCUITS

### 3-terminal regulators supply 100 mA

Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. 94042. (415) 962-3816. 50¢ to \$1.05 (100-999); stock.

Three-terminal voltage regulators, the 78L series, provide up to 100 mA of output current. The 78L circuits are fixed positive voltage units that eliminate the need for external transistors and resistors and reduce circuit-board space. Available output voltages range from 2.6 to 15 V with tolerances of 5% and 10%. The series comes in TO-92 plastic and TO-39 metal-can packages.

CIRCLE NO. 259

### Access improves in upgraded 1103s

Nortec Electronics Corp., 3697 Tahoe Way, Santa Clara, Calif. 95051. (408) 732-2204.

Three versions of the standard 1103, a fully decoded dynamic 1024 × 1-bit RAM—the NEC 1103, 1103-146 and 1103-1—come in either plastic or ceramic 18-pin DIPs. A fast 300-ns access time is a feature of the NEC 1103, with the 1103-146 accessible in 220 ns. The NEC 1103-1 has a 150-ns access time. Read cycle on the NEC 1103 RAM is 480 ns and write cycle is 580 ns. The new memories have a 2-ms refresh cycle and dissipate only 250 mW, primarily during precharge.

CIRCLE NO. 260

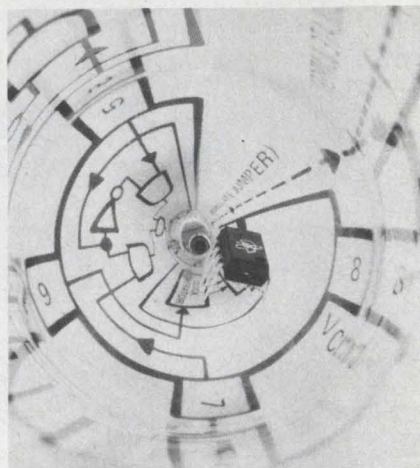
### 256 bit RAMs offer 30-ns access

Signetics, 711 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. \$28 up (100); 4 wks.

Two 256-bit RAMs—the 82S16 with three-state outputs and the 82S17 with open-collector outputs—feature an access time of less than 30 ns. Write time for both models is 20 ns. Each RAM dissipates typically 1.5 mW per bit. Input loadings are 25  $\mu$ A for a logic ONE and -100  $\mu$ A for a logic ZERO. The memories operate from a single 5-V supply.

INQUIRE DIRECT

### 1024-bit static SR consumes 0.2 $\mu$ W/bit

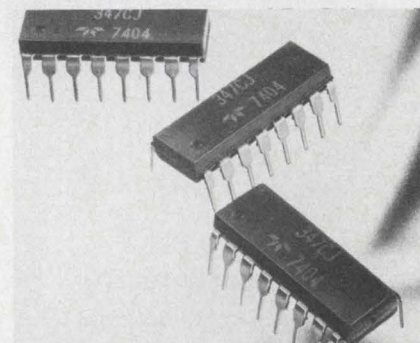


Texas Instruments, P.O. Box 5012, MS 308, Dallas, Tex. 75222. (214) 238-3741. \$7.25 (100); stock.

A 1024-bit static shift register, the TMS3133, comes with two data inputs and a "stream select" control to simplify recirculation. It features a low dissipation of 0.2  $\mu$ W per bit, TTL-compatible inputs and outputs, single TTL-compatible clock, dc-to-2-MHz operation and standard power supplies of 5 and -12 V. Push-pull output buffers can drive directly TTL and MOS loads.

CIRCLE NO. 261

### Dual one-shot ignores transients



Teledyne Semiconductor, 1300 Terra Bella Dr., Mountain View, Calif. 94043. (415) 968-9241. \$1.96 (100).

The HiNIL 347 dual retriggerable monostable multivibrator has a guaranteed minimum noise immunity of 3.5 V. It is offered in both 12 and 15-V versions. Each half of the 347 may be triggered or retriggered independently. Minimum input pulse separation is 300 ns. Output pulse times are set by external RC values.

CIRCLE NO. 262



# SIEMENS

## Cost - Effective Solutions to Semiconductor Test Problems



### GENERAL PURPOSE IC TESTER COMPUTEST 716A

Low-cost parametric and functional tester for digital and linear circuits

### DIGITAL CIRCUIT TESTERS COMPUTEST 720 SERIES

Provides complete DC parametric and functional verification of digital IC's

### LINEAR CIRCUIT TESTER COMPUTEST 735

Tests operational amplifiers, regulators, comparators, sense amplifiers and custom linear circuits

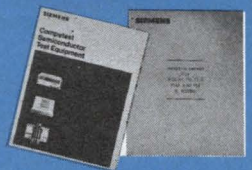
### BENCH-TOP MEMORY TESTERS COMPUTEST 901 SERIES

Provides real-time verification of semiconductor memory performance from the device to the complete memory systems level

**FOR APPLICATIONS ASSISTANCE . . .  
CALL US!**

**FREE!**

Send for the Computest catalog of Semiconductor Test Equipment and our Semiconductor Program Library



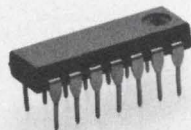
NAME \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_  
STATE \_\_\_\_\_ ZIP \_\_\_\_\_

**Siemens Corporation**  
Electronic Systems Division  
Computest Products

3 Computer Drive, Cherry Hill, N.J. 08002 (609) 424-2400



**All those little  
wires have been  
pushed around  
long enough.**





Until now, all those wires have been at the mercy of packaging materials that expand when things get hot.

So we developed new Dow Corning® 480 semiconductor molding compound.

Dow Corning 480 has a low coefficient of thermal expansion.

So it virtually eliminates the hot intermittent open. And moisture penetration.

Which means that an integrated circuit stays integrated. Through all sorts of temperature and atmospheric extremes.

But that's not all that's different about 480 molding compound.

Its resistance to salt spray is excellent.

And it reduces your packaging costs because it saves time. Molding times are short—less than one minute for some components. Post curing is unnecessary.

Of course, Dow Corning 480 molding compound also has the advantages of our other silicones. Consistency. Long shelf life. Less cleaning downtime because there's no buildup. Non-flammability. And, because it doesn't irritate skin, there's no need for special handling.

Dow Corning 480 semiconductor molding compound is the kind of improved product you can expect to keep getting from Dow Corning. Our Technical Service and Development Department has more manpower and greater technical facilities than any other in the industry.

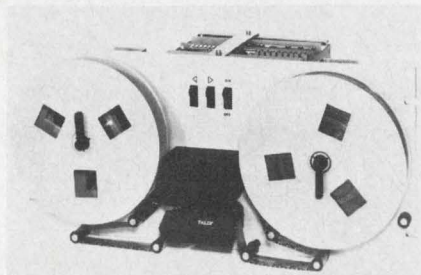
If you want to know more about 480, call us at 517 636-8000, or write Dow Corning Corporation, Dept. A-4334, Midland, Michigan 48640. **DOW CORNING**

DOW CORNING





## Paper tape reader has 300-char/s steady speed

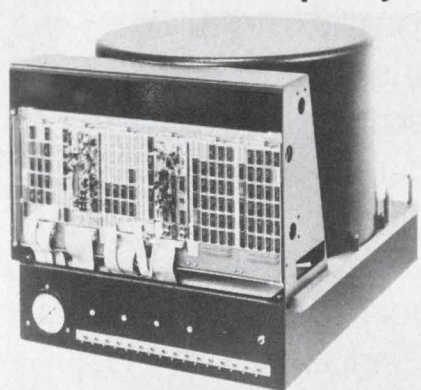


Tally Corp., 8301 S. 180th St., Kent, Wash. 98031. (206) 251-5500. \$546; 30 days.

A medium speed tape reader, the Model R2000, reads bidirectionally to 300 char/s and up to 200 char/s asynchronously. The unit reads tapes with up to 60% transmissivity and the tapes can have five, seven, or eight levels. Average error rate is  $10^{-7}$ . A standard light bulb is used with this photoelectric reader and the electronics are DTL and TTL compatible.

CIRCLE NO. 263

## Fixed-head disc drives offer 153 Mbit capacity



Digital Development Corp., 5575 Kearny Villa Rd., San Diego, Calif. 92123. (714) 278-9920. See text.

The A7310 and 9110 series head-per-track disc memories offer storage capacities from 6.7 to 153 Mbits. Average access times range from 8.5 to 17 ms. Each model includes the necessary circuitry to write, read, select tracks and generate timing signals. The modular system uses read/write heads in groups of 64 that service up to 1024 tracks. The design life of these systems is said to be 10 years minimum. The cost—about 0.25 cents a bit.

CIRCLE NO. 264

## CRT displays printed for less than two cents

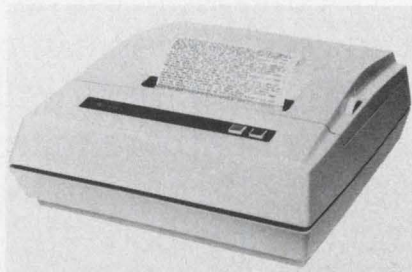


Alden Electronic & Impulse Recording Equipment Co., Alden Research Center, Westboro, Mass. 01581. (617) 366-8851. From \$795.

A 400 or 600 "Push to Print" Recorder interfaced to a scan converter gives frame-by-frame hard-copy. The converter (not included in the price) converts standard 525 TV line frames into slow TV frames suitable for transmission over voice grade telephone lines and/or direct to graphic printout on the recorder. Higher resolutions are available with different scan converters. There are two systems available. One provides a resolution of 1300 TV lines per diameter equivalent to 80 characters a line. The other system provides 750 TV lines per diameter or 50 characters a line. Either system works with CRT displays. Single copies cost less than two cents.

CIRCLE NO. 265

## Compact serial printer operates at 110 char/s

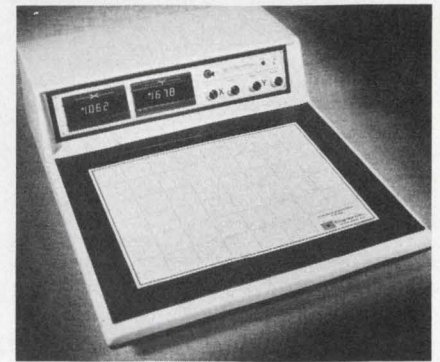


Okidata Corp., 111 Gaither Dr., Moorestown, N.J. 08057. (609) 235-2600. \$900; 60 days.

The Model 110 is a serial desktop printer that produces 80 columns of  $5 \times 7$  dot-matrix characters at 110 char/s. The print head moves in both directions and pauses only at the end of each line. An 80-character buffer holds the print line. The 64-character ASCII set is standard, others can be furnished as an option.

CIRCLE NO. 266

## Graphic digitizer has low error

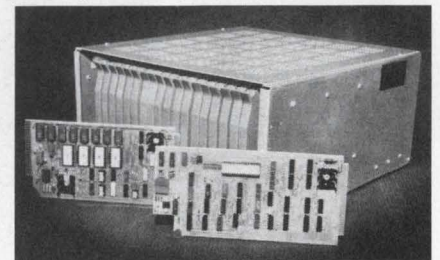


Elographics, P.O. Box 388, Oak Ridge, Tenn. 37830. (615) 482-4039.

Model E241 is a graphics digitizer that generates X,Y coordinates with pressure from a ball-point pen or similar stylus. The work area is 15-by-11 in. and the standard error is better than 0.02-in. Coordinates require 125 ms for digitization. Dual 3-1/2-digit displays show the X and Y coordinates. Interfaces are available for programmable calculators or data terminals.

CIRCLE NO. 267

## Plug-in CPU designed for process control



Process Computer Systems, 5467 Hill 23 Dr., Flint, Mich. 48507. (313) 744-0225. From \$2950; 90 days.

The CM4400 CPU module includes six 8-bit registers, 8-bit accumulator, 8-bit parallel arithmetic unit, 16-bit program counter, 16-bit stack pointer, and a 2-MHz clock. The I/O concept used permits arithmetic/logic operations directly with the I/O devices, and allows the use of re-entrant software. Four different associated CM4500 memory modules may be used in any combination for up to 64 k bytes of read-only and random access-memory. A wide array of standard modules provides all the facilities needed for process control requirements.

CIRCLE NO. 268



## Tape cartridge unit meets MIL specs

*E S L Inc., 495 Java Dr., Sunnyvale, Calif. 94086. (408) 734-2244.*

The Model P830R is a ruggedized magnetic tape cartridge unit designed for use in military and other applications that require reliable operation under adverse environmental conditions. The P830R uses the 3M DC300A data cartridge as the storage media. It is capable of writing or reading digital data at a rate of 160-k bit/s when all four tracks are used simultaneously; these tracks are electronically deskewed for simultaneous read operations. Each of the four tracks can also be used independently in accordance with ANSI specification X3B1. Recording density is 1600 bit/in. on each track, and the cartridge capacity is greater than  $20 \times 10^6$  bits. The tape speed for read or write is 25 in/s; the search and rewind speed is 90 in/s. All cartridge loading and unloading operations are sequenced automatically. Mechanical and environmental specifications for the P830R meet applicable requirements included in MIL-STD-167B, MIL-STD-810B, and MIL-E-5400.

CIRCLE NO. 269

## Weight printed by electronic printers

*Streeter Amet Div., Dept. M3, Mangood Corp., Slusser and Wicks St., Grayslake, Ill. 60030. (312) 223-4801.*

Two precision, high-speed printers for electronic weighing systems, Model 301 and 302, are designed to accept and print weight information. They can be installed either as permanent rack-mounted units or as portable instruments. The two printers have modular plug-in circuit boards for ease of servicing. They print on paper tape, pressure-sensitive tape or multicopy tickets, as required. Model 301, the more versatile of the two, provides a positive sprocket paper advance; is designed for longer operating life between servicings. Model 302 is a more economical unit for use in weighing applications that require only tape output.

CIRCLE NO. 270

# There's a world of difference between Dow Corning and the other semiconductor packaging-materials suppliers.

The difference is that only Dow Corning has available worldwide a complete line of silicone molding compounds, an accomplished technical service and development team, the advantage of a completely compatible product line, and the convenience of worldwide delivery and service. If you want to give your packaging operation a competitive advantage, just call or write. One of our representatives is nearby.

J. Guillot  
DOW CORNING S.A.R.L.  
140, Avenue Paul Doumer  
92500 Rueil Malmaison  
France  
Telephone: 977.00.40

M. Tedone  
DOW CORNING SpA  
Viale Restelli 3/7  
20124 Milan, Italy  
Telephone: 688.2458

### ASIA

H. Takahashi  
DOW CORNING ASIA LTD.  
P&O Building, 9th Floor  
21 Des Voeux Road, C.  
Hong Kong  
Telephone: 5-258035

H. Hotta  
DOW CORNING ASIA LTD.  
Room 803, Cathay Building  
Mount Sophia  
Singapore - 9  
Republic of Singapore  
Telephone: 321213-5

### AUSTRALASIA

H. Tuynman  
DOW CORNING AUSTRALIA PTY. LTD.  
36 O'Dea Avenue  
Waterloo, N.S.W. 2017  
Sydney  
Telephone: 699 8055

P. Winter  
DOW CORNING AUSTRALIA PTY. LTD.  
103 High Street  
Pahran, Vic. 3181  
Telephone: 51 5450

Dow Corning semiconductor molding compounds...quality and dependability worldwide.

A-4335

### NORTH & SOUTH AMERICA

Resins and Chemicals Marketing  
DOW CORNING CORPORATION  
Midland, MI 48640  
Telephone: 517 636-8682

### EUROPE

R. Hediger  
DOW CORNING INTERNATIONAL LTD.  
Chaussée de La Hulpe 177  
1170 Brussels, Belgium  
Telephone: 73.80.60

B. Sneddon  
DOW CORNING LTD.  
Reading Bridge House  
Reading RG1 8PW  
Berkshire, England  
Telephone: Reading 57251

R. Jones  
DOW CORNING GmbH  
1150 Vienna  
Mariahilferstrasse 180/4  
Austria  
Telephone: 83.85.38

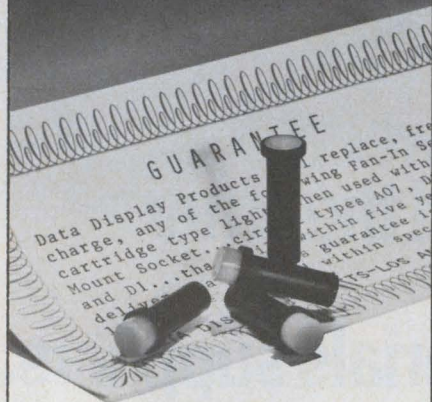
S. Haberer  
DOW CORNING GmbH  
8000 Munchen 50  
Pelkovenstrasse 152  
West Germany  
Telephone: 14.861

# DOW CORNING

DOW CORNING



## INCANDESCENT PANEL LIGHTS WITH A 5 YEAR GUARANTEE?



**RIGHT!**

**Our self driven incandescent panel indicator lights\* will last 5 years, or we'll replace them free . . . now who else do you know guarantees their lights for even 1 week?**

These good looking, high performance subminiature lights come with built-in drivers and keep alive bias. They operate from standard TTL, MOS or ECL; with positive or negative logic input available.

Also available with long life ratings are low cost standard incandescents, neons, LED's (3 colors with built-in resistors for 3 to 28 volt applications) and PCB indicator lights (with built-in TTL integrated circuits). All lights are available on an immediate delivery basis.

**PANEL MOUNT SOCKETS**, for easy front panel replaceability, are available for all incandescent, neon and LED models . . . at very low prices.



\*Fan-In Series, Cartridge type, when used with Panel Mount Socket. Circuit Types: A07 & D07 (5 V, 30 mA lamp current) and A1 & D1 (5 V, 60 mA lamp current).

NOTE: Guarantee is valid when lights are operated within specifications.

**Call or write for more information today . . . we guarantee you'll be glad you did!**

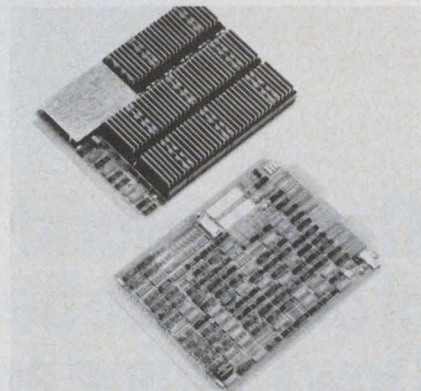
## DATA DISPLAY PRODUCTS

5428 W. 104th St., Los Angeles, Ca. 90045  
(213) 641-1232

INFORMATION RETRIEVAL NUMBER 70

### DATA PROCESSING

## 16-bit microprocessor debut on PC board



*General Automation, 1055 S. East St., Anaheim, Calif. 92805. (714) 778-4800. Under \$1000 (200 quan.).*

For a cost of \$1000 a board you can now have a 16-bit mini-on-a-card, the LSI-16. In fact a 7.75-by-11 in. board holds CPU and 32 k words of 1.8  $\mu$ s MOS memory. The LSI-16 replaces the SPC-16 mini and uses a two-chip silicon-on-sapphire technology to build the CPU. One chip, the arithmetic logic unit contains the equivalent of 8000 transistors in a chip 0.2-in. square. The other chip is the control memory. In addition, the company offers a 32-k word MOS memory on the same size board.

CIRCLE NO. 271

## Low-cost computer terminal has own coupler



*MITS, 6328 Linn, P.O. Box 8636, Albuquerque, N.M. 87108. (505) 265-7553. \$595; 60-90 days.*

Priced below most computer terminals, the Comter 256 can store 256 characters and display a 32 character line. A Burroughs Self-Scan display is used. A built-in acoustic coupler makes computer hookup very simple. And the operator can transmit material line-by-line instead of character-by-character. ASCII coding is used with 110/300 baud transmit/receive rate. Terminal storage is expandable to 1024 characters.

CIRCLE NO. 272

## Extra processor used in graphics terminal



*Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754. (617) 897-5111. \$17,500.*

The GT42 graphics terminal can be used as a stand-alone graphics system or as a terminal that interacts a variety of host computers. The terminal is configured around the PDP-11/10 mini and features a hardwired display processor that drives a 17-in. CRT. The display processor performs the most used graphical techniques and minimizes CPU overhead. The terminal's 10-bit resolution (1024  $\times$  1024 addressing) in X and Y is precise enough to allow overprinting. Standard equipment includes a light pen, ASCII keyboard and character set with 31 special mathematical and scientific symbols, and a serial communications interface.

CIRCLE NO. 273

## Disc controller handles 400-Mbyte system

*Data Systems Design, 1122 University Ave., Berkeley, Calif. 94702. (415) 849-1102. See text.*

Both PDP-8 and PDP-11 mini-computers can be equipped with 400 Mbytes of disc storage with the Model 240. The controller plugs directly into the PDP-8 bus or mounts inside a PDP-11. Up to 8 discs can be accessed and the unit is compatible with either machine's operating system. The controller has a 16-word buffer and can read or write any format and preamble under program control. The price of a memory system is \$2500 for the controller plus the cost of the disc drive used.

CIRCLE NO. 274



# Hughes heat pipes. Order 'em hot off the shelf.

Now you can order heat pipes just like you order nuts and bolts. Because now Hughes stocks heat pipes in a variety of standard, off-the-shelf sizes and thermal capacities. (If you have a heat transfer problem that calls for a custom solution, we solve those, too.)

## 1333H STAINLESS STEEL AND AMMONIA

Thermal transport capacity: 50 watts with evaporator 90° below condenser, 15 watts horizontal operation, 7 watts with evaporator 90° above condenser. Recommended operating range: -80° to +90°C. Weight: 8 grams. Active Length: 5.69 inches. Diameter: 3/16". \$37.00.

## 1370H COPPER AND WATER

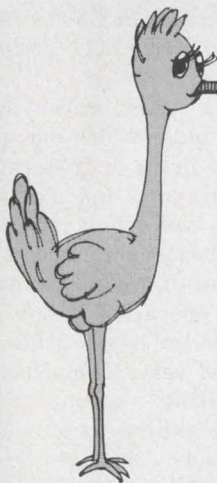
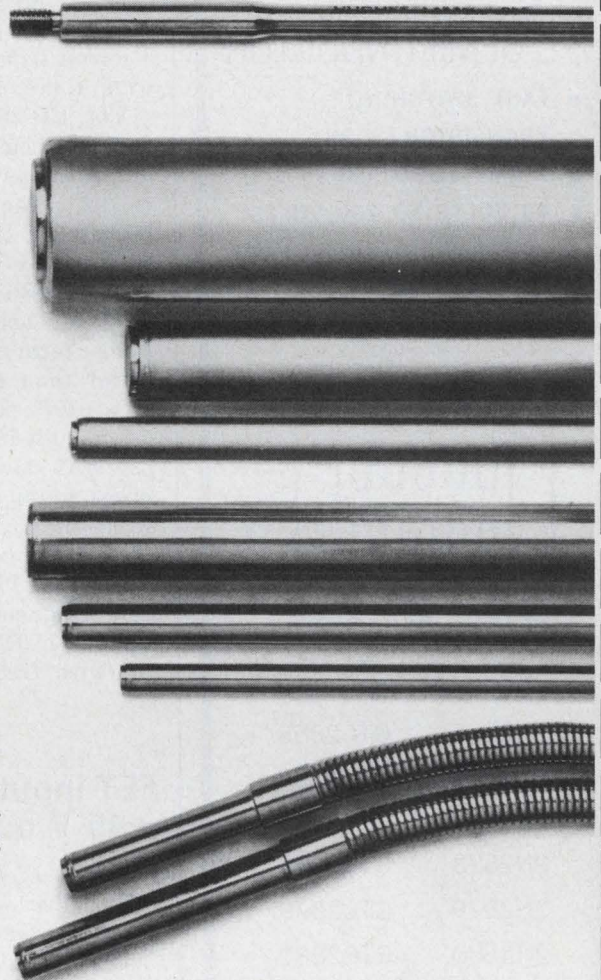
Available in diameters of 1/4", 1/2", and 1" at \$37.00, \$40.00 and \$50.00, respectively, with thermal transport capacities of 345, 750, and 6000 watts with the evaporator 90° below condenser; 115, 250 and 2000 watts horizontal operation; 38, 60, and 500 watts with evaporator 90° above condenser. Recommended operating range: +50° to +150°C. Weight: 21, 70, 550 grams. Standard Active Length: 6, 6, 12 inches.

## 1350H STAINLESS STEEL AND METHANOL

Available in diameters of 3/16" and 1/4" at \$37.00 each and 1/2" at \$40.00. Thermal transport capacities are 55, 75, and 180 watts with evaporator 90° below condenser, 17, 25, and 60 watts horizontal operation, and 6, 10, and 20 watts with evaporator 90° above condenser. Recommended operating range: -40° to +120°C. Weight: 8, 11, and 38 grams. Standard Active Length: 6 inches.

## 1361H FLEXIBLE STAINLESS STEEL AND METHANOL

Available in active lengths of 7" and 8" at \$75.00 each, with thermal transport capacities of 20 watts with the evaporator 90° below condenser, 7.5 watts horizontal operation, 2.5 watts with evaporator 90° above condenser. Recommended operating range: -40° to +120°C. Weight: 20 grams. Diameter: 1/4".



For detailed information, or if you have a hot requirement and want one now, just fill out and send in the coupon. Hughes Electron Dynamics Division, 3100 W. Lomita Blvd., Mail Station 2124, Torrance, California. (213) 534-2121.

PLEASE PRINT

SEND INFORMATION.

SEND QUICK ORDER FORM.

NAME \_\_\_\_\_ COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_ CITY \_\_\_\_\_

STATE \_\_\_\_\_ ZIP \_\_\_\_\_ TELEPHONE \_\_\_\_\_

All prices shown are effective in U.S.A. and Canada

ED-7

INFORMATION RETRIEVAL NUMBER 77



# POWER CHIPS

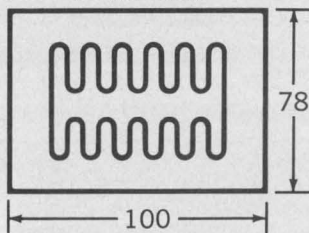
FROM



GENERAL SEMICONDUCTOR

- FAST SWITCHING TRANSISTOR CHIPS
- 1 AMP TO 30 AMPS
- 40 VOLTS TO 250 VOLTS
- LOW SATURATION VOLTAGE
- LOW LEAKAGE
- DELIVERY FROM STOCK

5 AMP CHIP



JEDEC NO.	CHIP NO.
2N2855	GTC2855
2N2856	GTC2856
2N2877	GTC2877
2N2878	GTC2878
2N2879	GTC2879
2N2880	GTC2880

The above is a partial listing of planar transistor chips available from General Semiconductor Industries, Inc. They are also available as the corresponding JEDEC part number in standard power packages. Call us for your other device requirements.

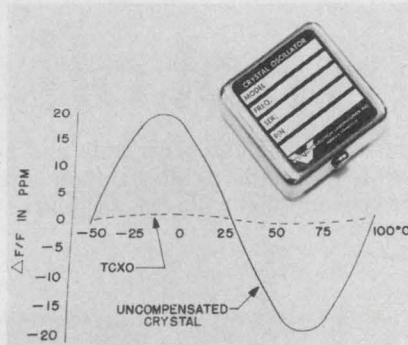


GENERAL SEMICONDUCTOR INDUSTRIES, INC.

2001 WEST TENTH PLACE • TEMPE, ARIZONA 85281  
MAILING ADDRESS: P.O. BOX 3078 • 602-968-3101  
TWX 910-950-1942

## MODULES & SUBASSEMBLIES

### TCXOs have stabilities of $\pm 2 \times 10^{-7}$



Vectron Labs, 121 Water St., Norwalk, Conn. 06854. (203) 853-4433.

The CO-254 series of vhf temperature compensated crystal oscillators achieves a stability of  $\pm 2 \times 10^{-7}$ . The unit meets this stability over the 0-to-50-C temperature range, and  $\pm 2 \times 10^{-6}$  over -55 to +85 C. They are available at frequencies up to 140 MHz. Long term stability (aging) is better than  $1 \times 10^{-8}$  per day and  $2 \times 10^{-6}$  per year. The TCXOs use a built-in oven that has a low (20 mA) power drain. The CO-254 series units operate from any desired supply voltage in the 5-to-32-V-dc range and provide sine or Schottky TTL compatible outputs. Low frequency models are available with CMOS compatible output with frequencies as low as 60 Hz.

CIRCLE NO. 275

### FET-input op amp gives $\pm 45$ V output swings

Optical Electronics, P.O. Box 11140, Tucson, Ariz. 85734. (602) 624-8358. \$62 (10 to 29); stock.

The Model 9736 high-voltage FET input op amp is completely protected against input overvoltage drive and output short-circuit conditions. The 9736 is packaged in a 1.125-in.-square-by-0.44-in. high module. Some of its specs include 90 dB open loop gain, 110 dB minimum common-mode rejection,  $\pm 40$  V common-mode voltage,  $\pm 45$  V at  $\pm 10$  mA minimum output voltage swing,  $\pm 30$  V/ $\mu$ s minimum slew rate, 10 MHz minimum gain-bandwidth product,  $\pm 20$   $\mu$ V/ $^{\circ}$ C maximum input offset-voltage drift and 50 pA maximum bias current.

CIRCLE NO. 276

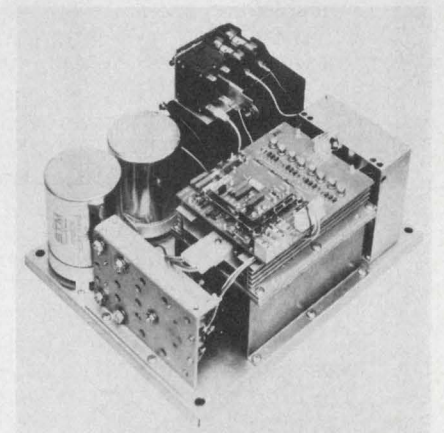
### D/s converter modules are accurate to $\pm 4$ min.

Computer Conversions, 6 Dunton Ct., East Northport, N.Y. 11731. (516) 261-3300. Under \$400; 4 to 6 wk.

A series of 14-bit digital-to-synchro converter modules provide  $\pm 4$  minute accuracies when driving CTs, CXs or CDXs. The  $2.6 \times 3.1 \times 0.82$  in. units accept a 14-bit natural binary angle and convert it into three-wire synchro or four-wire resolver signals. The output is short-circuit protected and loading of 1 or 2 VA is available. Standard output voltages are 90 or 11.8 V rms L-L, 60 or 400 Hz. Digital inputs are TTL/DTL compatible and the synchro output and reference is fully transformer isolated. Part No. DSC40-L requires a 26 V reference and +15 at 135 mA, -15 V at 100 mA and +5 V at 85 mA. Operating temperature ranges are 0 to 70 or -55 to 85 C.

CIRCLE NO. 277

### Servo amplifier delivers 90 V at 15 A peak



Westamp, 1542 15 St., Santa Monica, Calif. 90404. (213) 393-0401. \$750.

The Model A6286 servo amplifier is a pulse-width-modulated unit that can drive dc motors with ratings of up to 1 hp. The maximum output voltage is 90 V and the peak output current is 15 A. The unit contains a power transformer for operation from 115/230 V, 50/60 Hz lines. Other features include: servo compensation, current limiting, output circuit breaker, and ability to handle regenerative loads. The unit is compact, only  $10.5 \times 13$  in.

CIRCLE NO. 278





# NEW Simpson 360 Digital VOM

Handy and rugged enough for the field — accurate and versatile enough for the lab. And its simplicity and readability make it perfect for production line testing.

- 3-1/2" digit, non-blinking, auto-polarity 0.33" LED display
- AC line or battery operation
- 29 popular ranges including "low-power" ohms
- Analog indicator for scanning nulls and peaks
- Analog output signal permits interfacing with recorders and other instruments
- Up-down integration analog/digital conversion assures superior stability, accuracy and noise immunity

Supplied with test leads, AC line cord, operator's manual, without batteries ..... \$295



**SIMPSON ELECTRIC COMPANY**  
 853 Dundee Avenue, Elgin, Illinois 60120 • (312) 695-1121  
 CABLE: SIMELCO • Telex: 72-2416  
 IN CANADA: Bach-Simpson, Ltd., London, Ontario  
 IN ENGLAND: Bach-Simpson (U.K.) Ltd., Wadebridge, Cornwall  
 IN INDIA: Ruttonsha-Simpson Private, Ltd., Vikhroli, Bombay

ORDER NOW FROM YOUR LOCAL ELECTRONICS DISTRIBUTOR OR WRITE FOR NEW CATALOG 4200  
 INFORMATION RETRIEVAL NUMBER 73



**LED photoelectric control is coaxial**



Scientific Technology, 1157 San Antonio Rd., Mountain View, Calif. 94040. (415) 965-0910. \$137.65.

The 2010-series of LED coaxial photoelectric controls uses a patented optic system. Range of the 2010-series is up to 35 ft. (11 m) using a single 3 in. diameter (8 cm) reflective target. Increasing target size increases range. The 2010-series is completely self-contained in a cast aluminum Nema housing, 5.3 x 7.5 x 2.5 in. (13.4 x 19 x 16.4 cm). Standard input for the 2010-series is 115 V ac, and power consumption is less than 5 W.

CIRCLE NO. 279

**Solid-state time delays handle currents to 0.8 A**

Polytron, P.O. Box 984, Elkhart, Ind. 46514. (219) 294-3748. \$2.95 (100-up).

The PCT-31 series of time delay modules are rated at 0.8 A. Voltage ratings are 12, 24 and 120 V dc. The time delay can be factory set from 0.1 to 15 s. Units have two terminals connected in series with the load. Modules with higher current and other voltage ratings are also available.

CIRCLE NO. 280

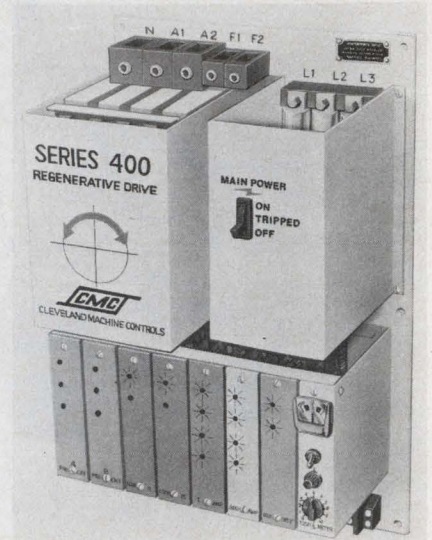
**DAC handles either TTL or CMOS logic levels**

Analog Devices, Rte. 1 Industrial Pk., P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. \$84 (1 to 9); stock.

The DAC1009 12-bit d/a converter has positive true logic inputs. It is 2 x 2 x 0.4 in. and it can interface with both TTL/DTL and CMOS logic systems and provide either current or voltage outputs. The DAC1009 can do two-quadrant multiplication when its reference input is supplied by a unipolar analog signal source. When used as a multiplier, the DAC1009 has a small signal bandwidth of 950 kHz. With appropriate external circuitry, the feedthrough is less than 1 LSB at 50 kHz. The unit settles to 0.01% in 4 μs and has a gain temperature coefficient of 11 ppm/°C. Its differential linearity error of 4 ppm/°C provides monotonicity over a 0-to-50-C temperature range.

CIRCLE NO. 281

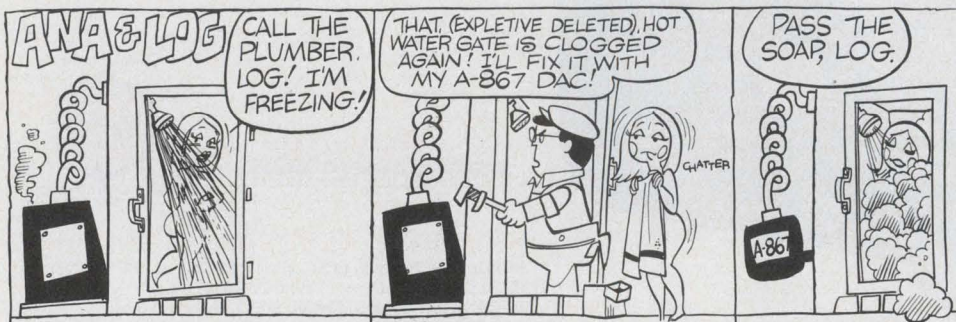
**Four-quadrant drives span 5 through 150 hp**



Cleveland Machine Controls, 7550 Hub Parkway, Cleveland, Ohio 44125. (216) 524-8800.

The Series 400 is a four-quadrant regenerative drive for use on three-phase, 50/60 Hz, 230 or 460 V lines. It will be made available from 5 through 150 hp, overlapping the horsepower range of the company's already established Series 300 adjustable-speed drives which are available from 40 through 500 hp. A variety of options required for machine tool applications are available. Some of the standard features include N/C input, overspeed and tach-loss protection, zero speed sensing, tool change and percentage set speed permission. Additionally, standards will also include adjustable current limit, armature voltage only or voltage and field control and test meter.

CIRCLE NO. 282



**ANALOGY**  
WHEN SLOW, BULKY INTERFACES BUG YOUR CONTROL SYSTEM, UPDATE FAST WITH INTECH'S NEW A/D AND D/A CONVERTER MODULES. THE A-867 DAC, FOR ONE, GIVES 16-BIT RESOLUTIONS IN 30 μs SEC AT CURRENT OR VOLTAGE OUTPUTS WITH ONLY 4 PPM/°C OFFSET TEMPCO. IT COSTS LESS AND MEASURES ONLY 2x4x0.4. SAME GOES FOR A-868 14-BIT DAC.

**intech** INCORPORATED  
(408) 244-0500  
1220 COLEMAN, SANTA CLARA CA 95050



# 85 amp DO-5



The ratings are back and even we're a little amazed at the fantastic results. We knew our upgraded DO-5 was a honey, but an 85 amp rating is (to say the least) a major breakthrough in power semiconductors.

Here's how it tested:

- Dimensions as per JEDEC DO-5 outline.
- Maximum Recurrent Peak Reverse Voltage . . . 100-1600 volts.
- Maximum Average Forward Current, Single Phase Half Wave Rating at 115°C. Case Temperature . . . . . 85 amps.
- Maximum Surge Current (One Cycle) . . . . . 1500 amps.
- $\Theta_{JC}$  . . . . . 0.6

For detailed information, contact:  
FMC Corporation  
Semiconductor Products Operation  
Homer City, Penna. 15748  
(412) 479-8011

**FMC** Special  
Products



# THE QUIET ONE



**So reliable you  
never hear from it.**

Not only a quiet running printer, but a printer that keeps running in the field. That saves service calls... and adds up to satisfied customers. Makes your business system look smart. And more profitable.

No matter how hard you drive the Tally printer, you'll be hard pressed to break it. That's why we're confident in giving a one year warranty on our mechanism. Without any duty cycle limitations.

Reliability isn't the only reason why users prefer Tally. There's much more. It's a data processing printer. For print runs measured in hours rather than minutes. Multiple copies. 200 lines per minute. 132 columns. 64 character set. Straight line print registration. Numerous options. Numerous interfaces.

Write or call Tally Corporation, 8301 South 180th Street, Kent, Washington 98031.

Phone (206) 251-5647.

## TALLY®

**The Line Printer  
For The Long Run.**

INFORMATION RETRIEVAL NUMBER 76

## MODULES & SUBASSEMBLIES

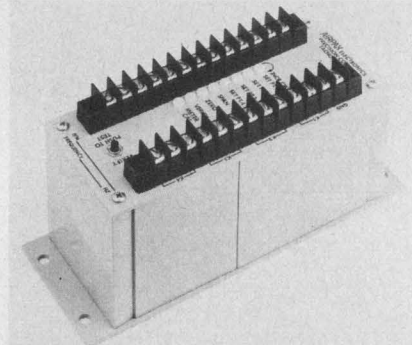
### Electronic speed control works with 3.5 kW loads

*Brush Electrical Machines, P.O. Box 18, Loughborough, Leics, LE11 1EZ, England. Stock.*

The type 10A variable speed motor controllers are suitable for any application requiring a variable speed drive. They can handle a power requirement of up to 3.5 kW (approx. 5 hp). The 10A has a closed (double) loop control circuit which uses an error actuated speed servo. A separate current servo, connected in parallel with the speed loop, provides overload and stalling protection. The units are available either as plate-mounted assemblies for fitting within customers own equipment or as self-contained units encased in styled steel enclosures. There are four output ratings of 9, 12, 18 and 28 A available, which are capable of controlling motors rated for 1.12, 1.5, 2.25 and 3.5 kW, respectively.

CIRCLE NO. 283

### Control tachometer has up to four set points

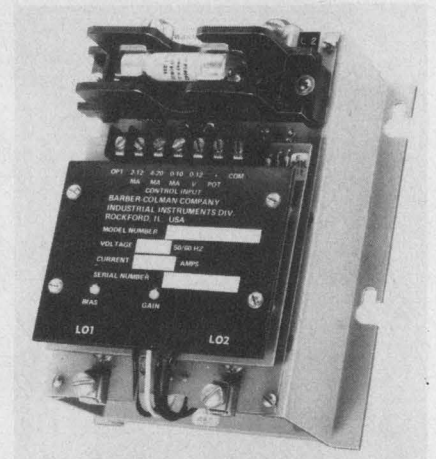


*Airpax, 6801 W. Sunrise Blvd., Fort Lauderdale, Fla. 33313. (305) 587-1100. From \$180.*

The Series 300 control tachometer has up to four switch points to control industrial processes. It will accept signals from any type sensor. The set points are adjustable from 0 to 100% of full-scale range. Other set point options are available for special application requirements. The input frequency ranges from dc to 20 Hz and the input sensitivity is 50 mV rms. Over-all accuracy is  $\pm 0.5\%$  and the industrial output variations are 1 to 5, 4 to 20 or 10 to 50 mA or 0 to 10 V dc. Power requirements are 120 V ac or 24 V dc.

CIRCLE NO. 284

### Proportional controller uses zero angle firing



*Barber Colman, Rockford, Ill. 61101. (815) 877-0241.*

Both single-phase (Series CB41) and three-phase (Series CB43) zero crossover proportioning power controllers handle loads from 15 to 75 A. The CB41 series spans a voltage range from 120 to 480 V ac while the CB43 spans 208 to 480 V ac. These units provide stepless power control for resistor heating elements that have a maximum cold to hot resistive change of 1 to 1.15, respectively. The three phase models are insensitive to phase sequence reversals and will handle four-wire Wye connected loads.

CIRCLE NO. 285

### Solid-state relays have wide choice of options

*Process Automation, G-7402 Fenton Rd., Grand Blanc, Mich. 48439. (313) 738-2340.*

The 0666 series ac control modules are solid-state relays that can control ac or dc voltages. Options available include: zero crossing control, phase control, full cycle control, on/off control, control voltage 3 to 240 V (ac/dc), I/O isolation up to 1500 V, NO/NC outputs, output voltages 120/240 V ac or 24/48/150 V dc, load current of up to 140 mA/2 A/8 A and three output filters. Zero-crossing and phase-control options can be combined to allow conduction angle control from zero crossing (full cycle) to less than  $10^\circ$ . Full cycle control forces the relay to stay on or off for N-full cycles. NO or NC outputs allow selection of fail-safe, control power off, conditions.

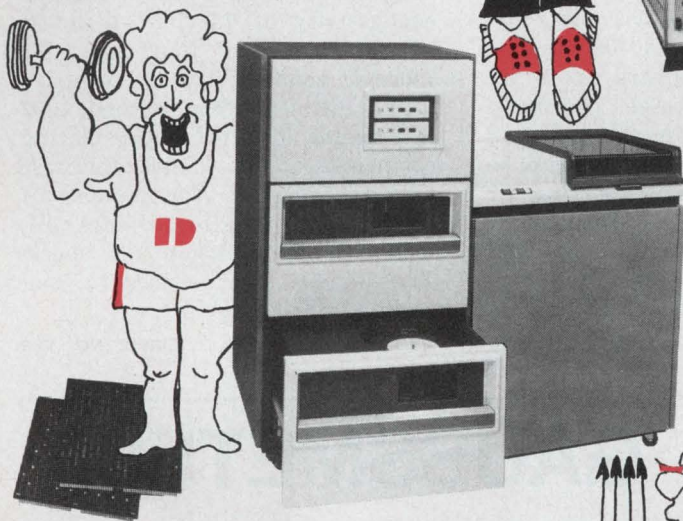
CIRCLE NO. 286



# DIVA Mini Maximizer Systems.

The lowest cost/byte in the industry.

**The big ones.** Large-capacity disc systems: 29, 58, 100, 116 Mbytes/spindle, up to 8-spindles/controller. Mini or IBM format. Systems are complete with controller interfaced to specified CPU, all interconnecting cables, diagnostic software, formatter program, and technical manuals. Optional I/O handlers are available for most mini software systems.



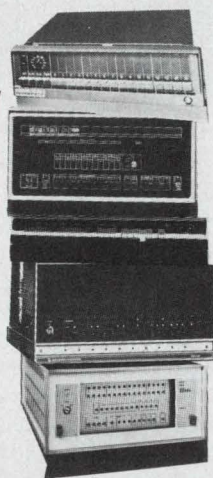
CIRCLE 201 ON READER CARD

**Our little devil.** Cartridge disc: 1,288,000 words/drive. Ideal for small-to-medium-size systems. An inexpensive replacement for DEC's RK 11/RD 02 and RK 05 cartridge disc drives. Software compatibility is provided through optional I/O handlers for most DEC, Interdata, Data General, and DCC software systems. Controller operates up to 4 drives.

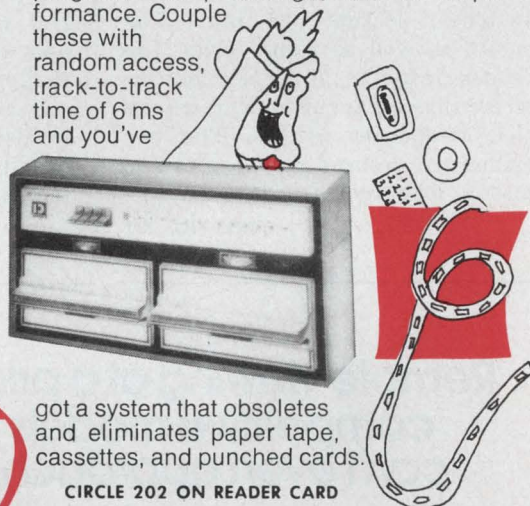
CIRCLE 203 ON READER CARD

**Move over, maxi.** DMT-1000 and DMT-1001 magnetic tape systems: 125 or 200 ips; 800 or 1600 bpi; 9 track; IBM compatible. DIVA controllers interface minis to these big tape drives that until now were usable only with big computers. Use any industry compatible 1/2-inch tape reels — from minis to 10.5-inch reels, as well as IBM wrap-around tape cartridges. 320 Kbytes/sec transfer, 500-ips rewind, 7-sec automatic load, photoelectric sensing, vacuum column guidance, air bearings, single capstan drive, and software compatibility are a few main features.

CIRCLE 204 ON READER CARD



**The eliminator.** Floppy disc: 3.1 Mbytes/drive unformatted, up to 4 drives controller, IBM compatible. Big disc drive features like initial program load, overlapped seek (option), logical unit select switches, disc sectoring, DMA or programed I/O provide great all-around performance. Couple these with random access, track-to-track time of 6 ms and you've



got a system that obsoletes and eliminates paper tape, cassettes, and punched cards.

CIRCLE 202 ON READER CARD

DIVA promises to maximize your mini for the lowest cost/byte in the industry and ship in 30-45 days. For complete details call any DIVA office.

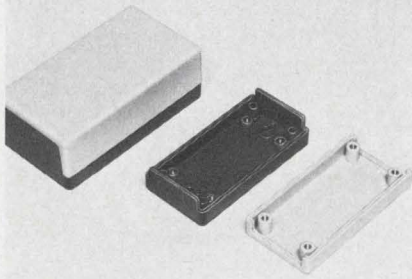


Mini maximizer systems

**DIVA, Inc.** 607 Industrial Way West / Eatontown, N. J. 07724 / Phone: 201-544-9000 / TWX 710-722-6645  
 REGIONAL SALES OFFICES: California: 213-889-4180 / Massachusetts: 617-275-1436 / Texas: 713-626-1390 / Washington D.C.: 703-370-5211



## Plastic box interlocks, houses electronic devices

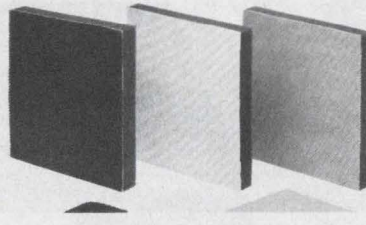


Vero Electronics, Inc., 171 Bridge Rd., Hauppauge, N.Y. 11787. (516) 234-0400. \$2.16 to \$4.04; stock.

An interlocking two-piece box, with a two-tone plastic body, is suited for either pocket or desk electronic devices. Two sizes are available. There are provisions for switches, sockets and other elements as well as cable inlets. Imbedded into the lower section are screw threads for mounting assembled component groups. The two halves are grooved for close fit and screws lock them together.

CIRCLE NO. 287

## Noise-absorption foam easily cut

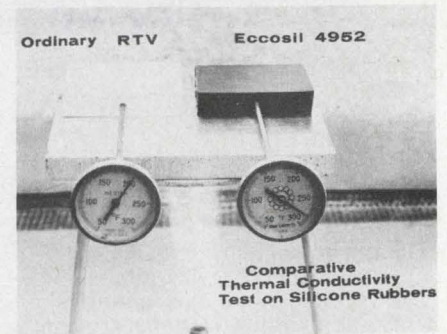


Ferro Corp., 34 Smith St., Norwalk, Conn. 06852. (203) 853-2123.

Ferro Cousti-Headliner noise-absorption material consists of high noise-absorption polyurethane foam bonded to a facing of a tough, perforated, reinforced PVC film with a leather-grain texture. The facing resists oils and greases and is easily washed with any vinyl cleaner recommended for automotive interiors. Standard colors are white, black and beige. The material is available in standard 1/2 and 1 in. thicknesses and can be easily cut with scissors, dies or any textile cutting equipment. It is also available with an optional backing of pressure-sensitive contact adhesive.

CIRCLE NO. 288

## Silicone rubber has high thermal K



Emerson & Cuming, Inc., Canton, Mass. 02021. (617) 828-3300. \$3.45 per lb (\$18 lb up); stock.

Eccosil 4952 is a silicone rubber formulation with the high thermal conductivity of 7.5 BTU-in/hr-ft<sup>2</sup> °F. This is about four times the thermal conductivity of ordinary RTV silicones. Thus Eccosil 4952 is recommended for encapsulating components that would otherwise tend to overheat. And because of its flexibility, it also provides protection from vibration and shock. The material can be used to temperatures of 500 F.

CIRCLE NO. 289

## Remote viewing at a price competitive models can't even approach.

This new, low-cost FS-100 Fiberscope with a 24" flexible length can reveal hidden flaws, peer into recesses, and trace vibrations to their source. Built with AO quality throughout, this battery-powered unit features a high resolution fiber bundle with a wide angle fixed focus objective lens and an adjustable eyepiece. For further information on the entire Fiberscope line, write or call American Optical Corporation, Fiber Optics Division, Southbridge, Massachusetts 01550. Tel. (617) 765-9711 Extension 2445.

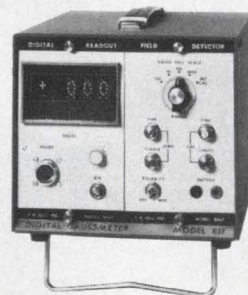


**Only \$295**  
Model FS-100  
Fiberscope

**AO**  
American Optical

INFORMATION RETRIEVAL NUMBER 78

# GAUSSMETERS



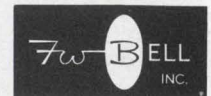
model 811

high accuracy  
excellent repeatability  
rugged

Bell gaussmeters measure magnetic field strength from .0001 gauss to 100,000 gauss. There are six gaussmeter models and 110 probe models for each gaussmeter. The resulting combinations meet the challenging requirements of all magnetic field measurement applications.

F. W. Bell has the experience and know-how to offer you the best instruments that are available. Your local representative is equipped to give you a demonstration. Use the inquiry card to find out how these instruments can benefit you.

4949 Freeway Drive East  
Columbus, Ohio 43229  
Phone: 614/888-7501  
TWX: 810-337-2851



a subsidiary of Arnold Engineering

INFORMATION RETRIEVAL NUMBER 79

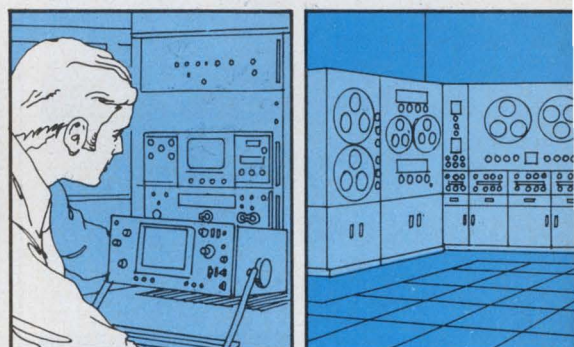
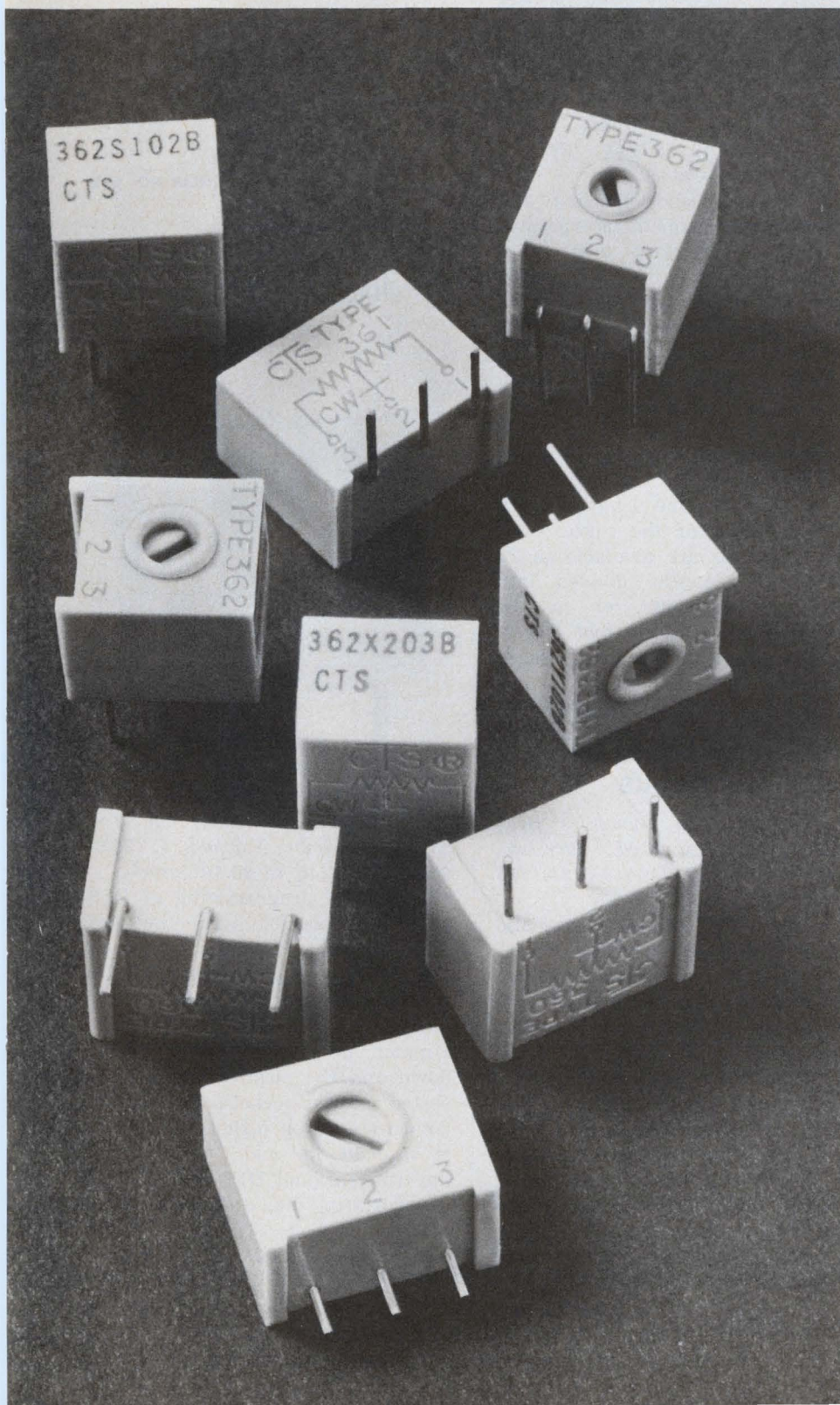
INFORMATION RETRIEVAL NUMBER 80 ►



**From instrumentation  
to computers,  
demanding OEMs**

# turn to CTS

**for the best cermet trimmer values**



CTS is the "engineer's choice" for quality cermet trimmers. CTS delivers proven performance, uniformity and reliability . . . at economical prices. The best known calculators and all types of fine tolerance instruments incorporate CTS trimmers. Our industrial 360 Series satisfies a wide range of critical OEM applications.

Nine popular styles give you the pin spacing you need. Choose from top and side adjust .100", .125", .150" and TO-5. Plus top adjust .200" grid, too. Units are flux sealed, and feature a low TC cermet element. Settability: 0.03%.

- 1 watt power @ 25° C., ½ watt @ 85° C
- 1.5% average ENR noise resistance
- 0.5% average CRV

Available off-the-shelf from CTS Industrial Distributors. CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Phone: (219) 589-3111.

**CTS CORPORATION**  
ELKHART, INDIANA

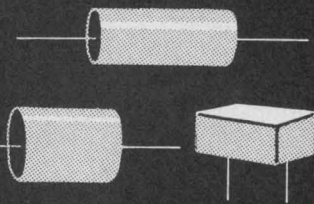






**our products  
are more fully  
developed...**

Standard Condenser capacitors are indeed fully developed to produce the optimum in performance and durability. Standard is in one business only, the design and manufacture of the world's finest capacitors. We have designed and delivered thousands of specialized capacitors for industry. In fact, what you think of as "special" may be among the many designs already available from stock at Standard. However, if you require capacitors of unusual shape, size, value and material, our engineering department will help you design and produce them to your exact specifications at stock prices. For immediate action, send us a sketch and complete details.



Write or phone for catalog and details.

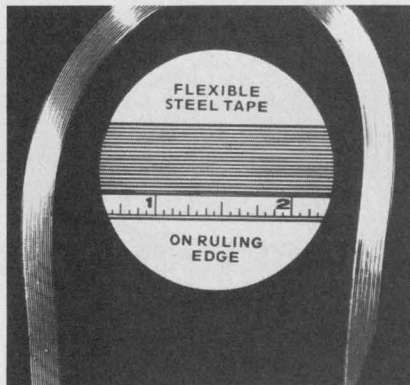
**Standard**  
**CONDENSER CORPORATION**

Dept. ED-7 1065 West Addison Street  
Chicago, Illinois 60613 • (312) 327-5440

INFORMATION RETRIEVAL NUMBER 81

PACKAGING & MATERIALS

**Adjustable curve has  
measuring scale**



Hoyle Engineering Co., 302 Orange Grove, Fillmore, Calif. 93015. (805) 524-1211. \$10.50: 22 in., \$14.90: 32 in.; stock.

A versatile curve-drawing and measuring instrument incorporates a steel measuring tape in a grooved channel on its outside edge. This calibrated curve is made up of 12 interlocking strips. The individual strips are extruded from a clear butyrate plastic. Friction between the strips locks the curve into position after it has been shaped with the fingers. The measuring tape enables the user to accurately determine lengths along the perimeter of the curve. Calibrated curves are available in 22 and 32-in. lengths divided into 1/16-in. increments, or in the metric system, in 55 and 80 cm lengths divided into mm increments.

CIRCLE NO. 290

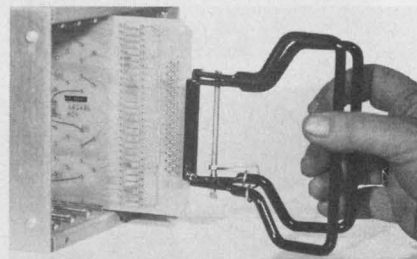
**Heat pipe flexes to  
1-1/8-in. radius**

Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, Calif. 90509. (213) 543-2121. \$75 (unit qty); stock

Model 1361H stainless steel and methanol heat pipe, for use where there is relative motion between the heat source and the heat sink, is available in 7 and 8-in. lengths. The pipes can be bent to a minimum 1-1/8-in. inside-radius curve. Flexing can occur in all radial directions without wick bunching problems. Thermal transport capacity of the flexible pipe for horizontal operation is 7.5 W max and thermal resistance is 1.6 C/W. Weight is 18 g for the 7-in. model and 20 g for the 8-in.

CIRCLE NO. 291

**Card puller needs  
only 1/8-in. grip**

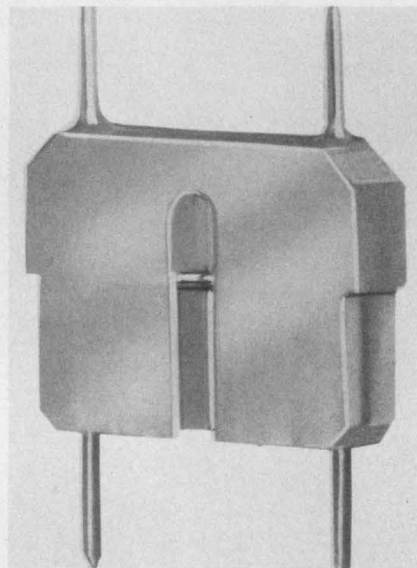


Calmark, 1820 San Marino Ave., San Marino, Calif. 91108. (213) 576-1838. Stock.

Series 112 PC-board puller features a positive gripping action. A sturdy wire-form design uses only 1/8 in. of board surface for gripping. Grips boards up to 1/8-in. thick. The unit is vinyl coated.

CIRCLE NO. 292

**Plug-in patch programs  
DIP logic circuits**



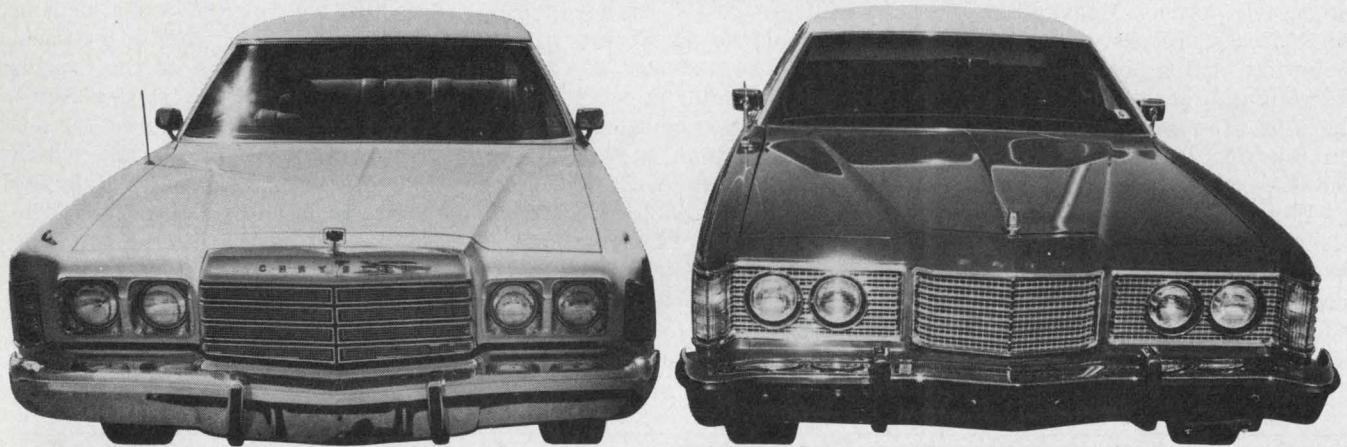
Aries Electronics, Inc., P.O. Box 231, Frenchtown, N.J. 08825. (201) 996-4096. \$0.15 to \$0.50; stock.

Individual programming of DIP sockets is possible with the new Aries Dipatch. For the ON position, the pins are inserted into the opposing socket contacts. For storage in the OFF position, the Dipatch is simply turned upside down and the plastic ears are inserted into the socket contacts. The device stacks on 0.100-in. centers; it is 0.400-in. wide; and it fits any conventional DIP socket. Pins are 0.018-in. dia., gold-over-nickel plated. The body is made of nylon and it is available in colors for color coding.

CIRCLE NO. 293



# Fresh from the Factory. Yet These Cars Should Be Recalled.



Because they're missing something.  
Like an ignition system built for today's driving.

Factory electronic ignitions were okay for yesterday. (All they do is eliminate the points and condenser, you know.) But today...with fuel shortages, the ever-growing cost of maintenance, power-robbing smog control devices, etc....there's a crying need for something better.

That something better is a Delta Capacitive Discharge Ignition System...the low-cost "now" system that really makes sense. Means up to 20% better gas mileage. 75% fewer tune-ups. Three to 10 times longer plug life. Instant starts...even at  $-40^{\circ}$ . Better acceleration and performance. Easy to install on any automobile engine, too; even goes on in minutes right over the factory electronic system with no rewiring.

Delta Capacitive Discharge Ignition Systems...extra energy to beat the energy shortage. Available in two models; Mark Ten CDI, or Mark Ten B. Priced as low as \$34.95 in kit form. Use coupon to order today!



**DELTA PRODUCTS, INC.**  
P.O. Box 1147, Dept. ED  
Grand Junction, Colo. 81501  
303-242-9000

Please send me free literature.  
Enclosed is \$\_\_\_\_\_  Ship ppd.  Ship C.O.D.  
Please send: \_\_\_\_\_ Mark Ten B assembled @  
\$64.95 ppd. \_\_\_\_\_ Mark Ten B Kit @ \$49.95 ppd.  
(12 volt negative ground only \_\_\_\_\_ Standard Mark  
Ten assembled, @ \$49.95 ppd. \_\_\_\_\_ 6 Volt: Neg.  
Ground Only \_\_\_\_\_ 12 Volt: Specify \_\_\_\_\_ Pos. Ground  
\_\_\_\_\_ Neg. Ground \_\_\_\_\_ Standard Mark Ten Deltakit®  
@ \$34.95 ppd. (12 Volt Positive or Negative Ground  
Only)

Car Year \_\_\_\_\_ Make \_\_\_\_\_

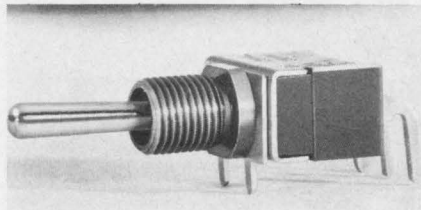
Name \_\_\_\_\_

Address \_\_\_\_\_

City/State \_\_\_\_\_ Zip \_\_\_\_\_



### Toggle switches mount sidewise on PC board

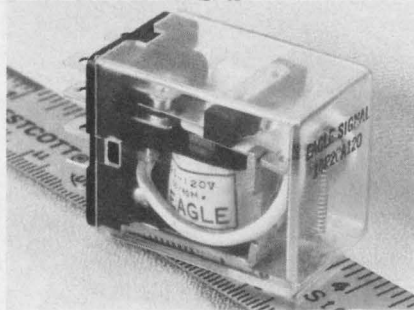


American Switch Corp., Sadler St., Gloucester, Mass. 01930. (617) 281-2224.

With five electrically different single-pole options, Model ST1 toggle switches are designed for side mounting on PC boards. A special restraining bracket adds rigidity to the unit after assembly. They are suitable for use in dry circuits, and the ratings for this line are 0.4-W max at 28-V max ac or dc. The units occupy approximately 1/2 by 5/8 in. of board space and they have a profile that doesn't exceed 0.3 in.

CIRCLE NO. 294

### Relay rated 10-A claimed half size of other types

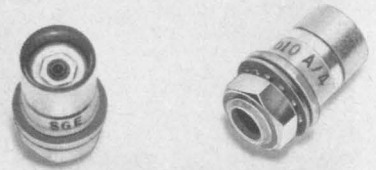


Eagle Signal Industrial Controls Div., 736 Federal St., Davenport, Iowa 52803. (312) 329-9292. \$2.50 (100 up).

A 10-A, DPDT enclosed relay, designated the 14 Series, is only half the size and cost of existing models of similar capabilities, according to its manufacturer. The relay is rated at 10-A, 1/10 hp, 120 V ac and 10 A, 24 V dc. The relay is also available in 6, 12, 48, 110-V-dc and 6, 12, 24 and 48-V-ac models. All models measure 7/8 x 1-7/16 x 1-1/8 in. and weigh 1-1/4 oz.

CIRCLE NO. 295

### Glass trimmer capacitor adjusts two ways



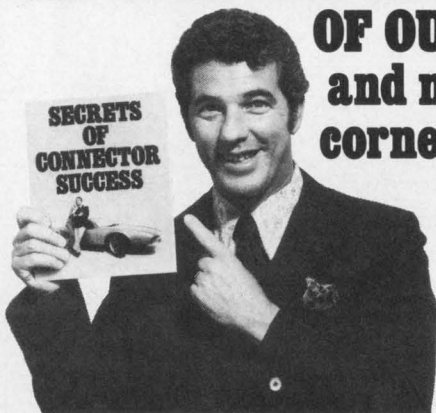
Sprague-Goodman Electronics, 371 Willis Ave., Mineola, N.Y. 11501. (516) 746-1385.

Glass trimmer capacitors are now adjustable both by the conventional screwdriver slot at the bushing end of the capacitor and by means of a hex socket broached into the piston end of the capacitor. A standard No. 2 (0.035-in.) Allen hex tool can be used for adjustment in the hex socket, which is recessed to make it easy to locate in blind-hole situations. The hex socket modification is available on all open-end Pistoncap capacitors made by Sprague-Goodman Electronics.

CIRCLE NO. 296

## "CANNON® MICRO-MINIATURE CONNECTOR CAPABILITIES GOT US OUT

## OF OUR BOX, and me into a corner office."



"Cannon showed us how their custom miniature connector assemblies could do the job better—and for less—than we could ourselves. Read about it in 'Secrets of Connector Success'—and get ready to move up."

Contact ITT Cannon Electric, International Telephone and Telegraph Corporation, 666 East Dyer Road, Santa Ana, CA 92702. (714) 557-4700.

# CANNON ITT

INFORMATION RETRIEVAL NUMBER 83

## The Gould 6000 Data Acquisition System: 128 fully floating and integrating inputs, scans to 200 points/sec.

The portable and rugged Gould 6000 analog to digital data logger-reader is the best way to monitor and precisely record low frequency data. It accepts both analog and digital input signals, converts the data to digital form, displays the data for real-time monitoring and stores up to 500,000 readings on a 3M 1/4" computer grade mag-tape. It offers high noise rejection, high input impedance, programmable gain and much more.

Write Gould Inc., Instrument Systems Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Or Kouterveldstraat Z/N, B-1920 Diegem, Belgium.



# GOULD

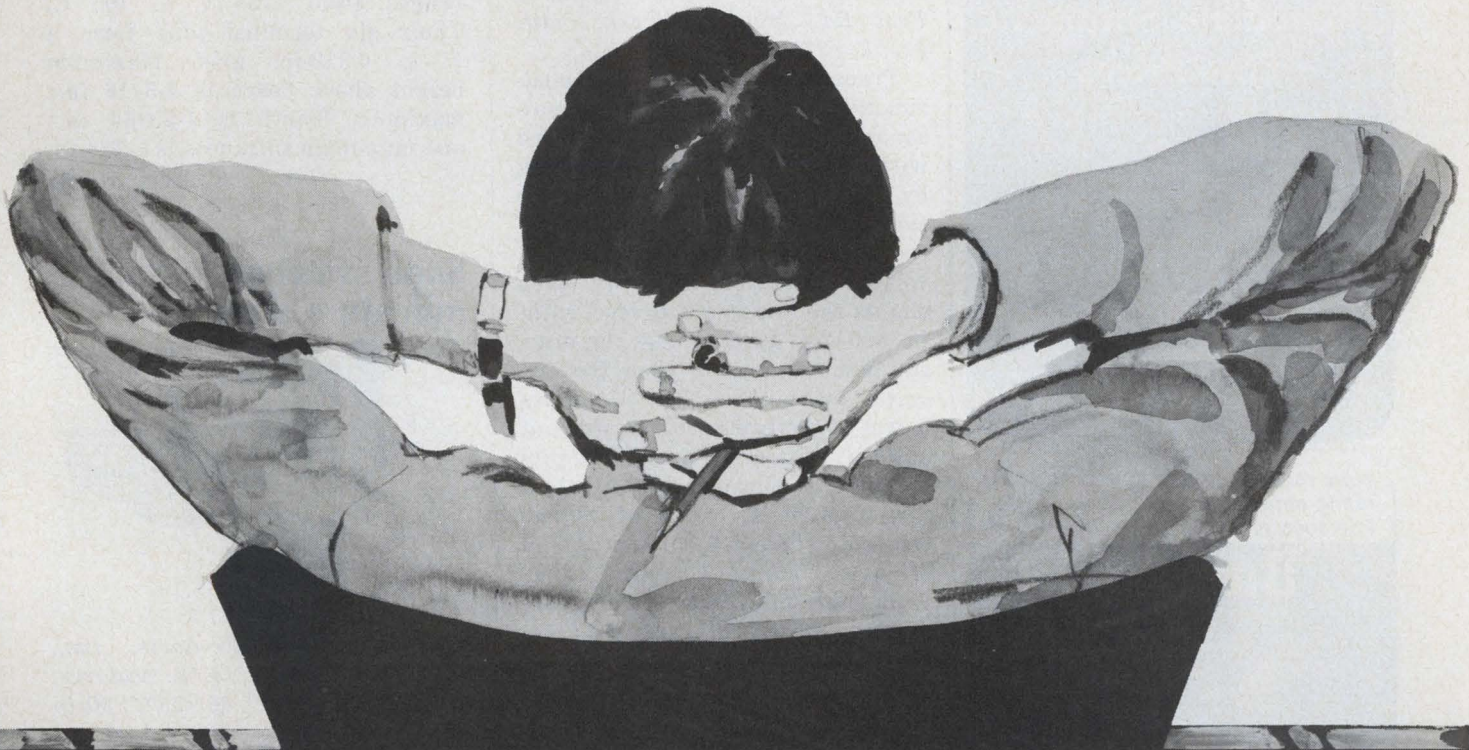
INFORMATION RETRIEVAL NUMBER 84

INFORMATION RETRIEVAL NUMBER 903 ▶



YOUR EDUCATION REPRESENTS  
AN IMPORTANT  
PERSONAL INVESTMENT--

**WHAT HAVE YOU  
DONE WITH IT  
SO FAR?**



"Got a job" isn't quite the full answer, is it? You're *you*. And there's more to life than just "a job" — or should be.

**What could you expect if you joined us? A quality of life that means the difference between "a job" and a way of living.**

We design and manufacture complete electronic systems of various kinds for business, industry and government. It is our practice to hire very able people and then put them to work doing what they most like to do.

Because we are a large company, we offer a total career growth-potential that is as big as we are. And because we work in relatively small product-oriented divisions, your abilities and contributions are highly visible from the time you join us, with prompt recognition of superior performance.

Whether you work for us in California, New York,

Ohio, Florida, Kansas or Delaware, you'll find yourself looking forward to coming to work in the morning. And your technology won't become obsolescent in 5 or 10 years, because, to remain a leader, we must continue to work on the far edge of the current state of the art.

**Professional involvement . . . continuing development as an engineer . . . an environment of individual responsibility that encourages new ideas and rewards initiative. These are *good* dividends on the personal investment you've already made on your education!**

If you're not realizing them now, write:

**NCR Worldwide Headquarters, Dept. ED 7-5  
Corporate Executive &  
Professional Placement  
Dayton, Ohio 45479**

*An Equal Opportunity Employer M/F*

**NCR**



**1** / %  
**AMERICAN MADE**  
**Tolerance**  
**SCHAUER**  
**1-Watt**  
**ZENERS**

**Immediate Shipment**  
**Low Prices**

ANY voltage from 2.0 to 16.0

Quantity	Price each
1-99	\$1.07
100-499	.97
500-999	.91
1000-4999	.86
5000 up	.82



Write for complete rating data and other tolerance prices.

**Buy the kit - Save a lot**



Kit contains a 51-piece assortment of SCHAUER 1% tolerance 1-watt zeners covering the voltage range of 2.7 to 16.0. Three diodes of each voltage packaged in reusable poly bags. Stored in a handy file box. Contact your distributor or order direct.

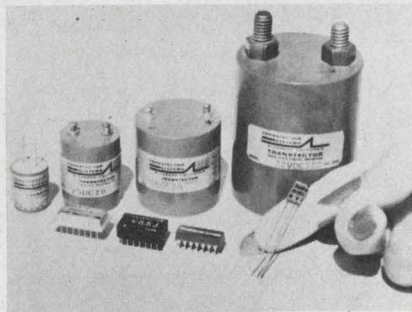
A \$54.57 value for  
**ONLY \$24<sup>50</sup>**

Semiconductor Division  
**SCHAUER**  
**Manufacturing Corp.**

4511 Alpine Ave. Cincinnati, Ohio 45242  
 Telephone: 513/791-3030

**COMPONENTS**

**Circuit protector stops nuisance tripping**



Transtector Systems, Div. of Konic International Corp., 532 Monterey Pass Rd., Monterey Park, Calif. 91754. (213) 283-9278.

Transtector System's new dual-function protectors eliminate nuisance tripping that is experienced with many high-speed protectors by clamping and absorbing the energy of transients in 50 ns. If the transient develops into an over-voltage condition, the unit then shunts the line to a safe level within 500 ns. It continues to draw sufficient energy to open the circuit's fuse or breaker. Upon removal of the power source, the unit automatically resets itself. The protectors have surge-current capabilities to 2000 A, choice of voltage trip points from 5 through 200 V dc and nominal current ratings from 1 through 100 A. The units are available in hybrid, radial-lead, 14-pin DIP or discrete cases.

CIRCLE NO. 297

**Optical proximity sensor uses pulsed infrared**

Electronic Products for Industry Corp., 1241 Birchwood Dr., Sunnyvale, Calif. 94086. (408) 734-8235. \$95 (unit qty).

Infrared optical sensor transmits a pulsed, narrow beam and detects reflected light from any object at ranges up to 60 in. from noncooperative targets, or as far as 30 ft with a retroreflector. A LED generates the light at a frequency of 10,000 pulses per sec in high-energy pulses of 10-ns and 50-mW peak power. The receiver frequency is phase locked to the emitter for synchronous operation and, therefore, rejects ambient light. A large aperture, f/1.0 lens provides high optical efficiency.

CIRCLE NO. 298

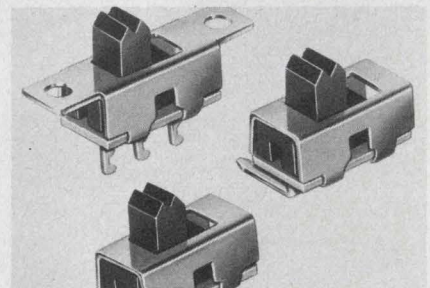
**PC transformers have two secondary windings**

Dale Electronics Inc., East Highway 50, Yankton, S.D. 57078. (402) 665-9301. \$2.10 (OEM qty).

Designed for easy PC mounting, the new PL-12 transformer line is built to UL specifications and rated at 1.5 W. Currently, 17 standard models are available, and with an input of 115 V at 60 Hz, they cover outputs from 8 to 230 V. Transformer secondaries may be series or parallel-connected for twice the voltage or twice the current rating. Operating temperature ranges from -55 C to 105 C. Their six terminal pins form a 1 x 0.312-in. grid. Maximum height above board is 1-3/16 in.; maximum length is 1-29/64 in.; and maximum thickness is 1-1/8 in.

CIRCLE NO. 299

**Slide switches feature miniature size**



Alco Electronic Products, Inc., 1551 Osgood St., North Andover, Mass. 01845. (617) 685-4371. 30 to 60 days.

New subminiature SPDT slide switches for calculators and test instruments feature a ball-and-spring-detent mechanism, contacts with wiping action and an improved tactile feel. The basic switch is available in three styles with dimensions of only 0.433 L x 0.213 W x 0.197 H in. Model SLS-121M has tabs for panel mounting; SLS-121M-1 is identical, except it doesn't have the mounting tabs; and Model SLS-121M-RA has 90-degree bent terminals for right-angle mounting. All models have silver-plated brass terminals and contacts encased in a corrosion-protective steel frame. Actuators are black thermoplastic resin. Normal life expectancy exceeds 10,000 operations. The switches are rated 0.3 A at 125 V ac.

CIRCLE NO. 300



# Frame them any old way

## Or any new way.

Then sit back and watch your Ise display electronics get your ideas across. Beautifully.

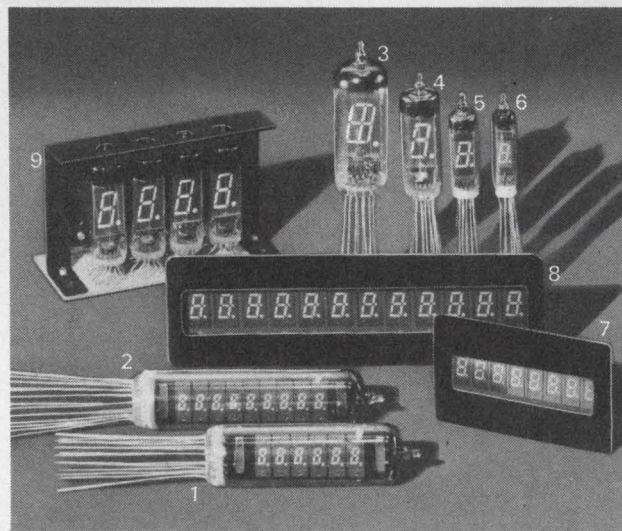
In an eye-easy fluorescent green glow.

At the same time, they're low on voltage and current drain.

High on stability.

Pick the readouts that offer more of everything, including variety, for a whole host of digital display ideas.

They're a difference you can see.



1. DP60A
2. DP90A
3. DG19E
4. DG12H
5. DG10F1
6. DG 8F
7. DP 89A
8. DP127F
9. DMCL12H (NEW)

**Display module w/counter & latch**

- Fluorescent green glow.
- 12-pin connector.
- Three performance perfect models.
- Custom ROM programming with other than BCD and seven-segment output.

The Brighter Side of Electronics



Creator of Fluorescent Digital Display:

**ISE ELECTRONICS CORP.** P.O. Box 46 Ise-city, Mie Pref., Japan  
Tel: (05963) 5-2121 Telex: 4969523

International Sales Div.:

**ISE INTERNATIONAL CORP.** 2-7-7, Higashi-Shinbashi, Minato-ku, Tokyo, Japan  
Tel: 433-6616~9 Telex: J26546 Cables: "ISEWORLDREP" TOKYO

Sales & Technical Office:

**ISE CORP. OF AMERICA** 1472 West 178th Street, Gardena, Calif., 90248 U.S.A.  
Tel: (213) 532-0470 Telex: 230674910

Representative: Paris, Munich, Amsterdam, Stockholm, Vienna, Milan, Bombay, Hong Kong, Taipei.

INFORMATION RETRIEVAL NUMBER 87



### Cooling fan runs on 12-V-dc brushless motor

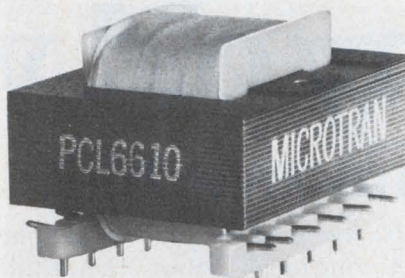


Alpha Components Corp., 115 Eucalyptus Dr., P.O. Box 947, El Segundo, Calif. 90245. (213) 322-7780. \$16.40 (1000 up); stock.

Model D-12 cooling fans operate from a nominal 12 V dc that is normally available in many electronic systems. The motor requires only 2 A. The fan supplies 130 cfm of air at 12 V and 150 cfm at 14.4 V. The unit weighs only 24 oz., complete with grille and venturi, and it is 5-in. diameter by 2-3/8-in. deep. The new unit mounts on 4.125-in. standard mounting centers.

CIRCLE NO. 301

### Miniature xformers mount on PC boards

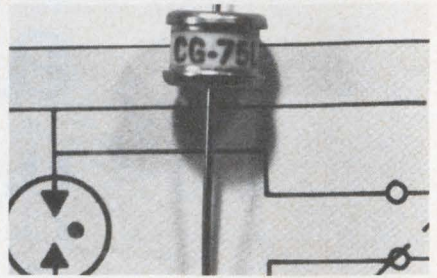


Microtran Co. Inc., 145 E. Mineola Ave., Valley Stream, N.Y. 11582. (516) 561-6050. Typical \$4.50 to \$5.50 (100 up); stock.

A new series of 35 plug-in PC power transformers allows the construction of low cost, miniaturized, regulated and unregulated dc power supplies to provide outputs of +5 and  $\pm 15$  V dc. Low-profile and miniature construction permit close stacking of PC boards. Precision spaced plug-in terminals also provide fixed mounting centers. The units are designed for 115 and 115/230-V, 50/60-Hz input. Output current ratings from 12 to 2000 mA dc are available.

CIRCLE NO. 302

### Gas-tube arrestor offers low breakdown voltage



Signalite, 1933 Heck Ave., Neptune, N.J. 07753. (201) 775-2490. \$1 (5000 up).

Signalite's CG-75 Comm Gap arrestor has a dc breakdown voltage of 75 V  $\pm 20\%$ , when subjected to a slowly rising dc voltage, and a pulse breakdown voltage typically between 400 and 600 V, when subjected to a fast rising voltage of about 5 kV/ $\mu$ s. The unit is of rugged ceramic-metal construction with a length of 0.265 in. and a diameter of 0.380 in. max. Typical capacitance is 1.4 pF. Life may be millions of operations, depending on pulse-current amplitude and duration.

CIRCLE NO. 303



### Join the Amphenol fan club.

We've got nearly every size fan you need in stock. Amphenol fans have aluminum frames for better heat dissipation plus ball bearings and a balanced, lightweight impeller for smoother, quieter, longer lasting cool power. Join our fan club today. Use the reader service number below for information and prices.

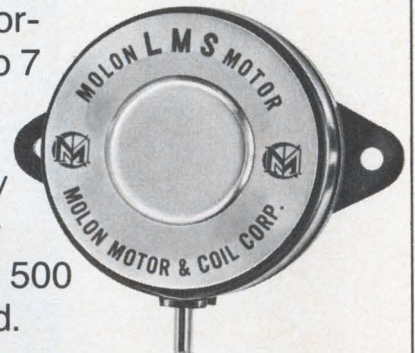
**BUNKER RAMO** **AMPHENOL**

INFORMATION RETRIEVAL NUMBER 88

## INGENUITY

in creating Stepper Motors.

Like our Model LMS:  $7\frac{1}{2}^\circ$  step angle. Torque ranges to 7 oz. in. Start-stop rates of 350 steps/second. Slew capability to 500 steps/second.



And that's not all you get at

**MOLON**

3737 Industrial Ave., Rolling Meadows, Ill. 60008  
Phone: (312) 259-8700

INFORMATION RETRIEVAL NUMBER 89

ELECTRONIC DESIGN 14, July 5, 1974



# AMPEREX HAS WHAT IT TAKES TO BE NUMBER ONE IN RF POWER SEMICONDUCTORS...

THE LINE - THE BOOK - THE BOARDS.



Amperex is going all out to support its state-of-the-art line of RF power semiconductors with a state-of-the-art program of applications engineering assistance.

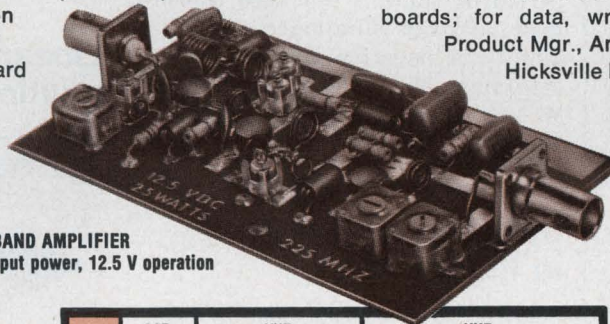
The line is a broad one with an RF power semiconductor to fill virtually any RF amplification need in fixed and mobile transmitting equipment—from 30 MHz single sideband through 960 MHz UHF FM.

At the heart of the program is a 640-page applications manual containing 24 detailed engineering reports. This manual, available to communications design engineers, will cut RF power amplifier design time and cost to a fraction of that normally required between the drawing board and the production line.

The engineering assistance doesn't end with the applications manual—it only starts there. You won't even have to build the prototypes to get these circuits into production! We will supply sample boards, built for you, here in the Amperex applications laboratory.

Use them to test, to evaluate, to demonstrate your system. Typical of the sample boards now being made available to Amperex customers, is a 25 watt, 225 MHz Class E Citizens Band Amplifier (illustrated at left) with 50 mV input power and 12.5 V operation.

For more information... on the line, the book, the boards; for data, write to Marty Burden, Group Product Mgr., Amperex Electronic Corporation, Hicksville Division, Hicksville, N.Y. 11802. Telephone: (516) 931-6200.



**CLASS E, CITIZENS BAND AMPLIFIER**  
25 W output, 225 MHz, 50 mV input power, 12.5 V operation

P out (watts)	SSB		VHF		UHF	
	30 MHz	175 MHz FM	175 MHz FM	470 MHz FM	470 MHz FM	470 MHz FM
	28 V	13.5 V	28 V	13.5 V	13.5 V	28 V
				Ampl. Modules		
2.0				BLX65		
2.5			2N3553	BLX66		
3.0		2N3924		BLX67		BLX92
4.0		BFS22A	BFS23A		BGY22	
6.0			2N3375			
7.0		2N3926		BLX68	BGY23	BLX93
8.0	BLX13	BLY87A	BLY91A			
12.0		2N3927				
13.0			2N3632			
15.0		BLY88A	BLY92A		BGY24	
20.0				BLX69		BLX94
25.0		BLY89A	BLY93A			
40.0						BLX95
50.0	BLX14	BLY90	BLY94			
150.0	BLX15					

## Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Sold through  
North American Philips Electronic Component Corporation

INFORMATION RETRIEVAL NUMBER 90



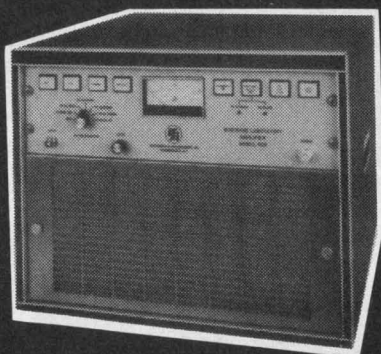
# THE NEXT GENERATION

## OF Broadband

## Power Amplifiers

Starts with  
The

# isfi M403



.01-250MHz  
100W min.  
50db gain

SMALLER  
LIGHTER  
QUIETER

DESIGNED FOR RELIABILITY  
AND  
EASE OF MAINTENANCE

Solid State protection and control  
circuitry with complete remote  
control capability. Write or Call.



**instruments  
for industry,  
inc.**

(516) 694-1414

151 Toledo Street,  
Farmingdale, N.Y. 11735

INFORMATION RETRIEVAL NUMBER 91

## MICROWAVES & LASERS

### Tetrode has improved cathode structure



Varian, 611 Hansen Way, Palo Alto, Calif. 94303. (415) 493-4000. About \$40; stock.

The Model 4CX250BC/8957 tetrode can replace the 4CX250B in broadcast applications. The new tetrode, featuring an improved cathode structure, is capable of high emission over an extended period of time. A modified screen grid virtually eliminates the possibility of negative screen current. Maximum plate dissipation is 250 W and maximum input power is 500 W.

CIRCLE NO. 304

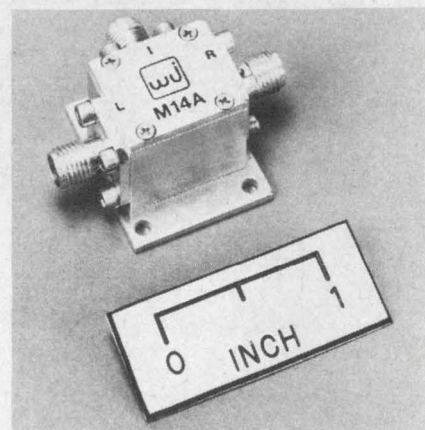
### Switch line housed in flat packs

Sanders Associates, Inc., Microwave Div., Grenier Field, Manchester, N.H. 03103. (603) 669-4615. \$40 up; 2 to 4 wks.

The DS-10000L Series of octave and multioctave-band switches comes in standard flat packs for ground or airborne applications from 5 to 4000 MHz. The switches offer up to 60-dB isolation with insertion losses as low as 0.5 dB, and they feature typical switching speeds of about 100 ns. The switches are available in either SPST or SPDT configurations, and with or without the TTL-compatible integral drivers.

CIRCLE NO. 305

### C-to-Ku-band DB mixers isolate to 35 dB

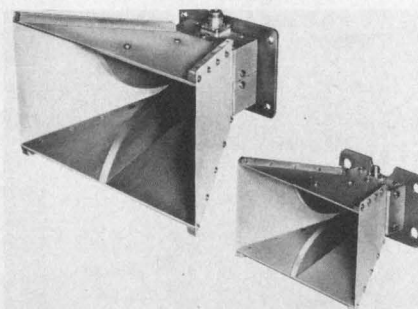


Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. 94304. (415) 493-4141. \$350 to \$500 (1-4); stock.

Two double-balanced mixers, having a frequency coverage up to 16 GHz, specify the following with a 7-dBm drive: a 5-to-6-dB noise figure, a 30-to-35 dB isolation and a VSWR of less than 2:1. Called the WJ-M14 (which can accept signals from 4 up to 9 GHz) and the WJ-M14A (which can accept signals from 4 up to 16 GHz), the new mixers also feature an i-f response of dc to 2 GHz, insertion loss of 2 to 3 dB, loss tracking of 0.2 dB and phase tracking of  $\pm 1$  to 1.3 degrees.

CIRCLE NO. 306

### Linear horns spec multioctave range



American Electronic Lab., Inc., MS/1123, P.O. Box 552, Lansdale, Pa. 19446. (215) 822-2929.

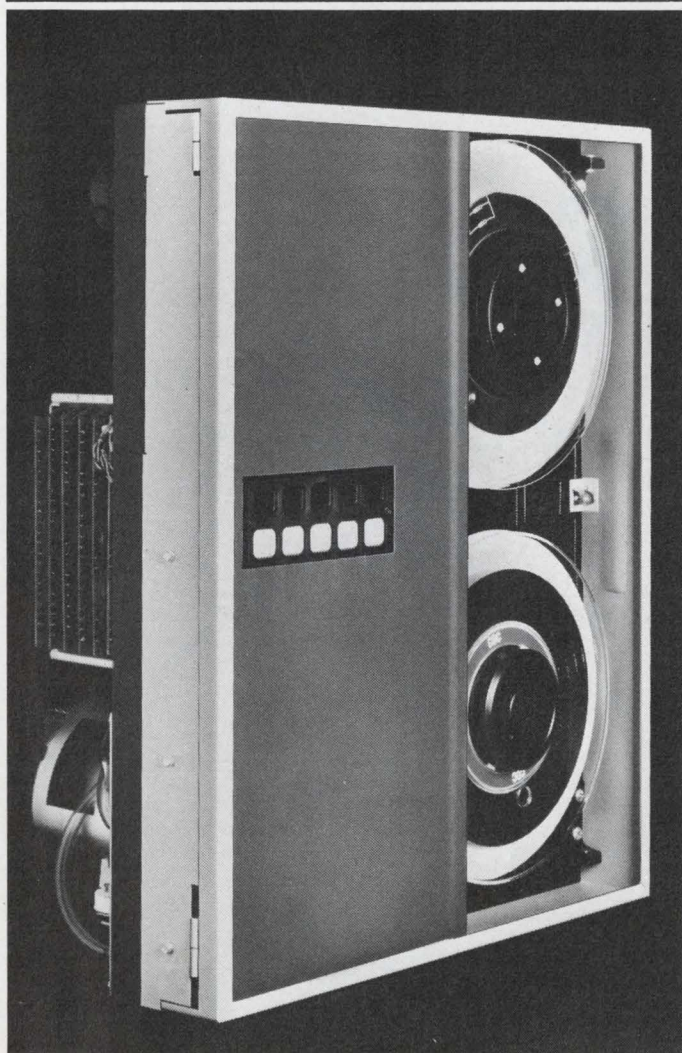
The Model H-1479 and H-1498 linearly polarized horns combine multioctave coverage with compact size. These coaxially-fed double-ridged horn antennas have an essentially constant gain of 11 dB. They cover the 1-to-18-GHz frequency band in overlapping ranges of 1 to 12 GHz and 2 to 18 GHz.

CIRCLE NO. 307



# OEM Buyers take note:

## CDC<sup>®</sup> Model 92000 Magnetic Tape Transport for best price/performance.



The CDC<sup>®</sup> Model 92000 Series Transports are rack mounted, budget priced, reliable, 25 and 50 IPS single capstan units compatible with ANSI standards.

These transports are used on our own systems and feature exceptional data and mechanical reliability.

- Vacuum column operation for improved tape handling
- Digital tachometers provide precise tape control
- Programmable clip levels for enhanced reading capability and improved error recovery
- Modular packaging for easy maintenance

Let us show you how these units can help you. For complete information, dial our Hot Line collect (612/853-3535). Or return the coupon below today.

Milt Holec  
OEM Marketing Manager  
CONTROL DATA CORPORATION  
2621 Van Buren Ave., Dept. ED-74  
Norristown, PA 19401  
(215) 666-5000, ext. 574

**CONTROL DATA**  
CORPORATION

NAME \_\_\_\_\_

TITLE \_\_\_\_\_

COMPANY \_\_\_\_\_

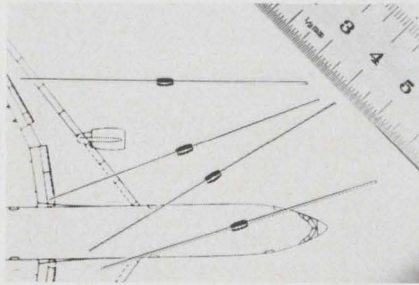
ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

I want to hear more about the CDC Model 92000 Series Tape Transports.



## Transient protectors handle bipolar signals



Semtech Corp., 652 Mitchell Rd., Newbury Park, Calif. 91320. (213) 628-5392.

A silicon bipolarity transient suppressor provides symmetrical voltage transient protection. These devices have breakdown voltages of from 10 to 110 V  $\pm 10\%$ . They can withstand peak power pulses (1 ms duration) of 500 W and will respond in 1 ps. The dynamic impedance of these transient protectors varies from 1.5 to 70  $\Omega$ . These devices have diameters of 0.14 in. and are 0.165 in. long.

CIRCLE NO. 308

## LED numeric display has 0.25 in. high digits

Bowmar Canada Ltd., 1257 Algoma Rd., Ottawa, Ontario K1B3W7. (613) 746-3100.

The B-27R is a 0.25 in. high single digit LED numeric display. It gives off a highly visible bright red light (660 nm) from a GaAsP material. Luminance is typically 0.3 millicandela and the power required for nominal brightness is 125 mW.

CIRCLE NO. 309

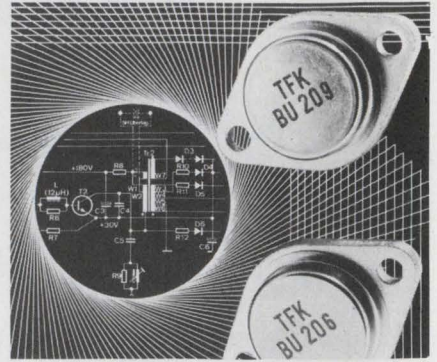
## S-band power transistor delivers 10 W

RCA, Box 3200, Somerville, N.J. 08876. (201) 722-3200. \$200 (25 to 99); stock.

The RCA2310 microwave transistor can supply 10 W cw at 24 V for operation at 2.3 GHz. The device has been designed for S-band (2.2 to 2.3 GHz) telemetry service. It uses 22-to-24-V supplies and is housed in a flanged ceramic-metal package, designated HF-46.

CIRCLE NO. 310

## High voltage transistors work at 1700 V



Energy Electronic Products, 6060 Manchester Ave., Los Angeles, Calif. 90045. (213) 670-7880. BU-206; \$4.65 (100 pc. price); stock.

The BU204 through BU209, power transistors are silicon npn devices that can handle up to 1700-V peak voltage (collector-base) at 4 A (BU209). The BU204 and 207 can handle 1300 V, the 205 and 208 1500 V and the 205 and 209 1700 V. The 204, 205 and 206 can handle collector currents of 2.5 A average while the 207, 208 and 209 can handle 5.5 and 4 A, respectively.

CIRCLE NO. 320

# BETA-LINE

**"Cadillac" Quality at Competitive Prices**



- ROUGH DIE CAST ALUMINUM SIDE FRAMES
- CONVENIENT MOUNTING HOLE PATTERN
- SLIDING 050 VINYL-CLAD ALUMINUM TOP AND BOTTOM COVERS
- REMOVABLE SIDE COVERS



- INTEGRAL COVER SLIDES
- LARGE HOLES ALLOW VENTILATION AND CALIBRATION ACCESS
- VERSATILE MOUNTING BRACKETS
- ATTRACTIVE ANODIZED ALUMINUM BEZEL

- PROVISION FOR RACK MOUNTING OPTION

\$59.98\*

**SAVE PACKAGING EXPENSE AND TIME!**

**IT'S A PROVEN FACT... OUR SUPERBLY CRAFTED ENCLOSURES WILL SELL MORE OF YOUR PRODUCTS!**

The new BETA-LINE series features beauty, quality and versatility at low prices. The hand-somely finished side frames, deep brown vinyl-clad aluminum covers combine to produce a rich, sumptuous appearance. Select from 63 standard models and a full complement of hardware options.

\*IN QUANTITIES OF 100 EACH AFTER MAXIMUM DISCOUNTS - MODEL B525-13-1700H LESS FRONT AND REAR PANELS

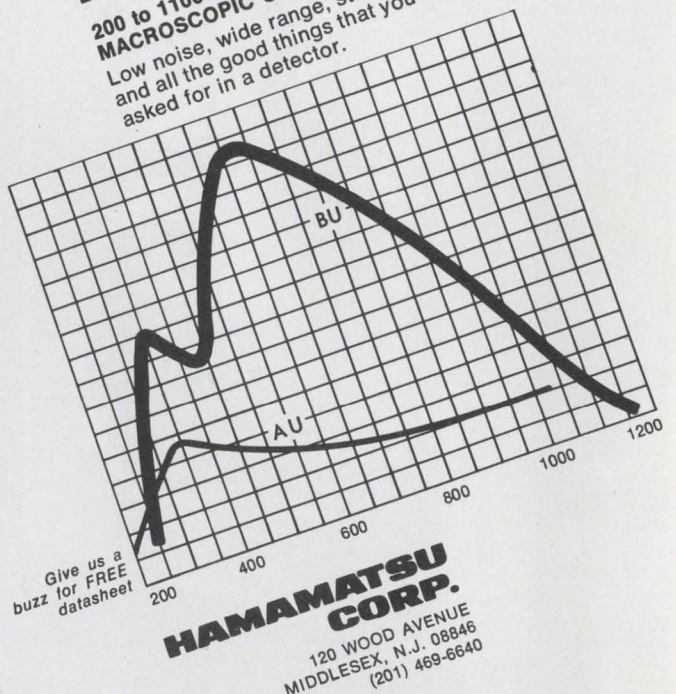
## T.D.J. COMPANY INC.

1152 Morena Boulevard • San Diego California 92110 • Telephone (714) 276-5920

INFORMATION RETRIEVAL NUMBER 93

## NEW UV SILICON PHOTOCELL

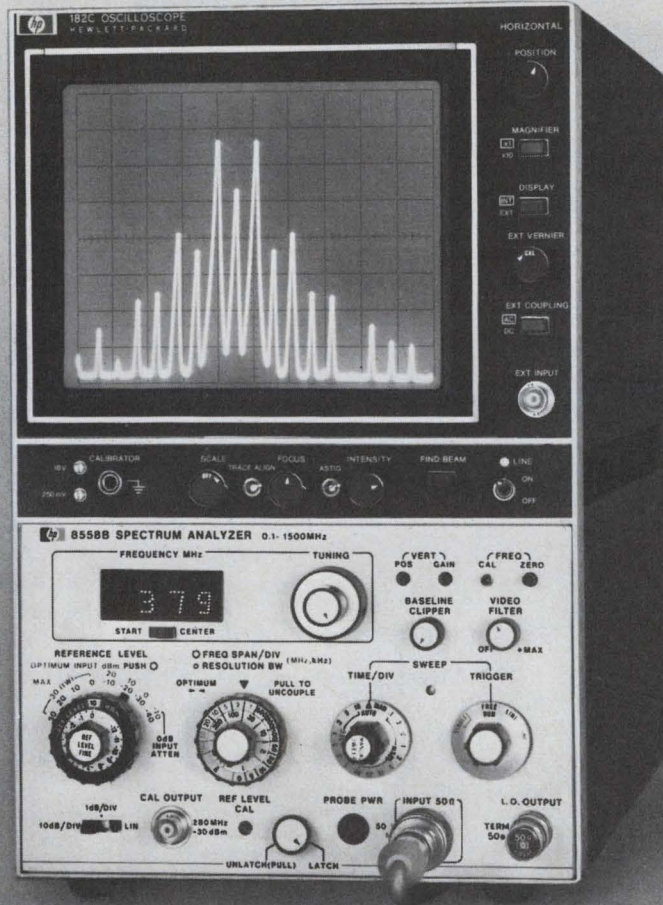
**200 to 1100 NM MACROSCOPIC COST**  
 Low noise, wide range, stable, fast and all the good things that you have asked for in a detector.



INFORMATION RETRIEVAL NUMBER 94



# Affordable spectrum analysis



## A new 1500 MHz plug-in for HP 180 series Scopes

**Just \$3900.** The 8558B Spectrum Analyzer plug-in is priced low enough to make it practical for every workbench; no need to "timeshare" the expensive analyzer. And since it's part of the HP 180 Scope family, the mainframe can do double-duty using the wide selection of other 180 plug-ins.

**Lab Grade Performance.** Compare the 8558B's frequency and amplitude accuracy against any other analyzer and you'll quickly see how good it is. Frequency response over the full 0.1-1500 MHz range is  $\pm 1$  dB, and there's an LED display of frequency with  $\pm 5$  MHz accuracy. Distortion free dynamic range exceeds 70 dB. Signal levels from +30 dBm to -117 dBm can be measured. Resolution bandwidths from 1 KHz to a wide 3 MHz are provided.

Domestic USA prices only.

**Three Control Simplicity.** For most measurements, you simply set two frequency and one amplitude controls. Resolution bandwidth and sweep time are automatically optimized. Panel markings guide you to control settings that minimize the possibility of errors from signal overloading.

For full information on this tremendous value in spectrum analysis, call your nearest HP field office. Or write.

**HEWLETT  PACKARD**

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



# COOLING COOLING COOLING

ALL DEVICES



## All Types PC Board Coolers



## DIP Clip-Sinks



## Modular Cooling Packages

On the PC board, on extrusions, in modular assemblies: for TO-5's, TO-3's, and all devices including compression-type SCR's and rectifiers: Thermalloy is ready to help you solve your thermal resistance problems.

We have the most complete line of coolers for semiconductor devices in the industry, and because our engineering staff works with our customers for optimum solutions, Thermalloy has become the leading supplier of heat sinks and coolers to the industry.

**Thermalloy  
is number one  
in cooling**



**Thermalloy Inc.**

P. O. BOX 34829  
2021 W. VALLEY VIEW LANE, DALLAS, TEXAS 75234  
PHONE 214-243-4321 / TWX 910-860-5542

INFORMATION RETRIEVAL NUMBER 96

## new literature



### Keyboards

"Applications Unlimited," a four-page two-color brochure, provides data on keyboards and suggests imaginative use of keyboard technology. A companion six-page full-color folder provides color reproductions of all 17 colors in which key-tops are available and the five colors of the anodized aluminum bezels or key-top containers. Bowmar, Fort Wayne, Ind.

CIRCLE NO. 321

### IEEE computer publications

The latest edition of the IEEE Computer Society Publications 16-page catalog covers its full line of computer technology books. Computer Society, Publications Offices, Long Beach, Calif.

CIRCLE NO. 322

### High-voltage assemblies

Fabrication and construction techniques for the company's custom high-voltage assemblies employed in military, aerospace instrument and industrial applications are described in a four-page brochure. Microsemiconductor Corp., Santa Ana, Calif.

CIRCLE NO. 323

### Relay data

The K167 relay test system, which performs all major tests of a relay in any sequence with only one device insertion required, is described in a 22-page brochure. Data include lot summary sheets, data logged parameter values and readily interpreted statistical information, all automatically gathered and presented on CRT display or on hard copy. Teradyne, Boston, Mass.

CIRCLE NO. 324

### Electron tubes and devices

An EEV/M-OV abridged data book details all of the company's products in one publication. A comprehensive equivalents index lists over 3000 types of tubes. English Electric Valve, Chelmsford, CM1 2QU, England.

CIRCLE NO. 325

### LEDs

A LED lamp for panel lighting, film annotation, circuit-status indication, numeric and alphanumeric displays and visual indicators is described in a brochure. Dialight, Brooklyn, N.Y.

CIRCLE NO. 326

### Instrument CRTs

A 16-page catalog provides data on instrument cathode ray tubes with diameters of from 1 to 7 in. Specifications include electrical and physical characteristics, maximum ratings, typical operation, phosphor characteristics, socketting, basing and shielding requirements, mounting considerations and safety precautions. RCA, Harrison, N.J.

CIRCLE NO. 327

### Test equipment

An electronic test equipment catalog includes a complete listing and description of the company's rental equipment. Prices are included. The catalog discusses the advantages of renting equipment and defines the rental, rental/purchase and leasing services available. Rental Electronics, Lexington, Mass.

CIRCLE NO. 328

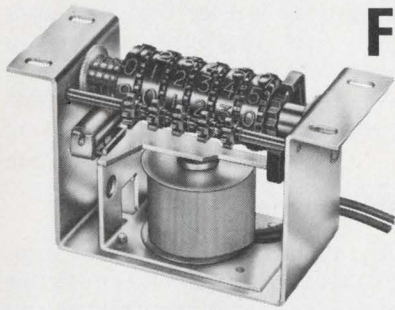
### Finger strips and rings

An eight-page catalog is devoted to finger strips and rings, micro-processed from beryllium copper for use in RFI-EMI shielding. Specifications with schematic drawings are included. Tables indicate attenuation factors at various frequencies. Instrument Specialties, Little Falls, N.J.

CIRCLE NO. 329



# A COMPLETE PRINTER FOR ONLY \$10<sup>00</sup>?



Well,  
maybe...

ENM has another All-American made counter that might enable you to add that printer you've always wanted on your product.

All it takes is a little imagination and ENM's Model EP1 printing counter module. Since it only costs \$7.06 in 1,000 lots, you have about \$3.00 to spend for your own hardware and printing method.

The electric Model EP1 has six large direct reading raised digits for impact, roller, or ballistic printing on self-contained paper, i.e. action paper or carbon card sets. Its flanged open frame construction makes mounting easy, and you have a choice of 24V DC, 24V AC, and 115V AC.

If you want to try one for test, send us \$10.00 and we'll ship one to you out of stock.

WRITE FOR DETAILS

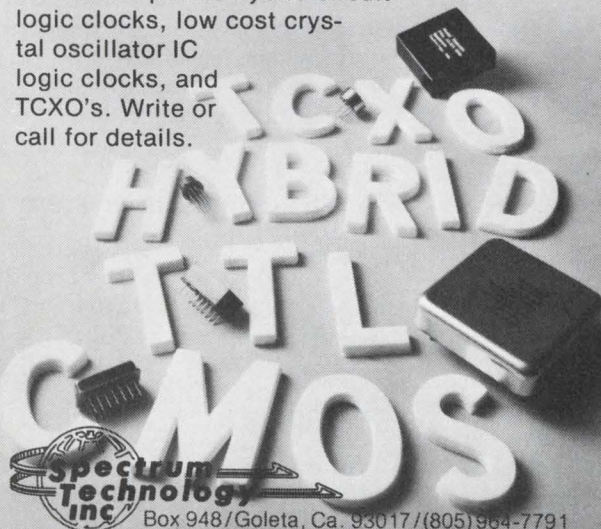
## ENM COMPANY

5340 Northwest Highway • Chicago, Ill. 60630 • (312) 775-8400

INFORMATION RETRIEVAL NUMBER 97

## THE COMPATIBLES

Spectrum Technology is your one source for frequency control devices that are compatible with the high technology logic of the Seventies. Standard, modified or custom designs include subminiature hybrid circuit crystal oscillators, dual in-line low profile hybrid circuit logic clocks, low cost crystal oscillator IC logic clocks, and TCXO's. Write or call for details.



Frequency Control & Timing Systems Products  
Crystal Oscillators • Logic Clocks • TCXO's.

INFORMATION RETRIEVAL NUMBER 98

ELECTRONIC DESIGN 14, July 5, 1974

## DC POWER SUPPLIES

QUALITY — ECONOMY — RELIABILITY

## ALL MODELS IN STOCK

FEATURING:

- IC REGULATION  
.01% LINE, .02% LOAD
- REMOTE SENSING
- EFFICIENCY 50-65%
- .1% TRACKING ACCURACY
- 2 YEAR WARRANTY

## SINGLE OUTPUT



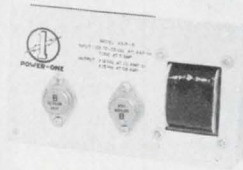
\$27.95 to \$179.95

5 VDC @ 3A TO 35A

15 VDC @ 1.5A TO 15A

24 VDC @ 1.2A TO 12A

## DUAL TRACKING

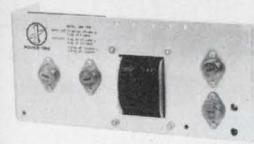


\$42.95 to \$84.95

± 12 VDC OR ± 15 VDC

@ 0.8A TO 3.4A

## TRIPLE OUTPUT



\$69.95 to \$126.95

5 VDC @ 3A TO 12A

AND

± 12 VDC OR ± 15 VDC

@ 0.8A TO 3.4A

For Sales or Technical Assistance Please Call:

Compumech, 2938 Scott Blvd., Santa Clara, Calif. 95050  
(408) 246-6070

Holsapple & Associates, 6840 E. Washington, Indianapolis,  
Indiana 46219, (317) 899-2890

Rave 1, 3131 Stemmons Parkway, Dallas, Texas 75247  
(214) 638-6575

Digital Sales Associates, 9 Spring St., Waltham, Mass. 02154  
(617) 899-4300

Burtis Power Dist., Inc., 6324 Variel, Bldg. 'E', Woodland  
Hills, Calif. 91364, (213) 887-1360



531 DAWSON DRIVE  
CAMARILLO, CA. 93010  
(805) 484-2806

POWER-ONE

INFORMATION RETRIEVAL NUMBER 99



Circuit Designers, Packaging and Production Engineers will find a complete family of easy-to-use, low cost production aids and PCB hardware in this 24 page Packaging Products catalog.

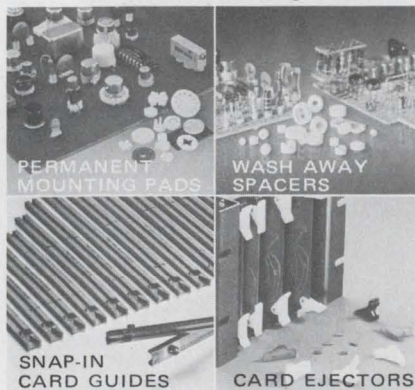
Complete specifications and pricing are included for Permanent and Temporary Mounting Spacers, Snap-in Card Guides and new Card Ejectors.

Easy-to-find data and prices on over 600 standard parts makes this handy digest a must. All items are available from factory stock or through leading local distributors. *BIVAR, Inc.* 1617 E. Edinger Ave., Santa Ana, Ca. 92705 (714) 547-5832.



# circuit & packaging problem solver.

*a brand new digest of cost saving ideas:*

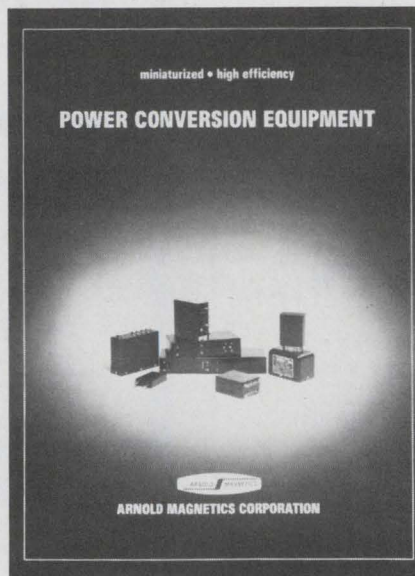


*specific samples on request.*

PACKAGING PROGRESS  
BY **Bivar**

INFORMATION RETRIEVAL NUMBER 100

## NEW LITERATURE



### Power conversion equipment

A 12-page catalog describes ac-dc regulated converters, ac-dc regulated power supplies, dc-dc regulated converters, dc-sine wave inverters and miniature power transformers and inductors. A "design-as-you-order" section provides instructions and technical information to specify custom power conversion systems from standard catalog modules. Arnold Magnetics, Culver City, Calif.

CIRCLE NO. 336

### Microwave diodes

A 32-page microwave diode catalog lists signal generation diodes, multiplier diodes, p-i-n diodes, devices for IC applications, tuning diodes, parametric amplifier diodes, reliability screening and case styles. Varian, Beverly, Mass.

CIRCLE NO. 337

### Circuit breakers

Two hydraulic circuit breakers are covered in a brochure. The Bendix Corp., North Hollywood, Calif.

CIRCLE NO. 338

### Tachometers

A catalog lists 64 types and models of electronic tachometers including industrial tachometers, stroboscopes, magnetic pickups, photoelectric counters, photoelectric pickups, torque meters and pulse generators. Prices are included. Power Instruments, Skokie, Ill.

CIRCLE NO. 339

## Sputtering systems

The latest in sequential sputtering systems is described in a brochure. The brochure contains a selector chart of available models, along with specifications. Materials Research Corp., Orangeburg, N.Y.

CIRCLE NO. 340

## Cable-harnessing systems

An illustrated eight-page brochure features cable-harnessing systems and heat-shrinkable components. Raychem, Menlo Park, Calif.

CIRCLE NO. 341

## Chromatograph system

The application of a process-computer chromatograph system is described in a 12-page brochure. Honeywell's Process Control Div., Fort Washington, Pa.

CIRCLE NO. 342

## Hardware and assemblies

A 57-page catalog describes electronic hardware and assemblies. The brochure contains information on terminal strips, telephone plugs and receptacles and circuitry terminations. Each of three sections shows dimensional drawings, specifications, photographs and model types. A fourth section is a quick-reference manual. Malco, Chicago, Ill.

CIRCLE NO. 343

## High-voltage relays

An eight-page, two-color catalog describes over 88 high-voltage relays for custom applications. The catalog includes photos, dimensional drawings, specifications, prices and ordering information. Magne-craft, Chicago, Ill.

CIRCLE NO. 344

## Data-transmission system

A 32-page technical bulletin provides information for the type 25C data-transmission system. GTE Lenkurt, San Carlos, Calif.

CIRCLE NO. 345

## EMI filters

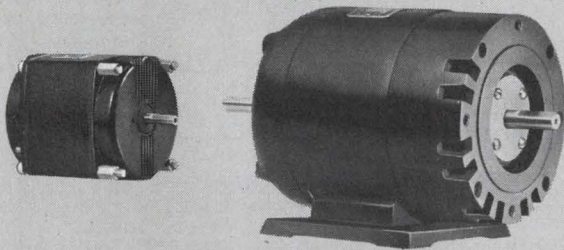
Information on EMI filters for residential, commercial and industrial use is given in a 16-page catalog. Cornell Dubilier Electronics, Newark, N.J.

CIRCLE NO. 346



# now, A-C torque motors from stock

Bodine fhp reversible torque motors are ideally suited for a variety of holding, positioning, tensioning and winding applications.



■ Four models from our popular Type "K-2" and "N" lines ■ For intermittent locked rotor operation at rated voltage and continuous locked rotor duty at reduced voltage ■ Four wire connection arrangement for servo operation ■ Variable voltage power supplies can be used to achieve an infinite number of speed settings ■ Four frame sizes: from 2.405" diam. in the KCI-26 motor to 5.68" in the NCI-55.

**BODINE  
ELECTRIC  
COMPANY**

Write for bulletin MTQ-CI.

Bodine Electric Co., 2554 West Bradley Place, Chicago, Illinois 60618  
INFORMATION RETRIEVAL NUMBER 101

# RF WIDE BAND TRANSFORMERS

- 0.1-500 MHz
- 50 ohm impedance
- 1:1 - 16:1 impedance ratio
- Micro-miniature case

**\$2.95**  
10 piece quantities  
Some models \$3.45



**ONE WEEK DELIVERY!**

Impedance ratios of standard models are 1:1, 2:1, 4:1, 9:1 and 16:1. MCL kit TK-1 includes 2 units of each type and sells for \$32.

We invite you to convince yourself. Place your order now and check our delivery, product performance and reliability.

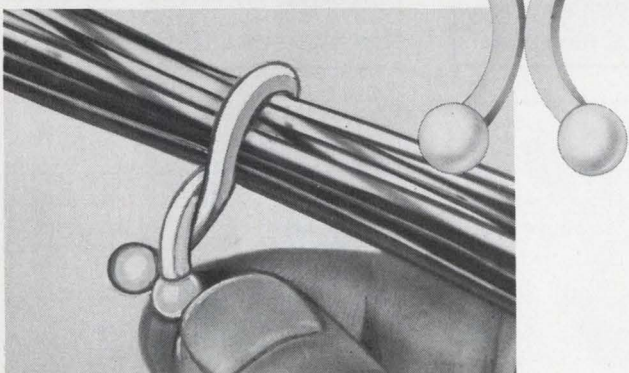
**Mini-Circuits Laboratory**  
A Division Scientific Components Corp.

2913 Quentin Rd., Brooklyn, N.Y. 11229  
(212) 252-5252 Int'l Telex 620156

INFORMATION RETRIEVAL NUMBER 103

# TWIST-LOK®

## A NEAT TWIST



Slip it in place and twist... it's locked. Reusable nylon TWIST-LOK wire ties cut time and costs to help you save a bundle on your bundles... the save and sane way. Available in six colors and four sizes for diameters from .200" to .800".

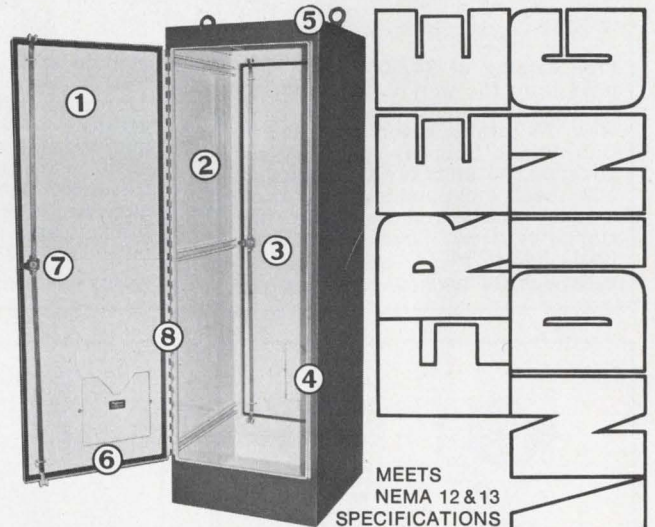
**FREE  
Samples**

**RICHLOK® CORPORATION**

5835 N. Tripp Ave. • Chicago, Ill. 60646 • (312) 539-4061

INFORMATION RETRIEVAL NUMBER 102

ELECTRONIC DESIGN 14, July 5, 1974



MEETS  
NEMA 12 & 13  
SPECIFICATIONS

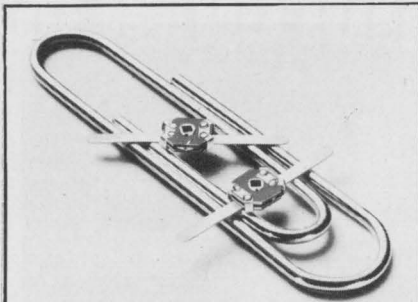
1. Single door or double doors on front or front and back.
  2. Numerous interior panels/relay rack angles available.
  3. Heavy gauge steel.
  4. All seams continuously welded.
  5. Lifting eyes for easy handling.
  6. Neoprene door gasket with oil resistant adhesive and steel retaining strips.
  7. 3-point latching mechanism, oil tight key locking handle.
  8. Heavy gauge continuous hinges.
- For detailed specifications on over thirty different sizes, write for latest bulletins.

**Hoffman® ELECTRICAL ENCLOSURES**

HOFFMAN ENGINEERING COMPANY  
Division of Federal Cartridge Corporation  
Anoka, Minnesota, Dept. ED-75

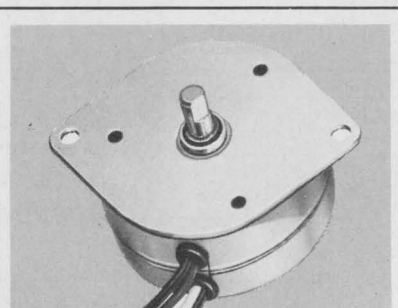
INFORMATION RETRIEVAL NUMBER 104





**Thin-Trim variable capacitors** provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

INFORMATION RETRIEVAL NUMBER 181



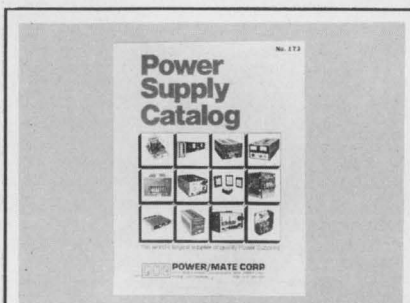
**PM Synchronous Motor.** Low cost motor provides torque to 10 oz-in at 300 RPM rotor. Electric reversibility, instant start/stop, quiet operation, and compact size—2-1/4" dia. x 1-1/8" long. For computer peripherals, control devices, chart drives, etc. ECM Motor Co., 1301 E. Tower Rd., Schaumburg, Ill. 60172. 312/885-4000.

INFORMATION RETRIEVAL NUMBER 184



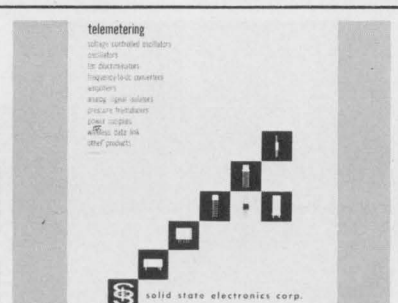
**New miniature D/A's** exhibit settling time as low as 15 nanoseconds under "worst case" conditions. Both the MDS and the MDP Series offer a complete range of 8 and 10-bit converters with 15mA, or +1.5V; or  $\pm 7.5\text{mA}$  at  $\pm 1.1\text{V}$  output. COMPUTER LABS, INC., 1109 South Chapman Street, Greensboro, N. C. 27403. Phone (919) 292-6427.

INFORMATION RETRIEVAL NUMBER 187



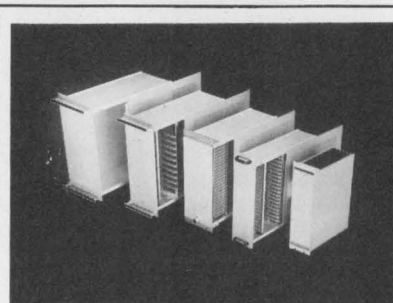
**Free catalog of 34,500 power supplies** from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

INFORMATION RETRIEVAL NUMBER 182



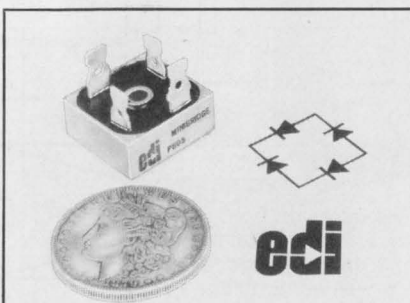
**Module catalogs—FM Telemetry-VCO's discriminators, oscillators, mixers, pressure transducers. Converters — voltage-to-frequency, frequency-to-voltage, phase-to-voltage, signal isolators. Choppers, relays, frequency, sensitive, time delay, analog.** Phone or wire. Solid State Electronics Corp. 15321 Rayen St., Sepulveda, CA 91343. (213) 894-2271.

INFORMATION RETRIEVAL NUMBER 185



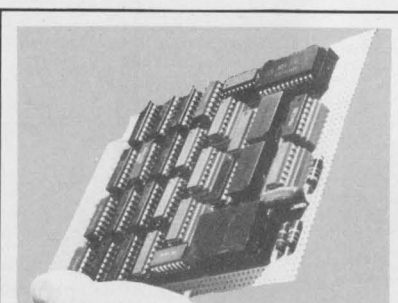
**Precision-engineered prefab modular rack-mounting chassis units, card cages, cabinets & accessories** assemble in many configurations to meet your space requirements. Kits & parts are in stock, ready for shipping. Free catalog includes prices. Techmar Omniclosure, 2232 S. Cotner Ave., Los Angeles, CA 90064, 213-478-0046.

INFORMATION RETRIEVAL NUMBER 188



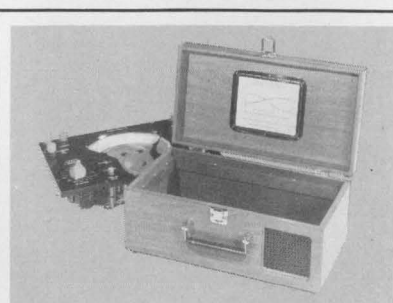
**Silicon Bridge Rectifier.** Fast Recovery: 300 ns. 15 Amp. 50 to 1,000 V. Single phase. Full wave. Heat sink and chassis mounting. Underwriter Lab component recognition. \$4.00 in quantity. Electronic Devices, Inc. 21 Gray Oaks Ave., Yonkers, N.Y. 10710. (914) 965-4400.

INFORMATION RETRIEVAL NUMBER 183



**DIGITAL MATCHED FILTERS CORRELATORS CONVOLVERS.** Ltd. quantities Model 328 (32 word x 8 bit) and Model 2561 (256 word x 1 bit) correlators available. Also custom units built to order. Inputs: Two digital signals, sampling/clock signals, 5V. Output: Correlation product. \$2/word x bit FOB ARO 90 days RCS ASSO., INC. (714) 624-1801.

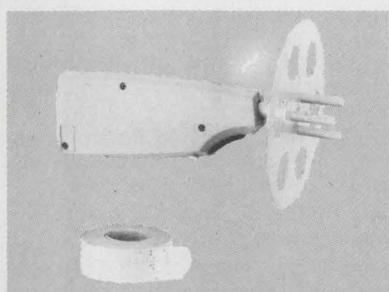
INFORMATION RETRIEVAL NUMBER 186



**Custom<sup>®</sup> made cases, cabinets and enclosures.** Exceptionally rugged construction, laminated Formica-wood-Formica. Internally reinforced corners. Attractive wood grain or solid color exteriors. Superb workmanship, competitive prices, small or quantity lots. W. A. Miller Co., Inc., 306 Mingo Loop, Oquossoc, Maine 04964. Telephone: 207/864-3344.

INFORMATION RETRIEVAL NUMBER 189

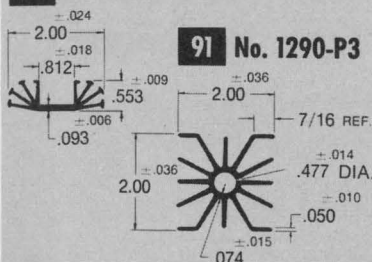




**Hi-Speed Cordless Paper Tape Winder** is light weight, portable and powered by its own internal battery pack. When not in use winder is attached to battery charging stand. Model 1000-1. \$50. A-B Supply Co., P.O. Box 5609, China Lake, Calif. 93555 (714) 375-1385

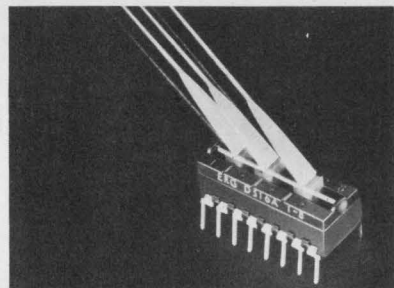
INFORMATION RETRIEVAL NUMBER 190

**37 No. 1284**



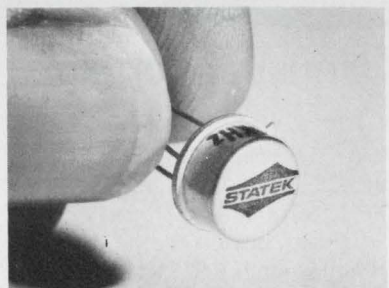
**Heat Sink Extrusions Wall Chart** on 99 dimensioned shapes with Surface Area/Inch; Thermal Resistance in °C/W per 3" length Nat. Conv.; Lbs/Ft; Scale 1/4" = 1". 2 Tech Articles also be sent: "Treat the Heat Sink as a System" & "Liquid Cooling High Power Semis." WAKEFIELD ENGINEERING, INC., Wakefield, Ma. 01880

INFORMATION RETRIEVAL NUMBER 193



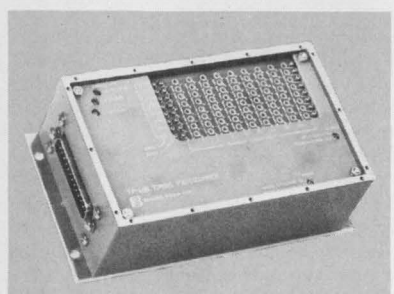
**DILswitch 16**, dual-in-line switch. Rated at 28V 250mA (240V and 2A carry) with gold on nickel plating for low level circuits. Sixteen standard types stocked including 1p/8w, 2p/4w and 4p/2w. Prices from about \$1.40 (100 rate). Erg Components, Luton Road, Dunstable, Bedfordshire, LU5 4LJ, England. Telex 82349. Telephone Dunstable 62241.

INFORMATION RETRIEVAL NUMBER 191



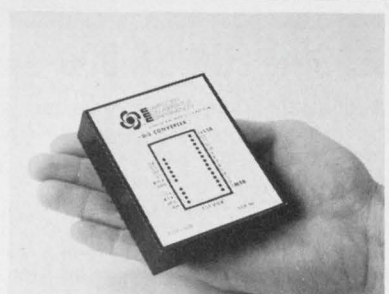
**Don't count down.** Use SX-1 10 kHz - 300 kHz Quartz Crystals • 20 stock frequencies • 0.185" high TO-5 • 1000g shock & 50g vibration • \$2.00 ea. in 1000 qty. (±0.01% accuracy) • STATEK CORP. • 1233 Alvarez Ave. • Orange, Calif. 92668 • (714) 639-7810 • Telex 65-5430.

INFORMATION RETRIEVAL NUMBER 194



**Timing programmer**—Activates 8 external relays in a preprogrammed sequence or relative to the starting time. Timing selectable in 0.25, 0.5, or 1 second increments to over 1000 seconds. Applications include rockets, missiles and aircraft.—BAYSHORE SYSTEMS—Springfield, Va.

INFORMATION RETRIEVAL NUMBER 192



**Digital to synchro converters**—14, 12 or 10 bit input, 11.8/90V, 400 or 60Hz transformer isolated output, accuracy ±4, ±15 or ±30 min. Driving 1VA, 2VA (2.6" x 3.1" x 82"H module) or 5 VA loads (4 1/2" x 9 1/4" pc card). Price from \$350 in qty. Computer Conversions Corp., East Northport, N.Y. 11731. (516) 261-3300.

INFORMATION RETRIEVAL NUMBER 195

Advertisers wishing to reserve Quick Ad units should note the following mechanical requirements: Specs—Supply glossy photo of product and approximately 40 words which will set no more than 10 lines of 34 characters each. AFTER SUBMISSION NO COPY CHANGES CAN BE ACCEPTED. Quick Ads cost only \$300 per insertion, less for frequency advertisers.

**RATES:**

1x  
\$300

7x  
\$280

13x  
\$255

19x  
\$250

26x  
\$245

39x  
\$240

52x  
\$235

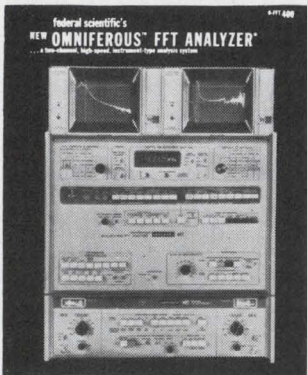
104x  
\$230



# Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card (Advertisement)

## Dual Hi-Speed FFT Processor Easy to Operate



Conceived from the point of view of the operating engineer rather than the computer programmer, the new Omniferous™ FFT Analyzer operates like an instrument, calculates like a computer. This Series OF-400 Analyzer is a universal digital signal analysis system for real-time viewing of changing functions, a complete instrument with all signal conditioning and display calibration built-in. For the first time an operator can observe transfer function, cross-spectra or coherence as the signal is changing without waiting for the analyzer to perform successive laborious calculations.

Features include high speed of 60,000 samples/sec throughput, and high resolution with a 2048 transform size and extra-sharp input anti-aliasing filtering. Calculates FFT, IFFT, power spectra, auto-correlation, cross correlation, and signal enhancement (time averaging), as well as the averaging of any calculated function in sum, peak or exponential mode.

The system excels in high dynamic range, ease of use, display flexibility with two simultaneous display outputs, frequency coverage to 100 kHz, and reasonable cost. Designed by the originators of the famous Ubiquitous® family of real-time spectrum analyzers.

CIRCLE NO. 171

### Federal Scientific Corp.

An affil. of Nicolet Instrument

615 West 131st St., New York, N.Y. 10027 (212) 286-4400

## Giant Free Catalog! 4,500 Unusual Bargains



New 164-page catalog! Packed with 1,000's of hard-to-find buys in Optics, Science, Electronics. Loaded with optical, scientific, electronic equipment available from stock. Rare surplus buys. Many "one-of-a-kinds". Ingenious scientific tools. Components galore: lenses, prisms, wedges, mirrors, mounts, accessories. 100's of instruments: pollution test equipment, lasers, comparators, magnifiers, microscopes, projectors, telescopes, binoculars, photo attachments, unique lighting. Shop, save by mail! Request free Catalog "DA"

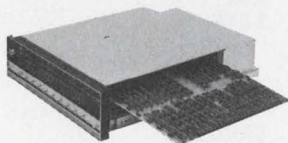
CIRCLE NO. 172

### Edmund Scientific Co.

America's Largest Science-Optics-Electronics Mart

300 Edscorp Bldg., Barrington, New Jersey 08007 (609) 547-3488

## FAST FOURIER TRANSFORM PROCESSOR FOR \$6,000



The 306/MFFT Fast Fourier Transform Processor is delivered with all control programs and plugs directly into any Data General Nova computer. It offers a complete Fourier Transform capability including Forward and Inverse FFT, Spectral magnitude, Hanning Weighting, and Complex Multiplication. Arrays from 16 to 16,384 real samples can be processed. An array of 1024 real samples is transformed in only 139 ms.

Time domain signal processing functions, such as correlation and convolution, can be calculated utilizing the high speed array operations  $X$ ,  $\div$ ,  $+$ ,  $-$ ,  $\sqrt$  and  $\Sigma$ .

Call or write today for brochures on 306/MFFT or Elsytec's complete line of Fourier Spectrum Analyzers and Higher Speed Hardware Fast Fourier Transform Processors.

CIRCLE NO. 173

### ELSYTEC INC.

212 Michael Drive, Syosset, New York 11791 (516) 364-0560

# Electronic Design

ELECTRONIC DESIGN's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

**Want a subscription?** ELECTRONIC DESIGN is sent free to qualified engineers and engineering managers doing design work, supervising design or setting standards in the United States and Western Europe. For a free subscription, use the application form bound in the magazine. If none is included, write to us direct for an application form.

If you do not qualify, you may take out a paid subscription for \$30 a year in the U.S.A., \$40 a year elsewhere. Single copies are \$1.50 each.

**If you change your address,** send us an old mailing label and your new address; there is generally a postcard for this bound in the magazine. You will have to requalify to continue receiving ELECTRONIC DESIGN free.

**The accuracy policy** of ELECTRONIC DESIGN is:

- To make diligent efforts to ensure the accuracy of editorial matter.
- To publish prompt corrections whenever inaccuracies are brought to your attention. Corrections appear in "Across the Desk."
- To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.
- To refuse any advertisement deemed to be misleading or fraudulent.

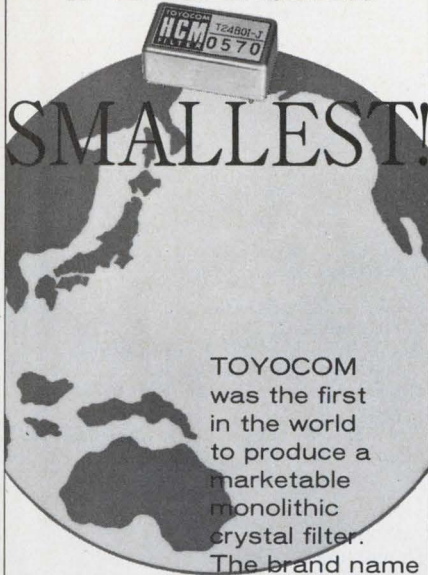
Microfilm copies are available of complete volumes of ELECTRONIC DESIGN at \$19 per volume, beginning with Volume 1, 1961 through Volume 20. Reprints of individual articles may be obtained for \$2.00 each, prepaid (\$.50 for each additional copy of the same article) no matter how long the article. For further details and to place orders, contact the Customer Services Department, University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106 telephone (313) 761-4700.

**Want to contact us?** If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor  
ELECTRONIC DESIGN  
50 Essex Street  
Rochelle Park, N.J. 07662



## TOYO HCM FILTER T-2 SERIES

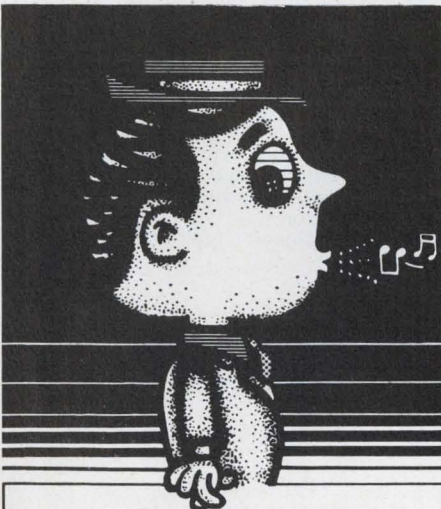


TOYO COM was the first in the world to produce a marketable monolithic crystal filter. The brand name was designated TOYO HCM FILTER.



EXPORT DEPARTMENT  
TOYO BUILDING, NO. 6-12-20, JINGUJMAE,  
SHIBUYA-KU, TOKYO, JAPAN  
CABLE: EXPORTOYOCOM-TOKYO  
TEL: (03) 406-3355  
TELEX: 02423001

INFORMATION RETRIEVAL NUMBER 105



**you're whistling  
in the dark.**

... if you haven't had your blood pressure checked lately. You could have high blood pressure and not know it. It can lead to stroke, heart and kidney failure. See your doctor—only he can tell.

For information  
Ask your Heart  
Association



## Electronic Design

### Advertising Sales Staff

Tom W. Carr  
Vice President &  
Sales Manager

### Rochelle Park, N.J. 07662

Robert W. Gascoigne  
Daniel J. Rowland  
(Recruitment, Quick Ads, Classified)  
50 Essex Street  
(201) 843-0550  
TWX: 710-990-5071

### Philadelphia

Thomas P. Barth  
50 Essex Street  
Rochelle Park, N.J. 07662  
(201) 843-0550

### Boston 02178

Gene Pritchard  
P.O. Box 379  
Belmont, Mass. 02178  
(617) 489-2340

### Chicago 60611

Thomas P. Kavooras  
Berry Conner, Jr.  
200 East Ontario  
(312) 337-0588

### Cleveland

Thomas P. Kavooras  
(Chicago)  
(312) 337-0588  
(call collect)

### Los Angeles 90303

Stanley I. Ehrenclou  
Burt Underwood  
2930 Imperial Highway  
Inglewood, Calif.  
(213) 757-0183

### San Francisco 94022

Jerry D. Latta  
P.O. Box 1248  
Los Altos, Calif.  
(415) 965-2636

### London

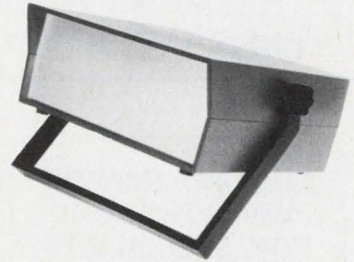
For United Kingdom and Europe  
John Ashcraft  
John Ashcraft & Co.  
12, Bear St.  
Leicester Square  
London WC2H 7AS England  
Phone: 01-930-0525  
W. J. M. Sanders  
John Ashcraft & Co.  
Herengracht 365  
Amsterdam C., Holland  
Phone: 020-24-09-08

### Tokyo

Haruki Hirayama  
Electronic Media Service  
5th Floor, Lila Bldg.,  
4-9-8 Roppong  
Minato-ku  
Phone: 402-4556  
Cable: Electronicmedia, Tokyo



## ELECTRONIC ENCLOSURE



Approximate size:  
3"H x 5"D x 7"W

Tracewell Enclosures are versatile, inexpensive, and adapt easily to a wide variety of stock or specialized applications.

The flat front panel readily accepts a wide range of digital panel meter sizes and can be easily punched and silkscreened. Both front and rear panels are 1/16 inch anodized aluminum; the exterior is 1/8 inch high-impact plastic.

Inside are molded-in vertical grooves for mounting printed circuit boards. The first four grooves are designed for many different style digital readouts. There are also molded-in standoffs for horizontal mounting. Several options including under-dash mounting bracket and height increase spacers are available.



**TRACEWELL ENCLOSURES, INC.**

200 Montrose Way

Columbus, Ohio 43214

INFORMATION RETRIEVAL NUMBER 106

## 2-WAY



## POWER DIVIDER

MODEL T-1000

- 10 MHz-1GHz Frequency Range
- 25dB Isolation
- 1 11/32" Square by 3/4"
- \$90/Stock Availability

**anzac**  
ELECTRONICS



39 Green Street, Waltham, Mass.

(617) 899-1900 • TWX 710-324-6484

INFORMATION RETRIEVAL NUMBER 107

157



# recruitment and classified ads

## SAME DAY SHIPMENT

Minis & Peripherals  
PDP SPECIALISTS  
8, 8I, 8L & 11

NEW 300 LPM  
PRINTERS

PDI CARD READERS

BRPE PUNCHES

\$750 Minis

TELETYPE 35 & 37  
DEC & HONEYWELL Modules  
617/261-1100

Send for Free Report "Maintenance  
of Computers"

AMERICAN USED COMPUTER CORP.

P.O. Box 68, Kenmore Sta.  
Boston, MA 02215

Members Computer Dealers Association

CIRCLE NO. 239

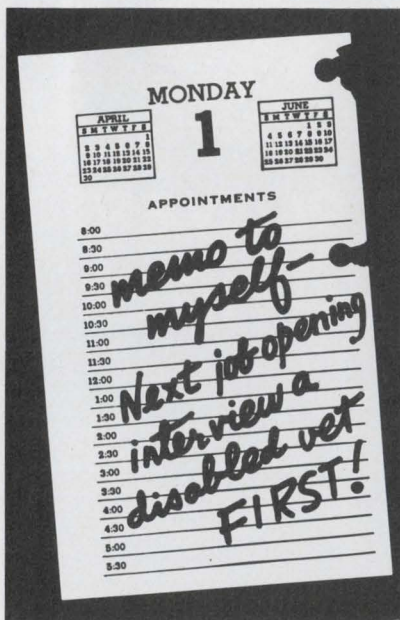
## SCOPES UNLIMITED IS NOT LIMITED TO SCOPES

Complete line of new and used  
electronic test equipment.

SCOPES UNLIMITED, INC.

1938 S. Anaheim Blvd.  
Anaheim, Ca. 92805  
(714) 772-0330

East Coast Office (617) 894-5670



The President's Committee  
on Employment of the Handicapped  
Washington, D.C. 20210

# advertiser's index

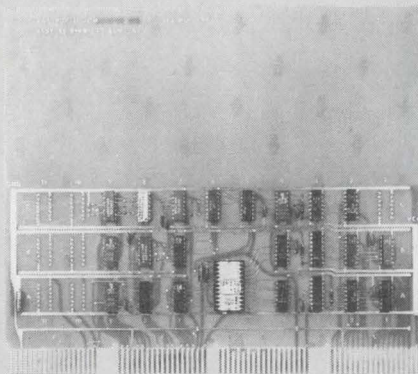
Advertiser	Page	Advertiser	Page
A. B. Supply Co. ....	155	GTE Automatic Electric .....	48, 49
ACDC Electronics, Inc. ....	20	GTE Sylvania .....	19
AMP, Incorporated .....	52	General Instrument Corporation, Semiconductor Division .....	90, 91
Acopian Corp. ....	109	General Semiconductor Industries, Inc. ....	130
Allen Bradley Co. ....	46	Gold Book, The .....	104, 105
American Optical Corporation .....	136	Gould, Inc. ....	140
Amperex Electronics Corporation .....	145		
Amphenol, Bunker-Ramo .....	144	Hamamatsu Corp. ....	148
Amphenol RF Division, The Bunker-Ramo Corporation .....	41	Hamlin, Inc. ....	81
Anzac Electronics .....	157	Hayden Book Company, Inc. ....	155
Applied Data Communications .....	159	*Hayden Book Company, Inc. ....	48
		Hewlett-Packard .....	2, 47, 82, 83, 149
Bayshore Systems .....	155	Hoffman Engineering Company .....	153
Bead Electronics .....	161	Hughes Aircraft Company, Connecting Devices .....	23
Belden Corporation .....	8, 9	Hughes Aircraft Company, Electron Dynamics Division .....	129
Bell, Inc., F. W. ....	136		
Bendix Corporation, The, Electrical Components Division ...	45	ITT Cannon, A Division of International Telephone and Telegraph Corporation .....	50, 140
Bivar, Inc. ....	152	Industrial Electronic Engineers, Inc. ....	88, 89
Bodine Electric Company .....	153	Inselek, Inc. ....	113
Bourns, Inc. Trimpot Products Division .....	39	Instruments for Industry, Inc. ....	146
Bud Radio, Inc. ....	74, 75	Intel Corporation .....	4, 5
		Intech, Incorporated .....	132
CTS Corporation .....	137	International Electronic Research Corporation .....	118
Centralab, The Electronics Division of Globe-Union, Inc. ....	24, 25, 26	Ise International Corporation .....	143
Cherry Electrical Products Corp. ....	115		
Computer Automation, Inc. ....	15	Jermyn Industries .....	57
Computer Conversions .....	155	Johanson Manufacturing Corp. ....	7, 154
Computer Labs, Inc. ....	154	Johnson Company, E. F. ....	27
Control Data Corporation .....	147		
		Keithley Instruments, Inc. ....	14
Data Display Products .....	128	Kinsekisha Laboratory Ltd. ....	159
Delta Products, Inc. ....	139	Kooltronics Inc. ....	161
Dialight Corporation .....	37		
Diva, Inc. ....	135	LH Research, Inc. ....	60
Dow Corning Corporation .....	10, 11, 124, 125, 127	Lemo USA, Inc. ....	22
Dynascan Corporation .....	98	Littlefuse, Subsidiary of Tracor....	12, 13
		Litton Industries, Advanced Circuitry .....	17, 18
ECM Motor Co. ....	154		
EECO .....	121	MCL, Inc. ....	120
EMN Company .....	151	Magnecraft Electric Company Cover III Microswitch, A Division of Honeywell .....	21
ERG Industrial Corp. ....	155	Miller Co., W. A. ....	154
Edmund Scientific Company .....	156	Mini-Circuits Laboratory .....	153
*Electronic Design .....	26	Molon .....	144
Electronic Devices .....	154		
Electronic Navigation Industries .....	122		
Elsytec, Inc. ....	156		
Exact Electronics, Inc. ....	159		
Exar Integrated Systems .....	1		
FMC Corporation .....	133		
Federal Scientific Corporation .....	156		
Futaba Industries .....	44		



Advertiser	Page
NCR Corporation .....	141
National Semiconductor Corporation .....	18A
North American Philips Controls Corp. ....	80
Optima, A Division of Scientific Atlanta, Inc. ....	51
Owens-Illinois, Inc. ....	99
*Philips Electronic Components and Materials .....	
Pico Electronics, Inc. ....	Cover II
Pomona Electronics Co., Inc. ....	96
Power/Mate Corp. ....	154
Power-One, Inc. ....	151
RCS Assocs. ....	155
RCA Solid State .....	Cover IV
Reader Service Card .....	162A, 162B
Rhombus Industries, Inc. ....	160
Richlok Corporation .....	153
Rolm Corporation .....	18D
Rotron, Inc. ....	97
Schauer Manufacturing Corp. ....	142
Semtech Corporation .....	43
Siemens Corporation .....	123
Signetics Corporation .....	18B, 18C
Siliconix, Incorporated .....	58
Simpson Electric Company .....	131
Solid State Electronics .....	154
Spectrum Technology Inc. ....	151
Sprague Electric Company .....	16
Statek Corp. ....	155
Standard Condenser Corporation .....	138
T.D.J. Company Inc. ....	148
TRW Semiconductors, an Electronic Components Division of TRW, Inc. ....	28
Tally Corporation .....	134
Techmar Omniclosure .....	154
Tektronix, Inc. ....	33, 55
Teledyne Relays, A Teledyne Company .....	31
Themalloy Company .....	150
Toyo Communication Equipment Co., Ltd. ....	157
Tracewell Enclosures Inc. ....	157
Triplett Corporation .....	111
United Systems Corporation .....	61
Vactec, Inc. ....	35
Viking Industries Inc. ....	117
Wakefield Engineering .....	155
Woven Electronics .....	6
Xerox Corporation .....	56

\*Advertisers in non-U.S. edition

## ROM for DEC PDP-11



- Bootstrap loader
- 128 or 256 word capacity
- Re-programmable
- DEC quad board
- Address jumper selectable

Model 20-100 . . . \$450

Optional ROM programming service available

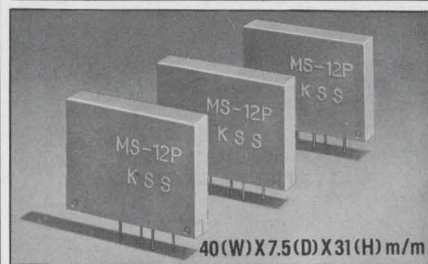
**ADC** APPLIED DATA COMMUNICATIONS

1509 East McFadden Avenue  
Santa Ana, California 92705  
Telephone: (714) 547-6954

Also . . .  
program loaders  
3M tape cartridge  
and  
floppy disk  
systems

INFORMATION RETRIEVAL NUMBER 109

**WOULD YOU BELIEVE?  
..... THE SMALLEST  
IN THE WORLD!**



**1H SOLID DELAY LINE**  
The MS-12 delay line is a small 1H type developed for video dropout compensation.  
The MS-11P is a color television receiver use delay line.

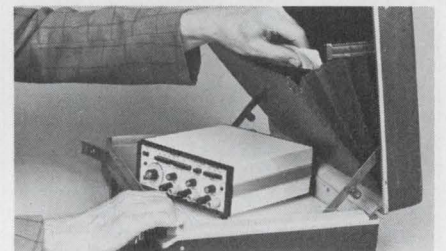
Items	Type	Unit	MS-12P	MS-11P
Nominal frequency	MHz		4.433619	4.433619
Nominal delay time	μS		63.1943	63.1943
Delay tolerance	ns		±30	±5
Bandwidth	MHz		±1	±1
Insertion loss	dB		12±3	8±3
Spurious	dB		20	3rd 22 others 30

Hour of Crystal...  
**Kinsekisha Laboratory Ltd.**

• Head Office & Plant: 23-17, 2-chome Miyasaka, Setagaya-ku, Tokyo, Japan. Tel: 429-2111  
• Mail Address: Central P.O. Box 350, Tokyo, Japan. • Cable Address: CRYSTAL TOKYO

INFORMATION RETRIEVAL NUMBER 110

## HIDE IT....



It fits nicely into your desk drawer, briefcase, glove compartment or under your arm. But more importantly, Exact's new Model 190 Function Generator fits your signal source needs from 0.1 Hz to 1 MHz with sine, square, triangle, pulse and ramp waveforms. VCF input, TTL pulse output, DC offset, too, all for only . . .

# \$245

f.o.b. Hillsboro, Oregon

**EXACT**  
electronics, inc.

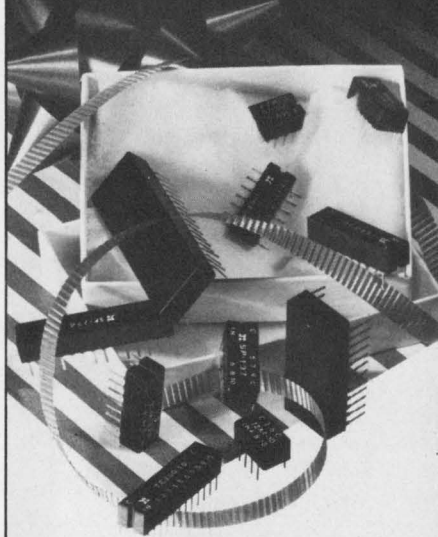
(A Subsidiary of Danalab, Inc.)

BOX 160, HILLSBORO, OREGON 97123  
(503) 648-6661 TWX 910-460-8811

INFORMATION RETRIEVAL NUMBER 111



# SURPRISE!



## dip

### DELAY LINES

Stop looking for DIP packaged electromagnetic delay lines . . . you've found 'em! Mini dip's, standard dip's, low profile dip's and double dip's . . . all with unmatched performance.

Leads	Length	Width	Height
8*	.510	.300	.225
14*	.750	.300	.225
16*	.850	.300	.225
20*	1.050	.300	.225
24*	1.250	.300	.225
28*	1.450	.300	.225
14*	.750	.300	.175
16*	.850	.300	.175
24	1.300	.600	.235
34	1.975	.600	.235

\*Also available in flat pack configurations.

#### SPECIFICATION HIGHLIGHTS

- Tap capabilities from 500 ps to 25 ns
- Delays from 5 ns to 1000 ns
- Rise time ratios from 5:1 to 30:1
- Std. impedances of 50, 75, 100 ohms
- Frequency capabilities to 300 MHz
- Temp. -55 to +125°C (TC 70 PPM/°C)
- Manufactured to MIL-D-23859; environmental to MIL-STD-202

Phone, wire or write for more information today!



**RHOMBUS  
INDUSTRIES INC.**

22119 S. Vermont Ave., Torrance, Ca. 90502  
(213) 325-7440 • TWX 910-349-7512

## 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.

Category	Page	IRN	Category	Page	IRN
<b>Components</b>			displays	81	50
arrestor, gas tube	144	303	LEDs (NL)	150	326
capacitors	7	6	phototransistors	35	28
capacitors	16	14	power chips	130	72
capacitors	138	81	power rectifier	56	42
connectors, micro-miniature	140	83	protector, transient	148	308
delay line	159	109	rectifier	133	75
delay lines	160	112	rectifiers, bridge	91	54
displays	44	33	semiconductors	145	90
displays	89	53	transistor, high freq.	148	310
fan cooling	144	301	transistors	125	70
fans	144	88	transistors, high-V	148	320
filter connectors	45	34	<b>Instrumentation</b>		
indicator lights	13	10	air conditioner	161	114
indicator lights	37	29	chromatograph system (NL)	152	342
indicator lights	128	71	curve tracer	119	250
indicators and annunciators	88	52	DMM	120	258
motors, ac torque	153	101	DMM, autoranging	14	11
motors, stepping	144	89	DPM	119	251
potentiometers	39	30	fiberscope	136	78
readouts	143	87	frequency control devices	151	99
relay	140	295	function generator	120	257
relays	49	37	function generator	159	111
relays, DIP	31	26	ignition system	139	82
resistors	26	23	multi-function tester	119	254
resistors, film	46	35	multimeter, 3-1/2-digit	98	57
sensor, optical prox.	142	298	oscilloscope	55	41
switch, toggle	140	294	power amplifier broad-band	146	91
switches, keyboard	115	63	pulse generator	119	255
switches, proximity	80	49	pulse generator	120	256
switches, pushbutton	21	16	recorder	119	252
switches, slide	142	300	scope	119	253
transformer, pc	142	299	spectrum analyzer	149	95
transformers	80	48	tachometers (NL)	152	339
transformers	11	243	VOM, digital	131	73
transformers, small	144	302	VOMs	111	61
transient suppressor	142	297	<b>Integrated Circuits</b>		
trimmer capacitor	140	296	integrated circuits	5	4
trimmers, cermet	137	80	one-shot, dual	122	262
<b>Data Processing</b>			RAMs	122	260
calculator	82	51	ROM	159	109
computers	15	12	regulators	122	259
controller, disc	128	274	SOS/CMOS ICs	113	67
data acquisition system	47	36	semiconductors	123	69
data acquisition system	140	84	shift register	122	261
digitizer, tablet	126	267	<b>Microwaves &amp; Lasers</b>		
disc system	135	201	amplifier, TWT	120	66
magnetic tape transport	147	92	horns	146	307
memory, cartridge	127	269	microwave diodes (NL)	152	337
memory, disc	126	264	mixer, double-balanced	146	306
microcomputer	126	268	power divider	157	107
microprocessor	128	271	switches	146	305
printer, graphic	126	265	tetrode	146	304
printer, serial	126	266	transistors, microwave	28	25
printer, ticket	127	270	<b>Modules &amp; Subassemblies</b>		
printing counter module	151	98	amplifiers, servo	130	278
reader, tape	126	263	control, photoelectric	132	279
recorders, digital	61	46	control, speed	132	282
terminal, computer	128	272	controller, motor	134	283
terminal, graphic	128	273	controller, propoat.	134	285
<b>Discrete Semiconductors</b>					
diodes, zener	142	86			
display, LED 7-segment	148	309			



Category	Page	IRN
converter, d/a	132	281
converter, d/s	130	277
delay, time	132	280
modules, control	134	286
op amp, high voltage	130	276
oscillator, crystal	130	275
rf power amplifier	122	68
tachometer, control	134	284

#### Packaging & Materials

adjustable curve	138	290
boards, multilayer	17	240
box, plastic	136	287
cable	6	5
cable harnessing systems (NL)	152	341
cable, ribbon	23	18
card puller	138	292
connectors	50	38
connectors	52	40
connectors	117	64
connectors	161	113
connectors, coaxial	27	24
connectors, multicontact	22	19
dip clip	96	55
enclosures	51	39
enclosures	75	47
enclosures	148	93
enclosures	153	104
enclosures	157	106
heat pipe	138	291
heat pipes	129	72
noise absorption material	136	288
PCB hardware	152	100
packaging system	118	65
patching plug, logic	138	293
rubber silicone	136	289
silicones	11	121
socket card	121	67
wire, cable and card	9	234
wire ties	153	102

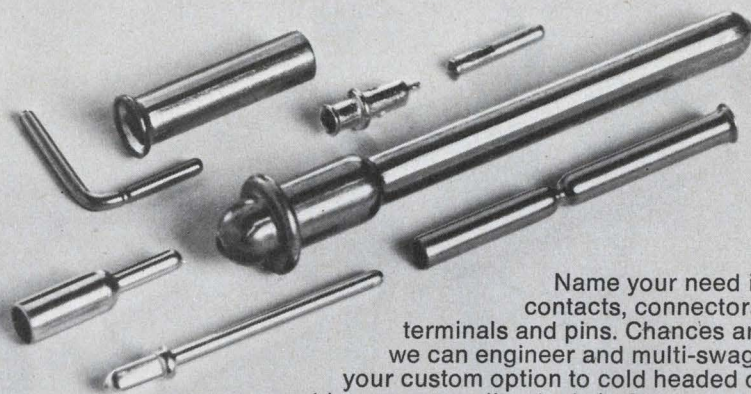
#### Power Sources

power modules	109	60
power supplies	60	45
power supplies, dc	20	15

#### new literature

cable harnessing systems	152	341
chromatograph systems	152	342
circuit breakers	152	338
data transmission system	152	345
EMI filters	152	346
electron tubes and devices	150	325
finger strips and rings	150	329
hardware and assemblies	152	343
high voltage assemblies	150	323
high-voltage relays	152	344
IEEE computers publications	150	322
instrument CRTs	150	327
keyboards	150	321
LEDs	150	326
microwave diodes	152	337
power conversion equipment	152	336
relay data	150	324
sputtering systems	152	340
tachometers	152	339
test equipment	150	328

## custom options at compact prices



Name your need in contacts, connectors, terminals and pins. Chances are we can engineer and multi-swage your custom option to cold headed or machine screw quality. And slash your costs 40% or more. Delivery is when you want it, too. Get all the details in our new catalog. Write or call.



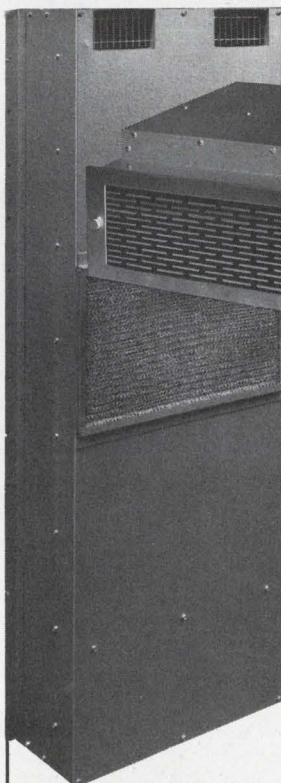
### bead electronics

A Division of Bead Chain Manufacturing Co.  
58 Mountain Grove St., Bridgeport, Conn. 06605  
Phone: (203) 334-4124

"See us at Nepcon 74 East Booth 4734"

INFORMATION RETRIEVAL NUMBER 113

#### KOOLTRONIC AIR CONDITIONERS



# COOL and PROTECT

ON-LINE ELECTRONIC SYSTEMS

Kooltronic air conditioners employ closed-circuit cooling to remove heat from sealed electronic enclosures. You can be assured of proper operating temperatures with the equipment fully protected from harsh on-line environments.

Use Kooltronic air conditioners to cool cabinets as much as 50°F below ambient. A full line of models is available for removing up to 12,000 BTU/hr. Rack mounted models take as little as 7 inches of panel space — vertical models mount entirely outside the enclosure.

Kooltronic also offers air-to-air heat exchangers that remove up to 2,000 watts of heat load from a sealed cabinet with a 20°F maximum internal temperature rise above ambient. Water-to-air heat exchangers and water-cooled air conditioners can be supplied for extreme environments.

Ask for free design guide for use in specifying cooling equipment. Write Kooltronic, Inc., Box 504, Princeton, N.J. 08540. Tel: (609) 799-1466.

# KOOLTRONIC®

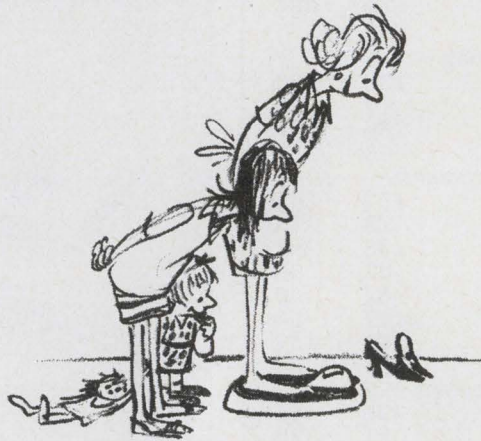
INFORMATION RETRIEVAL NUMBER 114



# Are you setting a good example for your kids...



by avoiding cigarettes?



by keeping weight normal?



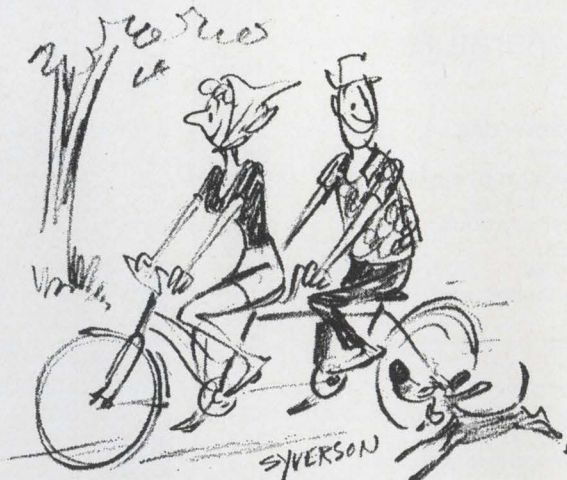
by serving tasty, low-fat foods?



by seeing your doctor regularly?



by not being a TV athlete...



but by exercising moderately instead?

Help your children form good living habits now  
to reduce their risk of heart attack later.

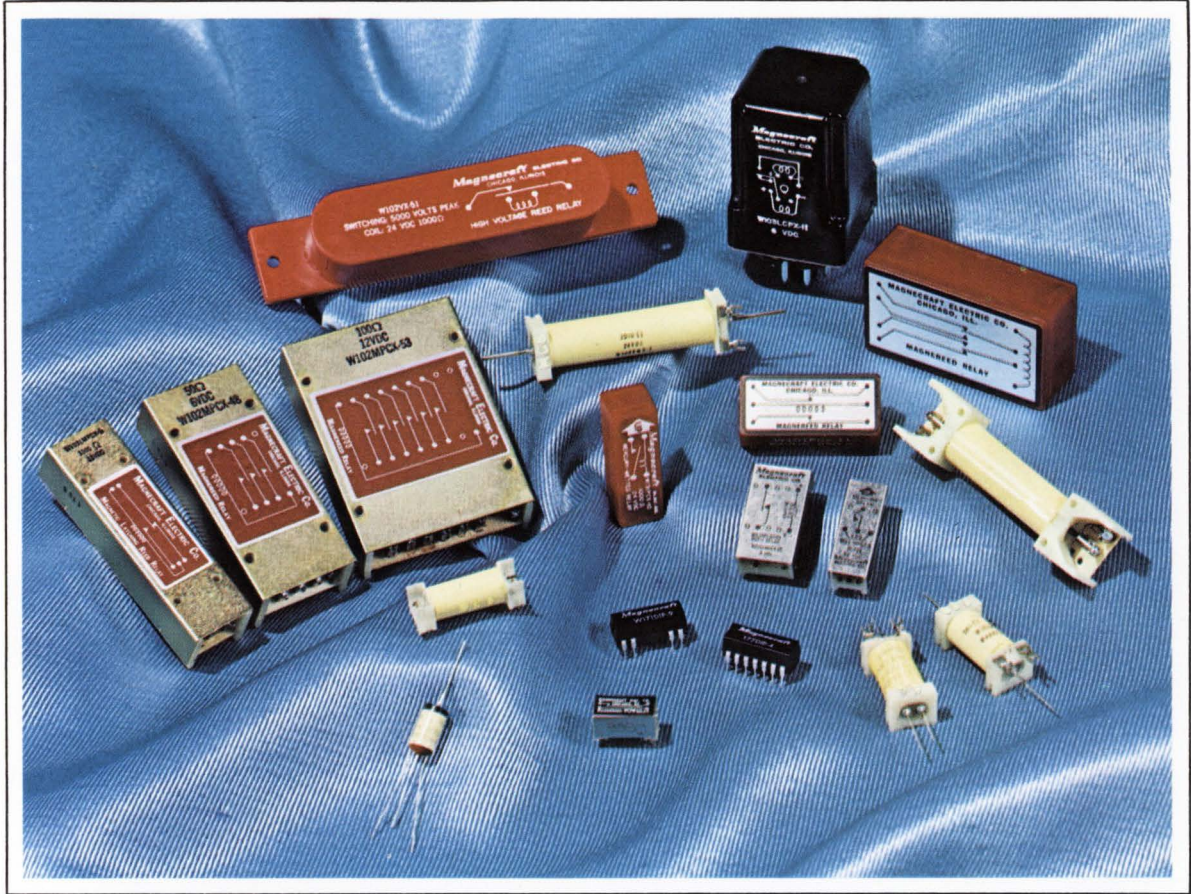
Help your Heart... Help your Heart Fund 

Contributed by the Publisher



Reed Relays in Stock with Long Life & Versatility

# READY REEDS



The Ready Reeds are ready for you! Over 290 high quality types of reed relays are in stock for immediate delivery. A wide variety of hermetically sealed contact combinations and packaging techniques are available. Versions offered include; dry, mercury-wetted, sensitive, latching, power, high voltage, time delay, electro-statically shielded, and dual-inline-package DIP's.

Magnecraft's reed relays can provide almost everything that a designer would want in order to accomplish a high speed switching function. The versatility of the relay is so great that it can be custom-fitted to almost any application at a lower cost in dollars and power and in a smaller space than almost any other device, conventional or solid state.

The photo above portrays the reed relay packaging characteristics available: epoxy encapsulated, axial leads, plug-in, eight and fourteen pin dual-inline-package, open styles, and standard, miniature, and micro miniature printed circuit packages.

Our nationwide network of distributors and Chicago plant stand ready to serve your applications. But, if you don't find what you need in stock we will make it for you!



**Free!**  
STOCK CATALOG

To help specify all your relay needs, ask for Magnecraft's new 1974 Stock Catalog with the most diversified line of over 1060 relays. A 68 page Designers Handbook and Catalog of Reed and Mercury Wetted Contact Relays with specific data drawings, and photos on all the various relays will accompany the Stock Catalog.

Find Magnecraft Relays in EEM sec. 4500.

**Magnecraft** ELECTRIC COMPANY

5575 NORTH LYNCH AVENUE • CHICAGO, ILLINOIS 60630 • 312 • 282-5500 • TWX-910-221-5221





## **The flat-as-a-pancake TV. If you want to design one tomorrow, we're ready with your linear IC's today.**

Whatever the idea you put on paper, we can probably help bring it to life.

Whether you want to design the world's flattest TV or the world's most advanced oscilloscope, chances are we've got the devices for the circuit functions you need to achieve your goals. Ready now to help your product perform the way you design it. And supply your needs in numbers from one to one million and beyond.

We're a full house in linear IC's offering standard as well as custom and proprietary types; a commodity supplier of power transistors; a recognized leader in CMOS building blocks; developers of liquid crystal displays; technology innovators of RF power components; and a major supplier of thyristors.

In addition to comprehensive technical product data, RCA gives you professional and experienced field engineering and applications

support. As well as a commitment to excellence in everything from research to manufacturing.

So whatever you're into, and whatever you need, we're here when you need us. With products that can anticipate your needs. And service that can meet your demands. A good place to start is to check our handy product line guide. Write RCA Solid State, Section 57G5, Box 3200, Somerville, N. J. 08876.

**RCA** Solid State