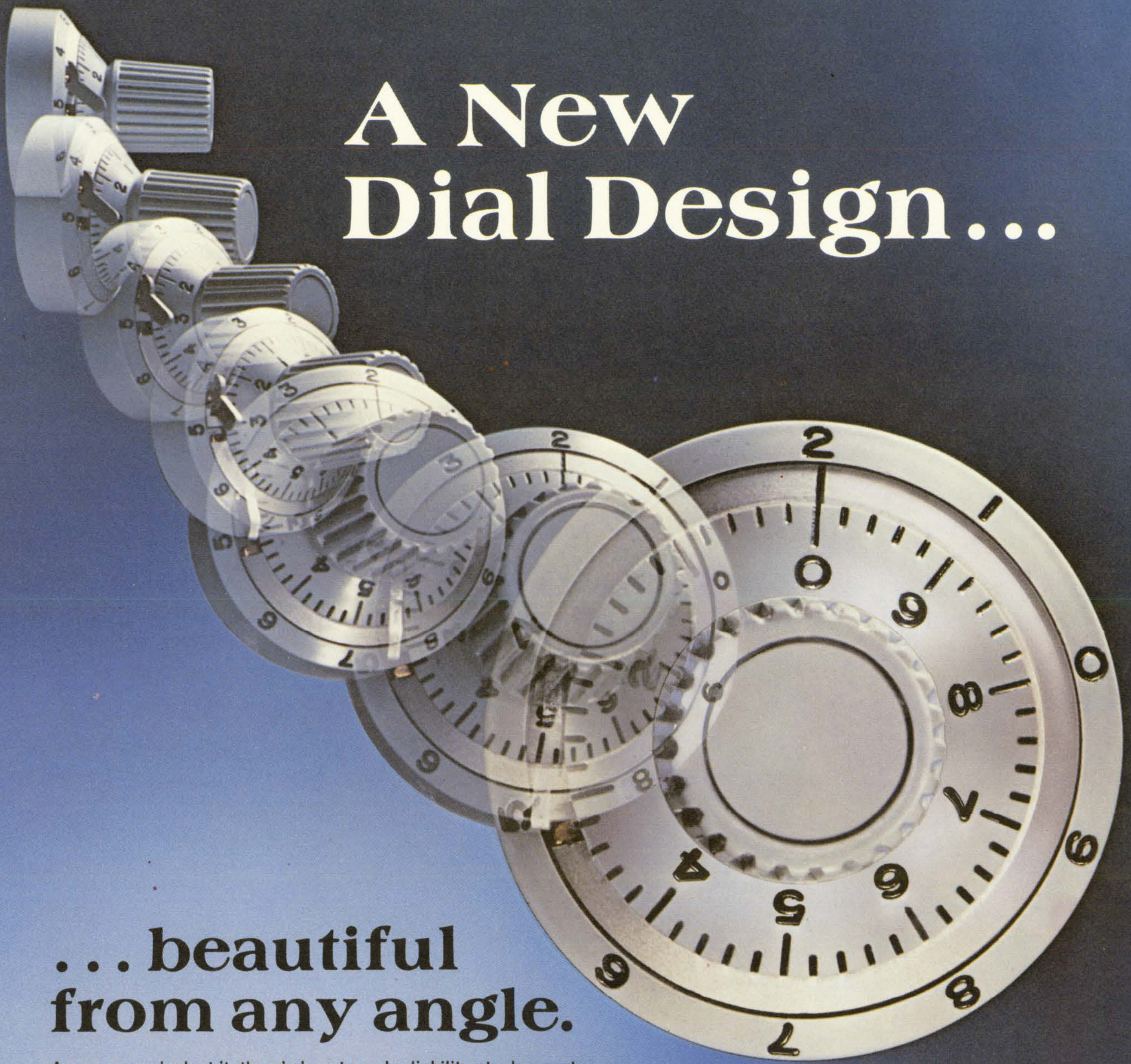
VOL. 25 NO.

Electronic Design 19

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 13, 1977

Analog subsystems are needed to interface microcomputers with the real world of analog signals. In process control, transducers for temperature, pressure and flow cannot be directly connected to a microcomputer. The interface board for data acquisition must bridge the gap. But will the cost be compatible? Plug in on p. 26.



A New Dial Design...

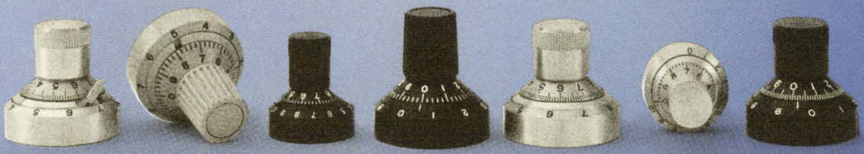
...beautiful from any angle.

Any way you look at it, there's beauty and reliability at a low cost in our new Model H-1400 turns-counting dial. From the smooth, high impact tapered plastic design . . . to the big, bold legible numbers . . . this dial will add to the aesthetics of any control panel. But, with beauty being only skin deep, we've put durable long-lasting metal inside where it counts — including the gears and set -screw thread insert. And, the price is just as attractive — only $4.26* in production quantities!

Send today for complete technical data and discover a beautiful new angle in turns- counting dials — from Bourns, naturally! Direct or through your local distributor.

TRIMPOT PRODUCTS DIVISION, BOURNS, INC. 1200 Columbia Ave., Riverside, CA 92507 Phone: 714 781-5123. TWX: 910 332-1252

*Domestic U.S.A. price only, H1411, without brake.



BOURNS®

International Marketing Offices: European Headquarters — Switzerland 042/23 22 42 • Belgium 02/218 2005 • France 01/2039633 • Germany 0711/24 29 36 • Italy 02/32 56 88 • Netherlands 70/87 44 00 • United Kingdom 01/572 6531 • Norway 2/71 18 72 • Sweden 764/20 110 • Japan 075/921 9111 • Australia 02/55-0411 03/95-9566 • Israel 77 71 15/6/7

For Immediate Application — Circle 130
or for Future Application — Circle 230

VOL. 25 NO.

Electronic Design® 19

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 13, 1977

News

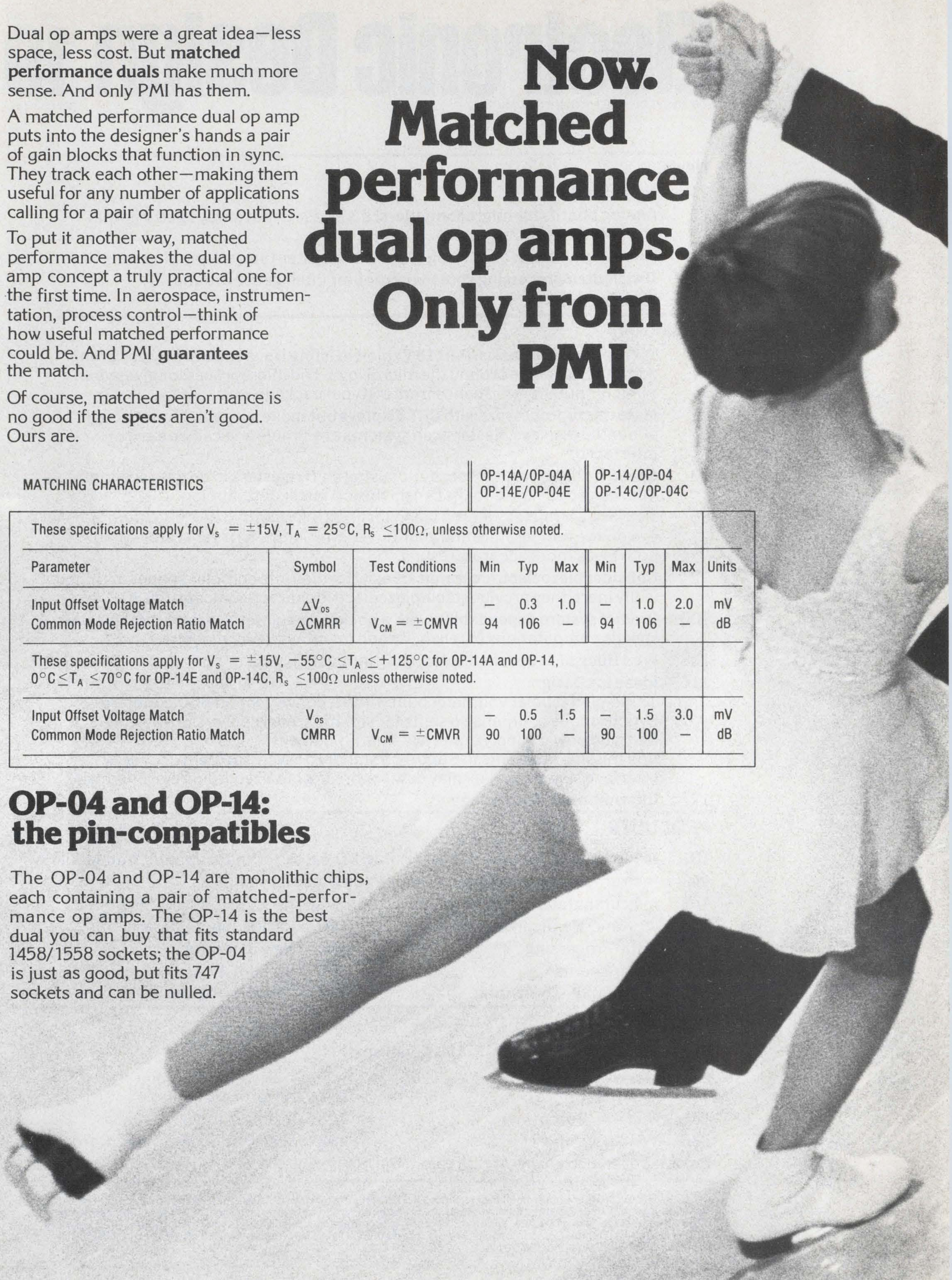
Technology

PRODUCTS

DEPARTMENTS

Cover: Cover design by Art Director, Bill Kelly.

ELECTRONIC DESIGN is published biweekly except 3 issues in July by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN. Controlled circulation postage paid at Waseca, MN and New York, NY, postage pending Rochelle Park, NJ, Atlanta, GA. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.



Dual op amps were a great idea—less space, less cost. But **matched performance duals** make much more sense. And only PMI has them.

A matched performance dual op amp puts into the designer's hands a pair of gain blocks that function in sync. They track each other—making them useful for any number of applications calling for a pair of matching outputs.

To put it another way, matched performance makes the dual op amp concept a truly practical one for the first time. In aerospace, instrumentation, process control—think of how useful matched performance could be. And PMI **guarantees** the match.

Of course, matched performance is no good if the **specs** aren't good. Ours are.

Now. Matched performance dual op amps. Only from PMI.

MATCHING CHARACTERISTICS

Parameter	Symbol	Test Conditions	OP-14A/OP-04A OP-14E/OP-04E Min	Typ	Max	OP-14/OP-04 OP-14C/OP-04C Min	Typ	Max	Units
These specifications apply for $V_s = \pm15V$, $T_A = 25°C$, $R_s \leq 100\Omega$, unless otherwise noted.									
Input Offset Voltage Match	ΔV_{os}		—	0.3	1.0	—	1.0	2.0	mV
Common Mode Rejection Ratio Match	ΔCMRR	$V_{CM} = \pm$CMVR	94	106	—	94	106	—	dB
These specifications apply for $V_s = \pm15V$, $-55°C \leq T_A \leq +125°C$ for OP-14A and OP-14, $0°C \leq T_A \leq 70°C$ for OP-14E and OP-14C, $R_s \leq 100\Omega$ unless otherwise noted.									
Input Offset Voltage Match	V_{os}		—	0.5	1.5	—	1.5	3.0	mV
Common Mode Rejection Ratio Match	CMRR	$V_{CM} = \pm$CMVR	90	100	—	90	100	—	dB

OP-04 and OP-14: the pin-compatibles

The OP-04 and OP-14 are monolithic chips, each containing a pair of matched-performance op amps. The OP-14 is the best dual you can buy that fits standard 1458/1558 sockets; the OP-04 is just as good, but fits 747 sockets and can be nulled.

OP-10: the only precision dual

The OP-10 is a nullable precision device consisting of two discrete chips in a single 14-pin DIP. Think of it particularly for instrumentation, where its extremely high performance is of greatest value. You could look at the OP-10 as two OP-05's in a single package. Military standard models are available.

The OP-10 will save you costly and laborious selection and matching of discrete amplifiers. Matching specifications include V_{OS}, I_B, I_{OS}, CMRR, PSRR; drift for V_{OS}, I_B and I_{OS} match with temperature.

When you think of matched-performance duals, remember: either they're unavailable or they're PMI parts. And ours are **available** now—on your distributor's shelf. Write on your letterhead for samples and applications notes.

Precision Monolithics Incorporated
1500 Space Park Drive, Santa Clara, California 95050.
Telephone: (408) 246-9222. TWX: 910-338-0528.
Cable: MONO.

MATCHING CHARACTERISTICS			OP-10AY			OP-10Y			
These specifications apply for $V_s = \pm 15V$, $T_A = 25°C$, unless otherwise noted.									
Parameter	Symbol	Test Conditions	Min	Typ	Max	Min	Typ	Max	Units
Input Offset Voltage Match	ΔV_{os}		—	0.07	0.18	—	0.12	0.5	mV
Average Non-Inverting Bias Current	$I_B +$		—	±1.0	±3.0	—	±1.3	±4.5	nA
Non-Inverting Offset Current	$I_{os} +$		—	0.8	2.8	—	1.1	4.5	nA
Inverting Offset Current	$I_{os} -$		—	0.8	2.8	—	1.1	4.5	nA
Common Mode Rejection Ratio Match	Δ CMRR	$V_{CM} = \pm$CMVR	114	123	—	106	120	—	dB
Power Supply Rejection Ratio Match	Δ PSRR	$V_s = \pm 3V$ to $\pm 18V$	100	112	—	94	110	—	dB
Channel Separation			126	140	—	126	140	—	dB

PMI®

CIRCLE NUMBER 6

Sr. Vice President, Publisher
Peter Coley

Editors

Editorial Offices
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Cable: Haydenpubs Rochellepark

Editor-in-Chief George Rostky

Managing Editors:
Ralph Dobriner
Michael Elphick

Senior Associate Editor
Stanley Runyon

Associate Editors:
Sid Adlerstein
Dave Bursky
Morris Grossman
Gene Heftman
Andy Santoni
Max Schindler

Contributing Editors:
Peter N. Budzilovich, Jules H. Gilder, John Kessler, Nathan Sussman

Editorial Field Offices

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

West
Dick Hackmeister, Western Editor
8939 S. Sepulveda Blvd., Suite 414
Los Angeles, CA 90045
(213) 641-6544
TWX: 1-910-328-7240

Dave Barnes, Western Editor
465 S. Mathilda, Suite 302
Sunnyvale, CA 94086
(408) 736-6667

Editorial Production

Marjorie A. Duffy, Production Editor
James Keane, Copy Editor

Art

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

Production

Manager, Dollie S. Viebig
Helen De Polo, Nancy Hurey

Circulation

Director, Barbara Freundlich

Information Retrieval

Paula Greenleaf

Advertising Promotion

Judith Nappo

Reprints

Maxine Correal

Across the desk

A baby trolley?

Your news story on the mother and baby elephants in the Rose Bowl parade (ED No. 2, Jan. 18, 1977, p. 15) evoked memories of a similar "float" on Engineers' Day at Ohio State University in the spring of 1940, which I attended as a high school senior from London, OH.

Electrical engineering students had built a battery-powered model of the Toonerville trolley from which they controlled (or tried to!) a baby trolley by radio. Straight-away control was O.K., but the baby usually ended up against the curb when the parade turned a corner.

William P. Reid
Staff Engineer

Otis Elevator Co.
Engineering Center
440 Franklin Turnpike
Mahwah, NJ 07430

When in Germany...

In "IR-Activated Headphone Works without A Cord" (ED No. 3, Feb. 1, 1977, p. 13), you described a device that I saw and tried out in a hi-fi store in Germany in the summer of 1975.

I don't know if Sennheiser Electronics Corp. was aware of the existence of the German device, but let's give credit where credit is due. The address of the German maker is Loewe Opta GmbH, Berlin Kronach, Germany.

Wolfgang Fischer
Project Engineer

Kepco, Inc.
131-38 Sanford Ave.
Flushing, NY 11352

About our counter...

I was very interested in Stan Runyon's review of all the frequency counters (ED No. 11, May 24, 1977, p. 54), but was sorry to see that our AIM-1005 did not get a mention. Maybe because it does not have a display for humans to read but is intended to be read by a microcomputer? It has gate times from 10 μs to one hour, which give it greater dynamic range than all the eight-digit counters, and at a fraction of the cost.

We also have a multiplexer so that 16 different frequencies can be measured at the same time. The data for the 16 channels are stored in the multiplexer memory so that the microcomputer can have direct access to the data without having to wait for a reading. How do you interface one of the 'SUPER' counters to a $1000 microcomputer and how much does it cost?

E. Barry Hilton
President

Automated Industrial Measurements Inc.
P.O. Box 125
Wayland, MA 01778

Misplaced Caption Dept.

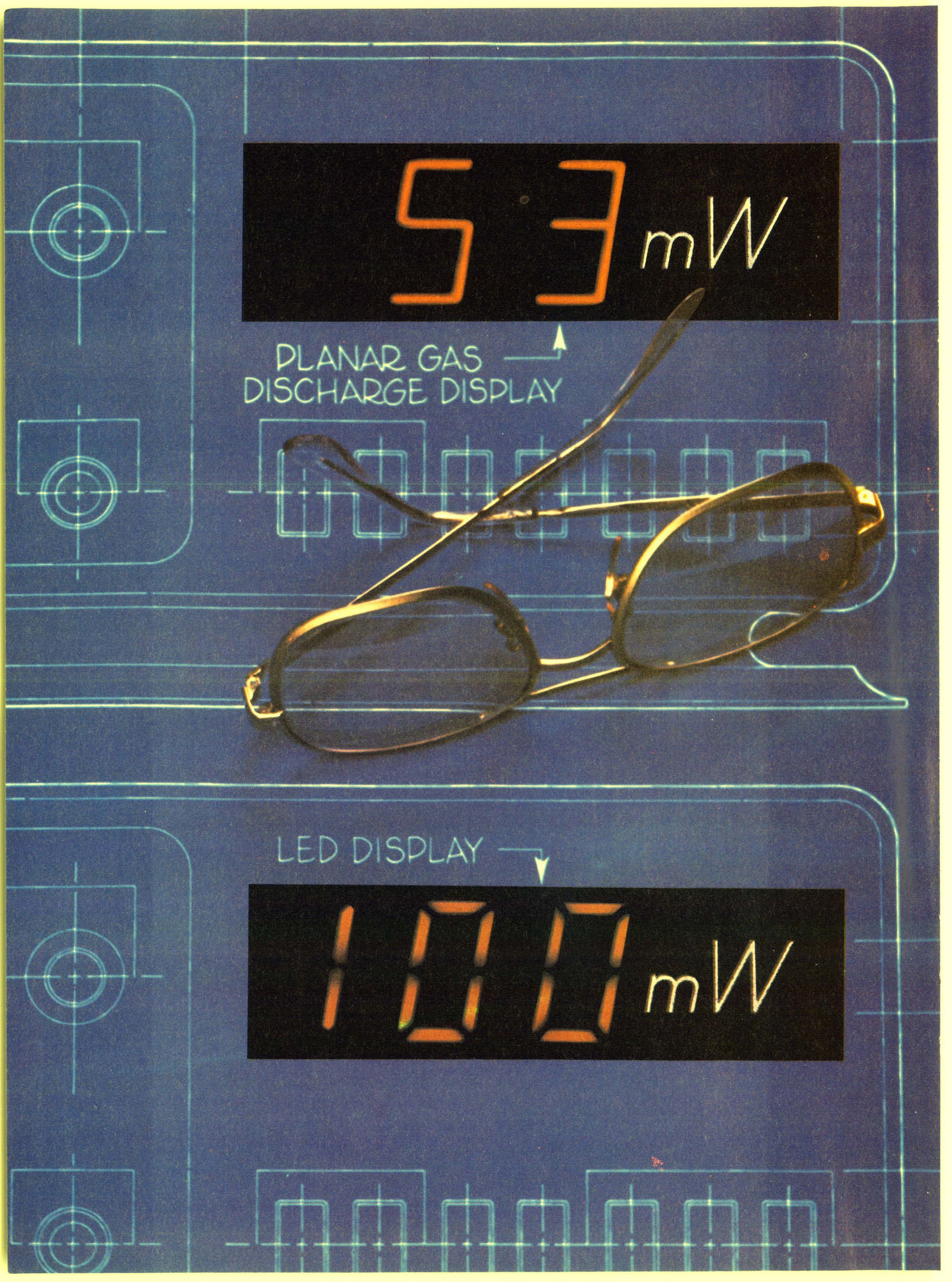
He's a very creative engineer so we tolerate some idiosyncracies.

Sorry. That's Lucas Cranach the Elder's "Cardinal Albrecht as Saint Jerome," which hangs in the John and Mable Ringling Museum of Art, Sarasota, FL.

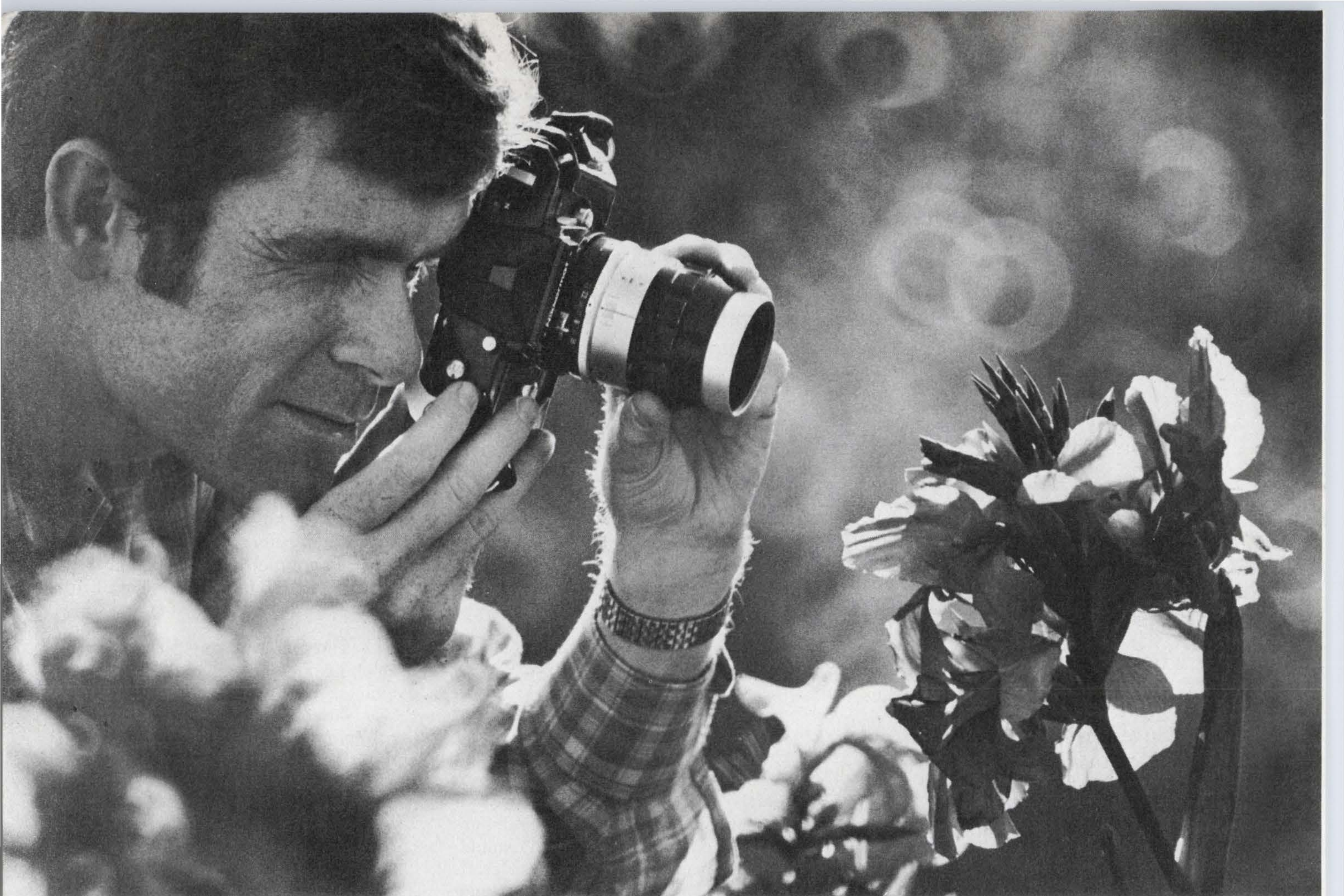
Viva second sources

After reading the article, "8080As Are Not All Alike" (ED No. 2, Jan. 18, 1977, p. 41), I couldn't help but make

(continued on page 16)



53 mW
PLANAR GAS
DISCHARGE DISPLAY
LED DISPLAY
100 mW



Circuits for systems that count.

Save space, time and system cost with Intersil counting and timing microcircuits.

For event timing, unit counting and frequency generation, Intersil has a line of circuits second to none. You get solid state reliability and size reduction, plus the time- and money-saving benefits of just the right product for your job...from Intersil.

Intersil stocking distributors: Advent Electronics, Inc. (Indianapolis); Arrow Electronics; Century Electronics; Components Plus (N.Y.); Diplomat (Fla., N.J.); Elmar/Liberty Electronics; Harvey (Upper N.Y.); Intermark (San Fran.); Kierulff Electronics; L Comp (Mo.); R.A.E. Ind. Elect. Ltd. (Van. B.C.); RESCO (Raleigh, N.C.); Schweber Electronics; Sheridan Assoc.; Zentronics (Canada).

Your best source for SCRs is one you may never have heard of.

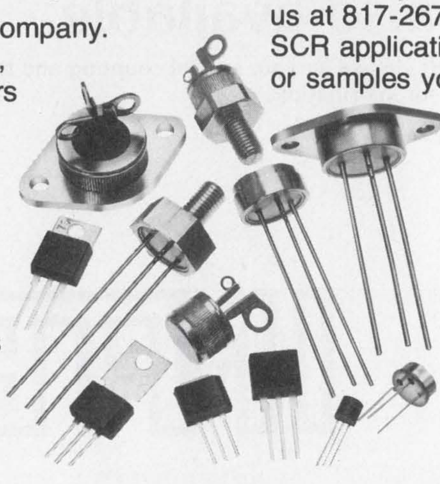
Would you believe Teccor? That's right. Teccor.

We're not a small components company. In fact, with over 1,000 employees, 3 plants, and over 16 million dollars in sales, we're not small at all.

Our reputation for dependable quality is known around the world. Has been for 13 years.

To give you the design flexibility you want, we offer the widest selection of SCR package designs in the industry.

At the same money you're paying now — maybe less.



Contact your local Teccor representative or call us at 817-267-2601. Tell us about your specific SCR applications. We'll get you the information or samples you need for evaluation.

You may not know us, but we figure it's only a matter of time.

Just think of us as the world's largest unknown source for SCRs.

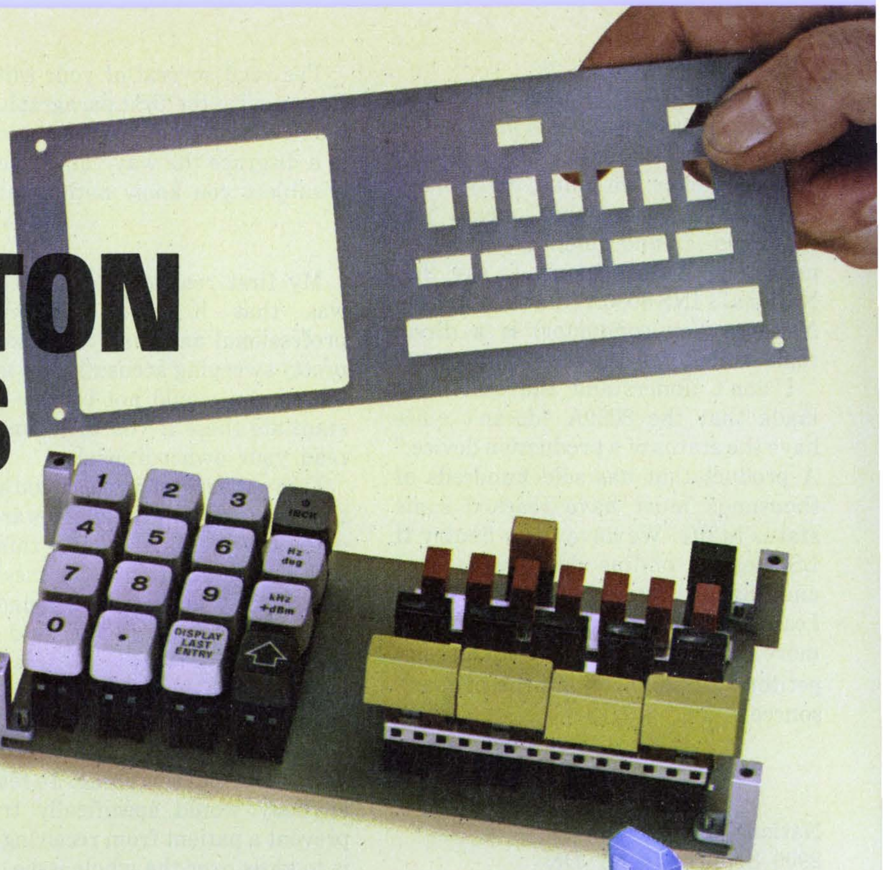
TECCOR

TECCOR ELECTRONICS, INC.
P.O. Box 669 Euless, Texas 76039

CIRCLE NUMBER 10

New from Centralab...

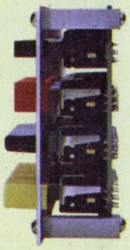
IMPS PUSHBUTTON SWITCHES



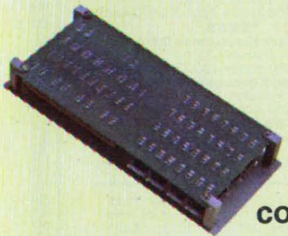
A new miniature modular building block system that offers microprocessor control designers more of what they need.

To meet the special digital and analog needs of today's μP-based controls, Centralab offers design engineers a whole new system of modular push-button switch building blocks. We call it IMPS — Integrated Modular Panel System. IMPS saves PC board and panel area and simplifies front panel design, cuts assembly costs, reduces back-panel space requirements, and meets the digital-analog needs of μP-based controls. Check these space saving, cost-cutting features.

Simplify front panel interface.



All IMPS switches regardless of function, are uniform in size, simplifying design and selection of front panel hardware. They have high volumetric efficiency, occupying .505" x .388" PC board area and require only .608" of space between PC board and front panel.



Cut assembly costs.

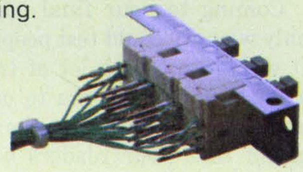
IMPS switches may be mounted on the front panel, and are designed for automatic wave soldering installation and PC board cleaning. Insert molded terminals prevent flux and solder wicking and contact contamination. Integral PC board stand-offs provide for efficient board cleaning.

Meet analog and digital needs.

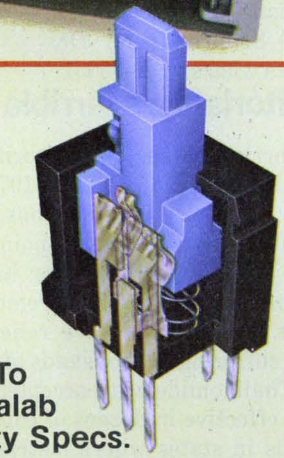
IMPS switches are available with momentary, push-push and interlocking actions, with a long-life contact system that switches both digital and analog signals. To accommodate critical signal requirements, housings are high-insulation molded plastic with UL 94V-0 rating.

Available options.

Optional installations include ganged assemblies, front-panel mounting and wire-wrapping.



All IMPS pushbutton switches are built to Centralab's highest quality standards (see specifications at right). They're priced as low as 41 cents in 1,000 quantity. For full technical details, samples and quotation, call (515) 955-3770, or write to the address below.



Built To Centralab Quality Specs.

IMPS Pushbutton Switches combine compact size, low cost and highest quality throughout.

- Silver or gold inlay wiping contacts for long-life and low-contact resistance.
- Less than 2 milliseconds contact bounce.
- SPST, SPDT, DPST, and DPDT switch contacts.
- Printed circuit, DIL socket or wire-wrap terminations available.
- 2.5 to 3.5 oz. actuation force (momentary).
- Choice of button interface — square or blade shaft (shown) — permits use of a variety of Centralab and industry standard buttons and keycaps.
- 10, 15, 20 or 25mm center-to-center spacing.

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

CIRCLE NUMBER 11

(continued from page 7)
a comment. I was amazed to find that "having an exact copy" of a product has become a disadvantage. At National Semiconductor, we found, early in our life, that "second-source" means just that: form, fit and function—no better, no worse. We are happy to say that National's INS 8080A (that's *I*ntel from *N*ational *S*emiconductor) is a direct replacement for Intel.

I don't understand the statement made that the 8080A "doesn't quite have the status of a production device." A product that has sold hundreds of thousands must have reached some status in life. We have three Sentry II LSI testers on-line doing wafer-sort and final testing on the 8080A. I believe I can safely say that our 8080A is tested more thoroughly than any of our competitors' parts (including the primary source).

Gene Carter
Director
Microprocessor Marketing
National Semiconductor
2900 Semiconductor Dr.
Santa Clara, CA 95051

Editorial was terrible

Sorry, George, your editorial on professionals (ED 15, July 19, 1977) wasn't very. My specific objections:

1)Laetrile has been annointed Vitamin B_{17} by its proponents; its need in human nutrition is not remotely evident. 2) Placebos have relieved pain and suffering in thousands of patients. 3) Thalidomide was accepted as safe and effective in dozens of countries. 4) Raids in states where laetrile is legal were conducted against those alleged to be shipping the drug across state lines. 5) Tests on real, dying *people* have not proven the drug effective. If you have evidence to the contrary, let's see it! 6) Your "dread diseases" are all vitamin-deficiency diseases. They have been conquered by the kind of careful scientific thought that is entirely absent in the laetrile controversy.

If you want to write about laetrile, learn the real issues, learn the facts. Then, and only then, express your opinion. I don't care if you write about medicine in a magazine directed to EEs, but I believe most engineers are better scientists than most doctors, so please don't offend them by defending this classic example of poor scientific method.

I'm appalled!

Gene James
Overly Manufacturing Co.
Greensburg, PA 15601

I've read several of your editorials. I agree with the first paragraph of this one. I couldn't believe the rest of it! It is a disgrace the way you wrote about a subject you know nothing about!

Anonymous

My first reaction to your editorial was that it was extremely unprofessional and that you made some pretty sweeping accusations. I am convinced you would not be able to substantiate these if you took time to reread your own editorial.

I am not sure why you should assume such a vitriolic attitude towards the medical profession. Do you think it is fair in your position to air these opinions if they are not well founded?

I am fortunate in the field of orthopedics not to have to treat many people with cancer. Each such encounter is a painful and difficult task, which usually involves a considerable amount of soul searching. To read that anybody would specifically try and prevent a patient from receiving a cure is to gloss over the whole issue. I have seen people who have been treated with laetrile and it is a very distressing negative result.

Your reference to the various vitamins is inappropriate and I think you should fudge up your knowledge on the history of vitamin deficiency. Just remember why a limey was called a limey, and remember it was not the medical profession, it was the seafaring people who objected to carrying excessive lime.

Coming to your final paragraph, I only wish we could test people like ICs. It would save us a lot of trouble and a lot of grief. For you to use that as a comparison is perhaps the only paragraph that your readers will understand.

My immediate reaction to your editorial was to withdraw my subscription. However, I do not need to read your editorials and I certainly enjoy reading the rest of the magazine.

William R. Risk, M.D.
Pontiac, MI 48053

Your editorial on laetrile shows the great distance between the heart and the head. The most generous explanation I can give for your unfortunate stand is that you have allowed your human feelings of compassion for the victims of cancer to over-ride your professional judgment.

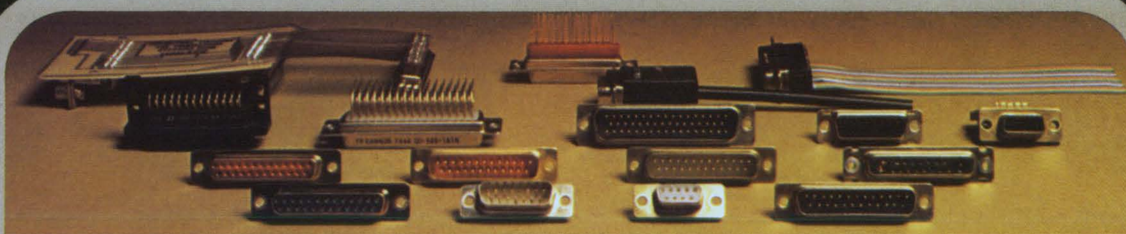
A careful reading of the history of

(continued on page 188)

The Cannon D Subminiature Store

PRODUCT OFFERING

CANNON'S GOT IT



PRODUCT LINE SUMMARY

SERIES	DESCRIPTION	DESIGNATION	INSULATORS	CONTACTS
D*	D Subminiature connector, low cost	ORIGINAL-D	Two-piece white Nylon	Solder, Wire-Wrap* and printed circuit
D*C	D Subminiature connector, low-cost for commercial applications	BURGUN-D (Mark IV)	Two piece, burgundy glass-filled Nylon	Crimp, snap-in rear release & printed circuit. Plastic cone retention.
D*U	Flame-retardant D Subminiature	BURGUN-D (Mark IV)	Two piece, black glass-filled Nylon (UL rated 94V-O)	Crimp snap-in, rear release & printed circuit. Plastic cone retention.
D*P	All-plastic 90° p.c.b. D Subminiature	BURGUN-D (Mark IV)	Black glass-reinforced thermo-plastic, UL rated 94V-O) (flame retardant)	Stamped printed circuit
D*M	D Subminiature connector for more critical applications conforms to MIL-C-24308	GOLDEN-D (Mark I)	Monobloc, dark green, Diallylphthalate glass-filled	Solder, printed circuit, Wire-Wrap* Coaxial, high power and high voltage.
D*MA	D Subminiature with LITTLE CAESAR® contact retention system conforms to MIL-C-24308	ROYAL-D (Mark III)	Monobloc, dark green, Diallylphthalate glass-filled	Crimp snap-in, rear release, coaxial and/or high voltage.
D*SP	Mass Terminated D Subminiature pin & socket connector	Mas/Ter-D (Mark V)	Black glass-reinforced thermo-plastic, UL rated 94V-O (flame retardant)	Non-removable insulation displacement termination.

*Trademark of Gardner Denver Corp.

BROADNESS OF LINE

Welcome to the ITT Cannon Electric D Subminiature store... Feel free to look around among one of the broadest lines of high quality, high reliability subminiature rectangular connectors found anywhere. Our store has been around for 60 years, serving industry worldwide. During that time customers have used billions of Cannon® D Subminiature connectors, contacts, and associated accessories and tooling. Why billions? Because people appreciate quality, and that's the concern of everyone in the ITT Cannon family. From the president to the assembly worker, we've a dedication to doing things right the first time. That's why our Quality Assurance department guarantees the high reliability of our products in meeting industry standards and MIL-Spec demands. And we're proud that this dedication is reflected in the numerous customer awards for excellence that we've received.

The versatile D Subminiature connector series is designed for applications where space and weight are prime considerations. Often the most economical solution to any interconnect problem, they accommodate a great number of circuits in relation to their size and weight. D series connectors can be adapted for cable attachments by use of one of the many accessory junction shells.

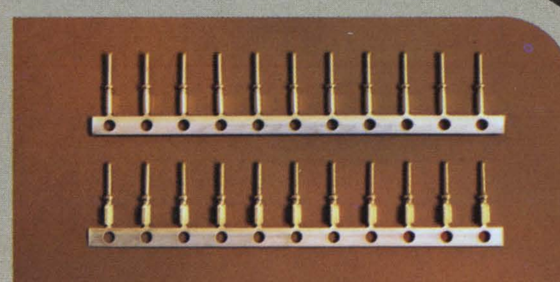
All seven of our D Subminiature connector types are fully intermateable, each accommodating up to 50 contacts in standard arrangements as well as high-density Double-D arrangements. Also available are combination arrangements with provision for coaxial, power, high voltage and printed circuit contacts. The versatility of D Subminiature connectors is enhanced by a variety of finishes and a complete line of accessories, most of which are UL-recognized.

AVAILABILITY
CANNON'S GOT IT

With manufacturing facilities on several continents and a global network of more than 200 distributors, ITT Cannon is geared to supply interconnect products to customers around the world. In North America most distributors are also Cannon Authorized Plug Specialists (CAPS).® Besides maintaining comprehensive off-the-shelf inventories, CAPS distributors operate local assembly centers set to our factory standards of stringent quality control. The combination of a vast distributor network and local and district sales offices gives you ready access to the Cannon storehouse of products.

No matter where you are, no matter what your needs, the Cannon capability means on-time delivery of the product you want, in the quantities you want, and at the right price.

PRODUCT SUPPORT
CANNON'S GOT IT



At the heart of our organization are our technical sales offices, all equipped to provide you service equal to that available from our home office. Our technical specialists have been thoroughly trained and can help you select the Cannon products that will meet your needs.

Shop at the Cannon store, and you'll find our product support doesn't stop when an application is implemented; field service personnel are available to study the changing requirements of your operation, and provide you with cost-effective solutions to your needs.

All Cannon interconnect devices—catalog or custom—are supported by the necessary termination tooling to speed production and *lower your total installed costs.*

As a product is being designed for your application, our engineering department is working with our customer tooling group to develop the insertion, extraction and crimping tools necessary for proper implementation. Standard customer tools available with every ITT Cannon product include a full range from simple hand tools to crimp machines, and both automatic and semi-automatic strip-and-crimp machines that can terminate up to 2,400 contacts per hour.

Six decades on the leading edge of interconnect technology.

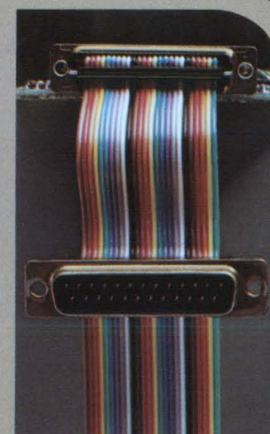
CANNON ITT

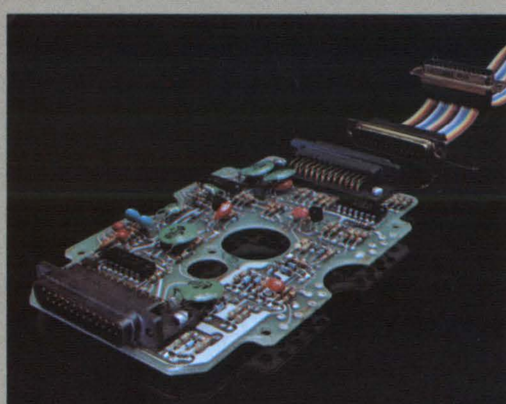
SOMETHING INNOVATIVE

CANNON'S GOT IT

MAS/TER-D MASS TERMINATED D SUBMINIATURE

Cannon Mas/Ter-D pin-and-socket D Subminiature connectors provide reliable high-speed mass termination at a lower total installed cost than conventional techniques. Fully intermountable and intermateable with all Cannon D Subminiature types, Mas/Ter-D connectors are terminated at one time with no insulation stripping or complex tooling. Cables may be terminated or used in daisy chain configurations with no cable breaks. Each contact size terminates two wire gages, solid or stranded, utilizing round conductor flat cable or individual wires with most standard insulation materials.





D SUBMINIATURE ALL-PLASTIC 90° D*P

This high performance, low cost D*P all-plastic 90° PCB connector is fully intermateable with all D Subminiatures, and can be mounted over PC patterns without causing short-circuits. It can replace other D Subminiature-type 90° PC connectors without board redrilling. A special contact retention technique holds pins precisely aligned for easier assembly to the PC board. The D*P offers lower total installed cost as well as improved performance and reliability in interconnect systems in such applications as telecommunications, computer and industrial control.

QUICK ACTION GETS YOU ALL THIS...

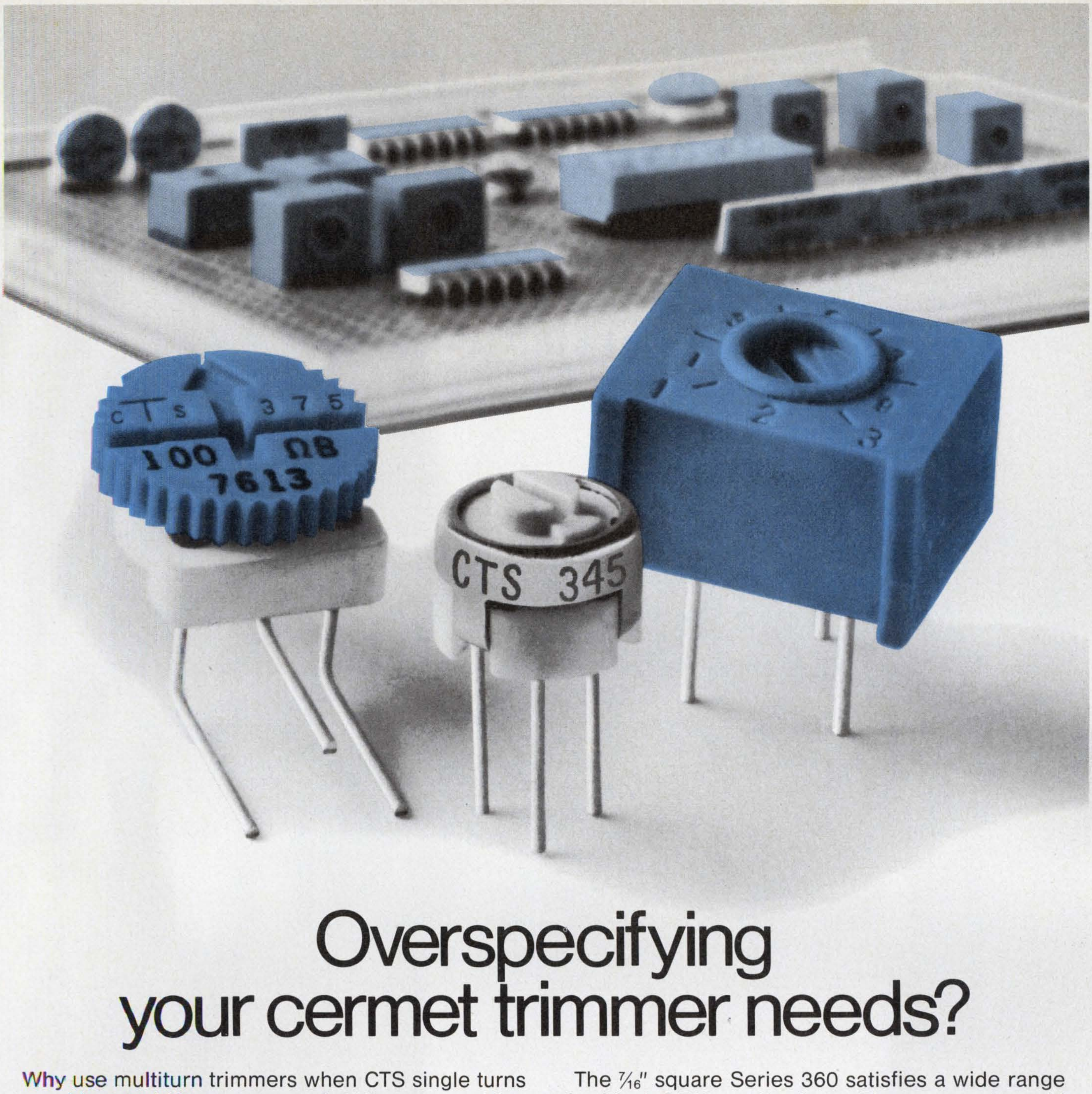
Got an interconnect problem? Let us help you solve it. Send today for complete product information and a Cannon Quick Action card. Once you've returned it to us, we'll send you a free old fashion apothecary jar filled with Cannon Candy. So take action today and send for our Quick Action card. And see for yourself that Cannon can! ITT Cannon Electric, 666 E. Dyer Road, Santa Ana, CA 92702. Toll-free, 24-hr. (800) 854-3573; in CA, (800) 432-7063. (And be sure to check the EEM Directory for all your Cannon Connector needs.)

Cannon can!

Six decades on the leading edge of interconnect technology.

CANNON ITT

Litho in U.S.A.



Overspecifying your cermet trimmer needs?

Why use multiturn trimmers when CTS single turns provide settability accuracy of .03%... approaching that of a 20-turn trimmer. Compactness, economy and excellent performance add up to a lot of efficiency in product design. You get all these benefits when you rely on CTS *single turn* cermet trimmers.

For example, the ⅜" diameter Series 375 is available in six popular terminal styles. And they're priced as low as 25¢ each in production quantities.

The CTS Series 345 is a "mini" ¼" round design featuring low .180" profile, sealed construction and production priced at just 70¢ each.

The 7/16" square Series 360 satisfies a wide range of critical OEM applications. Eleven popular grid spacings include both top and side adjust .100," .125," .150" and TO-5 centers. Low priced, too. Under 40¢ each in production quantities.

All available off the shelf from CTS Industrial Distributors. CTS single turns handle nearly every trimmer application... economically! You be the judge. Call for your *Free Sample*. **CTS of West Liberty, Inc., 6800 County Road, West Liberty, Ohio 43357. Phone (513) 465-3030.**

CTS CORPORATION

A world leader in cermet and variable resistor technology.

CIRCLE NUMBER 12

We've combined refresh with storage in a new modular graphics display.

You build from there.

Suddenly state-of-the-art display technology comes built for the OEM.
Tektronix' new GMA display modules let you integrate into your system our most impressive display capabilities ever. Including refresh and storage graphics in one tube. Complete character and vector generators. Big 19″ screen and fine resolution.

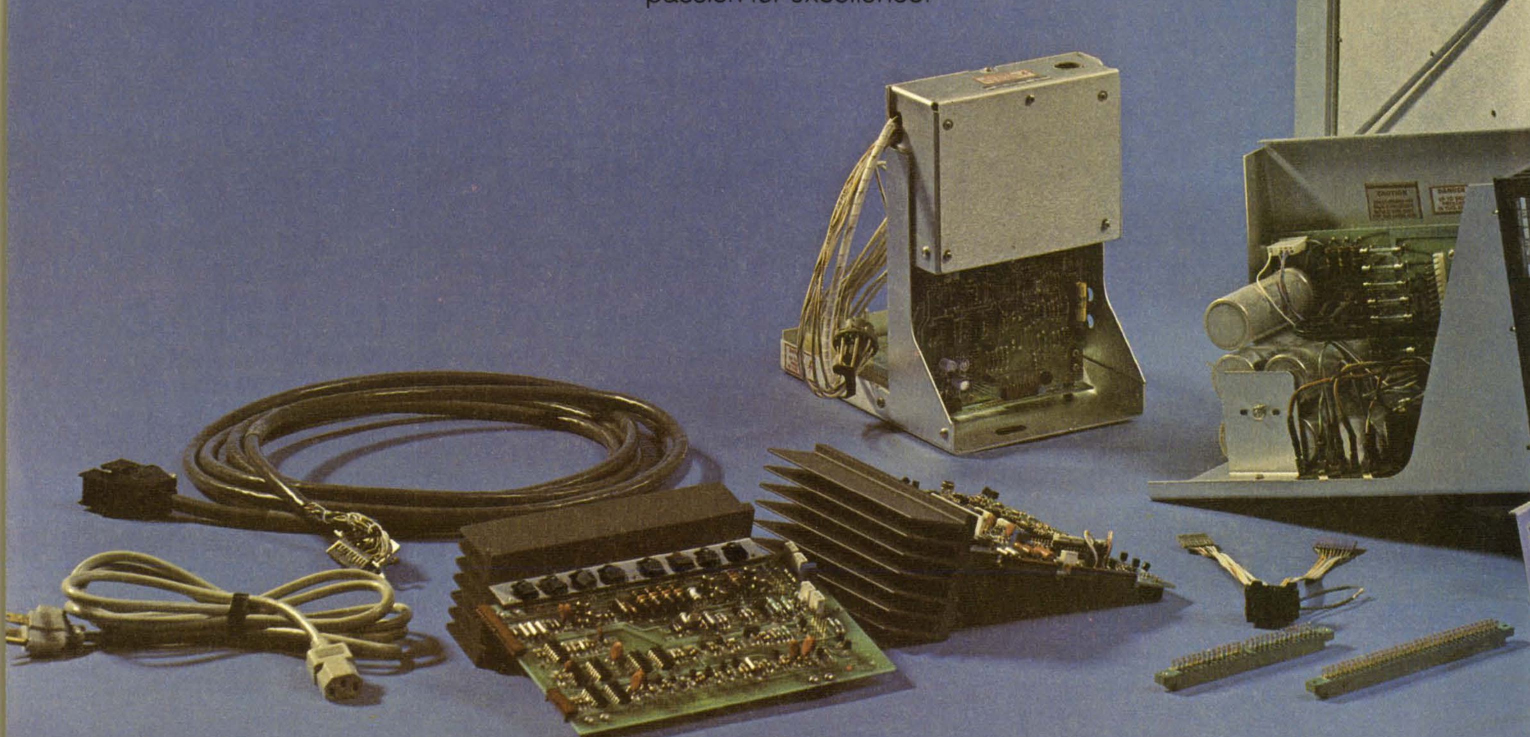
It's exactly what you need, because you can specify exactly what you want. Order CRT and power supply only, or select from a range of performance and packaging options in our extensive product line.

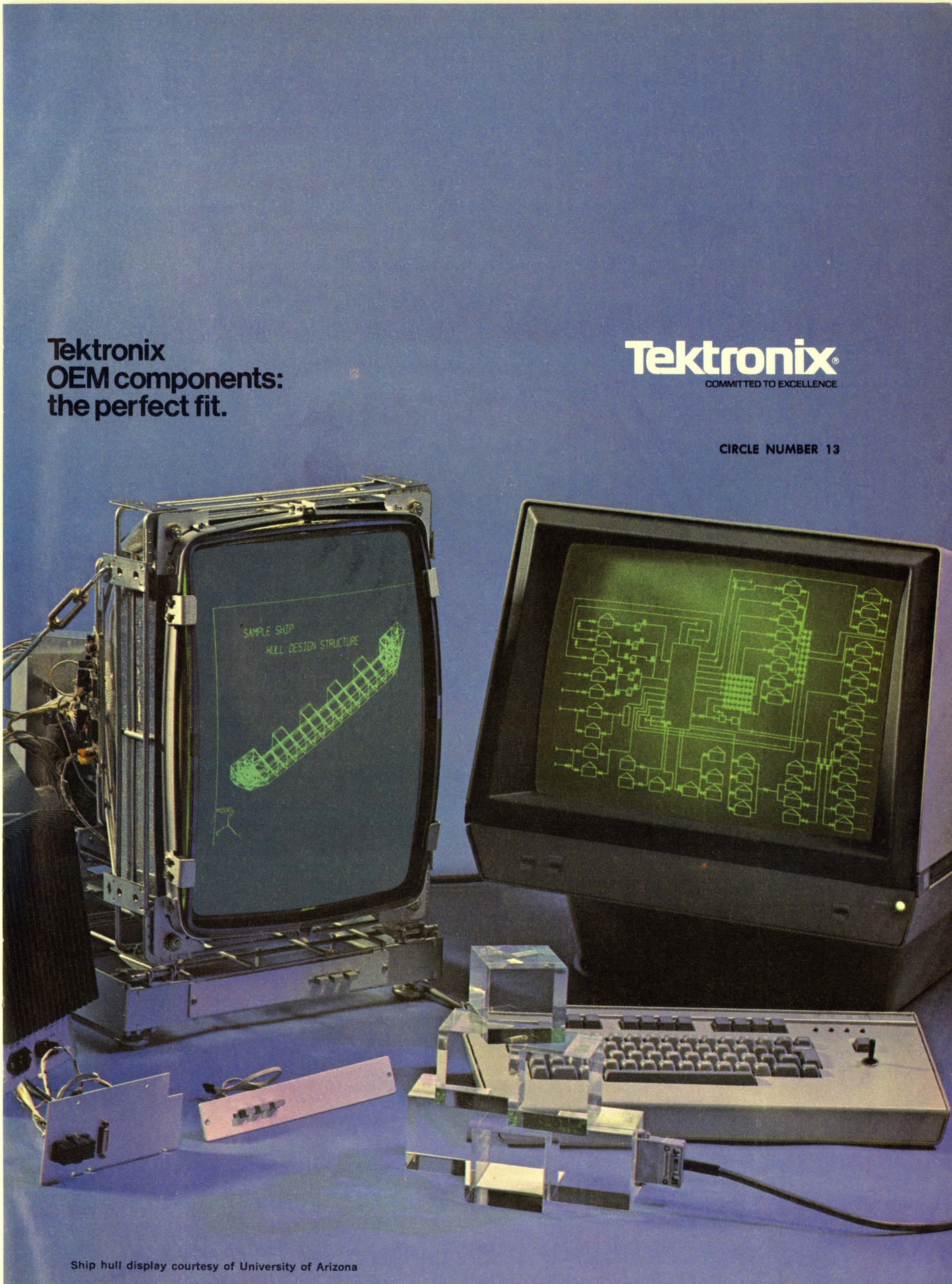
You can integrate other products from our graphics family, like hard copy modules. Or talk to us about other special product configurations, like our 11″ storage-only components.

No other package lets you pick such comprehensive graphic display capability at anywhere near the price.
It figures, because Tektronix has been the worldwide low-cost graphics leader for years. No matter what unique and unusual systems you're working with, we can help with manufacturing flexibility, engineeering assistance, and a passion for excellence.

Get capability you can build with. From a supplier you can work with. Get your Tektronix OEM Sales Engineer on the phone today. Or write us for more information.

Tektronix, Inc.
Information Display Group
OEM Components
P.O. Box 500
Beaverton, OR 97077

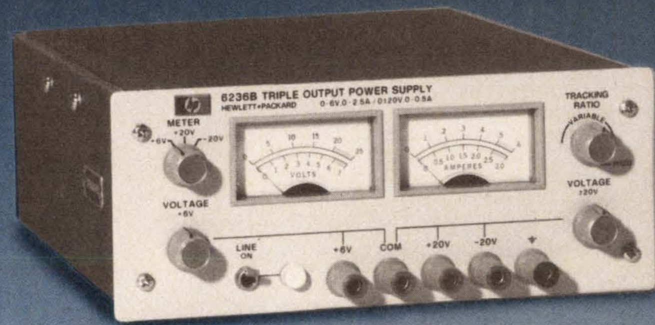




Ship hull display courtesy of University of Arizona

You Can Do More with HP Microprocessor Power Supplies...

BECAUSE YOU GET TRIPLE OUTPUT!



for the design stage...

of your microprocessor system, HP's compact, low cost lab power supplies offer more. For example, Models 6236B and 6237B offer three adjustable output voltages. Model 6236B covers 0 to 6V at up to 2.5A. Model 6237B is 0 to 18V at up to 1A. Both have plus and minus outputs of 0 to 20V that track within 1%, or you can switch to a variable tracking mode which allows the negative output to be separately set lower than the positive providing three different output voltages. There are no turn-on/off voltage transients so your circuit is protected against damage. Both models are designed to make development work with microprocessors easier.

for the end product...

where you can feature a triple output OEM Modular Supply specifically designed for powering microprocessor systems. Model 62312D provides three isolated, independently adjustable outputs. The main output is rated at 4.75V to 5.25V at 3A. Two others each range from 4.75V at 0.38A to 12.6V at 0.6A. Other standard features to help optimize your microprocessor design include an internal AC line fuse, fixed foldback current limit, over voltage protection on the main 5V output, remote programming terminals for margin testing and much more. Write for complete details or contact your nearby HP field sales office.

HEWLETT hp PACKARD

1507 Page Mill Road, Palo Alto, California 94304

For assistance call: Washington (301) 948-6370, Chicago (312) 255-9800, Atlanta (404) 434-4000, Los Angeles (213) 877-1282

21701

CIRCLE NUMBER 14

SEPTEMBER 13, 1977

From those who brought you Wescon—here's Midcon

An electronics exposition and convention that is similar to Wescon will debut November 8 to 10 at the O'Hare Exposition Center and Hyatt Regency O'Hare Hotel, just north of Chicago.

Midcon '77 will concentrate on four product areas: production and packaging, components and microelectronics, mini/microcomputers and peripherals, and instruments and control systems.

In addition to the exposition by various manufacturers, 30 half-day technical sessions will be held in the ballrooms of the Hyatt Regency hotel.

Among the topics to be covered at Midcon are universal programming languages and universal interface ICs. The universal programming languages will be covered in Sessions 1 and 6.

In a Session 1 paper, "A Universal Language for Microcomputers," P.J. Plauger, vice president of Yourdon Inc. of New York City, will discuss the industry's need for such a language. According to Plauger, such a universal language would eliminate users' dependence on the whims of different hardware vendors and help keep down the rising cost of program development.

Programming language C, developed at Bell Laboratories, is the ideal candidate for such a task, Plauger proposes. It is high-level enough to permit machine-independent coding across a variety of architectures and close enough to real hardware operations that it can be compiled into compact and efficient code, according to Plauger.

"C is moderately reminiscent of Pascal," says Plauger, "because it is a structured language with data types." Comparing C with Fortran, he points out that anything that can be said in Fortran can be said in C. And the two statements will look similar.

C would be ideal for engineers designing systems around micros that need at least 1000 bytes of code, Plauger believes. Not only that, but the software can begin development even before a final decision has been made on which micro to use. The reason is that C can generate code for any microprocessor.

Unlike other compilers that are relatively inefficient (PL/M produces a machine language program 10 times larger than necessary), the C compiler produces very efficient code. Inefficiency seldom reaches 30% and often is equal to what an experienced programmer can do directly in machine language.

Another discussion of universal software will be given by Roy Carlson of Tektronix in Beaverton, OR. In his Session 6 paper, "Portable Software," Carlson will discuss a compiler generator he developed that will produce object code for various microprocessors. His idea is similar to Plauger's—that is, to use one language to generate code for any micro. But while Plauger's approach requires the use of C, Carlson's approach enables the designer to make up his own language.

The universality theme is carried over into interfacing in Sessions 2 and 12.

A new universal interface chip, the 2656, will be highlighted at Session 2 by Robert Hartman of Signetics. This chip contains ROM, PROM, RAM and a programmable I/O port. Two notable features are an on-board comparator that makes it possible to place the ROM and RAM anywhere in the memory space and an I/O port that can be set up as either a bidirectional port or as chip-select lines. The chip-select capability, says Hartman, eliminates a lot of the TTL that usually surrounds μPs.

Another universal peripheral circuit, the UPI-41 will be discussed at Session 12. The UPI-41 is a single-chip slave micro that can be used to boost the processing power of other CPUs, says Don C. Phillips of Intel. The UPI-41 features a bit-oriented instruction set that performs control tasks efficiently, according to Phillips. In addition, the device is available in both a masked-ROM version and a UV EPROM version.

Long-term plans for the Midcon show call for the show to be rotated among two or three cities each year. Next year Midcon will be held in Dallas, TX.

Phase-sensing probe finds more shorts, opens

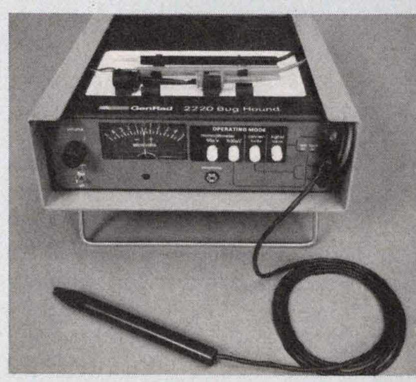
By sensing the phase as well as the magnitude of magnetic fields around current-carrying paths, a current tracer can find short and open circuits in backplanes and cables as well as in printed wiring.

The phase-sensing probe is combined with a dc microvoltmeter in the Model 2220 Bug Hound from GenRad Test Systems Division, Concord, MA. Priced under $800, the Bug Hound also has a source of 600-kHz stimulus signals that can be injected into a wire suspected to be shorted or open.

Two LED lamps are mounted near the pickup-coil tip of the current probe. One or the other lamp lights, depending on the phase of the magnetic field passing through the coil.

If the current probe were held precisely over the center of a current path, neither lamp would light. But as the probe is moved along the path, it inevitably shifts from one side to the other, and cuts through a different phase of the surrounding magnetic field, so the two lamps alternately light, explains Brendan Davis, product marketing manager at GenRad.

Earlier current-probe indicators, like those in Hewlett-Packard's Model



Tracking shorts and opens is simplified by sensing the phase of magnetic fields. This Model 2220 Bug Hound from GenRad has LED-lamp and audible indicators, as well as a microvoltmeter.

547A current tracer and in Testline Instruments Inc.'s Short Stop I and II, sense the amplitude of the magnetic field surrounding a conductor, and are brightest directly over the current-carrying lead. But looking for maximum brightness to determine which lead is carrying current is much more difficult than looking for a switch from one bulb to another, according to Davis. And amplitude-sensing tracers are almost useless for checking out cables and wire-wrapped backplanes because their probes cannot be held at a constant distance from the lead. The brightness of their indicators varies even when the current does not.

In some cases, shorts can be found simply by injecting a signal across two leads and tracking current with a microvoltmeter. The Bug Hound's microvoltmeter has two ranges—50 and 500 μV full-scale. Similar voltage sensing —and nothing else—is performed by the Short-Trak from Digital Facilities Inc., Dallas, and the Model 42 Microprober from Integral Electronics Corp., Commack, NY. While the recently introduced Microprober is a relatively simple microvoltmeter and nothing more, it does feature the lowest price for a current-tracing instrument—$94.50.

For more information, circle the following numbers:

GenRad	431
Hewlett-Packard	432
Testline Instruments	433
Digital Facilities	434
Integral Electronics	435

Videocassette player handles 4-hour tapes

Capable of recording up to four hours on a single cassette, the RCA SelectaVision color videocassette recorder has twice the capacity of previously available VCRs such as Sony Corp.'s Betamax. And with a "dealer-optional" price of $1000, the SelectaVision costs also a couple of hundred dollars less.

Made for RCA by Matsushita Electric Industrial Co. Ltd. in Japan, the SelectaVision runs at 0.66 ips in the four-hour mode or 1.31 ips in the two-hour mode. The Betamax records for two hours at 0.79 ips or for one hour at 1.57 ips.

The VCR can be connected to any monochrome or color TV between the antenna lead and the TV set. Tuners for uhf and vhf stations on the VCR permit recording one program while watching another. Programs can be selected in advance and recorded automatically with the recorder's built-in digital clock/timer.

Blank video cassettes will be available from RCA in two lengths—two-hour ($17.95) and four-hour ($24.95). An optional monochrome TV camera with a flip-up viewfinder goes for $299.95, while a deluxe black-and-white camera with zoom lens and through-the-lens viewfinder is priced at $399.95.

The SelectaVision VCR is compatible with the Video Home System (VHS) cassette standard developed by JVC Corp., a Matsushita subsidiary. VHS cassette players are marketed by JVC, Matsushita (under the Matsushita brand name, Panasonic), Hitachi, Mitsubishi, and Sharp, as well as RCA.

According to RCA forecasts, nearly 250,000 VCRs will be sold this year, with sales rising to 750,000 units in 1978 and well over 1-million units the following year. By contrast, it took color TV ten years to reach the million-a-year level.

RCA earlier used the SelectaVision name to describe its videodisc player. Despite a flurry of interest in video discs two years ago and an announced intention to manufacture its own players, the RCA videodisc effort is currently described as "dormant."

Plastic VMOS FETs vie with power bipolars

Thanks to plastic packaging, three vertical-channel MOSFET power FETs will be available for about one-third the price of similar devices packaged in metal. Moreover, with hundred-quantity prices of $.96 for the 40-V VN46AF, $1.00 for the 60-V VN66AF and $1.10 for the 80-V VN88AF, Siliconix expects its 2-A, 12.5-W units to make circuits that use them cost-competitive with designs using bipolar transistors.

Unlike power bipolars, VMOS FETs can be paralleled without the ballasting resistors that are needed to prevent current hogging that occurs when bipolars are paralleled. Negative drain-current tempcos provide self-regulation—as junction temperature increases, current decreases.

In VMOS FETs, a vertical current flow created by a V-shaped gate gives the devices a much higher current density than that of conventional lateral MOSFETs. In fact, the VMOS structure can handle amps in a chip area that conventional MOSFETs need for milliamps. Moreover, the VMOS structure improves switching speed, linearity, breakdown voltage and drain-to-source resistance.

The three Siliconix TO-202-packaged VMOS FETs have on-chip protection zeners and are produced by the deep-groove VMOS technology used by Santa-Clara-based Siliconix and its licensee, Semtech of Japan, to produce discrete devices. This process should not be confused with the shallower-groove technology that produces VMOS ICs.

Right now, small quantities of the plastic-housed VMOS FETs can be obtained for evaluation. Large quantities are expected to become available from stock in October.

CIRCLE NO. 436

Shuttle tolerates glitch—computer gets "voted out"

Milliseconds after the space shuttle orbiter Enterprise cut loose from its mother aircraft for its first free flight, three on-board computers sensed that a fourth was malfunctioning and immediately shut it down. The mission continued on to a textbook landing.

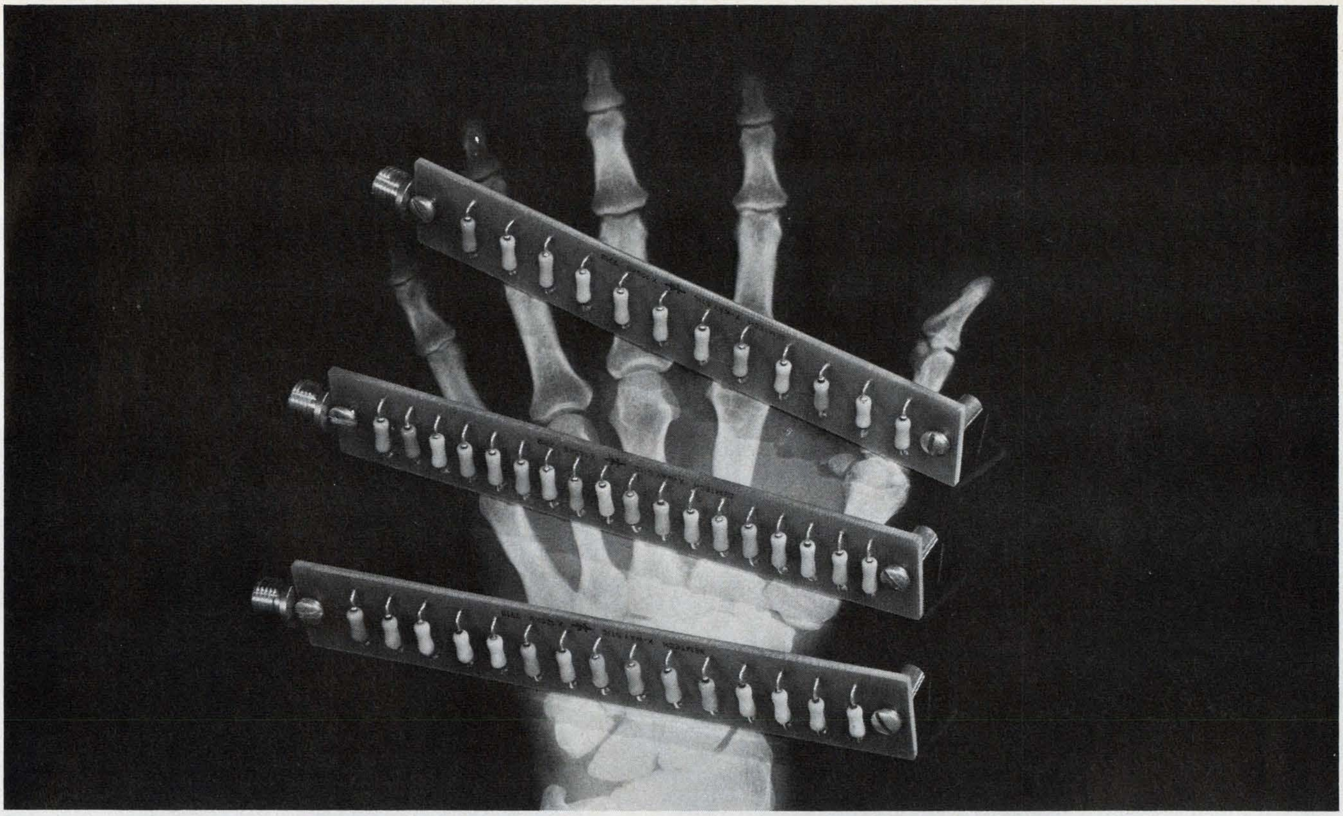
What's more, still another computer malfunction could have been tolerated by the ship's redundancy-management system before the crew had to switch-in a semi-automatic backup guidance and control system.

The Enterprise has a quadruple-redundant, intelligent-interactive computer network—the guts of a data-acquisition and control system so sophisticated it can guide the craft to a safe landing on Earth with less human intervention than it takes to drive a car. With most redundancy techniques a master/slave approach puts one element in control, with the others taking over in case of a failure. But not on the space shuttle orbiter.

The four computers operate in parallel from a common clock. They each acquire data from triple-redundant sources, such as accelerometers, rate gyros, and manual pilot controls and compare their inputs. Small differences aside, the four computers agree to use just one value—the median.

Each computer then makes its own calculation as to how much deflection an elevon rudder or air brake requires.

Before a control surface (or rocket thruster) is commanded to do anything, the four computers compare their outputs-to-be. Should any one computer disagree with the other three, it will be shut down by the others.



"X-WAY STIC"

High Quality - Low Cost Rectifiers for X-ray Power Supplies.

Semtech Corporation introduces "X-WAY STIC" a new series of open rectifier sticks specifically designed for X-ray power supplies.

Each X-WAY STIC utilizes hermetically sealed Metoxilite multi-chip "avalanche" rectifiers mounted on a PCB. These Metoxilite multi-chip rectifiers (technology initially developed for high reliability aerospace programs), are now available *at reduced prices.*

In addition to X-ray power supplies, these rectifiers can be effectively used in most standard, single and polyphase circuits. Designed for use in oil environment.

Types: X100KS, X125KS & X150KS
PIV (operating): 100, 125 & 150kV
PRV (test): 125, 150 & 175kV
Average Rectified Current @ 55°C Oil: 150mA
Reverse Current @ PRV: 1.0μA
Recurrent Surge (10 cycles @ 60 Hz rate): 7.5A
Single Cycle Surge @ 8.3ms: 25A
Forward Voltage @ 50mA: 160, 190 & 220V

RELIABILITY COSTS LESS!

OTHER X-WAY STIC TYPES AVAILABLE:

1975 NATIONAL SBA SUBCONTRACTOR OF THE YEAR

SEMTECH CORPORATION

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

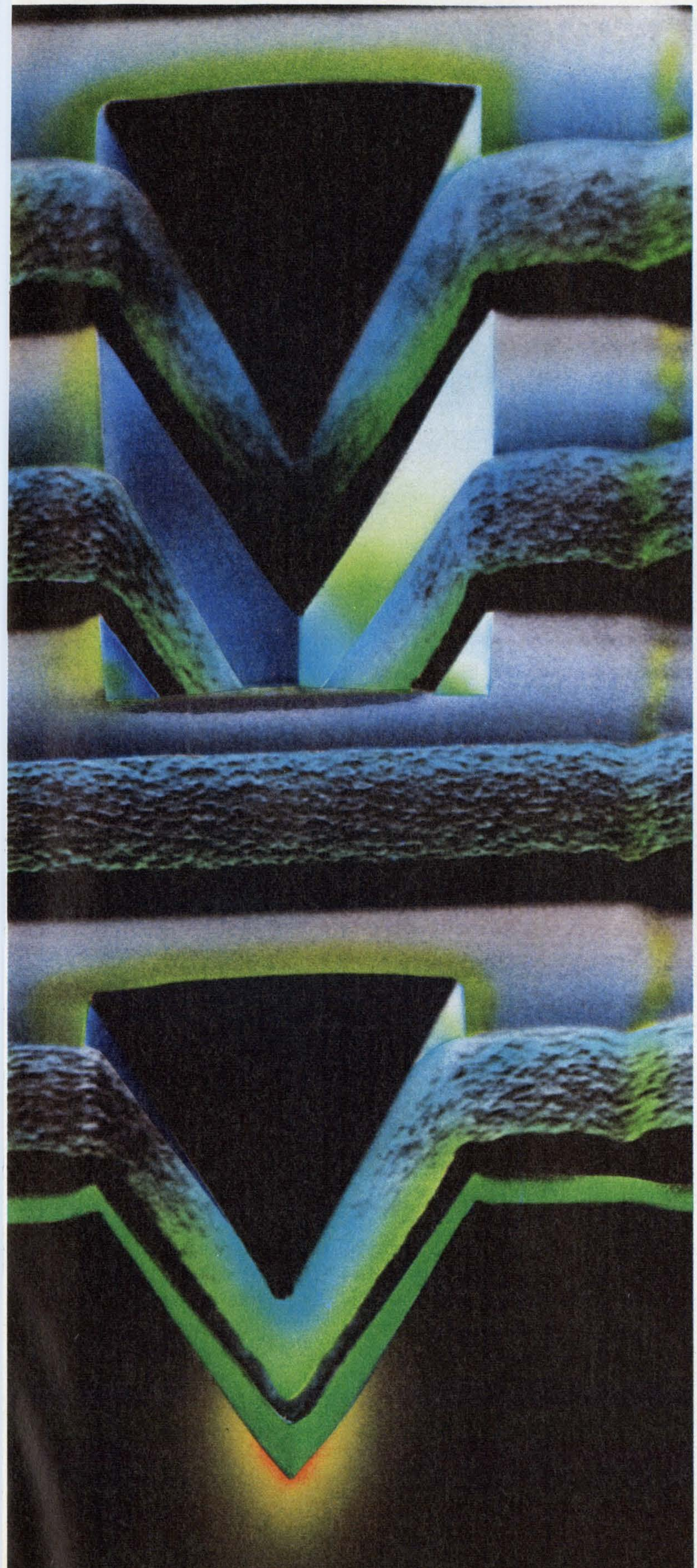
CHICAGO: (312) 352-3227 • DALLAS: (214) 234-6523
DAYTON: (513) 274-8356 • FLORIDA: (305) 644-5404
MARYLAND: (301) 937-0070 • NEW JERSEY: (201) 654-4884
SAN FRANCISCO: (415) 494-0113
EUROPEAN SALES: Bourns AG Zug, Switzerland (042) 232-242

CIRCLE NUMBER 15

The MOS world

A VMOS transistor, magnified 15,500 times.

is no longer flat.



AMI creates VMOS. This revolutionary idea revolves around a three-dimensional transistor, etched into the silicon substrate.

The result? A circuit that's extremely fast, dense and inexpensive.

It isn't blue-sky theory. The first VMOS RAM, the 1K S4015-3, is in volume production now. And a reputable second source has committed to manufacture VMOS RAMs in 1978.

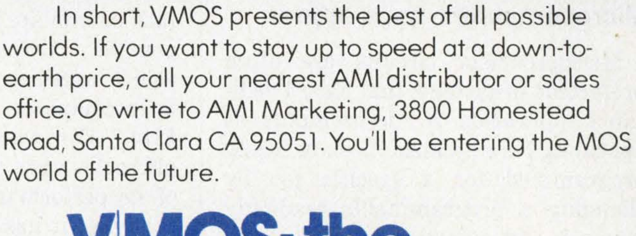
Our 35 nanosecond (typical, 45 nanosecond maximum) 1K static memory is pin compatible with the fast 1K NMOS and bipolar RAMs, and leads the way for the large family of VMOS products arriving soon. These will include:

NEW VMOS PRODUCTS AND TYPICAL ACCESS TIMES

4K fully static RAM	(1K x 4)	80 ns
4K fully static RAM	(4K x 1)	80 ns
4K fully static low power RAM	(4K x 1)	45 ns
8K fully static RAM	(1K x 8)	125 ns
16K ROM	(2K x 8)	100 ns
64K ROM	(8K x 8)	250 ns
16K EPROM	(2K x 8)	200 ns

The density permitted by vertical short-channel FETs produces VMOS circuits that are much smaller than competitive chips, increasing the speed and lowering the cost. For example, the latest bipolar 1K size is 61% larger, and the new fast NMOS 1K is 87% larger than AMI's S4015-3. And VMOS densities are achieved without stretching feature dimensions at the sacrifice of yields, as is necessary with bipolar and NMOS technologies.

"VMOS" refers to a short channel NMOS structure fabricated in "V" shaped grooves which penetrate the silicon surface and are combined with planar NMOS devices



In short, VMOS presents the best of all possible worlds. If you want to stay up to speed at a down-to-earth price, call your nearest AMI distributor or sales office. Or write to AMI Marketing, 3800 Homestead Road, Santa Clara CA 95051. You'll be entering the MOS world of the future.

VMOS: the new technology from AMI

AMERICAN MICROSYSTEMS, INC.

See VMOS at Wescon, Booth 821

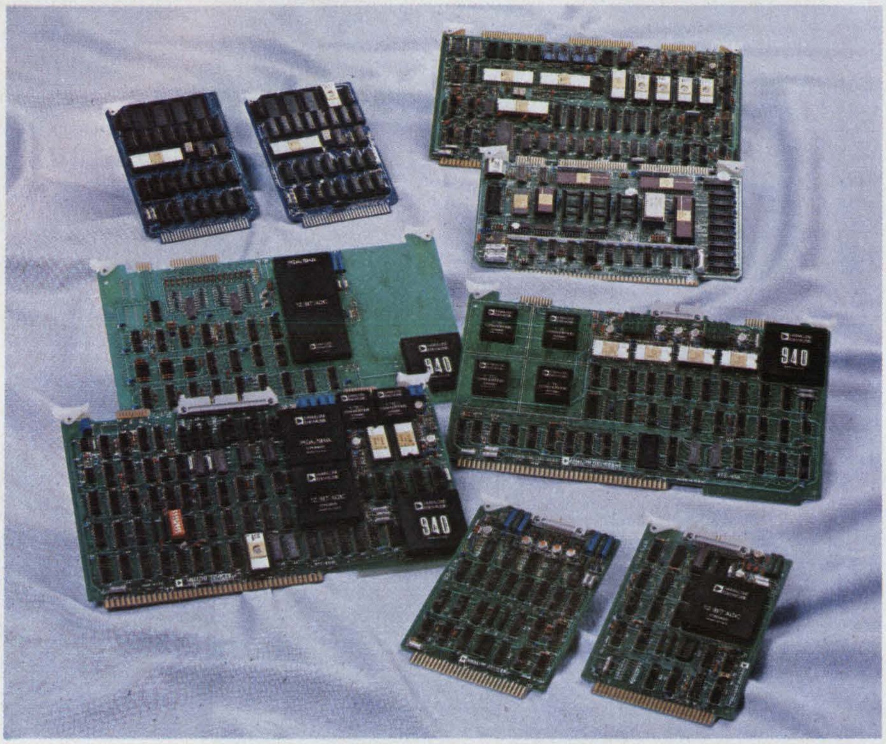
CIRCLE NUMBER 17

Analog boards for microcomputers: You can't always get what you want

Interfacing a microcomputer board with the "real world" of analog signals, such as those from thermocouples and other transducers, may prove more difficult than expected. Unless you're using one of the most popular microcomputers—say, from Intel, Motorola, Digital Equipment, Pro-Log or Zilog—you may not be able to buy a ready-made and compatible analog-interface board. And even if you do find a compatible board, you may find it doesn't have the specific features you need in your applications.

Worse, so much of the microcomputer's time may be spent controlling and waiting for analog circuits that your complete system will perform at a snail's pace. Performance may fall far short of the "megahertz" promised by the microcomputer's clock-rate spec or the "hundreds of kilohertz" promised by the analog board's throughput spec. Also you may have to sacrifice speed for either greater accuracy or channel capacity.

The situation is not a happy one for system designers. At this year's Industrial Electronics Control Instrumentation Conference in Philadelphia, PA, several engineers complained that the semiconductor industry had oversold them on microprocessors, while failing to provide compatible analog I/O circuits.



Microcomputer boards from Pro-Log, Intel and Motorola (top of picture) are seen here with compatible analog subsystem boards from Analog Devices.

Microcomputers have appeal

Microprocessor circuits are often preferable in systems that have a dedicated application. A microcomputer is appealing here because it can be easily programmed for a specific job by changing a programmable read-only memory and a few other parts.

But if you then have to design your own analog-interface system, development costs may skyrocket—and defeat the purpose of using a microcomputer in the first place. The answer? A predesigned analog board you can tailor to your application just as easily as you program your microcomputer.

Fortunately, several analog-interface boards are available for the more popular microcomputers. But, the choice narrows if you aren't using a microcomputer made by the "Big Five." For example, Data General's microNova has a lot of appeal because of its performance and software support. Yet it has no compatible analog board. Another powerful microcomputer that lacks analog-board support is the Texas Instruments TM 990/100.

However, analog support will soon be available for both these microcomputers. Datel plans to introduce an analog board for the microNova, and both Analog Devices and TI will soon bring out boards for the TM990.

Data General does, of course, provide analog boards for its older Nova minicomputers, while TI has an analog board for the 990/4 computer (also microprocessor-based), made by its Digital Systems Division.

Too many microcomputers

The over-all problem is that microcomputers are simply introduced much faster, and in greater quantities, than analog boards. There are signs, however, that the situation will have to stabilize. Microcomputer vendors now face a "chicken-or-the-egg" dilemma. The market for a microcomputer is severely limited unless it can be designed into analog systems. Yet who

Mike Elphick
Managing Editor

will risk introducing a compatible analog-interface system for a microcomputer that isn't being widely used?

Until recently, the traditional analog and data-conversion module manufacturers—like Burr-Brown, Analog Devices, Datel and Analogic—have been the most willing to introduce analog-interface boards. For these companies, microcomputers represented another opportunity to sell modules. Not only could they sell modules directly to engineers who were building their own interface boards, they could also sell complete boards that used modules as components.

Also among the first to offer analog-interface boards were a group of smaller companies—such as ADAC, Automated Industrial Measurements and Data Translation. These companies were often started by engineers who had left the larger data-conversion companies. The microcomputer-interface market, though small at the time was large enough for these companies to survive and grow.

Only recently have the larger microcomputer manufacturers started to sell analog-interface boards. Facing an increasingly competitive market for microcomputers, these companies now find that analog support is becoming an important factor when a system designer makes his choice.

Of course, for a microcomputer-based analog system, analog support is just as important as software support and other types of hardware support. Already, Intel, Motorola, Zilog, DEC, MITS, Cromenco and Wintek sell compatible analog-interface boards for their microcomputers. Several others are expected to follow suit.

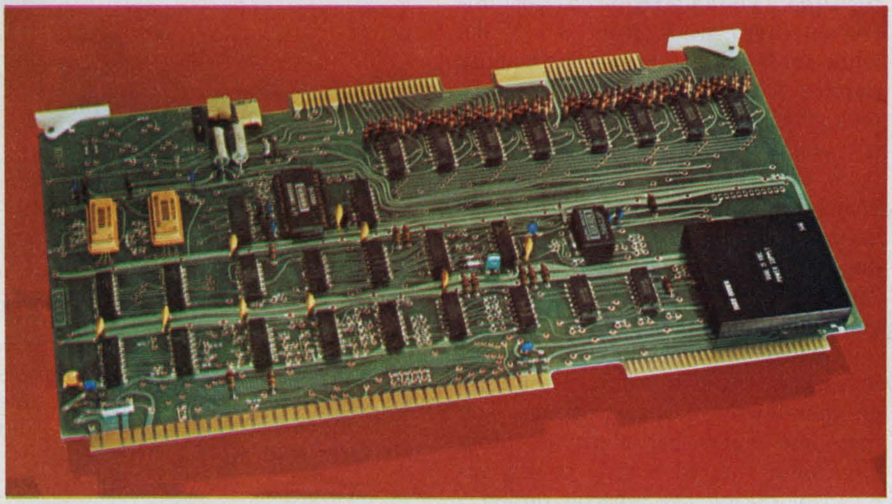
Where should you buy?

But which source is preferable? Provided you've chosen the right microcomputer and the right analog-interface scheme for your system, you can safely order an analog board from any reputable vendor.

However, microcomputer manufacturers argue that since they design digital systems, of course, they understand them better than do data-conversion specialists. Furthermore, they're in a better position to evaluate hardware-software tradeoffs in interface-circuitry design. Also, they say, they can test the combined analog-and-digital system completely by using computer-based equipment and an extensive diagnostics library.

Data-conversion specialists argue that they understand all the subtleties of analog and interface design—how to avoid ground loops, where to add filtering, how to minimize the many error sources and how to budget for a specified total error. Furthermore, they say, since they have extensive experience in analog-interface applications, they better understand their customers' requirements.

You don't have to go one way, however. Some microcomputer manufacturers test and resell analog boards designed by module manufacturers. For example, Motorola sells boards made by Burr-Brown. Intel's boards are developed in cooperation with Analogic and use that company's modular components.



Compatible with Intel's SBC 80 microcomputers, Burr-Brown's MP8600 analog I/O board costs as little as $198 (in quantities of 100) for a 16-channel input-only configuration.

Even when a microcomputer manufacturer designs and makes its own analog boards, it often uses components and subsystems made by analog-module manufacturers. Consequently, most critical analog and interface circuits are designed by experts. On the other side of the fence, the analog houses often perform comprehensive computer-based tests. And many of them supply diagnostic software, so that you can test an analog system with your microcomputer.

Remember, however, that a manufacturer will be more likely to help you make the right choice if the company has a broad line of products. For example, if a microcomputer manufacturer offers both 8-bit and 16-bit machines, the company will be more ready to tell you that the larger machine is better able to handle your high-level language. Similarly, a company that makes analog boards for several different microcomputers can afford to be objective when helping you decide which microcomputer will work best in your application.

Even when you consider yourself ready to select a compatible analog board, you're not out of the woods. As a first step, be sure that you and the prospective vendor agree on the meaning of "compatible."

What is "compatible"?

Some vendors may have a rather liberal idea of what constitutes a "compatible" board. At the very least, the board should be the same size as the microcomputer and have connector pinouts that conform to the microcomputer's bus standard. Further, the analog board should have the same supply voltages and logic levels as its digital partner. Unfortunately, some boards don't even meet these minimum requirements.

Most boards meet board-size and bus-compatibility requirements, but even here you run into a problem. One bus standard that's widely used by computer hobbyists, the S-100, is not really a standard at all. At best, it provides only fuzzy guidelines for designating its pins. About 15 undesignated lines are used by different manufacturers for different functions.

Because of problems with early *de-facto* standards like the S-100, more and more manufacturers are adopting other standards, such as Intel's MDS bus. Consequently, microcomputers from companies other than Intel can work with analog boards designed for Intel's SBC-80 series. For example, the Analog Devices RTI-1203, though designed for the SBC-80 series, works with National's BLC80 microcomputer as well.

Unfortunately, Intel's standard also has some undesignated pins. However, analog-board manufacturers will probably work closely with Intel this time around. Intel's arrangement has eight undesignated lines right next to the 8-bit data bus. Since this configuration obviously will allow simple expansion of the data bus for 16-bit microcomputers, interface-board designers will probably steer clear of those undesignated pins.

Perhaps the most commonly violated requirement for board compatibility is the supply voltages required. Most microcomputers work from +5 V dc, while analog-interface systems usually require that *and* ±15-V supplies. To make the board compatible, an inverter is usually added to derive the ±15 V from the +5-V line. Unfortunately, board manufacturers often list the inverter as an option so that they can quote a more competitive price for the "basic system." So check your supply-voltage requirements before comparing prices. And while you're at it, investigate the effects of inverter noise on your low-level analog signals. You may find you're better off providing your own filtered ±15-V power, instead of taking the inverter option.

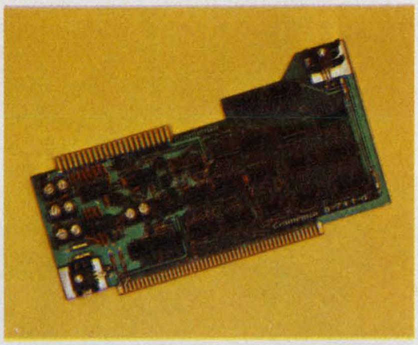
Another area of compatibility to investigate is the logic levels. Everybody talks glibly of "TTL levels." But if the fanout is only one, and the noise margin is near zero, you may run into system problems. Remember also that a microcomputer bus usually requires three-state logic, not just simple TTL.

Is performance compatible?

Even if an analog board meets the minimum requirements for compatibility, it may still be a poor match for the microcomputer. For example, a fast microcomputer may have to stop its calculations and wait for a slow analog board to deliver its data. Or the analog board may require elaborate software subroutines—which will tie up the microcomputer's time and memory—for simple tasks that could have been handled more efficiently by hardware on the analog board. The combined performance of the two boards will often fall far short of what you might expect from the individual board specifications. Synergism is rare.

If you look at the data sheet for an analog board, you'll find a bewildering array of specs. Even after you've pinpointed the key specs, you'll still have to interpret their significance to your system. And this interpretation requires an understanding of the different schemes used for interfacing with microcomputers. Often a block diagram can tell you just as much as the performance specs.

Every analog-output system requires at least one digital-to-analog converter. Similarly, every analog-input system needs some sort of a/d converter—usually, but not necessarily, implemented with hardware. Exceptions are schemes where a d/a converter, or just a comparator, is employed in a microcomputer-controlled feedback loop to perform a/d conversions. So even a basic single-channel system can have alternative schemes and hardware-software tradeoffs.



A low-cost analog I/O system from Cromemco has seven a/d channels and seven d/a channels. Compatible with the S-100 bus, it costs $145 in kit form and $245 assembled.

In more complex multichannel systems, which employ multiplexers, registers, sample-and-hold circuits and programmable amplifiers, the possible circuit permutations skyrocket.

There are three important configurations for data-acquisition systems, according to Jim Sherwin, Data-Acquisition Applications Manager for National Semiconductor:

- A "multiplexed random-channel-addressed" scheme—an analog multiplexer delivers one signal at a time to a sample-and-hold (s/h) circuit, which then stores momentary signal values for digitizing with an a/d converter.
- A "multiplexed-with-memory" scheme—the digital signals after conversion are stored in a RAM or shift registers for rapid access by the microcomputer.
- A "parallel-conversion" scheme—each analog channel has a dedicated a/d converter.

Most commercial data-acquisition boards use variations of the first and second methods. Up to now, parallel-conversion systems have been rare because of the high cost of the a/d converters for a multichannel system. However, such a scheme is becoming more and more feasible because low-cost monolithic converters with adequate performance are starting to appear.

Speed costs money

The random-channel-addressed scheme is low-cost, but tends to be slow. The microcomputer, after addressing a channel, is usually forced to wait while the multiplexer selects the channel, the s/h circuit acquires the signal, and the converter digitizes the signal and releases the microcomputer's Ready line.

The other two schemes allow the microcomputer to access the data as memory, which tends to be faster and more convenient for the microcomputer. Of course, with a multiplexed-with-memory scheme, the data will be more stale than with a parallel-conversion scheme, because of multiplexer delays. Nevertheless, both schemes can avoid tying up the microcomputer during conversions. Further speed savings can be achieved by using different interrupt techniques. But it's difficult to provide general guidelines because priorities depend on the application.

Of course, not every application requires flat-out speed. If you're digitizing slow-changing temperature signals, for example, you'd probably be happy to trade speed for accuracy. Though it's possible to achieve speed combined with accuracy where it's needed—in radar-signal processing, for example—this tends to be expensive. You're not likely to find this combination in the average microcomputer interface board.

Though the reasons for a speed-vs-channel-capacity tradeoff are quite obvious—primarily multiplexer and scanner delays—the reasons for trading speed-for-accuracy tend to be more subtle. In general, however, high-speed circuits tend to be noisy because they require that large currents be switched to charge stray capacitances. Noise, of course, can be a major contributor to system errors. Also, large currents in high-speed circuits can magnify the

(continued on page 30)

microNOVA keeps on trackin'.

Southern Railway has a long track record of being one of the most profitable rail systems in the country. To help stay on that track, they decided to increase the speed and flexibility of their online distributed communications network. So Southern Railway is now changing dumb terminals into intelligent ones throughout its rail system, using microNOVA microcomputers.

Southern Railway found that only the Data General microNOVA microcomputers could help them cut costs and keep track of some 75,000 freight cars moving over 10,500 miles of track, and do it the way Southern Railway wanted to. Controlling rolling inventory like that takes a lot of flexibility. And that's the big advantage Data General microNOVA microcomputers bring to any application. Whether in a chip, on a board, or as a packaged system.

With the speed, flexibility and software of a minicomputer and the economies of microprocessor technology, microNOVA microcomputers let you do things your way. That's why they're setting track records in all kinds of applications.

Mail to: Data General, Westboro, MA 01581

☐ Send microNOVA technical literature.

☐ Send literature and have your sales representative call.

Name ______________________________

Title ______________________________

Company ______________________________

Address ______________________ Tel. __________

City __________ State __________ Zip ______

Data General, Westboro, MA 01581, (617) 366-8911. Data General (Canada) Ltd., Ontario. Data General Europe, 15 Rue Le Sueur, Paris 75116, France, 50-006-06. Data General Australia, Melbourne (03) 82-1361. ED913

Data General
It's smart business.

CIRCLE NUMBER 18

Some manufacturers of analog boards for microcomputers

Company	Microcomputers for which compatible boards are offered										
	Altair, IMSAI and S-100 bus systems	Digital Equipment LSI-11 series	Intel MDS-800 and SBC-80 series	Motorola Micromodules and EXORciser	National Semiconductor PACE and IMP boards	PCS Superpac	Pro-Log 4-bit and 8-bit boards	Texas Instruments TM990 series	Wintek WINCE module series	Zilog Z80-MCB series	Circle No.
ADAC Corp., 15 Cummings Park, Woburn, MA 01801		•	•								501
Analog Devices, Route 1 Industrial Park, Box 280, Norwood, MA 02062			•	•			•	• (Note 1)			502
Analogic, Audubon Road, Wakefield, MA 01880			• (Note 2)	• (Note 2)							503
Automated Industrial Measurements, Box 125 Wayland, MA 01778			•								504
Burr-Brown, International Airport Industrial Park, Box 11400, Tucson, AZ 85734			•	•			•			•	505
Cromemco, 2432 Charleston Road, Mountain View, CA 94043	•										506
Cybernetic Micro Systems, 2460 Embarcadero Way, Palo Alto, CA 94303			•								507
Data Translation, 23 Strathmore Road, Natick, MA 01760		•	•		•	•				•	508
Datel Systems, 1020 Turnpike Street, Canton, MA 02021		• (Note 3)	•	•							509
Digital Equipment Corp., Main Street, Maynard, MA 01754		•									510
Intel, 3065 Bowers Avenue, Santa Clara, CA 95051			•								511
MITS, Div. of Pertec, 2450 Alamo SE, Albuquerque, NM 87106	•										512
Motorola, Box 20912, Phoenix, AZ 85036				•							513
PCS Inc., 750 N. Maple Road, Saline, MI 48176						•					514
SEA, 620 S. Rangeline Road, Carmel, IN 46032							•				515
Signal Laboratories, 202 N. State College Blvd., Orange, CA 92668										•	516
Wintek, 902 N. 9th Street, Lafayette, IN 47904									•		517
Zilog, 10460 Bubb Road, Cupertino, CA 95014										•	518

Note 1: Available January 1978 **Note 2:** Available only from the microcomputer manufacturers, not from Analogic **Note 3:** Available later this year.

(continued from page 28)
errors caused by thermal drift.

If you don't need speed, then, it usually pays to specify a slower system. A system with an integrating a/d converter—popular for DPMs and low-cost DVMs—will tend to filter out low-frequency noise, whereas a faster successive-approximation converter will be prone to jitter of its least-significant bits in the presence of noisy analog signals. Of course, you can always ignore the last digit or two—using, say, a 10-bit converter in an 8-bit system. But why pay for more resolution than you really need?

For good accuracy and low speeds, other data-acquisition schemes may work better than those using conventional a/d converters. In industrial systems that often require long trans-

ducer cables in a noisy environment, such techniques as voltage-to-frequency conversion and delta-sigma modulation are gaining in popularity.

One advocate of voltage-to-frequency conversion is Barry Hilton, President of Automated Industrial Measurements. His company makes what he calls a "microcomputer frequency meter," which is compatible with most 8-bit microcomputers.

"The low-level signals from the transducers are converted to frequencies at the transducer location so that analog errors and noise problems are minimized," Hilton explains. The output frequency is then transmitted over a twisted pair which also carries the power to the voltage-to-frequency converter. "To interface with the microcomputer, Hilton continues," we use a digital multiplexer (which includes memory) and our frequency-meter card. Thus we avoid having to handle analog signals."

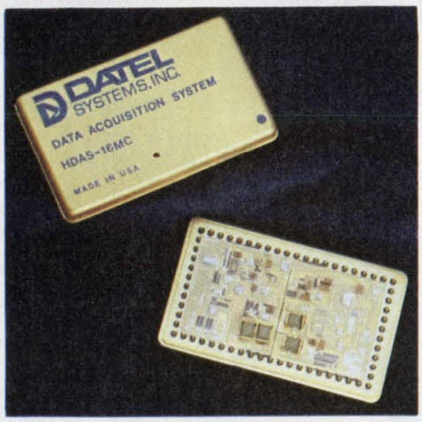
Hilton's scheme not only avoids the problems involved in processing analog signals, it also avoids the need for a frequency-to-voltage converter to decode the signals after transmission. Ripple in the output of many commercial f/V converters has prevented widespread use of f/V conversion for data acquisition.

Noise can be an especially tough problem when you're handling low-level signals. Though several companies offer analog-input boards that accept low-level signals of 10 mV or so, you usually shouldn't try to do all the amplification on the interface board. A better approach is to amplify the signals at the transducer, or, even better, convert at the source, as with Hilton's system. Certainly, if you choose to use a board with low-level inputs, you should make sure the input amplifier has good common-mode rejection. But even then, the approach isn't advisable with input leads of more than a few feet in length.

Check the options

If manufacturers don't recommend low-level inputs for analog boards, why do they provide boards with this capability? The answer, of course, is that customers have requested boards that accept low levels. It turns out that manufacturers can quite easily tailor boards for a specific market because the boards are assembled from standardized modular or IC components. To meet a specific need, the manufacturer merely changes a few components on his basic board. So if a manufacturer's catalog doesn't list a board that has exactly the features you need, don't be afraid to ask if a certain basic board can be modified to your custom requirements. For example, you may decide you don't want voltage inputs —you prefer an isolated 20-mA current loop. Some boards offer this feature outright, while others can be modified.

Another area of analog-board performance that can often be customized is converter speed and accuracy. Fred Molinari, President of Data Translation, explains how this works for his company's boards: "Our standard boards have a throughput specification of 35 kHz (or 28.5-μs conversion time per channel). We can offer 125-kHz throughput (8-μs conversion time) simply by plugging in our high-speed DT5710A." Incidentally, standardized modular construction is one reason why Data Translation is able to offer perhaps the broadest line of microcomputer analog-interface boards on the market. The company offers a total of 26 different boards, each with a wide range of optional modifications.



For the engineer who builds his own boards, Datel's new HDAS-16 packs 16 channels of 12-bit conversion in a tiny hybrid IC measuring only 2.3 × 1.4 × 0.24 in.

Of course, if your system is well-defined, you'll probably want to buy boards tailored to your requirements. But, as a development aid for breadboarding a system, you'd prefer a board you can optimize yourself. Several companies sell analog boards that you can reconfigure. For example, Analog Devices boards have terminal pins at various strategic points so that they can easily be strapped with a Wire-Wrap tool. Some of Burr-Brown's boards have plated-through holes that can be drilled out and interconnected with hookup wire and solder.

Jumper connections allow you to interconnect analog and digital grounds, establish the required imput voltage range, or define the clock frequency for conversions, among other things. Several companies have amplifiers whose gain can be programmed by changing a resistor value. And some boards—from Analog Devices and Cybernetic Micro Systems—include software-programmable amplifiers.

Big boards are versatile

The most versatile boards are the larger ones, like those for the Intel, Motorola and DEC microcomputers. They have the most room for the various optional circuits. However, the smaller analog boards, like those for Pro-Log and Wintek microcomputers, also have advantages for breadboarding. You need only buy the individual circuits as you need them. You don't have to start with an expensive fully loaded board. Also, Wintek's boards are the same size as the popular Vector boards, which allow you to easily hook up your own circuitry.

The larger boards have enough room to include both an analog-input system and an analog-output system. With smaller boards, these are usually separate. Larger boards can also fit in such features as a PROM, a local controller or a crystal-controlled real-time clock. It's often convenient, too, to have digital inputs and ouputs on an analog board. For example, if an analog board is driving a chart recorder, you may need digital signals to control pen-lift and color-change functions.

Even with the wide range of options available for today's analog-interface boards, you can't interface with every microcomputer on the market. In many cases you'll be forced to design your own boards. But this task is greatly simplified by data-acquisition modules that contain the key circuits you'll need. Some examples of these modules include Burr-Brown's Microperipherals, a two-chip hybrid-IC set from Micro Networks, and Datel's MDAS and HDAS circuits (modular and hybrid, respectively).

Finally, manufacturers are starting to pay attention to the much neglected area of industrial applications. For example, Burr-Brown has just introduced a set of industrial boards for Motorola's M6800. For more on this, see p. 131.■■

NOW DELIVERING

The 1602A A lot more computer in a smaller package

We've taken our proven and powerful 1602 (AN/UYK-19) and doubled the internal memory to 64K, developed a single microprogrammed CPU module, included space for seven I/O interface boards and two RAM/ROM slots, and value-engineered the whole package into a single 19½ inch ATR chassis. In the process we trimmed off weight and added a combined Floating Point/Built-in Test (BITE) capability... plus a number of other options.

End result—You get a microprogrammed military processor with a 150 to 250 nanosecond microcycle time that's most economical in terms of size, weight and memory requirements. And it's absolutely compatible with your previously developed 1602 software.

What we didn't reduce is our extensive set of software, our quick delivery and our world-wide service.

That's Why We're #1 in Mil-Spec Computer Systems

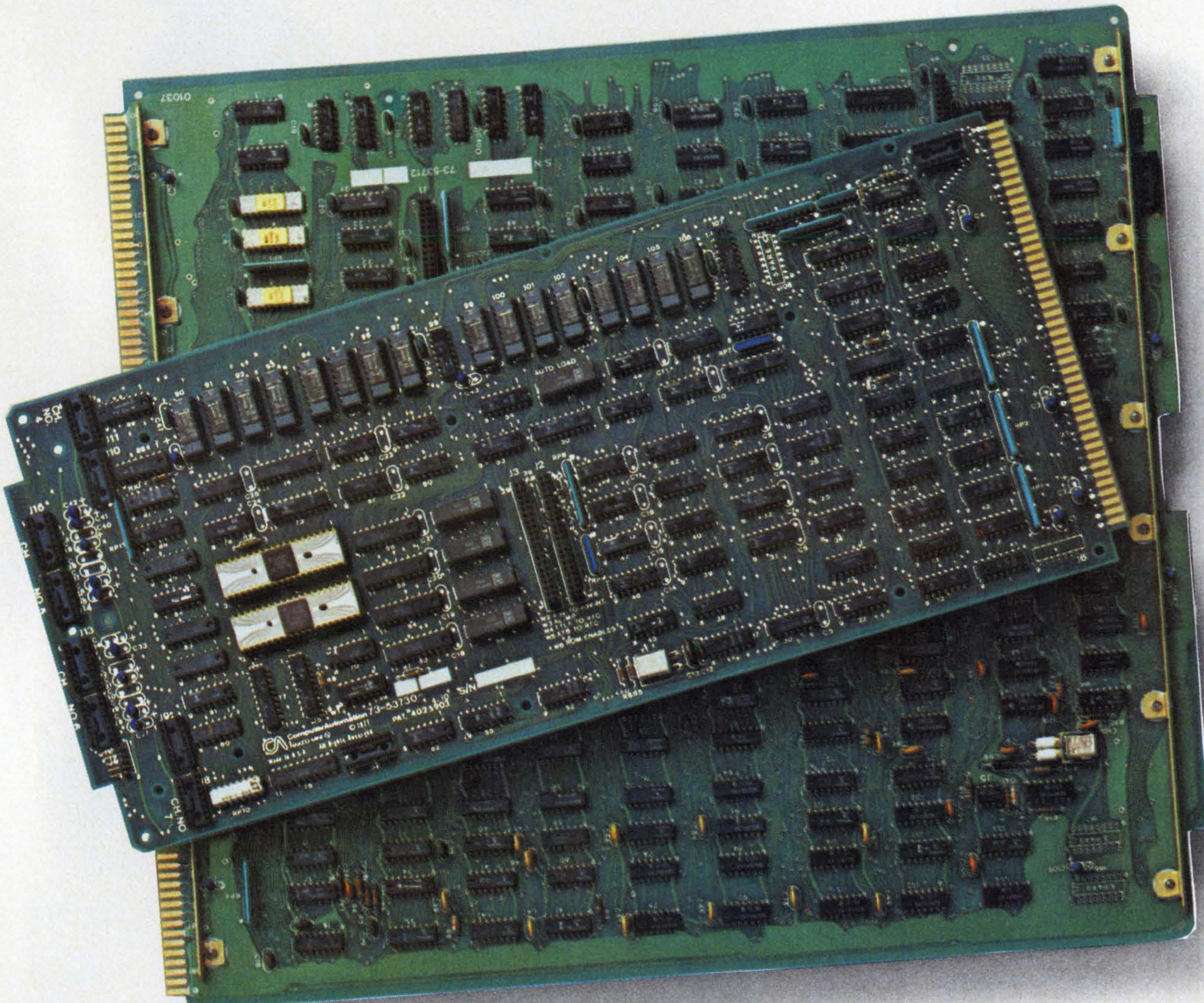
ROLM | MIL-SPEC Computers

4900 Old Ironsides Drive, Santa Clara, CA 95050. (408) 988-2900. TWX 910-338-7350.

In Europe: 645 Hanau, Muehlstrasse 19, Germany, 06181 15011, TWX 418-4170.

CIRCLE NUMBER 20

BRAND NEW MINICOMPUTERS



BRAND NEW BROCHURE

Circle Reader Response No. 270

ComputerAutomation®
NAKED MINI® Division
18651 Von Karman, Irvine, California 92713
Phone (714) 833-8830

At Wescon '77

Home computers: from a bag of parts to a system you simply plug in

The home computer is about to become a major consumer item—like televisions, microwave ovens, and videotape recorders.

This forecast as well as the developments in the home computing field itself will be covered at Session 22 of the Western Electronic Show and Convention (Wescon) in San Francisco, September 19 to 21.

Introduced just three years ago, home-computing systems are

- Evolving into complete, ready-to-use systems.
- Declining steadily in price.
- Creating a market for software and maintenance services.

Jules H. Gilder
Associate Editor

Originally, home computers were available as a bag of parts that had to be assembled. Two years ago, assembled and tested boards became available. Now, assembled systems that can simply be plugged into the wall are beginning to appear. The latest entry in the home-computing market costs $600.

Personal computers are the natural outgrowth of existing markets for programmable desk-top calculators, hobby computer kits and even programmable video games, says Robert F. Wickham of Vantage Research in "Home Computers: The Future is Here." Some of the high-priced games use microprocessors and ROMs. And the programmable games being readied for 1978 will have alphanumeric keyboards, user programmability and high-level language programming.

The PET computer is a complete home data-processing system that features BASIC language, a CRT display, cassette-tape mass storage and a low price tag. It costs only $595 with 4 k of RAM and 14 k of ROM.

Another key ingredient in the growth of the personal-computer market will be the easy availability of support and maintenance services, says Wickham. Even now, several companies are offering ready-to-use software on a variety of media, such as printed paper, tape cassettes, optically encoded pages, records and telephone-accessed subscription services.

As a matter of fact, repair and maintenance will be handled primarily by the existing consumer-electronics repair shops, Wickham foresees. Like CB radios, home computers will be serviced by either independent service shops or factory-repair stations. Indeed, TV sets with integral programmable games, to be introduced next year, will pull the conventional TV repair shops into the computer age.

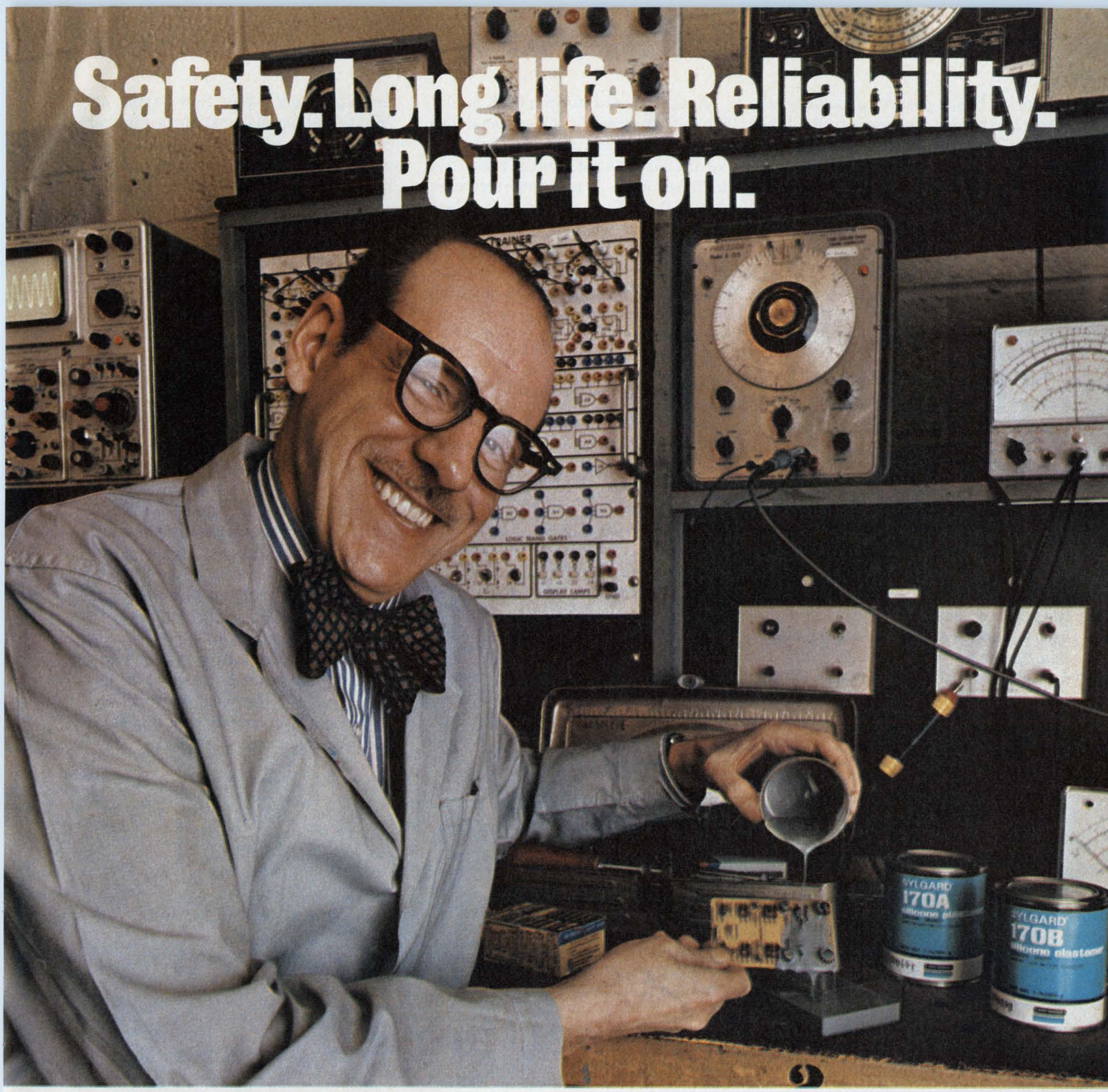
Noting the potential size of the market, Wickham predicts that by 1985 the market for home computers will be close to $2-billion. This includes $800-million worth of equipment that will be used by small businesses.

PETs belong at home

Several personal-computing systems will be introduced this year. One home system that has already been announced is the Personal Electronic Transactor computer (PET) from Commodore Business Machines, Palo Alto, CA. In his paper, "PET Computer," Charles Peddle of Commodore describes some of the characteristics and capabilities of this complete home system, which sells for $600.

A stand-alone computer, the PET consists of a 9-in. black-and-white CRT that can display up to 1000 characters (25 lines by 40 columns), an ASCII keyboard and numeric pad, and a cassette-tape recorder for program storage.

The PET also contains a memory-



Now there's an all-purpose encapsulant that gives you silicone performance at the price of organics. Dow Corning Sylgard® 170 A&B silicone elastomer. A two-part liquid encapsulant that cures at room temperature or can be heat accelerated to increase production rates.

Sylgard 170 carries the UL 94VO rating, the very highest rating for flame retardancy for this type of product.

Sylgard 170 offers excellent temperature stability. It is reversion resistant at high temperatures. And that means greater reliability and longer product life under the most severe environmental conditions.

Sylgard 170 has great dielectric properties, too. So it's perfect for general potting and encapsulating jobs like modules, relays, power supplies, amplifiers, ferrite cores and connectors. At a price that'll let you keep a margin of profit in your product as you build in an extra margin of safety.

So add it up. Safety and reliability throughout the temperature range. Longer product life. Reasonable price. Sylgard 170 silicone elastomer. Pour it on.

Call your Dow Corning representative or write Dow Corning Corporation, Department A7-511, Midland, Michigan 48640.

DOW CORNING

DOW CORNING

CIRCLE NUMBER 23

expansion bus, a port for an additional cassette recorder, a user-controllable 8-bit bidirectional parallel port and an IEEE 488 interface port.

The home system works primarily in BASIC, notes Peddle. Plugged in and powered on, it determines the amount of memory available to the user and displays the result on the CRT. At this point, the PET can accept a program from the tape cassette, keyboard or from an auxiliary storage device such as a floppy disc.

The PET was designed with consumers in mind, notes Peddle:

- It had to be priced to attract the average consumer.
- It had to be packaged and presented so that the normal retail clerk can sell it to someone who knows very little about computers.
- It had to be serviceable through normal retail service networks.

With its ability to self-diagnose and its modular design, the PET will be easy to service, notes Peddle. The main board, which would be the least familiar to TV repairmen, contains LEDs that indicate a problem immediately. The board can then be snapped out and replaced with a new one.

Another board, for the CRT, is similar to those used in conventional TVs. A third board contains the electronics for the cassette recorder. It is identical to those used in standard recorders, except that the audio section has been eliminated.

While the PET provides everything needed to get started in home computing, according to Peddle, expansion will be possible with additional peripherals, which are now being planned.

Industry uses them, too

Not all home computers will be used at home, states Don M. Muller a senior vice president at Pertec Computer Corp. In fact, by 1980 20% of the home computers sold will actually be used in business, Muller notes in "Home Computers in Small-Business Applications." Like Robert Wickham of Vantage Research, he believes that by 1985, business applications will account for \$800-million—or more than 40% of the market.

Billing and office work are among the more obvious potential business applications, according to Muller. Computers can keep ledgers, make out bills and statements, flag slow-paying accounts and handle most of the number crunching required by a small business. They can also manage mailing lists and help handle word processing.

The future is bright, but...

But bright as the future may appear, Muller warns, several problems remain to be solved—and the biggest is supplying useful software, and at a low price. But, this problem is on its way to being solved, Muller points out. Many personal-computer owners are writing their own software and packaging it for sale.

In addition, manufacturers are providing ever-increasing support. MITS, for example, which started the whole home-computing market rolling just three years ago, has set up a separate subsidiary, the Altair Software Distributing Company, soley for handling software—obtaining it, refining it, licensing it and distributing it. The new company is also putting together collections of programs designed to perform such specific business functions as office accounting or handling sales data for insurance clients. ■■

At Wescon '77

Distributed processing spreads computer intelligence around

As the need for large, centralized computer resources dissolves and computer costs fall, computer power is finding its way into more and more areas of business. That's the over-all conclusion of "Transition to Distributed Processing," Session 23 at Wescon '77.

"Integration of computers into all aspects of business is best achieved through decentralization. "The only way computers can play their proper role in business is within a decentralized structure," says Jacob Sternberg, chairman of Session 23 and president of Conversational Systems Corp., New York. Lower cost, easier control of costs, and improved information flow are among the reasons Sternberg cites for switching to distributed processing.

Andy Santoni
Associate Editor

Distributed processing is "an umbrella term for a variety of processing structures whose common goal is the placement of local computer power at the disposal of every unit of the business," according to Sternberg. This dispersion should enhance each unit's operations and control the flow of information among the units, he says.

Not so easy to implement

But breaking up the centralized computer establishment to achieve the goal of distributed processing may not be a simple task, Sternberg cautions, explaining: "The investment in a centralized facility is usually large. Disturbing the operational calm of such a facility may be disastrous. The decision of how to decentralize may be painful for top management, [which] does not really know or trust 'those machines.'"


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

A centralized data processing structure has a "social order" of users, and the conflicts that go along with such an order, Sternberg goes on. Yet, despite the expense and the problems involved in centralized processing, such facilities manage to perform their assigned role of supporting the daily operations of a business.

Centralized processing even has some advantages, says Sternberg. "Equipment breakdowns are not excessive and are handled properly. Generalized packages handle immediate problems."

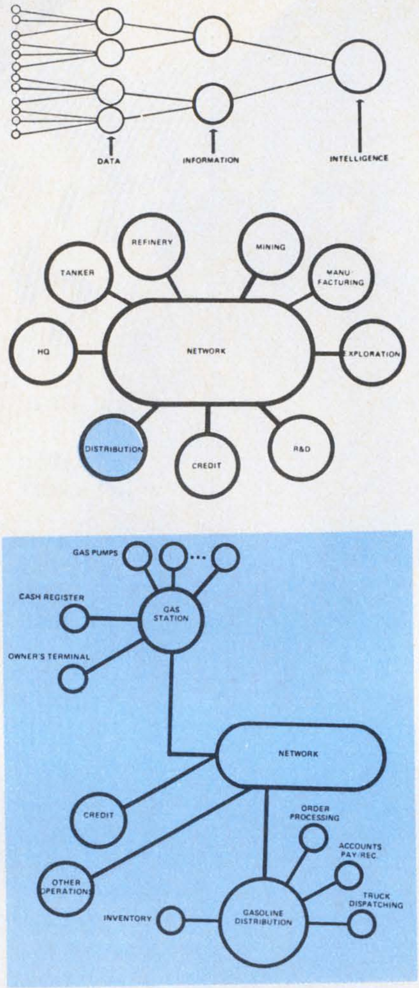
Lack of understanding

But one big disadvantage is that many corporate executives don't understand how a computer center operates. Besides being a problem when a centralized system is being used, this lack of understanding can hinder efforts to switch to more efficient methods, says Sternberg. "Since software is viewed as a massive and expensive effort, the obvious question of what it would take to change to decentralization brings visions of vast expense. Even though management is aware that theoretically decentralization is possible, data-processing management hasn't explained *how* to get there. Worse, the technologist hasn't explained *why* it is necessary to get there."

But management can be convinced that a change is possible and advantageous, he says, because major computer manufacturers, led by IBM, are committed to distributed processing, and can provide the education necessary for managers and technicians. In addition, successful implementations already exist, so companies won't have to be pioneers—a very costly occupation. Moreover, there are many small companies ready to augment the corporate staff in solving local and central problems, and a large pool of technically competent personnel to develop and maintain distributed systems.

Small computers improving

Engineers can now develop low-cost distributed-processing systems in part because small computers are highly reliable, and are becoming even more so—the designer needn't worry anymore that hardware placed "in the boondocks" will require excessively expensive maintenance. In addition, remote peripherals—taking advantage of microprocessors—can be as simple or complex as required, and can easily be customized by changing hardware or software. Hardware interfaces, controllers, peripherals and communications devices all have enough intelligence to enable simple hookups. And compatible software is available.



There's more than one way to distribute processing power through an organization. A hierarchically distributed structure (top) is simplest and easiest to visualize and expand. But some computer users, like oil companies, have systems so complex they can be represented graphically by only the most over-simplified diagram (center). Just one node of the oil company's processing system—distribution, for example—has a complex representation (bottom).

Meanwhile, economics will force the semiconductor industry to standardize parts designed for distributed-processing applications, at least at the interface, predicts Mark Levi in another Session 23 paper. And as low-cost hardware becomes more prevalent, the marketplace will cause the current mini and macrocomputer houses to take a closer look at standardization. "Perhaps IBM's active pursuit of Series 1 peripheral suppliers is a nod in that direction," says the director of microcomputer systems at National Semiconductor Corp., Santa Clara, CA.

Microprocessors improving

Microprocessors will have greater throughput, adds Levi, as cycle times improve and architectures become more efficient, and as instruction repertoires become larger and more powerful. "Processors may contain ancillary circuits, or may be microprogrammable, stack-oriented, language processors or in fact anything that has been done in the mini or macrocomputer world."

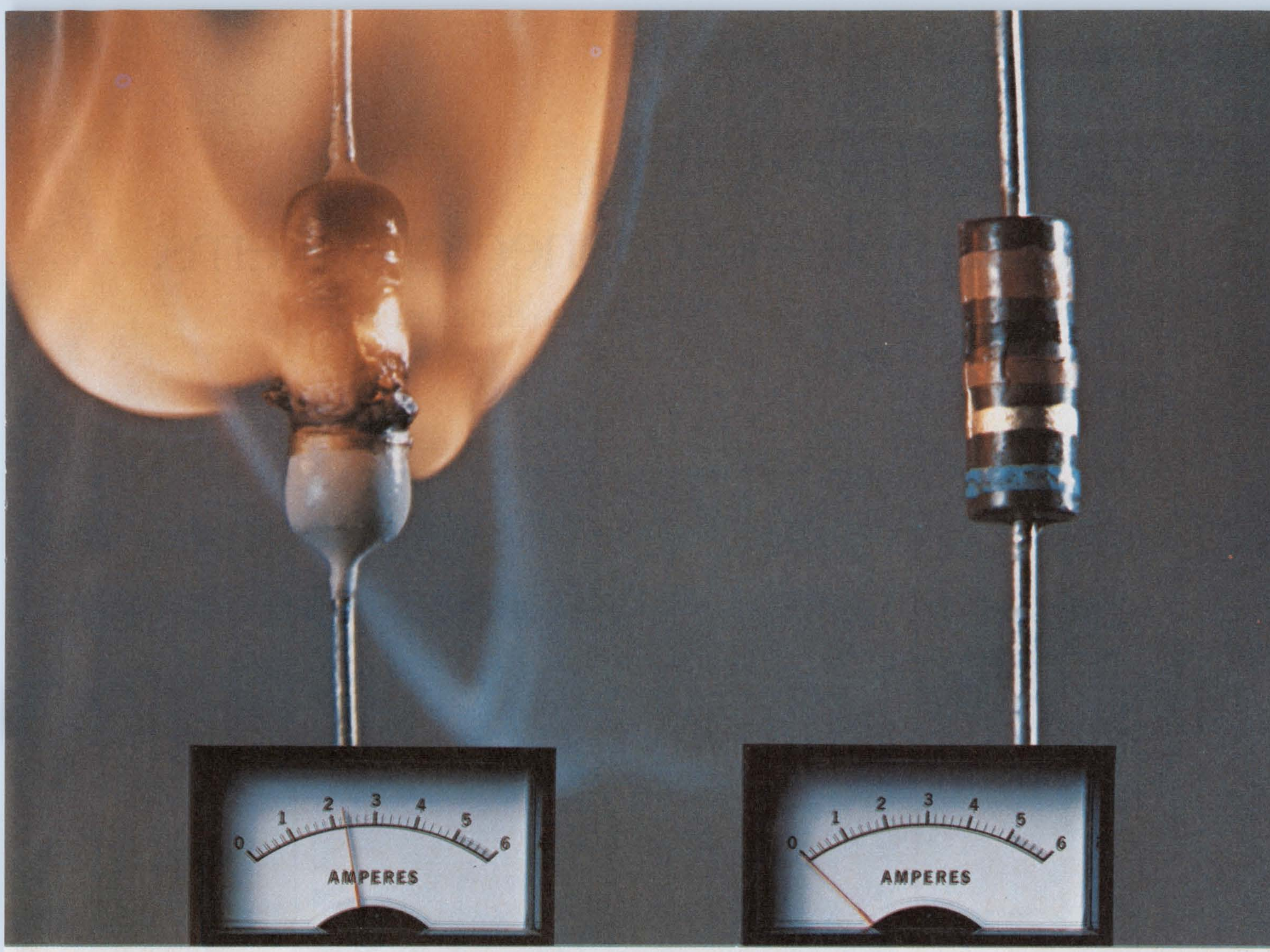
Of course, "RAMs and ROMs will continue to get larger, cheaper, and lower power," says Levi, adding that 16-kbyte ROMs are not far off. Peripheral control chips will proliferate and be programmable to allow wider differentiation of standard products, he adds. "All parts will be designed to allow easier interconnection, and to put the burden on hardware as much as possible. Manufacturers will tend to standardize the universal buses and avoid specialized chip families."

The number of microprocessor components to be purchased indicates the scope of the change taking place, Levi continues. "In 1980, National forecasts a consumption of 1.5-million 8080 software-compatible microprocessors. Although many will be used in dedicated and/or control applications, that is still a lot of intelligence that will be absorbed by industry."

This intelligence can best be used to displace the present centralized processors with one of two types of distributed processing systems, says Conversational Systems' Sternberg—hierarchically or nonhierarchically structured.

In a hierarchically distributed structure, as shown in the figure, growth occurs by duplicating modules. Such a structure is relatively easy to implement, says Sternberg.

On the other hand, the nonhierarchical structure of an oil company's processing system is so complex that a graphical presentation of data flow must be oversimplified or unwieldy. Just one segment of the structure requires a complicated diagram.■■



The failure. A 16 W overload causes this 1/2 W carbon film resistor to burst into flame. The initial failure mode is a short circuit, causing even more current to be drawn as shown on the meter.

The successful failure. The TRW 1 W rated BW-20F (1/2 W size) stays cool and fuses quickly and safely under identical power surge conditions. The failure mode, as shown, is an open circuit.

A failure your circuit can live with.

Failsafe, Fusible, Wirewounds Offer Built-In Circuit Protection.

Cool wirewounds like our BW failsafe series have a dual personality.

They provide stable resistance to normal operating current. But at specific overloads, they open circuit like a good fuse. So, as shown above, they'll protect your circuit from excess heat and fire in places where severe fault conditions are encountered.

The BW failsafe series, UL listed per Document 492.2, can save cost by eliminating the need for both resistor and fuse. Save space, too, because they're about half the size of standard 1 and 2 W devices.

Depending on your specific circuit parameters, other TRW film and wirewound resistors can be engineered to meet your requirements.

For more information on resistors your circuit can live with, contact TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., 401 N. Broad St., Phila., Pa. 19108. Tel. 215-922-8900. Telex: 710-670-2286.

TRW IRC RESISTORS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

CIRCLE NUMBER 25

new KEPCO/TDK triple-output switching modules

for microprocessors and logic applications

The KEPCO/TDK series RMT combines a logic 5 Volt ± 10%, 10 ampere output with various combinations of auxiliary voltages (see table). All outputs are stabilized by high efficiency switching circuits.

RMT

FEATURES

- Each output protected by overvoltage monitor.
- Each output protected by self-resetting overcurrent circuit.
- Soft start circuit reduces primary surge current.
- Remote on-off using logic level switching
- High density: more than 75 watts in less than 100 cu. in.

FOR YOUR MICROPROCESSOR

MODEL	OUTPUT #1		OUTPUT #2		OUTPUT #3		PRICE
	Volts	Amps	Volts	Amps	Volts	Amps	
RMT 001-AA	+5V	10 A	+12V	1 A	−12V	1 A	$329.00
RMT 002-AA	+5V	10 A	+15V	1 A	−15V	1 A	329.00
RMT 003-AA	+5V	10 A	+12V	1 A	−5V	1 A	329.00
RMT 004-AA	+5V	10 A	+15V	1 A	−5V	1 A	329.00
RMT 005-AA	+5V	10 A	+12V	1 A	−9V	1 A	329.00

Custom volt-ampere combinations are available. Please consult the factory.

KEPCO® For complete specifications, write Dept. BVF—05

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 U.S.A. • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER NEWYORK

CIRCLE NUMBER 27

Washington report

Cruise-missile flyoff set for 1979

Two competing air-launched cruise missiles, the Air Force's long-range ALCM-B and the Navy's Tomahawk, will participate in a flyoff during 1979, with the winner to become the new strategic weapon for the B-52 bomber early the following year.

Development of both missiles was accelerated after President Carter decided against the B-1 bomber. The flyoff will include 10 launches of each cruise missile from the wings of B-52s. To simulate operational conditions, half these tests will be conducted by Air Force Strategic Air Command crews without assistance from the contractors.

The winner of the flyoff will be tested nine more times, also from a B-52, during 1980. Even before these latter tests are completed, the Defense Department expects to start producing the winning design for installation on operational bombers during the first three months of that year.

Congress has been briefed on the competition and has been advised that funds will be needed for it as soon as the new fiscal year begins Oct. 1. The funds may be slow in coming, however. In recent years, Congress has been reluctant to fund concurrent development and initial production of new weapons.

F-16 radar problems fixed in nick of time

A radar pick-up problem on an Air Force F-16 fighter was corrected during an intensive flight-test program in August at the Baltimore facilities of Westinghouse Electric Corp., prime radar contractor. The corrections came none too soon. A formal decision on production for the F-16 is scheduled for later in September by the Defense Systems Acquisition Review Council.

The radar system on F-16 No. 3 reportedly picked up false signals from ground clutter while operating in the look-down air-to-air mode. The problem was fixed by making changes in the low-power rf unit, which acts as the analog/digital interface. The No. 3 is the first F-16 to have a production-model design radar. Changes made on that aircraft will be duplicated on other flight-test aircraft.

Earlier this year, the F-16 radar passed a major milestone, the production-readiness review. The Air Force plans to order the first 105 aircraft in the fiscal year beginning Oct. 1 and another 45 the following year. In all, 1388 F-16s are expected to be purchased for use by the U.S.

Hydrofoil patrol boat reinstated

The Defense Department, following the lead of Congress, has reversed a decision to cancel the Patrol Hydrofoil Missile (PHM) program. As a result, prime contractor Boeing will build five more vessels for the U.S. Navy and may be able to sell 10 more to the West German Navy.

Defense Secretary Harold Brown decided to kill the program in April after experience with the first boat, the PHM-1 Pegasus, had indicated that the other hydrofoil patrol boats would cost twice their original price (from \$20-million each in 1974 dollars to \$41.4-million). He asked Congress to rescind the \$272.7-million appropriated for construction, but Congress refused to act.

The vessels, which will be used for antisubmarine warfare around coastal areas, will be armed with Harpoon antiship missiles and the Sperry Mark 92 fire-control system, which the Navy calls an Americanized version of the Dutch Mark 94 system.

Boeing will deliver five more PHMs to the Navy between January, 1, and February, 1980, four of which will be assigned to PHM squadron operating with the Sixth Fleet in the Mediterranean. The fifth will join the Pegasus for testing.

West Germany and other NATO navies have expressed interest in the PHMs, but only if the U.S. produces more than the PHM-1.

Radiographic techniques used to test jet engines

After a year of delays, an organization to coordinate procurement methods has been put into operation by the major government agencies under a regulation requiring government-wide uniformity. The institute is supposed to be the focal point for training federal-procurement officers and conducting studies of how to achieve a uniform procurement system.

The Federal Procurement Institute was established shortly after the White House put out the famous Office of Management and Budget Circular A-109 calling for the agencies to set up a single procurement system. But because of the change in administrations, no director was named and the institute consisted only of a skeleton staff housed in the Pentagon.

Then, in late August, the White House appointed a director, Dr. John Bennett, former Assistant Secretary of Defense for installations and logistics, and moved the institute to permanent facilities at the Army's Development and Readiness Command headquarters, Cameron Station, VA.

Federal Procurement Institute activated

Radiographic techniques by Varian Associates are being used by Pratt & Whitney to measure clearances between parts in operating aircraft engines for both commercial and military jet aircraft.

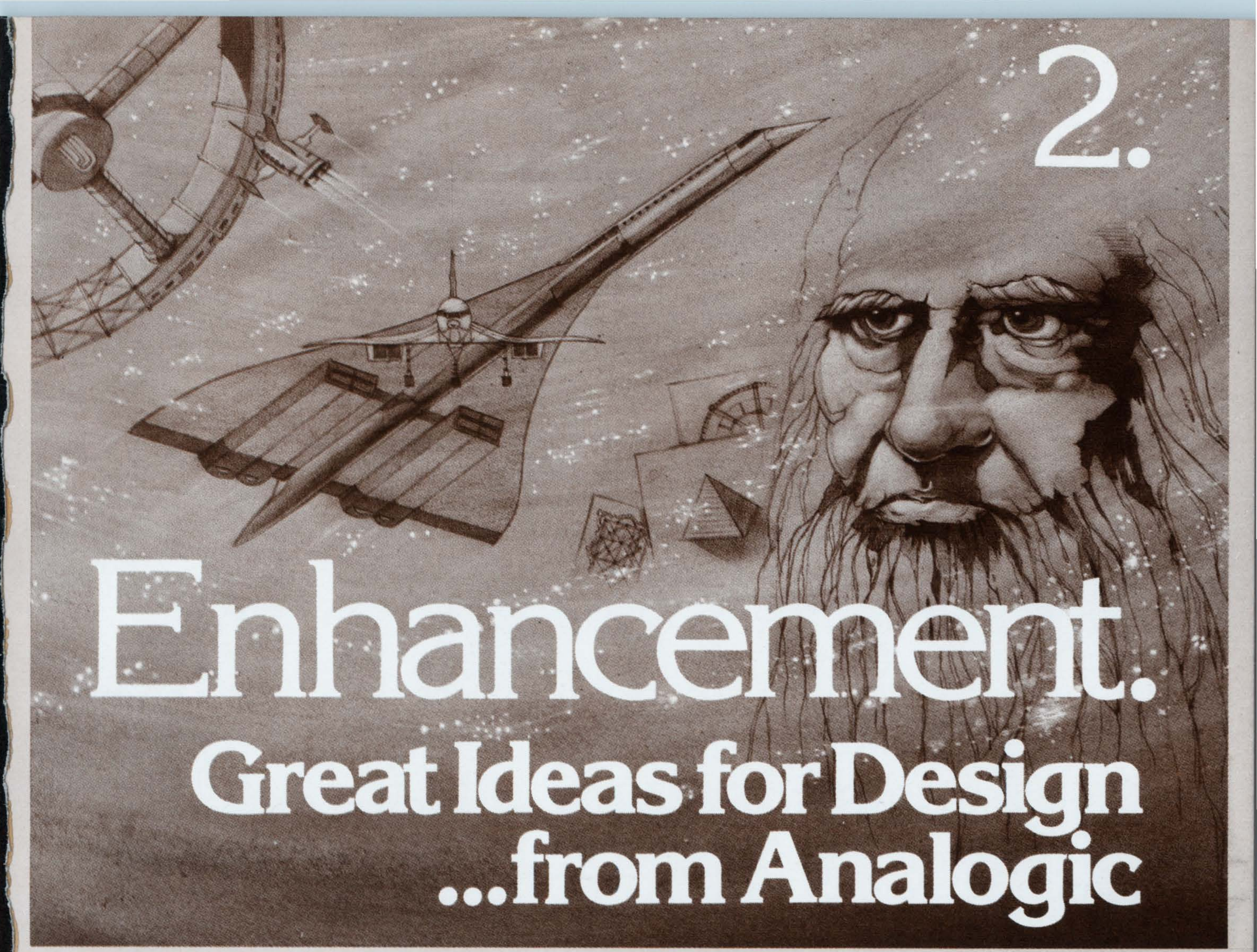
The measurements are made in an attempt to improve fuel efficiency and thrust and are conducted while engines aren't running, during steady thrust and during sudden accelerations and decelerations.

A Varian linear accelerator is mounted in a lead shield next to the engine to be scanned. Typical measurements include axial and radial clearance of seals, radial clearance of unshrouded blades, clearances in the compressor seals and component deflections due to thermal and mechanical stress.

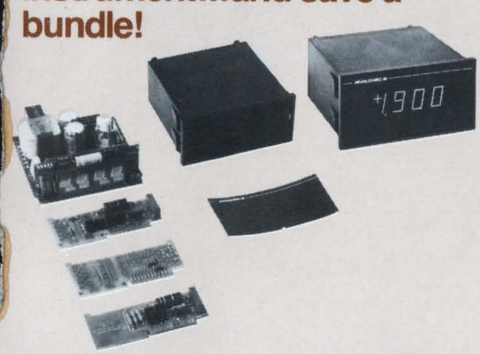
Capital Capsules:

The Air Force has put its **second E-3A Airborne Warning and Control System aircraft into operation** at Tinker Air Force Base, OK. The first production aircraft was delivered in March. . . .In preparation for a decision next year on whether to develop the M-X advanced intercontinental ballistic missile, guidance-system contractor Northrop has been extended through April, 1979. The firm has delivered its first **advanced inertial reference-sphere (AIRS) guidance system, which is said to be far more accurate than those used on the present Minuteman ICBMs.** Northrop will build and test three more. . . .The Defense Department now estimates its **TRI-TAC program to replace all three services' current analog, non secure battlefield communications with new all-digital and end-to-end secure-equipment will cost $3.1-billion,** including $995-million for development. Procurement is due to begin next year. . . .British Aerospace Corp. is planning an **improved Sky Flash air-to-air missile incorporating the monopulse seeker, which is reportedly less vulnerable to enemy jamming.** The U.S. Air Force and Navy are interested in the concept and will test it on the current Sky Flash this year.


10 nsec. $69.95
Meet CSC's LP-3. The multi-family logic probe that's as fast as a high-speed memory scope. At about 1/100th the price.
You won't want to be without this compact, enormously versatile test and troubleshooting tool that does the work of a level detector, pulse detector, pulse stretcher and memory probe. It gives you instant, positive indications of circuit conditions—capturing one-shot and low-rep-rate pulses (down to 10nsec) that are barely visible, even on a fast scope.
Easy to use. No sync, polarity or circuit loading to worry about: just set a switch to the proper logic family, connect two clip leads to the circuit's supply and touch the probe tip to the node under test. You get an instant picture of circuit conditions: Separate LED's indicate logic "1", logic "0" and all pulse transitions. To store single-shot and low-rep-rate pulses, simply set the PULSE/MEMORY switch to MEMORY.
At $69.95, LP-3 simplifies testing, debugging and servicing all types of digital circuits, with pulses as fast as 10nsec. See your CSC dealer today. Or call 203-624-3103 (East Coast) or 415-421-8872 (West Coast) for the name of your local stocking distributor and a full-line catalog.
Logic Family Switch—TTL/DTL or CMOS matches Logic "1" and "0" levels; CMOS position also compatible with HTL, HiNIL and MOS logic.
PULSE/MEMORY Switch & LED—PULSE position detects and stretches pulses as narrow as 10 nanoseconds to 1/10 sec.; MEMORY stores single-shot and low-rep-rate events indefinitely; HI/LO LED's remain active.
HI/LO LED's—Display level (HI-logic "1", LO-logic "0") of signal activity.
Interchangeable probe tips—Straight tip supplied; optional alligator clip and insulated quick-connecting clip available. Optional input ground lead.
Plug-in leads—24" supplied, with alligator clips. Virtually any length leads may be connected via phono jack.
Specifications
Input impedance 500,000Ω
Thresholds (switch selectable) DTL/TTL HTL/CMOS
logic 1 thresholds (HI-LED) 2.25V±.10V 70% Vcc±10%
logic 0 thresholds (LO-LED) 0.80V±.05V 30% Vcc±10%
Min. detectable pulse width 10nsec. guaranteed
Pulse detector (PULSE LED) in PULSE position of PULSE/MEMORY switch, 1/10-sec. pulse stretcher makes high-speed pulse train or single events (+ or − transitions) visible; in MEMORY position, first transition lights and latches LED
Operating temperature 0-50°C
Physical size (l x w x d) 5.8 x 1.0 x 0.7" (147 x 25.4 x 17.8mm)
Weight 3oz. (.085Kg)
Power leads removable 24" (610mm) with color-coded insulated clips; others available
Input protection overload, ±25V continuous; 117 VAC for less than 10 sec.; reverse polarity, 50V
HI LED ON
LOGIC "1"
LOGIC "0"
LO LED ON
PULSE LED BLINKS ON FOR 1/10 SEC
HI LED ON
LO LED ON
T = 1/10 SEC
HI LED ON
PULSE LED OFF
PULSE LED OFF
LO LED ON
DURING PULSE TRANSITIONS PULSE LED BLINKS AT 10 Hz RATE
HI LED ON
LO LED DOES NOT RESPOND TO NARROW PULSES
DURING PULSE TRANSITIONS PULSE LED BLINKS AT 10 Hz RATE
LO LED ON
HI LED DOES NOT RESPOND TO NARROW PULSES
CMOS
DTL/TTL
PULSE
MEMORY
PULSE
LOW
HIGH
CSC Continental Specialties Corporation High Speed Probe LP-3
CONTINENTAL SPECIALTIES CORPORATION
CSC
44 Kendall Street, Box 1942, New Haven, CT 06509
203-624-3103 TWX 710-465-1227
West Coast: 351 California St., San Francisco, CA 94104
415-421-8872 TWX 910-372-7992
See us at WESCON Show Booth #'s 1114, 1116 & 1118
*Manufacturer's Recommended Resale
©1977 Continental Specialties Corporation
CIRCLE NUMBER 29
NEW LP-3!



We Invite You to Build *Your* Instrument Inside of *Our* Instrument...and save a bundle!



At first glance, the AN2553 is merely another superb Analogic DPI—a digital panel *instrument,* not a "meter"... but that's another subject. What's unique about *this* DPI is that **it comes ready to take apart** —with or without our help—and to be equipped with *optimized* plug-in interface circuitry that lets it measure virtually *anything,* from nanoamperes to Amperes, from microvolts to kilovolts, from degrees F or C to pounds or kilograms... and (literally) *hundreds* of other parameters.

How do we help? Five ways:

• **Sockets** are provided in the AN2553 for P.C. cards—front end (analog) and tailend (digital). We call them "Kluge Cards." (The DPI provides them with regulated power, too.)

• **Kluge Cards** are available in two forms: *blank* (but bused and drilled, ready for your personal circuits); and *loaded* with proven, high-performance standard circuits for the 18 most popular analog and digital interfaces.

• **Recommended Circuits** for all 18 standard kluges, so you can build your own versions of them, if you wish.

• **Production Services,** if you *develop* a kluge, but want *us* to produce it in OEM quantities.

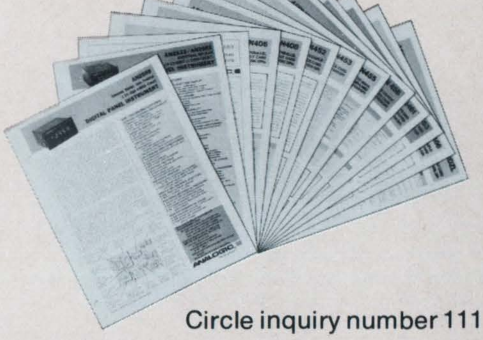
• **Applications Engineering** in depth, as always, from the world's largest manufacturer of panel digitals.

With the standard *digital* kluges, by the way, you've got *more* than an instrument—you've got a pretty fair *subsystem.* Compatible with printers, computers, remote displays, limit comparators, and remote D/A s, these BCD output cards give you all the required control, programming, latching, timing (*and* isolation if needed) that lifts the AN2553 up to the data-acquisition/logging and process-control level—"just short of a microcomputer," we like to say... at about one-fifth the usual cost, by the way!

The AN2553 itself is worth a lot of attention, but space is tight, so here's a quick look: ±3½ digit, 2,000-count resolution **(want more? a "stretch" version, our AN2559, gives you 3¾ digits, 4000 counts, same kluge-card accommodation)** ±0.05% ±1 count limit of error; *very low* T.C.'s, internal dissipation, and bias current; *very high* CMRR, CMV, NMR, line-noise rejection, and input impedance; our exclusive "universal powering" (100, 117, 220, or 240 VAC, 50 *or* 60 Hz, jumper selected; DIN/NEMA case (metal optional); and our famous 96-hour heat-and-stress burn-in on every unit. Value? How about a 100's price of $99?

Standard analog front ends include Thermocouple and RTD interfaces, current and voltage receivers, true-RMS, AC line monitors, and a microvolt receiver for load cells, strain/pressure gages, etc.

Move up to the DPEI—the Digital Panel EVERYMAN'S Instrument... and start with this data file!



Circle inquiry number 111

ANALOGIC CORPORATION / AUDUBON ROAD / WAKEFIELD / MASSACHUSETTS 01880 / (617) 246-0300

For Sale—222, 221 NBS-Traceable Secondary-Standard DC Voltage Levels (μV to Volts)...for only $695.

The AN3100 Secondary DC Voltage Standard is *not* a new instrument. For seven years now, the AN3100 has been a standard of the industry. There are *thousands* in use worldwide. The design is, by far, still the most accurate, stable and versatile available in this price range.

Here's what we give you:

• **Five Dialable, Digital Decades of DC Voltage**—two simultaneous ranges: 0-11.1110 Volts with 100μV resolution, and 0-111.110 Millivolts with 1μV resolution.
• **Current Capability up to 50 Milliamperes**—Short-circuit proof. No restrictions on load capacitance.
• **Reversible Polarity, Isolated Output**—Can be floated 500 Volts above or below ground.
• **Very High Stability**—±2ppm/°C and ±15ppm for 60 days.
• **Absolute Accuracy of 50ppm of Reading**—(±50μV) for 6 months, without recalibration.
• **Low Noise**—less than 0.001% of reading +50μV.
• **NBS Traceability**—4 pg. Test Report and Certificate of Performance provided with each instrument specifying calibration voltages, equipment employed and final calibration accuracies to six places (±5ppm ±instrument uncertainty of 2ppm) and their direct traceability to NBS primary standards.

We've never been able to list *all* of the applications for this versatile box of tricks, but there must be hundreds. Here's just a sampling...

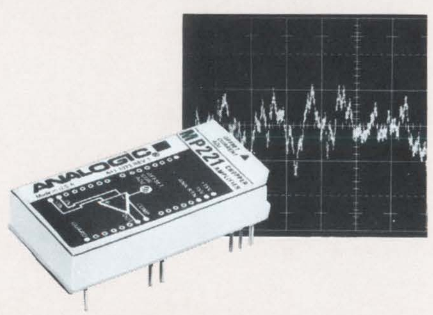
• Calibration of digital voltage instrumentation of all kinds, right up to 5 digits.
• Calibration of voltage dividers, resistance ratios, precision pots, and resistive-ratio transducers.
• Precise monitoring and measurement of regulation and stability of power supplies, D/A converters, amplifiers, and other analog-output circuits.
• Precise, absolute gain, linearity, and stability measurements of DC amplifiers.
• As the dialable reference and programmer in precision current generators.
• Calibration of analog multiples, log-ratio modules, and other "function generator" circuits.

One word of warning: unless you work alone, in a locked room, get more than one. The AN3100 is habit forming, and there's no cure. Beware of borrowers because they can become addicted to your AN3100. (The AN3100 fits neatly into desk-drawers and glove compartments.) By the way, it's the most *portable* secondary standard you've ever seen—light, small and tough.

Get Full Specs—plus our famous Application Note: "31 Ways to Use the AN3100"

Circle inquiry number 112

Got Your Back to the NOISE/DRIFT Wall? Here's Immediate 10:1 Relief.



Check that scope photo. It's the output of our MP221 ultra-low-noise, ultra-low-drift chopper amplifier, the best in its class by *at least* an order of magnitude. What's really impressive about that photo is that it was taken at a gain of 1000, and with a 10 kHz bandwidth... a "tell-it-all" test that other amplifiers costing far more will flunk miserably!

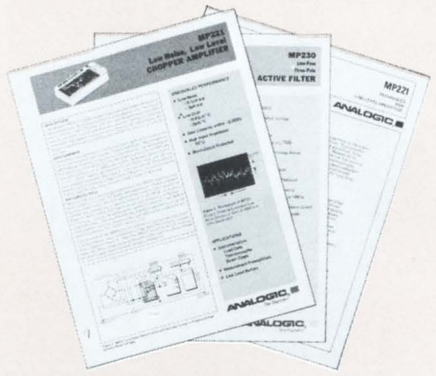
But low voltage and current noise is only a part of the MP221 story. It's stability is equally impressive: <0.03μV/°C, <2pA/°C. Together, they make it possible to buffer and amplify any microvolt-to-millivolt-level signal source (load cells, strain gages, thermocouples, biophysical pickups, etc.) with truly impressive accuracy, without excessive tradeoffs of bandwidth or gain. The gain linearity, by the way, is better than ±0.002%.

There are no ugly surprises lurking in the specs, nothing to constrain you to the use of weird architectures. Input impedance is 1000 megohms, the output is short-circuit protected, the output range is a full ±10V at up to ±3mA, the frequency response is −3dB at 100 Hz, and CMRR is 140dB.

By the way, if your application lets you limit bandwidth to 1 Hz, the noise drops to a state-of-the-art 0.1μV p-p level! And that's the *whole* bag of worms, *including* flicker and Johnson-noise components. We even gold-plate the pins, so that you can use low-thermal-EMP solder, and approach ideal passivity at the input!

The MP221 is *easy* to use. No sandpapering the fingers, no walking on tip-toe, no muttering of incantations. Just set the gain from 10 to 10,000, select the roll-off frequency for system compatibility and you're ready to go.

Get the File on the MP221—for Optimum Low-Level Amplification.



Circle inquiry number 113

From Handshake to Marriage in Less Than Two Years

For a couple of years now, our AN5400, the world's most versatile "Real-World" Data Acquisition and Distribution System, has been engaged in polite conversation with practically every mini under the sun.

From the beginning, we have always offered standard register interfaces to eight general-purpose minis, including DEC's PDP-11 family, Data General's Nova line, the Hewlett Packard HP2100, and the Texas Instruments TI960/980 family, just to mention a few. Interfacing is accomplished through a variety of simple plug-in, handshake modules that enable easy communication via the mini's parallel I/O Bus. But now we've added a new dimension to that communication.

Before proceeding with the "hard news," let's briefly review the unprecedented flexibility of the AN5400, starting with the availability of the following User Modules; 13 different D/A Modules, six High Level Mux Modules, our unique line of Standard Thermocouple Amplifiers and Low-Level Isolation Amplifiers, Two Simultaneous-Sample-and-Hold Modules, as well as digital I/O capability. Combine these with over 13 different types of A/D Modules, *plus* the interface modules, *and* the ability to combine **any combination** of up to 16 User Modules in one chassis, and you have a *truly* flexible Data Acquisition and Distribution System... the world's most flexible, we call it, and no one challenges us, either.

Consider further that with combinations of the above standard modules one can configure systems with Resolutions of from 8 to 16 bits, throughput rates of up to 100kHz, and input capacity of up to 4096 High Level, Single Ended Input Channels.

ANALOGIC CORPORATION / AUDUBON ROAD / WAKEFIELD / MASSACHUSETTS 01880 / (617) 246-0300

Also consider that the 16 User Modules per chassis **may be virtually any combination of standard User Modules, all within the same chassis.** Hence, flexibility is maximized and user investment is minimized.

Due to this unique design and total system flexibility we felt we were years ahead of the field, and you agreed. You've bought millions of dollars worth of AN5400 equipment, and the sales curve just keeps climbing.

However, nothing ever stands still in electronics, and every landmark design like the AN5400 starts generating new ideas from the day it's introduced. About a year ago, some of you began to see the potential for bigger, faster, more sophisticated computer-based systems. The result is that we've just succeeded in arranging not one, but two "marriages" between the AN5400 and the two most widely used minis: the DEC PDP-11 and the Data General NOVA. Yes, you can now take *complete* advantage of the AN5400's 100kHz throughput rate, by the use of these two new DMA interfaces. (In addition, considerable software overhead is eliminated in the process.)

Why DMA? Because *D*irect *M*emory *A*ccess is the only way to handle high-volume data traffic between the mini and its real-world interface, *without slowing everything down by requiring data transfer through the I/O port.* Throughput is no longer limited by the time-consuming hardware-and-software interaction required for I/O port interfacing, and 100% of the AN5400's maximum rated throughput may now be utilized thereby increasing the overall system throughput.

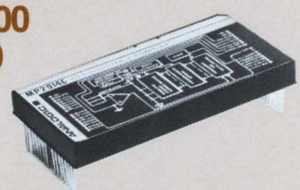
With the PDP-11 DMA interface, we furnish a remarkably complete and versatile software package, *compatible with* the host computer's standard operating software. It provides just about everything you need to converse with the AN5400 via keyboard, to exercise and verify the performance of the AN5400, and to carry on virtually any data acquisition/distribution function for which the AN5400 was designed—at *no* added software-design expense!

We've prepared special data sheets on these two DMA interfaces; and, if you write for them, we'll send along the *complete* AN5400 book—32 pages of fascinating exposition on how to match *your* mini (of any kind) to the world around it... easily, economically, and with maximum before-and-after flexibility.

Get the AN5400 Briefing—A "Short Course" in Computer Interfacing!

Circle inquiry number 114

When There's No Room for Compromise—and No Budget for Mistakes—Think 2900 and 2700



Seasoned Analogic watchers know that we excel in providing state of the art performance and hard-nosed economic value. In fact, if price/performance juggling is what you need, then, you should talk to us.

BUT—sometimes there's no way to bend a requirement without breaking it. In fact, a cold, dispassionate examination of the *realities* of many digitizing applications would reveal that they are woefully *underimplemented.* The circuits used just don't hack it, and the only things that save the designer from an outright rejection are luck and user pessimism ("none of these things *ever* work to spec"—how often have you heard that, or said it?).

Here's one point: if you need, in one A/D converter, top speed, high resolution, fully compatible accuracy and linearity, and rock-solid temperature/time stability, we've got a design that delivers them *all, simultaneously,* at a price that makes good sense, even in small quantities. Our MP2900 and MP2700 series are, we believe, the only families of moderately priced successive-approximation A/D converters that don't ask for, or need, any kind of "tradeoff relief" to keep it in spec. From the 14-bit MP2914C downward (13,12,10 and 8 bits are standard), this is a no-excuses design. Check these specs—and bear in mind, when you do, that at 14 bits, the LSB represents about 60 PPM.

MP2914C*—14-Bit Premium A/D
Absolute Accuracy: 0.006% NBS traceable
Relative Accuracy: 0.004%
Differential Linearity: 0.004% FSR
3-Sigma Noise: 0.005% P-P (RTI)
Monotonicity: Guaranteed Perfect
T.C. of Diff. Lin.: $<\pm3$PPM/°C FSR
Gain T.C.: $<\pm7$PPM/°C
Offset T.C.: $<\pm12$PPM/°C
Conversion Time: 10μsec.
***MP2714C**—specs differ slightly.

That's just a quick look—but we promise you that when you've finished reading the complete data sheet, you won't have a single quibble with our claim: *this is a design without compromise.*

And, like *all* Analogic A/D converters, a 2900 or 2700-series module is shipped to you with its own *individual* computer printout, recording the results of the most exhaustive tests ever applied to a product in this class—tests so comprehensive that we also furnish a four-page engineering supplement, describing them in detail! (If we didn't computer-program them, they'd cost more than the module, and take a week or more to perform.)

Do you have an A/D requirement that's tough enough to separate the grownups from the kids? We've got the MP2900s and MP2700s. Let's get them together.

Full Data-Including Our Unique Computer-Based A/D Test Procedures—FREE.

Circle inquiry number 115

ANALOGIC CORPORATION / AUDUBON ROAD / WAKEFIELD / MASSACHUSETTS 01880 / (617) 246-0300

For Immediate Action... Use This Card Today!

If card has already been used, circle the inquiry number indicated on this publication's reader service card.

FIRST CLASS
Permit No.336
Wakefield, Mass.

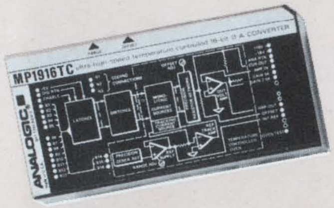
BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By

ANALOGIC®
CORPORATION

AUDUBON ROAD
WAKEFIELD / MASSACHUSETTS 01880

A New Twist to the "LONG DAC" Game: Real Bits!



Have you been having fun counting the pseudo-bits on those new "break-through" D/A converters you read about almost every month? The latest in our collection is an 18-bit wonder that works out to somewhere between 14 and 15 real, meaningful bits, when you take it out of the magazine pages and put it in even the gentlest of environments. The extra three or four bits are apparently as useful as spigots on a bull... and you can't milk a bull, nohow.

Apparently, the reasoning behind these recent 15, 16, and 18 bit fantasies is that it makes a system designer *feel* better to have lots of extra terminals that appear to give him higher resolution than the DAC's linearity and stability can support. But the circuits that *surround* the DAC can read the fine print. They can multiply so many ppm/°C by so many °C, and come up with 3 LSB's of drift over a modest range.

The most curious part of all this is that, for the same money or less, we offer *true* 14-bit, 15-bit, and 16-bit DAC's – with real and meaningful 14-to-16-bit performance, mind you. Our MP1900 series, for example, comes in a number of grades, of which the MP1916TC is the "top of the line," sells for about five bills (lots less in quantity), and delivers specs like these:

MP1916TC Premium 16-Bit DAC

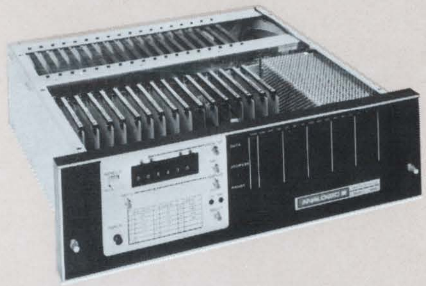
Relative Accuracy: $\pm$0.001% FSR
Differential Linearity: $\pm$0.001% FSR
T.C. from All Sources: <1PPM/°C
(That is not a misprint!)
Current-Mode Settling Time: 3μsec to ½LSB
Voltage-Mode Settling Time: 20μsec to ½LSB

And, *for substantially less money,* we've got 14-to-16-bit DAC's in this same 1900 series, any one of which will *still* outperform those unreal "lotta-bits," as we've begun to call them around our lab. We invite you to try the real thing...

Send for the Analogic File on Real LONG DAC's – Fascinating True Stories of Actual Resolutions!

Circle inquiry number 116

GREAT NEWS – "Remote" Capability for the World's Most Flexible Computer-Interface System.



Turn back to page 2, and read our capsule description of the AN5400. That leaves us more space to talk about one of the new optional capabilities we've developed for this continually evolving system... an asynchronous communications interface.

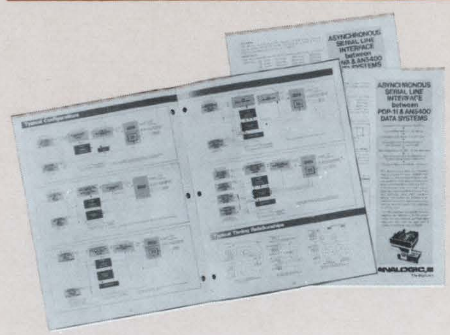
With this new plug-in option, you are free to locate the AN5400 Data Acquisition System *anywhere*... regardless of where its host computer is located. You can build the AN5400 right into the process racks – where the wiring to hundreds (or even thousands) of transducers, control relays, solenoids, positioning motors, etc., etc., can be done most easily and economically – and then link the *digital* traffic to and from the computer, via dedicated serial line, or even directly over standard telephone lines.

Here are the key numbers and features...

- Complete Conformance to RS-232-C
- Plug-In 4-Card Module – No Wiring
- Compatible with 20-mA Current Loops
- Compatible with Standard Modems and Dedicated Lines (RS-422)
- Baud Rates: 50 to 19,200 – Switch Selectable
- Built-In Status and Error Registers for System Debugging and Diagnostics
- Choice of Protocols

With this added capability, the AN5400 becomes more than just the most flexible system to configure, but it also makes it the easiest to **locate**, in the application environment and master-system architecture in which you must work. Watch future issues of **Enhancement** for more good AN5400 ideas – we've got some *beauties* in final development. In the meantime, call us and discuss what you need now or will be needing. We can almost always contribute significantly to improve interface design!

Send for the Serial-Interface Specs – and We'll Include the Complete AN5400 Brochure – FREE



Circle inquiry number 117

ANALOGIC CORPORATION / AUDUBON ROAD / WAKEFIELD / MASSACHUSETTS 01880 / (617) 246-0300

For Full Details on one or more of our products, please fill out the coupon and mail.

☐ SEND DATA SHEET/CATALOG
☐ HAVE SALESMAN CALL FOR DEMONSTRATION

111 112 113 114 115 116 117

NAME ______________ TITLE ______________
COMPANY ______________ TEL ________ EXT. ____
ADDRESS ______________
CITY ______________ STATE ____ ZIP ____

ANALOGIC®
...The Digitizers

ED2

For Immediate Action . . . Use This Card Today!

If card has already been used, circle the inquiry number indicated on this publication's reader service card.

Down with professionalism

I don't know if laetrile can help cancer sufferers. But I know of many who think it can. So when I wrote my July 19th editorial, "Professionalism," I didn't intend to endorse laetrile. Rather, I wanted to urge that our industry shun the kind of professionalism we find in outfits like the Food and Drug Administration.

A storm of letters, mostly from readers who feel that laetrile is a useless fraud, showed that I wasn't clear. (We'll publish these letters in this and coming issues as space permits.)

While I dislike some laetrile supporters, I despise opponents like the FDA, who set their "professional" interests ahead of the interests of humanity. One reader hit the point precisely when, opposing my views, he wrote: "I most respect the Medical Profession for looking out for #1."

The FDA has succeeded in banning interstate shipment of laetrile and has been battling intrastate acceptance on several grounds: It's useless. It may be toxic in large doses. It enriches profiteers. And terminal cancer patients might try it rather than listen to their physicians, who may have nothing better to offer.

Yet the FDA has sanctioned many drugs that proved useless or dangerous. When it finally bans something (like carcinogenic food additives) it tends to issue a years-later ban, so inventories can be sold off for public consumption. Almost anything is toxic in large doses including, I understand, aspirin, alcohol, tobacco and most food additives. Does the FDA ban them? As to profiteering, that's easy. Legalize laetrile and you wipe out the black market. Then the $300/gram U.S. price might approach the $3/gram Mexican price.

Whether laetrile works or not, it should not be banned by a government bureaucracy protecting the interests of one economic group while pretending, as always, to protect the public. We engineers often view the medical industry as the archetype of professionalism. But if professionalism means that we must hound and jail people who don't like our ideas and won't accept our verdict that their plight is hopeless, then I say to hell with professionalism.

George Rostky

GEORGE ROSTKY
Editor-in-Chief


TIME INTERVAL MULTIMETER
HEWLETT • PACKARD
2.83
LINE
OFF ON
V
A
PE (275 MHz)
INTENSITY
TIME INTERVAL
START
STOP
1 You simply set two intensified markers at the desired points using the START and STOP controls.
2 For maximum accuracy, switch to delayed sweep and use the STOP control to overlap the expanded traces.
SIGNAL OVERLAY (ΔT=0)
ΔT OFF
CH A START
CH B START
1725A OSCILLOSCOPE (275 MHz)
HEWLETT • PACKARD
100
90

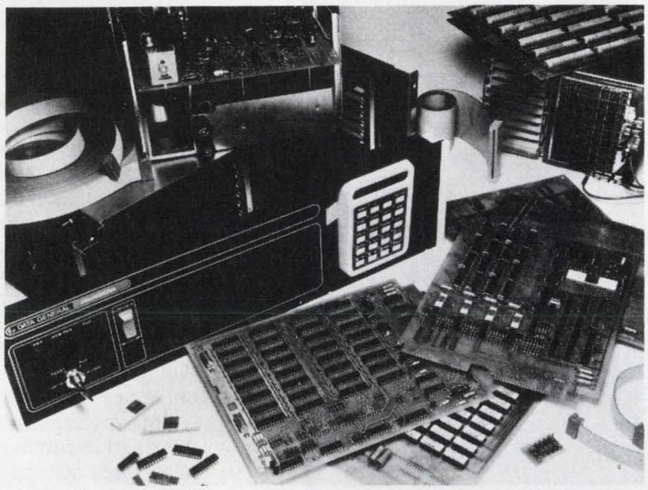
Exploit existing Nova software by designing computer systems around the microNova. The microprocessor gives you minicomputer performance from a 40-pin package.

Using the existing Nova instruction set, the microNova microprocessor can help you eliminate much of the time spent developing software. And, because it's also functionally compatible with the existing Nova, you will have many design shortcuts (Fig. 1).

Like the Nova minicomputer, the microNova has a 16-bit word length and a set of 42 instructions, including multiply and divide. But the microNova is a single-chip, NMOS circuit housed in a 40-pin DIP. It operates at a typical clock frequency of 4.166 MHz.

Although the μP operates on 16-bit data, the addressing range is only 32-k words—not the 64-k words that would normally be expected. However, because the microNova, known as the mN601, uses a 16-bit data word, it offers many advantages generally associated with 16-bit minicomputers. For instance, in many data-acquisition systems, 12, 14 and even 16-bit data words are often used. Most μPs would have to "double up" to gather in the data, with extra control circuitry and commands needed for the shorter word-size devices.

In spite of its minicomputer capability, building a processor system around the mN601 is simple (Fig. 2). And, as shown in Table 1, the mN601 needs only a handful of circuits for the basic system.



1. Depending upon your needs, you can purchase any form of processor you want in the microNova family—from the bare chips to a full minicomputer.

Bidirectional buses do the work

Two independent buses on the microNova are used to communicate with the memory and I/O devices (Fig. 2). The memory bus both accesses and refreshes the memory. With 16 bidirectional data lines and three control lines, this bus requires almost half the available pins of the package (Fig. 3).

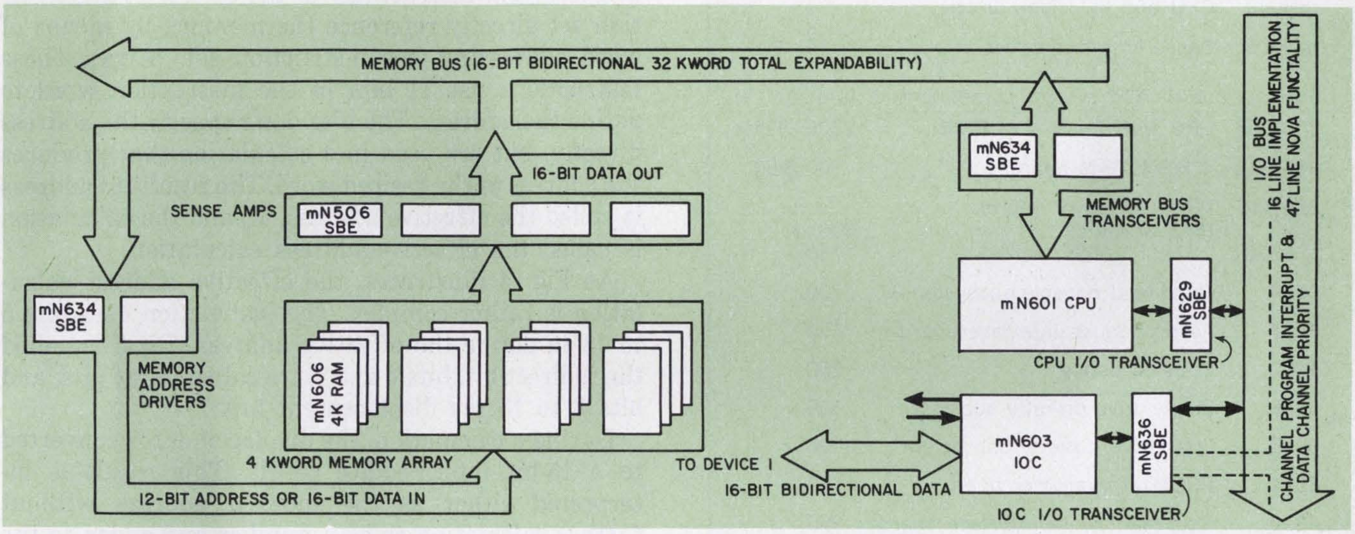
The control lines on the memory bus, called the P, SAE and WE signals, are all active-High output signals. All memory cycles are controlled by the P signal—the rising edge of the P signal indicates that a valid address is on the memory bus. The selected memory should then prepare for either a read or write operation. SAE indicates a data transfer from memory (read). A WE signal indicates a data transfer to memory (write).

Daniel Falkoff, Natalio Kerllenevich and **Philip Kreiker,** Design Engineers, Data General, 15 Turnpike Rd., Route 9, Westboro, MA 01581

Two bidirectional data lines can handle serial data. These lines, called I/O Data 1 and I/O Data 2, are active-Low and can carry all data, address and I/O command information between I/O devices and the mN601. Information is transferred serially at the full master-clock rate of 8.3 MHz over each I/O Data line for an aggregate transfer rate of 16.6 MHz. The processor can do five types of transfers—Request enable, Data-channel acknowledge, I/O command, I/O data in and I/O data out. Each transfer is identified by the value of the I/O Data 1 and 2 lines at the first I/O clock pulse.

During a Request-enable operation, a 2-bit request-enable code is transmitted via the I/O data pins to synchronize program-interrupt and data-channel requests from peripherals. The CPU performs these operations at irregular intervals determined by the other operations it is performing. When a Data-channel acknowledge operation is being performed, the CPU also transmits a 2-bit code to indicate that it has begun a data-channel break.

For an I/O command operation, a 2-bit code and a 16-bit command are transmitted via the I/O data pins to specify a preprogrammed I/O operation that the peripheral is to perform. The CPU performs an I/O command operation whenever it executes an input/output instruction.



2. **There are three major buses on the processor**—the memory bus, the serial I/O bus and the control bus. And building a system around the microNova requires the usual RAM, ROM and I/O arrangements.

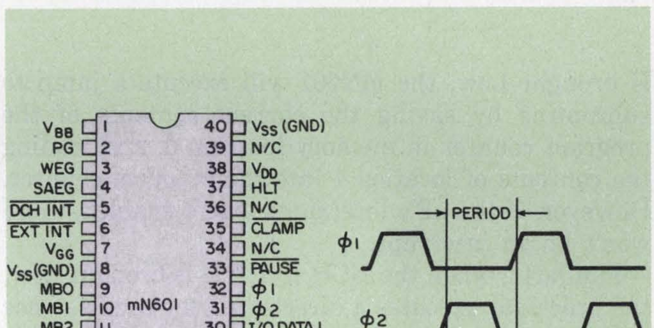
Similarly, for an I/O data-out operation, a 2-bit code and a 16-bit data word are transmitted via the I/O data pins. This operation occurs during data-channel breaks and while I/O instructions are being executed.

When an I/O data-input operation takes place, a 2-bit code and a 16-bit data word are received from a peripheral in response to a data-acknowledge code or an I/O command. I/O operations are always preceded by a Data-channel-acknowledge operation or by an I/O command.

Besides the two normal clock inputs needed for the two-phase processor clock, a separate clock input for the I/O channels—the I/O clock line—is used to synchronize all I/O operations. An I/O input line that is active-Low is used to indicate the direction of the I/O transfer. When the line is High, the mN601 expects to receive data. When Low, it indicates that the processor is sending data on the I/O lines.

The microNova has two interrupt lines—the External I/O interrupt (EXT INT), which handles program interrupts generated by an external peripheral, and the DMA request (DCH INT), which is a data-channel break request. In this case the processor doesn't go to a program subroutine. Instead, it stops so that data can be fed directly to the memory.

Both lines are active-Low. When the EXT INT line



3. **Of the 40 pins on the microNova,** 16 are required by the memory bus, four are used for the serial I/O, eight for control, seven for power, two for the clock and three more are not connected (a). The two-phase nonoverlapping clock (b) controls all system timing.

Table 1. MicroNova hardware

Model #	Description	Price (100 qty)
mN601	16-bit NMOS microprocessor	$114.
mN603	I/O controller (IOC)	70.
mN606	4-k dynamic RAM	19.
mN629	CPU I/O transceiver	30.
mN634	Memory transceiver	12.
mN636	IOC I/O transceiver	10.
mN638	Memory clock driver	7.
mN640	CPU and I/O clock driver	7.
mN506	Sense amp/bus driver	15.
Support boards and system components		$ (unit qty)
8562/63	CPU with 2 k/4 k of RAM	$800./$950.
8572/73	4 k/8 k RAM board	600./950.
8567 to 8570	PROM memory boards (512 words to 4096 words)	300. to 750.
8564	Hand-held console subsystem	700.
4207	Asynchronous interface board	250.
4208	Console debug	200.
6038	Single-drive diskette subsystem	2900.
6039	Dual-drive diskette subsystem	3900.
8574	PROM programmer board	1650.
4210	General-purpose interface board	250.
2303A	Extender board	200.
4212	9-slot card-frame assembly	250.

is brought Low, the mN601 will execute a jump to subroutine by saving the current contents of the program counter in memory location 0, and loading the contents of location 1 into the program counter. However, if the μP's interrupts aren't enabled, there won't be an interrupt.

Similarly, when the DCH INT line is brought Low, the processor executes a direct-memory access. Once the line goes Low, a data-channel-acknowledge code is sent out by the processor on the I/O bus. The μP then reads the memory address and direction mode from the interrupting device. If the request was to output data, the data from the memory are sent to the device. If the request was to input data, the data are read from the device and written directly into memory.

Just three other control lines are included on the microNova—Halt, Clamp and Pause. The Halt is an active-High output signal. When the processor is stopped (idling) as a result of the execution of a Reset or Halt instruction, the Halt output will provide a stream of positive pulses.

The Clamp line, an active-Low input, is used to initialize the processor. For instance, when the μP is first powered up, it doesn't perform any operation as long as the Clamp line is held Low. When the line goes High, the processor is initialized and enters the Halt state.

The Pause line is also an active-Low signal. When Low, it indicates that the phase-A and phase-B clocks can be stopped so that the memory can be accessed by other devices sharing the same bus.

Accessing the memory is simple

The main memory is partitioned into 32,768 different locations, each of which can be randomly accessed. Six instructions in the microNova instruction set directly reference the memory by means of word addressing (see instruction set, p. xx). These instructions use 11 bits in the instruction word to define the address. The bits don't specify the address directly, but are used in a calculation that produces the address of the desired word. The resultant address is called the effective address, E, and the calculation is called the effective-address calculation.

As Fig. 4 illustrates, the effective address calculation is rather complex. The instruction uses bits 5 to 15 to define the effective address. Bit 5 is called the indirect bit, bits 6 and 7 are called index bits, and bits 8 to 15 the displacement bits.

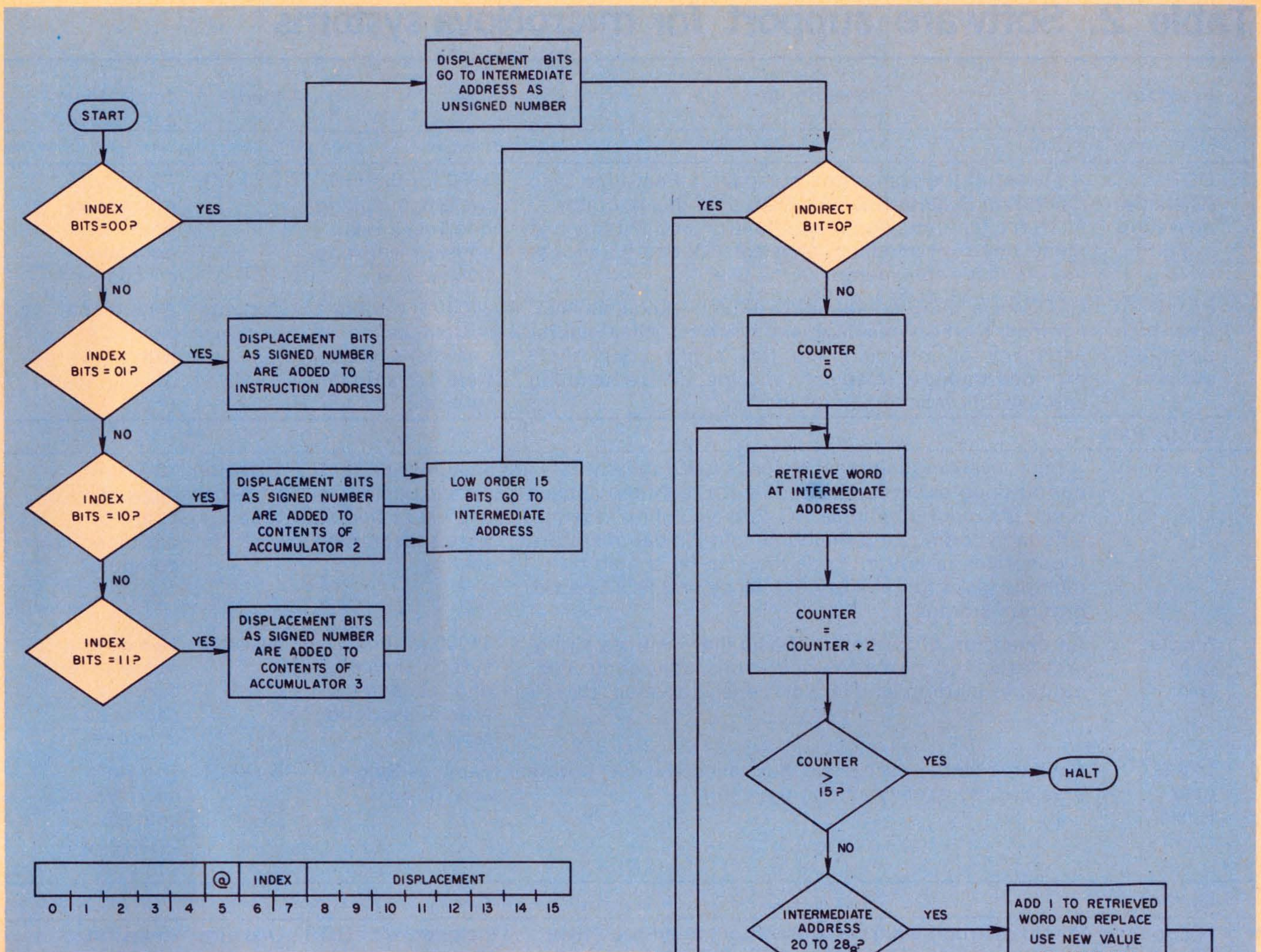
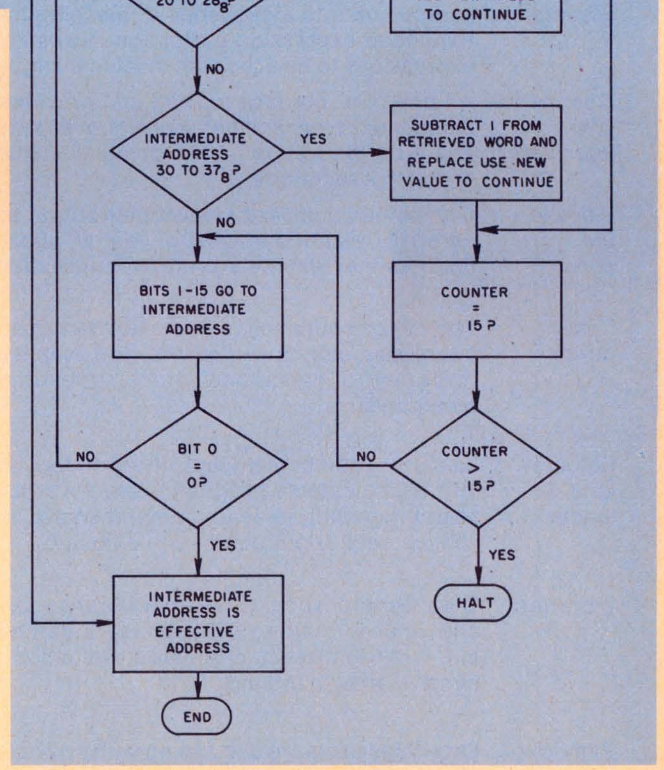
During a calculation, the displacement is converted to a 15-bit intermediate result. This result is interpreted either as the indexed address without further calculation or as a number and added to the contents of the program counter, accumulator 2 or accumulator 3.

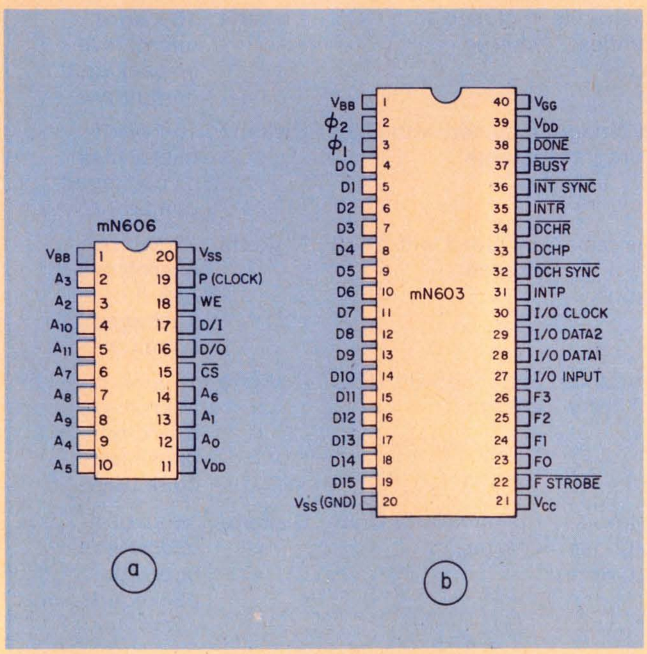
If the CPU adds the intermediate result to one of the registers, the indexed address is bits 1 to 15 of the result. Bits 6 and 7 of the instruction that the CPU is currently executing determine to what register, if any, the displacement is added—accumulator 2, accumulator 3, or the program counter.

Although bytes in the main memory cannot be directly addressed by the CPU, some programming aids ease the manipulation of byte-sized data. The microNova software makes use of a byte pointer—a word in which bits 0 to 14 are the address of a normal 2-byte word and bit 15 is the byte indicator. If bit 15 is High, the pointer indicates the lower-order byte. When bit 15 is Low, the pointer indicates the higher-order byte.

If all address locations aren't filled with RAM or ROM, and an attempt is made to retrieve a word from the nonexistent memory, the CPU functions as though the memory is there, but brings back all ONEs.

The CPU does any of four operations on the memory—Read, Write, Read-modify-write, and Refresh. During the first three, data are transferred over the 16-line bidirectional bus. A Read-modify-write operation permits a 16-bit word to be pulled from memory and a different word to be put back into the same location. During a Refresh operation, the CPU specifies a group of 512 memory locations to be refreshed but transfers no data. The 512 locations are 1/64 of the memory



5. **Housed in a 20-pin package, the 4-k dynamic RAM** developed by Data General keeps the memory-support circuits needed by the processor to a minimum (a). The I/O controller circuit, housed in a 40-pin DIP, is almost as complex as the processor (b). One controller must be used with every peripheral device connected to the μP.

4. **To calculate the effective address,** the microNova goes through a very complex procedure. The first step in the process is to check the two index bits so that the processor knows what to do with the displacement bits in the instruction before performing the calculation.

Table 2. Software support for microNova systems

Program	Description	Cost	Media	Minimal system needed
Operating systems				
DOS (Diskette operating system)	A subset of the company's compatible Real-time Disc Operating System (RDOS), DOS provides operator interface features, peripheral control, and file management. Interrupt handling, physical I/O, and file processing are made transparent to the user.	$300 for the first system, including one year's free software subscription service.	Diskette	16-kword microNova board or packaged computer
RTOS (real-time operating system)	RTOS is a DOS-compatible runtime executive that is compact memory-resident, and has a real-time multitask capability for controlling real-time applications. RTOS provides standard interrupt servicing, device handling, and execution-scheduling functions.	$100 for the first system, including one year's free software subscription service	Diskette or paper tape.	Any microNova CPU with 8 kwords of main memory
Languages				
Fortran IV	A high-level language that exceeds ANSI standards, with multitasking extensions essential for real-time applications. It supports multiple I/O formats, inline assembly language coding, and relational and logical operators. It generates re-entrant code that can be shared by multiple tasks for memory efficiency and ROM-based program storage.	$500 for first system, including one year's free software subscription service.	Diskette or paper tape.	16-kword microNova board or packaged computer
Single-user Basic	An extension of Dartmouth Basic that includes string arithmetic and matrix I/O operations, user-controlled output formatting, and comprehensive access to data files.	$1000 for first system, including one year's free software subscription service.	Diskette	16-kword microNova board or packaged computer
Multi-user Basic	Similar to single-user Basic, but having the user program area divided equally among the users.	Same as Single-user Basic	Diskette	16-kword microNova board or packaged computer
Utilities				
Macro assembler	Macro instructions translate a single multi-argument source line into a sequence of machine instructions. Expanded expression evaluation allows Fortran-like expressions to be used with machine language efficiency.	Included with DOS charge.	Diskette	16-kword microNova or packaged computer
Command line interpreter	An operator interface to DOS that provides extensive file maintenance capabilities, control over system utilities, and a simple way to invoke complex sequences of program executions.	Included with DOS charge.	Diskette	16-kword microNova or packaged computer
Library file editor	Combines compiler or assembler output to form binary libraries, resulting in a set of central, updatable program libraries that eliminate program duplication.	Included with DOS charge.	Diskette	16-kword microNova or packaged computer.
Text editor	The editor combines multiple text streams, "remembers" often-used editing sequences, and even executes a "program" of conditionally-looping text modification commands.	Included with DOS charge.	Diskette	16-kword microNova board or packaged computer.
Relocatable loader	Lets users combine multiple independent binary modules into an executable program. Includes automatic library search, conditional load, comprehensive load map listings, and origin definition flexibility.	Included with DOS charge.	Diskette	16-kword microNova board or packaged computer.
Libraries	Data General supplies a set of libraries for complex character-formatting I/O routines, logarithmic, exponential, and trigonometric function evaluation, and comprehensive array handling.	Included with DOS charge.	Diskette	16-kword microNova board or packaged computer.
Symbolic debugger	Facilitates program debugging with symbolic designation of user labels, assembler mnemonics, and program offsets. Symbolic references allow program debugging in source-language terms that do not require cumbersome binary translation.	Included with DOS charge.	Diskette	16-kword microNova board or packaged computer.

Internal architecture of the microNova

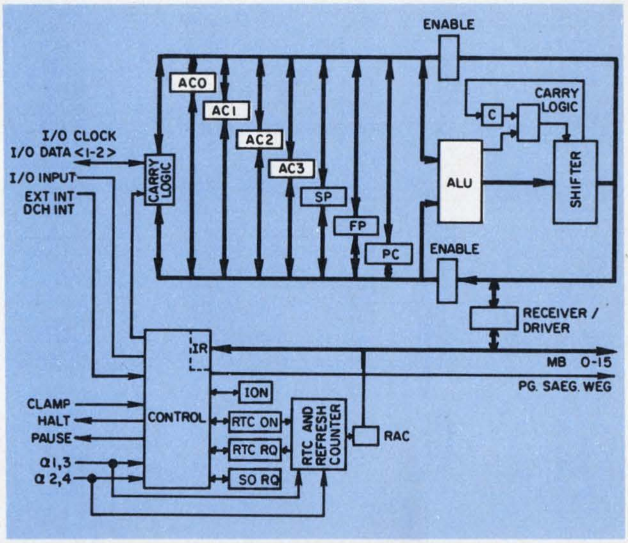
Since the mN601 microprocessor is software-compatible with the Data General line of Nova mini-computers (it operates with the Nova-3 instruction set), the internal architecture is very similar to that of the Nova minis. The CPU has four general-purpose accumulators, each 16 bits wide.

The arithmetic and logic unit on the processor chip accepts any two 16-bit accumulator outputs and one bit from the carry register. Among other on-chip registers, there are three 15-bit registers—the stack pointer, the program counter and the frame pointer. There are also four more 1-bit registers—an interrupt-enable bit, a real-time-clock-enable bit, a stack-overflow-request bit and a real-time clock-request bit—as well as a 6-bit refresh address counter.

The stack pointer is a register that contains the address of the top of a stack. It is affected by operations that either push or pop data from the stack. The program counter contains the memory address of the next instruction to be executed. Somewhat like the stack pointer, the frame pointer points to the stack—but not necessarily to the top. It points to the portion of the stack storing the status information to be used in returning from a subroutine.

As can be seen from the accompanying CPU block diagram, all 15 and 16-bit registers are "paralleled" onto the main internal buses. During the execution of instructions, program interrupts and data-channel breaks, information is transferred among the registers, the memory-address/data pins and the I/O data pins. When arithmetic operations are performed on the data held in these registers, each word is interpreted as a binary number, whether it be a 15 or 16-bit register.

If the contents of a register are transmitted to the memory-bus pins as data, the contents of the register's bit 0 are sent to bus pin MB(0), all the way up to bit 15, which is sent to the MB(15) line. When the register contents are sent as an address to the MB bus, the contents of bits 1 to 15 are transmitted as before. However, the contents of bit 0 are not transferred. The state of the MB(0) line depends on the operation that the CPU is performing on the pins of the memory port. It's High when a refresh operation is being performed and Low for normal addressing.



To perform arithmetic and logic operations, each instruction specifies two accumulators to supply operands to the function generator (ALU). The function generator performs the operation dictated by control bits 5, 6 and 7 of the instruction. A carry bit is also generated by the function generator. This carry bit depends on three quantities—an initial value specified by the instruction, the inputs and the function performed. The initial value is often derived from the previous value of the carry bit, otherwise the instruction can specify an independent value.

The 17-bit output of the function generator, composed of the 16-bit function result and the carry bit, then goes to a shift network where it can be rotated one place left or one place right. Or the two 8-bit halves of the function result can be swapped without affecting the carry bit. A test command then permits the shifter output to be examined for a skip instruction. After the output has been tested, it can be loaded into the carry-bit register and the output accumulator (ACO), or it can be fed into any of the other registers.

To keep all the circuit operations perfectly timed, a two-phase clock is needed by the processor. The maximum frequency of the clock can reach 4.166 MHz.

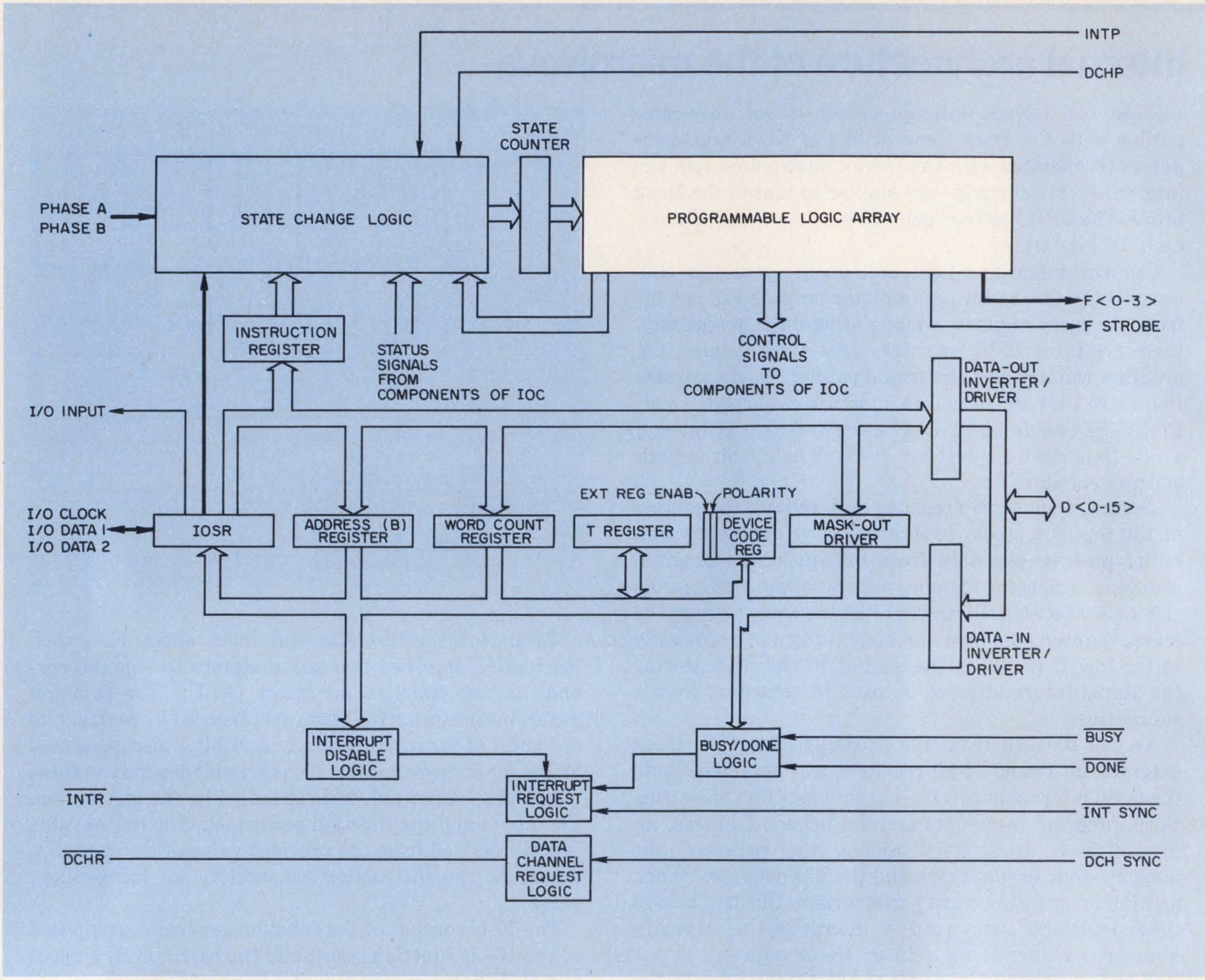
and are selected by a 6-bit refresh address placed on the lower six address lines.

Other circuits help the processor

Some specialized support devices help the processor interface to the outside world. The main devices include a 4-k dynamic RAM, the mN606, and a peripheral interface and control circuit, the mN603 —often referred to as an I/O controller (Fig. 5). Although other dynamic memory chips can be used with the processor, the mN606 has been specially designed to simplify the interface requirements—just two control lines (the chip-select and write-enable) and a clock are required.

The I/O controller (or IOC), on the other hand, is almost as complex as the processor. It comes in a 40-pin package. Usually, one IOC is used with every peripheral device connected to the computer system. Connecting it to the system is relatively simple. There are 16 bidirectional bus lines, five supply pins, two clock inputs, five function-control pins, four I/O lines and eight assorted control and indicator lines.

Many subsystems inside the IOC work together to coordinate the transfer of data and the control of a peripheral device by the processor (Fig. 6). The main



6. **The many registers inside the mN603 controller** keep track of where data are to be sent, where data are coming from and what operation is to be performed An internal PLA controls the operation of the mN603.

control element within the IOC is a programmable logic array that defines the machine states for the various control functions. The IOC also requires a two-phase nonoverlapping clock, just like the processor. However, instead of being called phase A and phase B, as on the processor clock, the phases are labeled A/B and B/A. To ensure that handshaking functions are properly executed between the CPU and IOCs, the processor is the source of timing for the entire system. The timing information is transmitted to the IOCs over the I/O bus. The I/O transceiver (mN629) used with the CPU transmits to all the other I/O transceivers (mN636s) connected to the IOCs. A differential signal called BMCLOCK is used by the IOCs to synchronize themselves to the CPU. Up to 20 mN636s plus one mN629 can be connected to the I/O bus.

Both the mN629 and 636 are very similar—their internal circuitry is identical except for one change in the signal flow in the MCLOCK, BMCLOCK and $\overline{\text{BMCLOCK}}$ lines (Fig. 7b). On the 629, the MCLOCK line is the clock input from the processor. The

MicroNova software and instruction set

With a set of 42 instructions, the microNova μP can rival the performance of its bigger brothers in the Nova series of minicomputers. The basic instruction set contains commands that perform fixed-point arithmetic between accumulators, including multiply and divide; transfer operands between accumulators and main memory; perform logic operations between accumulators; transfer program control; and do all I/O operations.

The instructions are one 16-bit word long and can address memory either directly or indirectly. Chains of indirect addresses can be up to eight-levels deep. Also available is a direct-memory-access channel to help speed data transfers from peripherals to the main memory.

In one instruction, the arithmetic and logic instructions can execute a command, shift the result one bit left or right, test the result of the shift, then conditionally skip the next instruction. In addition, this entire sequence can be done without affecting either of the operands.

A last-in, first-out stack is maintained by the processor in the external memory, and up to 32-k 16-bit words can be directly addressed by the microNova. Each word is set up so that, by convention, the highest-order bit is numbered 0 and the lowest-order bit is 15.

Several addressing modes are available to the processor:

■ *Direct addressing,* which is similar to direct addressing on other processors.

■ *Indexed addressing,* where the effective address is calculated by the processor from the data included in bit positions 8 to 15 of the instruction plus the contents of either the program counter, accumulator 2 or accumulator 3.

■ *Indirect addressing,* where the actual address of the operand and is contained in a memory location addressed by the instruction. This mode of addressing can be made eight levels deep.

Several memory locations (addresses 20_8 to 27_8) are called auto-incrementing locations. During the calculation of an indirect address, the CPU performs Read-modify-write operations on these locations, and during the write portion increases the contents of the location by one. Similarly, other locations are used for auto-decrementing applications (addresses 30_8 to 37_8). In this case, the data held in the location specified are automatically decremented during the write portion of the operation.

The instructions of the microNova can be split into five basic groups—Memory reference, Arithmetic and logic, Input/output, Stack manipulation, and Central processor control commands. One of the few processors to include hardware multiply and divide capability, the microNova can perform these operations in 41.3 and 59 μs, respectively, with a 4.166-MHz clock.

Four basic instruction formats used for microNova instructions permit an extensive instruction set without going beyond the one-word instruction. The four formats are:

■ *No accumulator — effective address.* Bits 0 to 2 are 000 and bits 3 and 4 contain the operation code. The effective address is computed from bits 5 to 15.

■ *One accumulator — effective address.* Bit 0 is 0 and bits 1 and 2 contain the operation code. Bits 3 and 4 specify the accumulator used for the operation and the effective address is computed from bits 5 to 15.

■ *Two accumulators — multiple operation.* Bit 0 is 1, bits 1 and 2 specify the source accumulator, bits 3 and 4 specify the destination accumulator, bits 5 to 7 contain the operation code, bits 8 and 9 specify the action of the shifter, bits 10 and 11 specify the value to which the carry bit will be initialized, bit 12 specifies whether or not the result will be loaded into the destination accumulator, and bits 13 to 15 specify the skip test.

■ *Input/output.* Bits 0 to 2 are 011, bits 3 and 4 specify the accumulator for operation, bits 5 to 7 contain the operation code, bits 8 and 9 specify the control signal to be used, and bits 10 to 15 contain the device code of the referenced device.

Mnemonic	Octal code	Operation
Memory reference instructions		
DSZ	014000	Decrement location E[1] by 1 and skip if result is zero.
ISZ	010000	Increment location E by 1 and skip if result is zero.
JMP	000000	Jump to location E
JSR	004000	Load PC+1 in AC3 and jump to subroutine at location E
LDA	020000	Load contents of location E into AC
STA	040000	Store AC in location E
Arithmetic and logical instructions		
ADC	102000	Add the complement of ACS[2] to ACD[2]
ADD	103000	Add ACS to ACD
AND	103400	AND ACD with ACD
COM	100000	Place the complement of ACS in ACD
INC	101400	Place ACS+1 in ACD
MOV	101000	Move ACS to ACD
NEG	100400	Place negative of ACS in ACD
SUB	102400	Subtract ACS from ACD
DIV	073101	If overflow, set Carry. Otherwise divide AC0–AC1 by AC2. Put quotient in AC1, remainder in AC0.
MUL	073301	Multiply AC1 by AC2, add product to AC0, put result in AC0–AC1
Input/output instructions		
DIA	060400	Data in, A buffer to AC
DIB	061400	Data in, B buffer to AC
DIC	062400	Data in, C buffer to AC
DOA	061000	Data out, AC to A buffer
DOB	062000	Data out, AC to B buffer
DOC	063000	Data out, AC to C buffer
NIO	060000	No operation
SKPBN	063400	Skip if Busy is 1
SKPBZ	063500	Skip if Busy is 0
SKPDN	063600	Skip if Done is 1
SKPDZ	063700	Skip if Done is 0
Stack manipulation instructions		
MFFP	060201	Move contents of frame pointer to AC
MFSP	061201	Move contents of stack pointer to AC
MTFP	060001	Move contents of AC to frame pointer
MTSP	061001	Move contents of AC to stack pointer
POPA	061601	Move top word on stack to AC and decrement stack pointer
PSHA	061401	Increment stack pointer and move contents of AC to top of stack
RET	062601	Restore accumulators, program counter and carry from last return block on stack
SAV	062401	Push a five-word return block on stack
MSKO	062077	Set up interrupt-disable flags according to mask in AC
RTCEN	071077	Enable interrupts from CPU real-time clock
RTCDS	065077	Disable interrupts from CPU real-time clock
TRAP	100010	Software interrupt (ALC format no-skip, no-load)
Central processor control instructions		
HALT	063077	Halt the processor
INTA	061477	Acknowledge interrupt by loading code of nearest device that is requesting an interrupt into AC bits 10 to 15
INTDS	060277	Disable interrupt by clearing interrupt ON
INTEN	060177	Enable interrupt by setting interrupt ON
IORST	061077	Clear all I/O devices

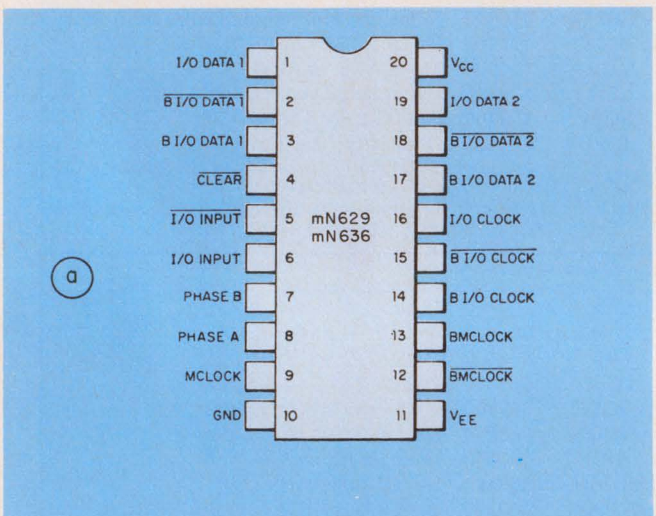
[1] E - "location E" pertains to a location with an address computed using bits 5 to 15 of the word and either the PC, AC2 or AC3.

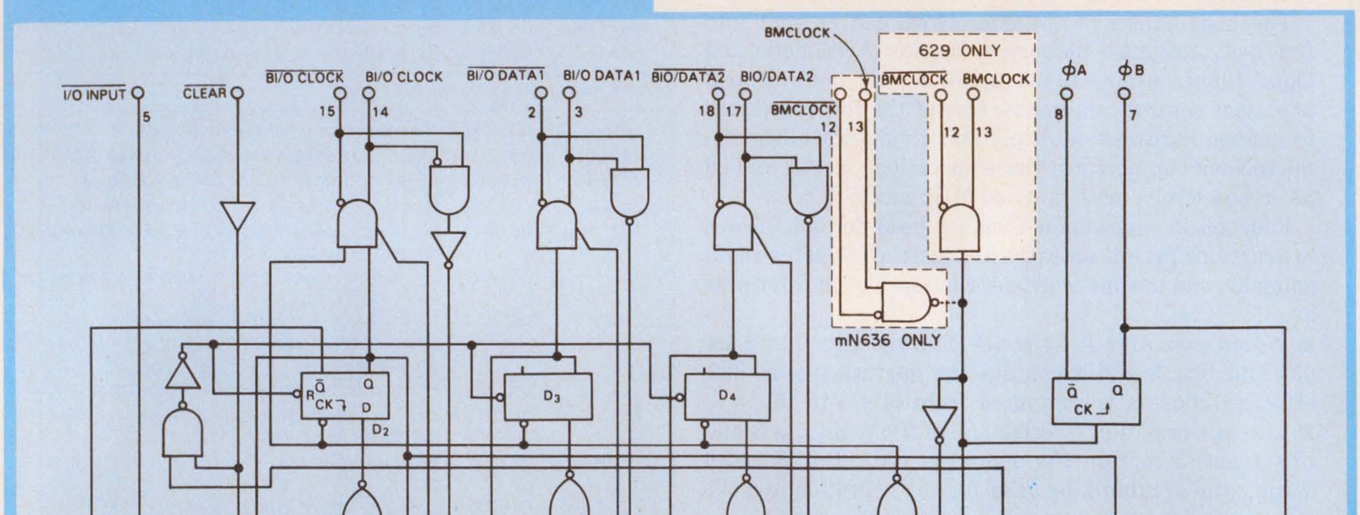
[2] ACS and ACD refer to source and destination accumulators, each selected by a 2-bit section of the instruction.

BMCLOCK lines provide a differential clock signal for the I/O transceivers. Two other clock outputs from the 629 or 636—the ϕA and ϕB lines— are designed to feed the clock drivers for the CPU and IOCs.

The other lines on the transceivers are used to buffer the I/O Data 1, Data 2, input and clock lines from the processor. Not only are the lines buffered, but they are designed to handle data differentially so that line-driving up to 100 feet is possible without any other drive circuits.

One unusual feature of all the microNova circuits is the capability to clear the system under the control of the mN629 and mN636s. When the Clear line on the 629 or any 636 is brought Low, it pulls Low the buffered I/O clock lines in the mN603s and mN601s for a comparatively long time—milliseconds instead of microseconds. All circuits connected to the I/O clock lines have special detection circuits built in that can sense the longer shut-off of the signal and, in turn, signal each circuit to reset itself.





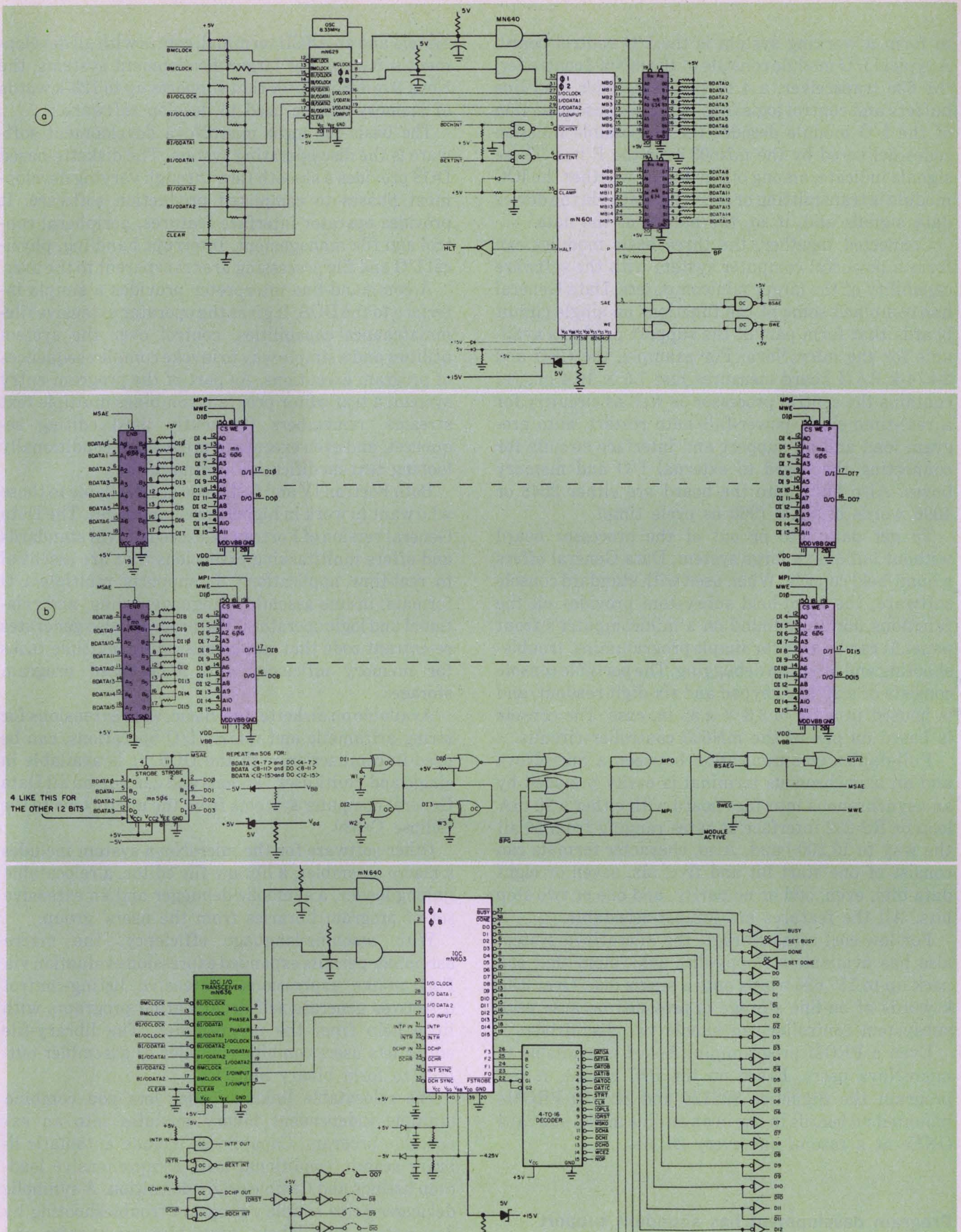
Put together a working system

Getting all the components to work together requires that you connect a two-phase clock to the processor, buffer the I/O data lines with an mN629, buffer the address bus with mN634s and connect the power supplies (Fig. 8a). Shown in Fig. 8a is a complete processor (CPU module) that can be used in a minimal system configuration with static memory or in larger systems with dynamic memories.

A typical 4-k × 16 memory board can be built from the mN606 memories, the mN634 address drivers, the mN506 sense amp/bus driver and some simple control logic. The wiring interconnect is mainly a mass of bus interconnects, since all the address lines as well as the supply and control lines are paralleled (Fig. 8b).

The last board, or circuit section, that must be added

7. **Designed to buffer clock and data signals,** the mN629 and 636 transceivers are used for I/O expansion. One 629 can drive up to 20 mN636s. For every I/O controller circuit, there must be one mN636.



8. **By combining a processor chip,** two mN634 buffers, an mN640 clock driver and an mN629 transceiver, you can build a complete CPU module (a). Data General also has available a 4k memory card (b) and an IOC card (c).

to form a working system is the I/O control board. A typical I/O module consists of the mN603 controller, the 636 transceiver, a 4 to 16-line decoder, and line buffers and control logic (Fig. 8c). The decoder section of the I/O module decodes the 16 possible function codes delivered by the mN603 over the F bus. These signals indicate, among other things, whether the IOC module is transmitting or receiving data via the device data signals and, if so, the nature of the data.

Connected together, the three basic modules can form a powerful computer system with the software capability of the larger minicomputers. Data General has combined some of the functions on single circuit boards that form part of the support products available for the microNova. For example, the CPU and 2-k/4-k RAM board measures just 7.5 × 10.4 in., yet contains the central processor as well as circuitry for a real-time clock, power-fail/auto restart, auto program load and all support and interface circuits for connecting the board to external I/O and memory buses. Also built onto the board are either 2048 or 4096 words of RAM (960 ns cycle time).

To get data into or out of the processor board without building a large system, Data General offers a hand-held console. When used with standard console software, the hand-held subsystem provides all the functions normally found on a minicomputer's front panel. It can be used for simple programming, troubleshooting and program debugging. The portable console consists of a 20-key keypad and six-digit readout, and is housed in a 1.2 × 3.3 × 4.85 in. case. The console is based on one of the mN603 controller circuits.

Full-duplex communication between a microNova and an asynchronous terminal is easily provided by an asynchronous interface board with either a 20-mA loop or RS-232 interface at rates ranging from 50 all the way to 19,200 baud. Also, character formats can consist of one start bit and five, six, seven or eight data bits, even, odd or no parity, and one or two stop bits. All the features are jumper-selectable.

For low-cost mass storage, the microNova system also has available a floppy-disc subsystem that can pack up to 157,696 words onto a single disc. Over 300-k words of on-line storage is provided because each subsystem controller can handle two disc drives.

Even a PROM programming board is available to microNova users. Based on the IOC circuit, it can program the Signetics 82S126 and 82S130 PROMs mounted on boards in use in an on-line mode, and zaps ONEs at a rate of one every 20 ms.

Program development has abundant support

Since the microNova family of products is compatible with all the other Data General computer products, a great deal of development software is readily available (Table 2). A basic development system, consisting of the microNova, a diskette subsystem and an ASCII terminal, comes with all development software. For larger development systems, the Nova-3 minicomputer that supports up to 128-k words of memory can be used to develop software.

The basis for most microNova development software is the disc-operating system. The diskette-based DOS provides a smooth flow through varying development phases to completed production software. It provides operator-interface features, peripheral control and file management. Interrupt handling, physical I/O and file processing are transparent to the user.

A command-line interpreter provides a simple interface to the DOS. It gives the operator extensive file-maintenance capabilities, control over the system utilities and a simple way to invoke complex sequences of program executions. As part of the program-entry system, a text editor program combines multiple text streams, remembers frequently used editing sequences, and even executes a program of conditionally looping text-modification commands.

Both Fortran IV and full Basic are available to those who want to work in higher-level languages. The Data General version of Fortran IV exceeds ANSI standards and offers multitasking extensions that are essential to real-time applications. It supports multiple I/O formats, in-line assembly-language coding, and relational and logic operators. The program also generates re-entrant code that can be shared by multiple tasks for memory efficiency and ROM-based program storage.

Available on diskette, full Basic, with extensions for string arithmetic and matrix I/O operations, can be used in conjunction with the DOS. It is available in single and multi-user versions and can run on all Data General computer systems from the microNova to the Eclipse C/330.

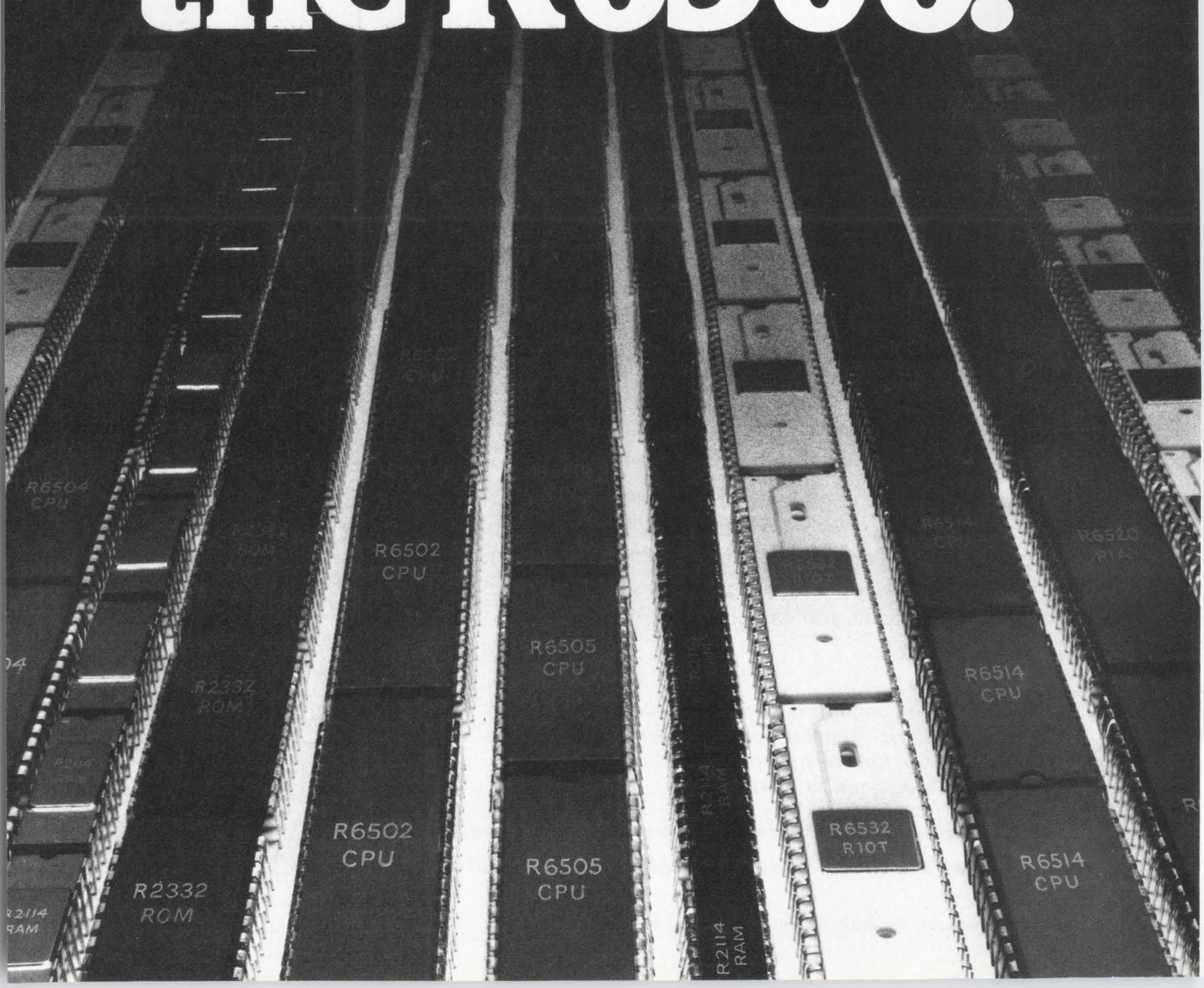
Other software for the microNova system includes a macro assembler, a library-file editor, a relocatable linking loader, a symbolic debugger and an extensive set of program libraries from the users' group.

With machine-language efficiency, the macro assembler permits expanded expression evaluation via Fortran-like expressions. Extensive listing-control directives generate self-documenting programs with little help from the programmer. The library-file editor lets users combine compiler or assembler outputs to form binary libraries.

The relocatable linking loader lets you combine multiple independent binary modules into an executable program. Capabilities include automatic library search, conditional load, comprehensive load-map listings and flexible origin definition. A symbolic debugger helps simplify program troubleshooting by designating user labels, assembler mnemonics and program offsets. Multiple-format printout directives let data be listed as characters, half-words, or symbols, or in octal format. ■■

Note: Nova and Eclipse are registered trademarks of Data General Corp.

Rockwell introduces the R6500.



R6500: the third generation microprocessor system

Now you can move up to the proven 2 MHz performance of an NMOS 8-bit microprocessor, the R6500 from Rockwell.

Third-generation R6500 architecture and instructions with 13 powerful addressing modes make it easier for you to design more functions in, more cost out. And the R6500 is design-compatible with systems you may now be using.

R6500 economics are on your side

Smaller R6500 chips and single 5V power supply keep costs down as performance goes up. To get the right fit, choose from 10 software-compatible CPUs, eight versatile I/Os, ROMs, RAMs, and memory-I/O-timer circuits.

Rockwell adds solid development support

For fast and efficient system design, Rockwell offers SYSTEM 65—one of the smartest and lowest-cost disk-operating, complete development systems available. It's equipped with two mini-floppies, resident two-pass assembler, text editor and monitor/debug package.

KIM-1, TIM, timeshare, complete documentation, plus extensive applications engineering are also available.

Rockwell is delivering in volume now

R6500 DIP circuits are already being produced in quantity with Rockwell's N-channel, silicon-gate, depletion load process. All of the initial family of 18 different chips will be in volume production by the 4th quarter of 1977.

And new chips are in design. The first, now in prototype production, is a fully-static 32K ROM.

A Rockwell one-day seminar can get you started

Plan now to attend a free, one-day seminar at a city near you. You'll see the SYSTEM 65 in operation and get all the information you need to start designing the R6500 into your application.

CITY	DATE	CITY	DATE
EAST		MIDWEST	
Rochester	9/19	Detroit	9/26
Boston	9/20	Cleveland	9/27
Bridgeport	9/21	Chicago	9/28
New York City area	9/23	Minneapolis	9/30
Philadelphia	10/13	Dallas	10/10
Washington D.C.	10/12		
		WEST COAST	
CANADA		Bay Area	10/3 & 10/4
Toronto	10/17	Seattle	10/5
Montreal	10/18	Denver	10/6
		Los Angeles	10/19
		Orange County	10/20

For your reservation or R6500 brochure, send the coupon below or write: D-727-C, Marketing Services, Microelectronic Devices, Rockwell International, P.O. Box 3669, Anaheim, CA 92803, U.S.A. or phone (714) 632-3729.

☐ I would like to attend a Rockwell R6500 seminar on ________ in ________. C
Have a Rockwell rep confirm it with me.
☐ Send me your new R6500 brochure.
I have ☐ have not ☐ worked with the 6500.

Name ____________ Title ____________
Company ____________ Ph ____________
Street ____________ City ____________
State ____________ Zip ____________

Rockwell International

...where science gets down to business

Plan to attend a 1 hour R6500 briefing at WESCON.
Offered daily at 9:00, 11:00, 2:00, 4:00, San Francisco Civic Auditorium, Room 303.

Mate microprocessors with CRT displays

but make sure you know enough about the displays. Raster-scan systems are simple and can be interfaced with little extra circuitry.

Interfacing a microprocessor to a CRT display is a reasonably simple task. But before designing an interface, you must decide on the type of display format and the drive technique—how many lines, how many characters per line, how many dots per character position and whether interlaced or noninterlaced raster scanning will be used.

In general, a CRT-based display system is the most flexible display you can interface with a microprocessor. Under program control, the CRT's electron beam can be made to form any character or pattern desired. Highly reliable, a CRT offers the lowest cost per character for displays of 50 or more characters.

Raster scanning works like this. . .

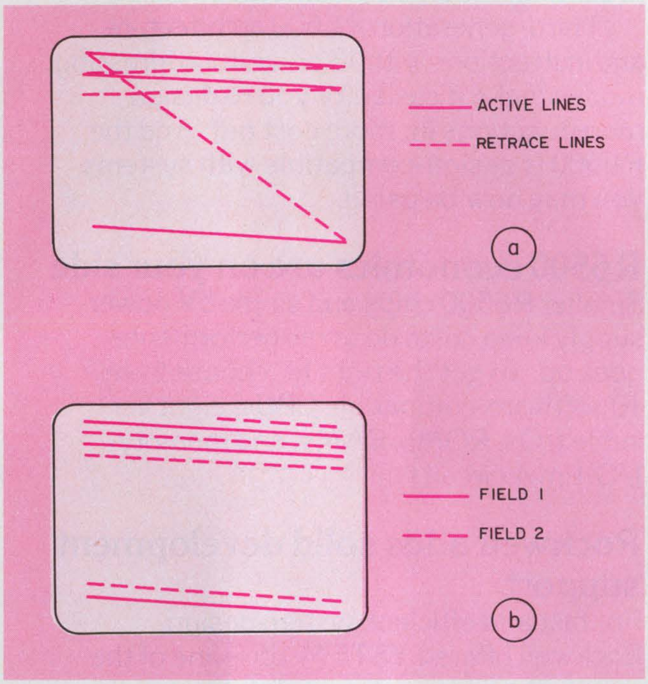
The image on raster scanned CRT displays is built up by generating many lines across the face of the CRT. Typically, the electron beam starts in the upper left corner of the display, moving from left to right and top to bottom, to "paint" a series of zig-zag lines on the screen (Fig. 1a). Two independent circuits, operating simultaneously, control the horizontal and vertical movement of the beam.

As the electron beam moves across the face of the screen, a third circuit controls the intensity of the beam so that the phosphors can be made to light in any desired pattern—from a simple on/off dot pattern to either a complex grey-scale arrangement for black-and-white displays or multicolor variations for color displays.

When the beam reaches the end of a line, it is brought back to the beginning of the next line faster than it moved to generate the line. Usually during this "retrace" period, the electron beam is shut off (blanked) so the retrace line doesn't appear.

As the beam is moved horizontally, it is also moved slightly downward. As a result, each successive line starts below the previous line. When the beam reaches the bottom of the screen, it retraces vertically at high speed back to the first line. The network of lines that are traced on the CRT screen is called a raster.

Branko Matic, Engineering Manager, and **Lorne Trottier,** Marketing Manager, Matrox Electronic Systems, P.O. Box 56 Ahuntsic Stn., Montreal, Quebec, H3L, 3N5, Canada.



1. **Both a non-interlaced video display** (a) and an interlaced display (b) generate images on a CRT screen. But, the interlaced display effectively provides double the resolution of the non-interlaced version.

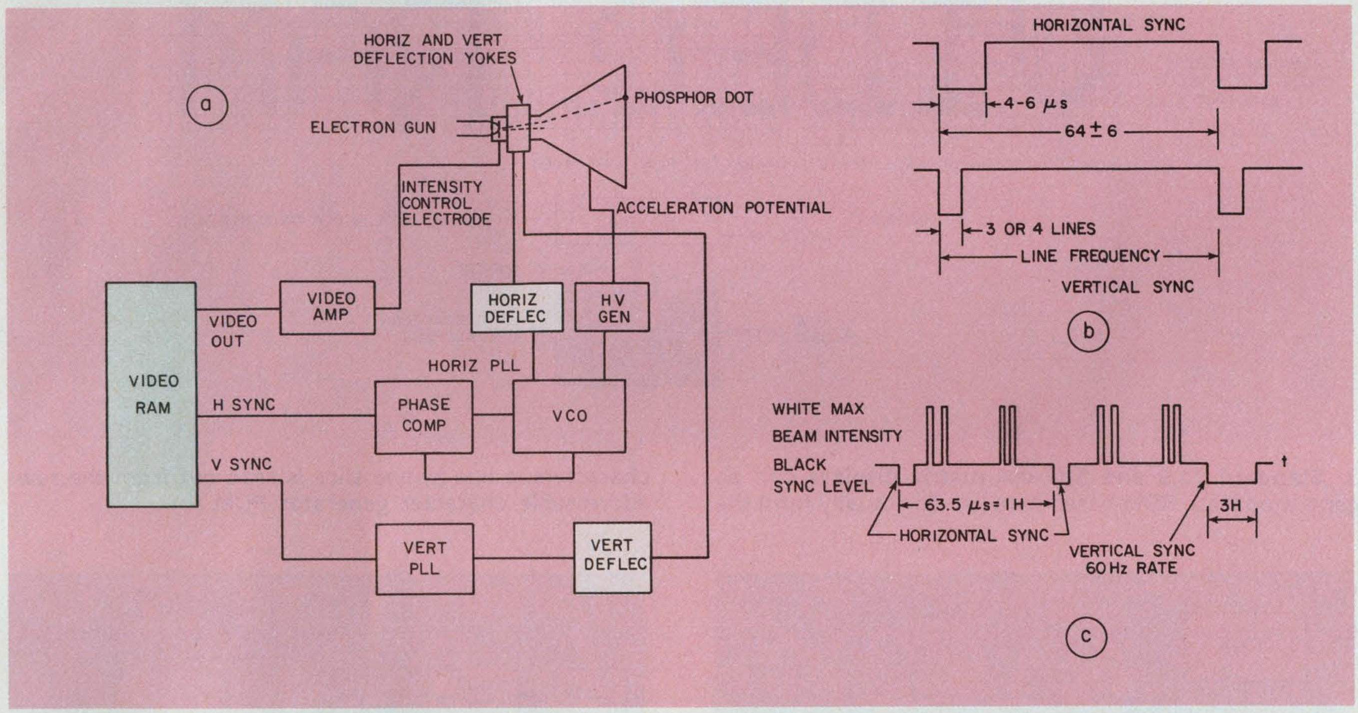
Although manufacturers have standardized at a frequency of 15.7 kHz for the horizontal sweep frequency (63.5 μs/line), this can vary by 10% for most display systems. Vertical sweep will usually be between 45 and 65 Hz. However, in many CRT display systems, the power supplies are poorly filtered and shielded, which causes some line-frequency modulation of the raster. Ideally the sweep rate should be equal to the power-line frequency for the best display. If the sweep isn't synchronized, the raster will appear to move or "breathe" at the difference of the two frequencies. If the two frequencies are equal, this motion cannot be noticed because a stroboscopic effect freezes the motion.

For 60-Hz line frequencies, there are normally 262 lines per complete raster scan (often referred to as a field); for 50-Hz systems, normally 312 lines. In many applications, though, neither line count provides enough resolution. But you can effectively double the number of lines (Fig. 1b) by inserting a second set of lines between the first set (interlacing). However, the line sets aren't generated simultaneously. For a 60-Hz system first all the even-numbered lines are scanned: 0, 2, 4, . . . 524. Then all the odd-numbered lines: 1, 3, 5, . . . 525. Each set of lines (field) usually contains different data.

However, interlacing has some disadvantages. First of all, the circuitry necessary for scanning is more complex than noninterlaced display circuits. Second, the over-all vertical refresh rate is half that of noninterlaced units. As a result, the display can flicker when a CRT screen has fast reacting phosphors.

Many TV monitors accept one signal that combines all three signals into a composite video signal (Fig. 2c). Circuits inside the monitor separate the composite signal into its component parts. The major advantage of a composite video signal is that it can be sent over long distances on a single 75-Ω coaxial cable.

The main part of any CRT-monitor control system is its sync generator, which provides all the sync and timing signals necessary to control the display. There are several approaches to designing one. To provide the proper signals in the simplest way, first the CRT screen is divided into tiny cells. Then the beam's position is controlled by keeping track of the cell number where it is positioned.



2. **The sync-generator control block** (a) provides both the vertical and horizontal sync signals (b) for the CRT display. Both the horizontal and vertical signals can be combined with the video data to form a composite signal that can be transmitted over long distances with just a single coaxial cable (c).

For the best viewing, use CRTs with P33 or P39 high-persistence phosphors. In most TV receivers, the flicker cannot be noticed, since both fields contain almost identical information.

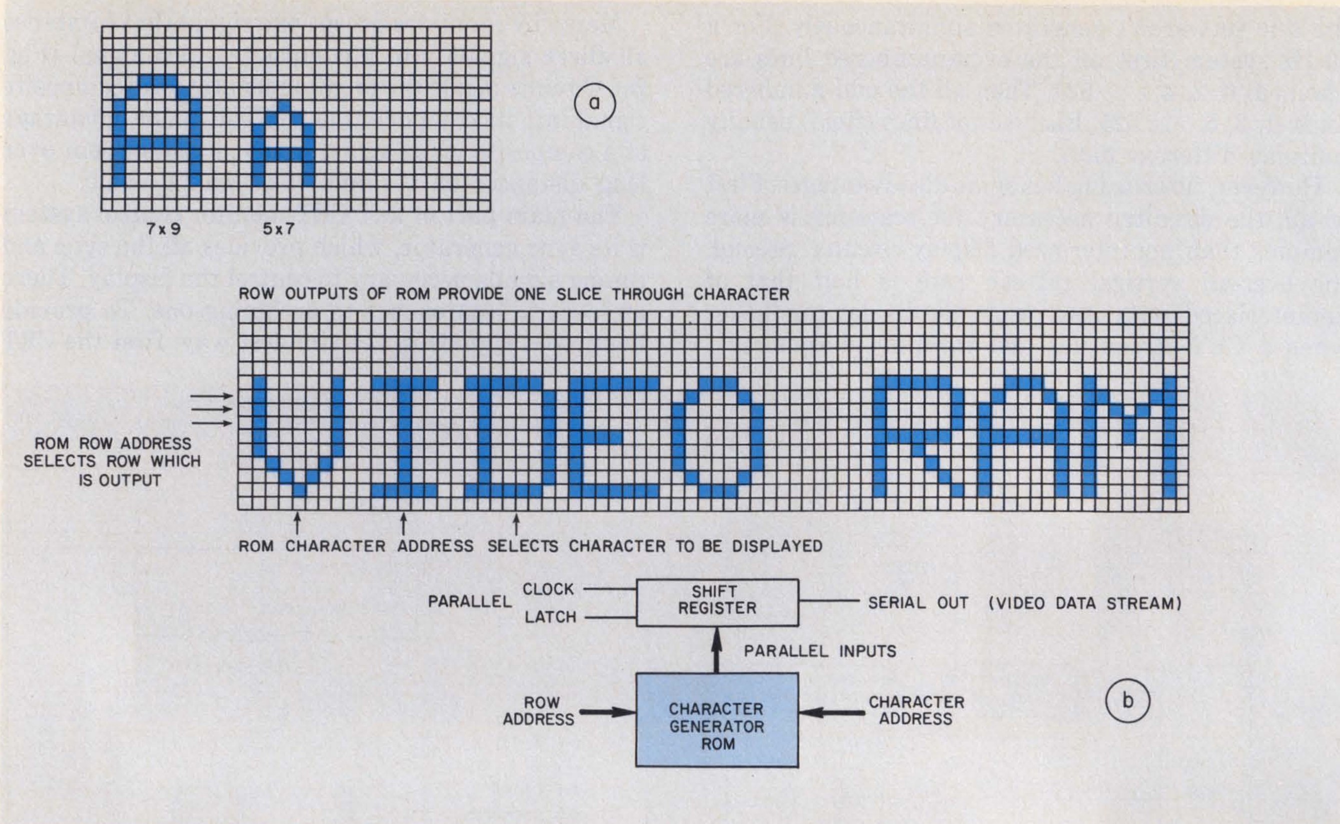
Of course, another way to get good resolution is to use a special CRT system that operates at a higher horizontal sweep frequency. These systems are more expensive than TV monitors and use nonstandard horizontal scanning components.

Several signals control the display

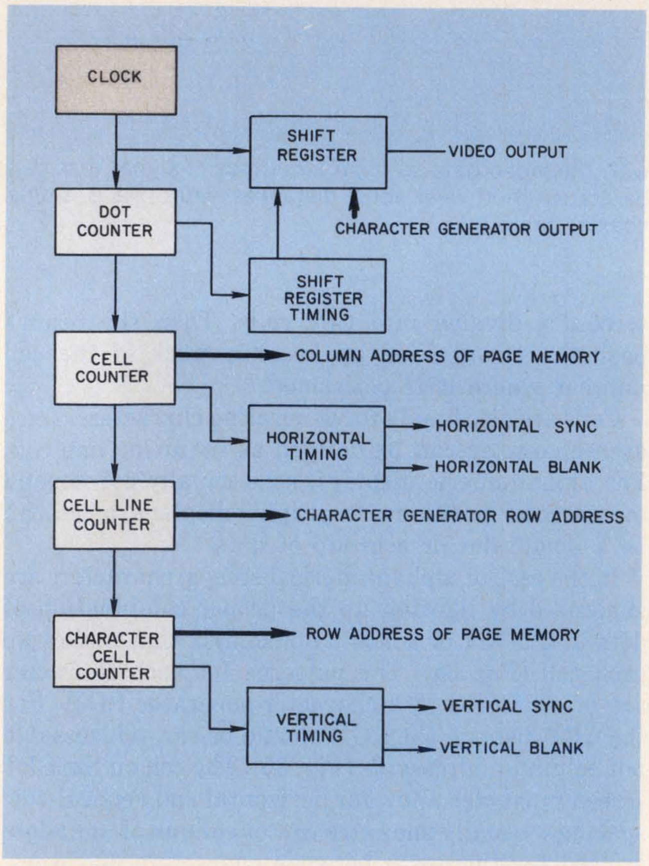
The internal sweep circuits of most CRT-display systems are free-running—that is, they aren't synchronized to any master timing circuit. However, to obtain a meaningful display, the sweep must be sync'd to an external controller (Fig. 2a). This is done by horizontal and vertical sweep signals generated by the controller (Fig. 2b). Lower-cost CRT monitors usually require one signal source for horizontal sync, one for vertical sync and one for the data.

Cells are also handy for generating characters, since each character can be defined as requiring one cell. For alphanumeric displays, cells usually correspond to character positions. In graphic displays, a cell can be a single dot or a group of dots.

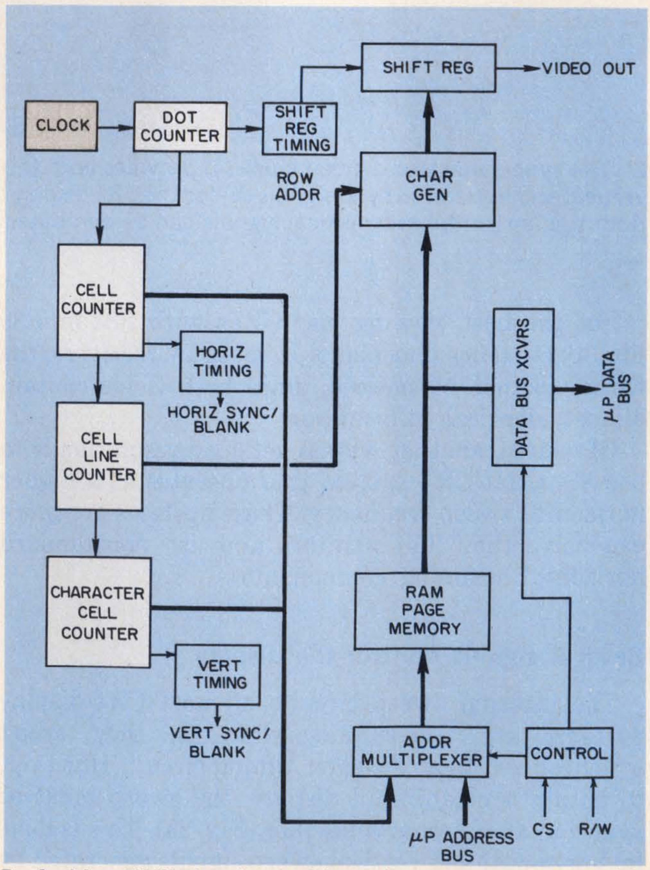
In the case of alphanumeric displays, characters are generated by lighting up the proper combination of dots in a 5 × 7 or a 7 × 9 dot matrix that makes up each cell (Fig. 3a). The patterns for each character are often stored in a character-generator ROM. For the CRT display, the ROM should be row-addressable not column-addressable (Fig. 3b). The cell on the CRT screen must also allow for horizontal and vertical-row spacing—usually one extra row or column of unlit dots is used for the space between characters and rows. Then the cell is either 6 × 8 or 8 × 10 dots. Some of the ROMs also include the blank lines of dots, so the external circuits can be simplified even further.



3. **Standard 7×9 and 5×7-dot matrix displays** can be generated from ROM-based data (a). To actually form the characters, a line-by-line slice is read out from the row-addressable character generator ROM (b).



4. **Inside the sync generator** many counters are used to generate all the various timing signals and provide the addresses for the RAM where the displayed data are temporarily stored.



5. **A video RAM circuit** combines the sync generator with all the counting circuits, the character generator and the necessary memory pages to form an almost complete video display system.

ROMs require two sets of input addresses—one for the character to be addressed and one for either the row or column of the character to be displayed. The ROM inputs are usually ASCII-encoded so that a keyboard's output can be fed directly to the ROM.

In a CRT display, the electron beam provides slices of the characters, one row at a time, as it scans a line. The row outputs of the ROM are usually held in latches, which are transferred to a parallel-input shift register, then shifted into the video-generation circuits via the shift register's serial output.

Inside a video display, the character generator receives stable row and character addresses to determine which character is to be displayed. Then the output of the generator is latched into a shift register and clocked out to form the video signal (Fig. 4). So a master clock is needed to do all the timing.

The clock that drives the sync generator and video-shift register operates at what is called the dot frequency, which can be calculated by:

$$f_{dot} = f_{line} \times \text{number of lines} \times \text{number of cells per line} \times \text{number of horizontal dots per cell.}$$

$$\text{Number of lines} = \text{number of character lines} \times \text{number of lines per cell.}$$

The dot frequency is fed into a counter that divides by the number of dots per cell. Logic circuits driven by this counter control the flow of data to the shift register delivering the serial video data. The final output of the dot counter drives another counter that keeps track of the number of cells on the current line.

Make allowances for the number of displayed cells along with the necessary retrace time. Typically, an 80-character line should have at least 104 cells (retrace should have at least 25% of the total number of displayed cells).

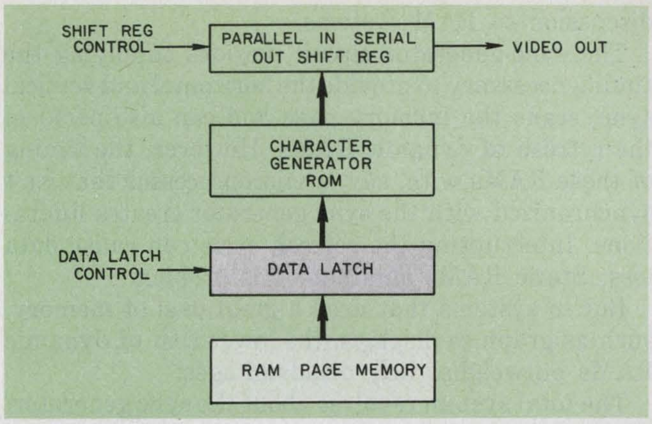
Logic circuits connected to the cell counter can generate the necessary sync and blanking signals during the nondisplay portion of the line. And the outputs of the cell counter can also be used to drive some of the address lines of the display memory.

The output of the cell counter also feeds to another counter that keeps track of the number of lines displayed for a particular cell. This cell-line counter feeds its outputs directly to the row-address lines of the character generator.

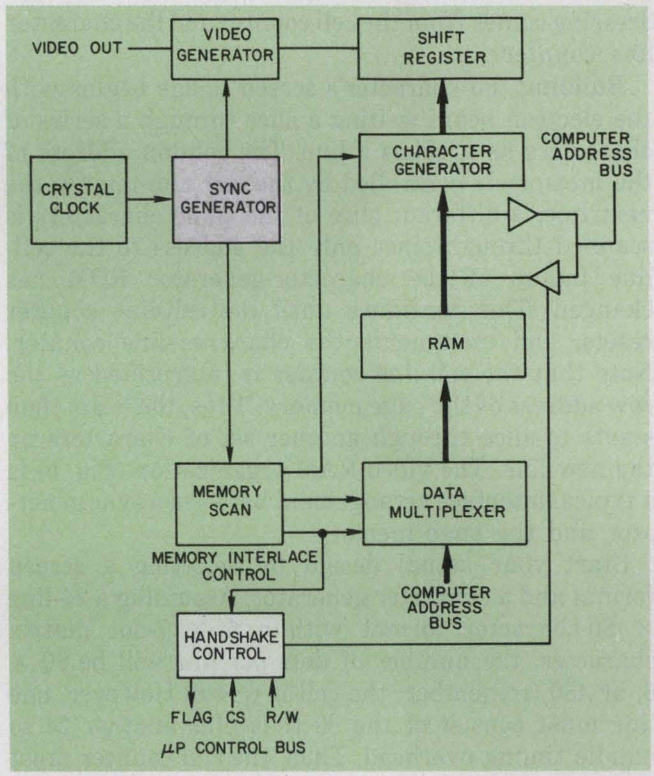
One more major counter is used in the system—a character-line counter. Fed by the final output of the cell-line counter, it keeps track of how many character lines are being displayed. To permit enough time for the vertical retrace of the beam, the count value must be 20 to 25% more than actually needed.

The logic that generates the vertical sync and blanking signals is controlled by this counter. What's more, some of the outputs can be used to drive the remaining address lines of the character memory.

Since a CRT doesn't hold data on the screen indefinitely, all video data must be refreshed, every 1/30 of a second at least. To hold all the data that must be displayed, a block of fairly fast RAM must be used for temporary storage. Each full screen of data is often referred to as a page, and the minimum storage usually included for a display is one page. However, some monitors that are designed to handle large amounts of data, can often store several pages of data.



6. **With pipelined memory organization,** the total access time for the ROM and RAM combination is simply the longest of either rather than the sum of the two.



7. **A typical interlaced memory system to make a video RAM** uses a crystal clock to generate the proper dot-clock frequency and some handshake control logic to make sure the processor doesn't disturb the display accidentally.

Hold the pages in memory

The type of memory page used is governed by the type of memory circuit and the method of interface. Almost any kind of memory can be used in page storage—circulating memories, such as CCDs and other shift registers, or static or dynamic RAMs. Since RAMs are the easiest memory to use, let's confine this discussion to RAM systems.

The sync-generator circuit, besides supplying the timing necessary to provide the horizontal and vertical sync, scans the memory page and can also perform the refresh of dynamic RAMs. However, the timing of these RAMs with, say, a microprocessor that isn't synchronized with the sync generator creates limitations. Interrupting the refresh cycle can cause data loss. Static RAMs eliminate this problem.

But in systems that need a great deal of memory, such as graphics displays, the lower cost of dynamic RAMs outweighs their disadvantages.

The total system revolves about the sync generator. All necessary timing is generated by decoding appropriate counter states. Note that the sync pulses should be positioned in the middle of the retrace interval. The row addressing of the character generator comes from the cell-line counter. Memory addressing comes from the cell counter and the character line counter.

Building the character's screen image begins with the electron beam writing a slice through a series of characters as it scans a line. The column address of the memory is controlled by the cell counter. On the next line, a different slice of the same characters is scanned through since only the address to the cell-line inputs of the character-generator ROM has changed. This continues until the cell-line counter resets, and increments the character-line counter. Note that the cell-line counter is interpreted as the row address of the page memory. Thus, the beam then starts to slice through another set of characters on the new line. The video RAM organization (Fig. 5) is a typical interface arrangement between a sync generator and the page memory.

Start your actual design by selecting a screen format and a character generator. Assuming a 24-line × 80-character format with a 5 × 7-dot matrix character, the number of dots per line will be 80 × 6, or 480 (remember, the cell is 6 × 8) However, one line must consist of the 80 cells plus another 24 to handle timing overhead. Thus, the cell counter must divide by 104. The number 104 is an easy one for binary counters to handle (64 + 32 + 8).

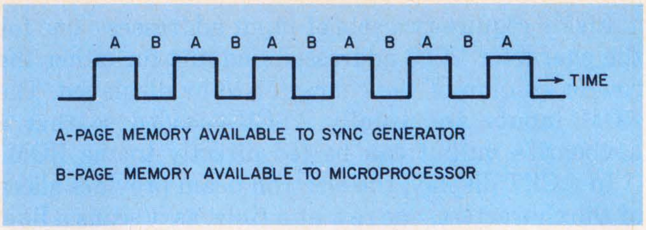
Since there are eight lines per cell, the cell-line counter must divide by 8. A minimum 24 character lines are required, but 9 additional line-time periods should be included to permit vertical retrace. So, a divide-by-32 counter will do the trick.

For every frame, then, there are eight lines per character and 32 character lines, for a total of 256 dot lines. This is well within 10% of the 262 lines desired.

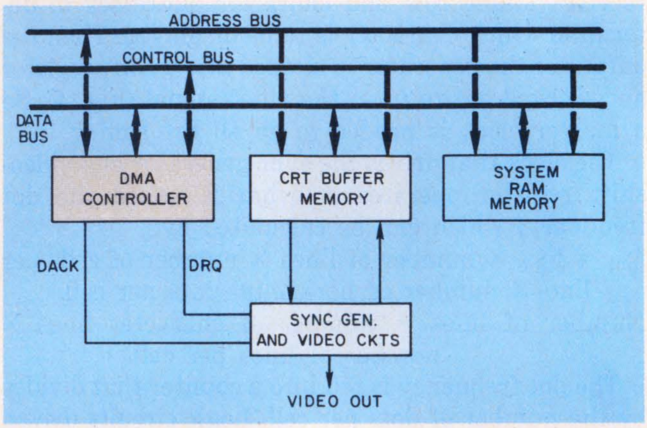
The dot frequency can now be calculated from the formula described earlier:

$$f_{dot} = 60\text{ Hz} \times 256\text{ lines} \times 104\text{ cells/line} \times 6\text{ dots/cell} = 9.58464\text{ MHz.}$$

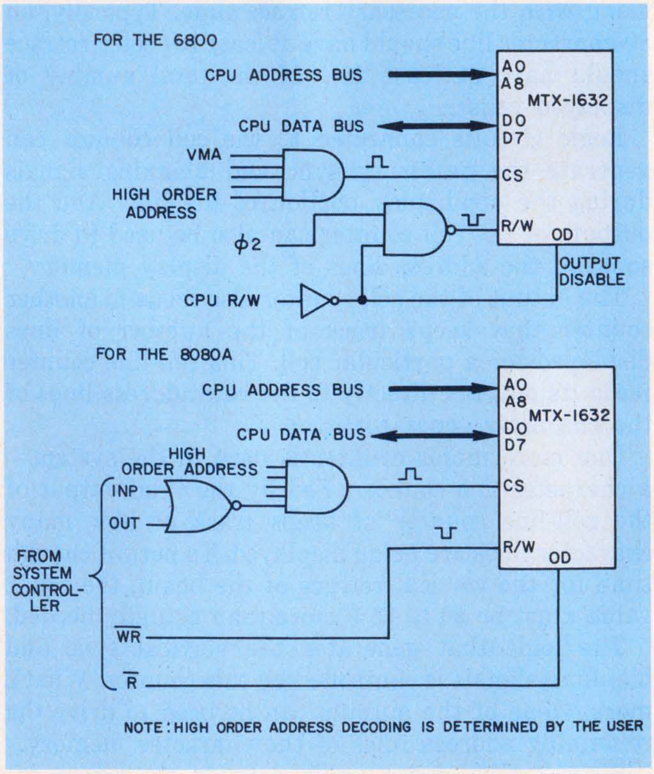
You can vary the aspect ratio of the characters by varying the intercharacter spacing. In this example the character can be made narrower by using seven or eight dots per cell.



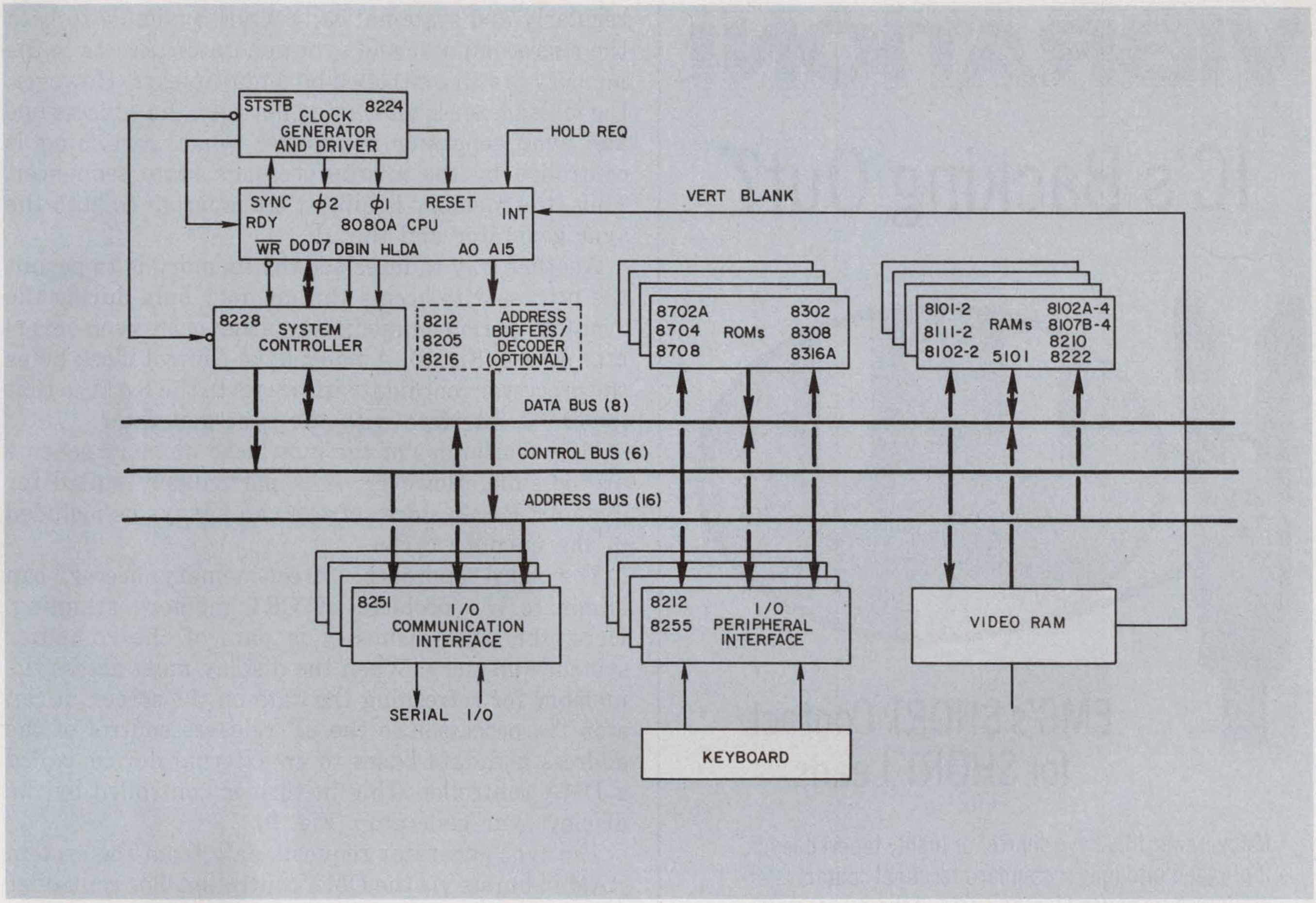
8. **To control the timing** all that's needed is a single-phase clock. When High it lets the sync generator feed into the multiplexer. When Low, it lets the processor control the display memory through the multiplexer.



9. **By using a DMA interface** between the processor and the video display, the main system memory can be constantly updated then transferred to the display's buffer in one operation every time the display wants an update.



10. **Connecting the video RAM to either the 8080A or 6800** is easily done with some gates and the μP's read/write line. The video RAM can be located anywhere in the computer's memory space and is, in fact, addressable just like any random-access memory.



11. **Building an intelligent terminal** with a video RAM is as simple as adding some more RAM. Just connect the video RAM to the address, data and control buses and another line to the processor's interrupt line.

Speed is important, especially when a large number of characters must be put on a screen. The greater the number of characters on the screen, the higher the dot-clock frequency. However, the CRT monitor itself is often the limiting factor (many monitors are limited to 5 or 10 MHz).

Display performance can be affected by the access time of the memory system (the cell-to-cell spacing in time). In the example shown, this time can be calculated as

$$t_{cell} = (1/f_{dot})\ (\text{number of dots/cell}) = 626\ \text{ns} = (1/9.58464\ \text{MHz}).$$

This is the total time available for both the page memory access and the ROM lookup. A pipeline organization of the two elements, as shown in Fig. 6, reduces the cell's time requirements to the greater of either the page memory or ROM-access speed.

Interface the memory to the display

Ideally, the RAM used in the display system should be accessible from two sources—the sync generator and an external device such as a microprocessor. Three alternative approaches can be used to do the job simply: a video RAM interface, an interlaced memory interface and a direct-memory-access interface.

Of these easy methods, the video-RAM interface is probably the easiest. It uses a memory-mapped addressing technique to access the characters. And access to the memory is controlled by a two-input multiplexer (Fig. 7).

Normally, the sync-generator's address outputs control the memory. The address lines of the memory can thus be switched between two sets of address data. The switching is controlled by a single line that is treated much the same way as a chip-select line.

The memory output and input buses can also be connected to the external system's data bus via three-state transceivers. The transceivers are, in turn, controlled by a μP's read/write and chip-select lines.

By activating the chip-select line, the external system can take control of the RAM. This organization creates a display interface that looks like a RAM to the computer. Similar approaches are used by Matrox and other companies to form low-cost display modules for CRT display systems.

One disadvantage is that the computer interrupts the normal scanning of its memory whenever a read/write operation is attempted. Moreover, this interruption can be seen as streaks or flashes on the CRT screen. This problem usually doesn't matter if memory accesses occur in infrequent bursts for updates. Still, the problem can be eliminated if memory accesses are confined to the video-blanking intervals.

The interlaced memory interface is similar to the video RAM interface, except that the memory is regularly and systematically made available to both the microcomputer and sync generator. Access to the memory is still controlled by a multiplexer. However, the multiplexer is alternated between the address bus and sync generator no matter what. Switching is controlled by the microprocessor's state sequencer. Thus, the memory is almost transparent to both the sync generator and the μP.

Another way to interlace the memory is to permit the processor to access the memory only during the "vacant" period immediately after each sync-generator access (Fig. 8). A handshake-control block helps the processor coordinate its access to the RAM so that it doesn't interfere with the sync generator.

Many variations of the interlaced memory scheme are possible. However, it is particularly suited for dynamic RAMs since refresh can always be included in the memory cycle.

The third approach, direct-memory access, can eliminate the problem of CRT memory scanning. Here, the page memeory is part of the computer system's memory. When the display must access the memory for refreshing the data on the screen, it can stop the processor so the μP releases control of the address and data buses to an external device, called a DMA controller. This in turn is controlled by the display sync generator (Fig. 9).

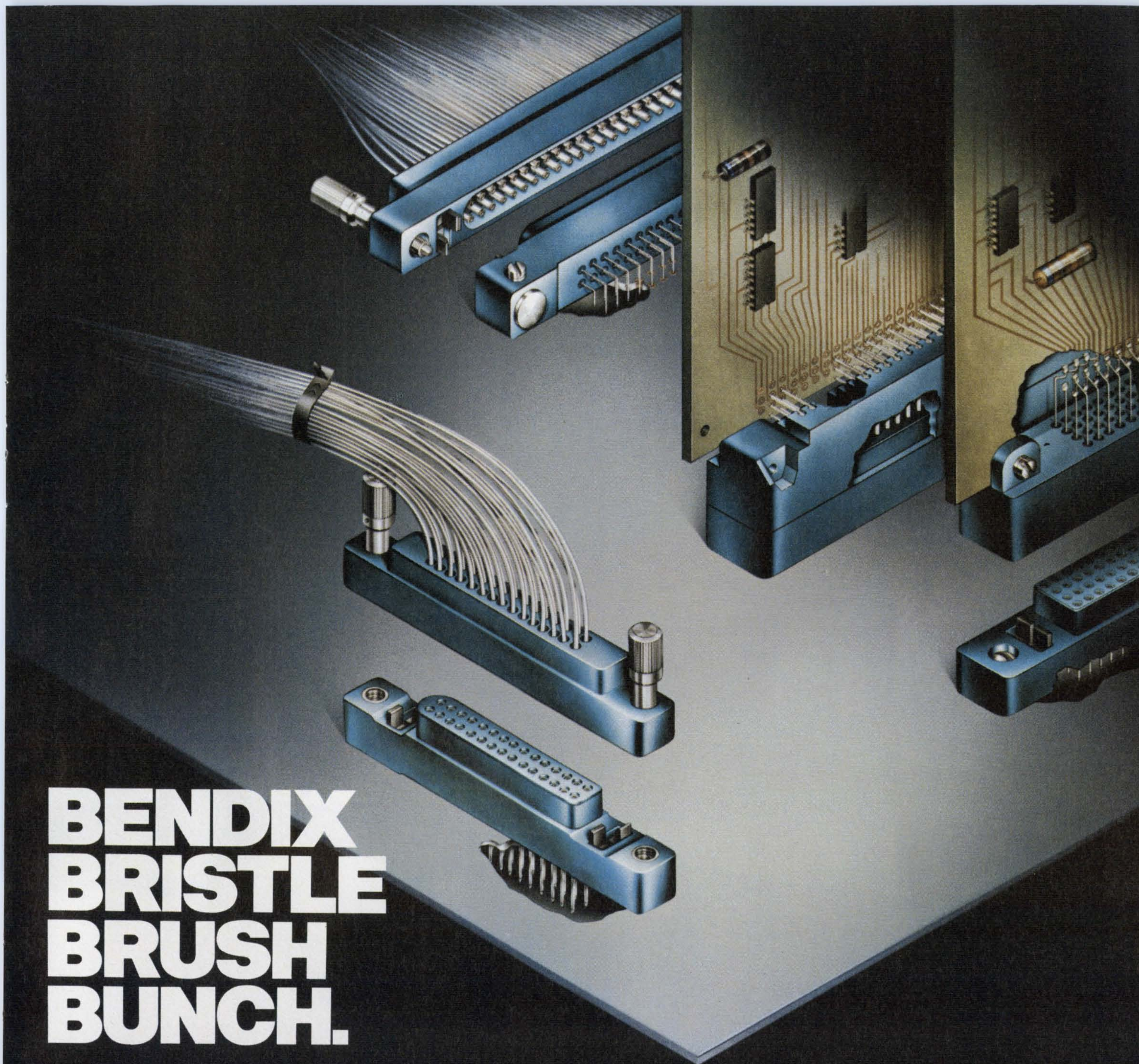
The sync generator requests data from the system RAM in bursts via the DMA controller. The controller transfers information from the RAM to the CRT display's buffer memory, which can then be read out by the sync generator and put on the screen.

While this method avoids the interference problem of the video RAM, it is more complex—and more expensive to put into use. What's more when a DMA occurs, the processor must stop, thus slowing down any calculations or stopping any control functions the processor is doing.

Naturally, weigh the advantages and disadvantages of these three video-interface methods when you design a display system. And remember: There are other ways to do the job that haven't even been touched upon. Also, many other features can be added to the display system—scrolling, cursor generation, and multipage storage, to name just a few.

Connecting a circuit such as the video RAM into a processor system is relatively simple. Fig. 10 shows the interface necessary to connect the Matrox MTX-1632 VRAM to either the 8080A or 6800 microprocessor-system buses. The MTX-1632 provides a 16-line × 32-character display and can be located anywhere in the processor's memory.

You can also build an intelligent terminal around a video RAM (Fig. 11). The unit must be connected in the terminal system so that it becomes part of the memory. The intelligence of the terminal depends completely on the program stored in ROM. Typically, keyboard entries are read by the μP via the parallel-interface port. After processing the data, the information can be displayed by writing it into the RAM. ■■



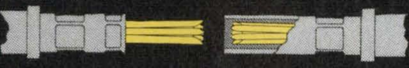
BENDIX BRISTLE BRUSH BUNCH.

Opens new horizons for PCB design.

70%-90% Reduction in Mating and Unmating Forces

- simpler board support systems
- fewer damaged boards

Extended Circuit Count Potential

- up to 400 Bristle Brush  contacts per connector

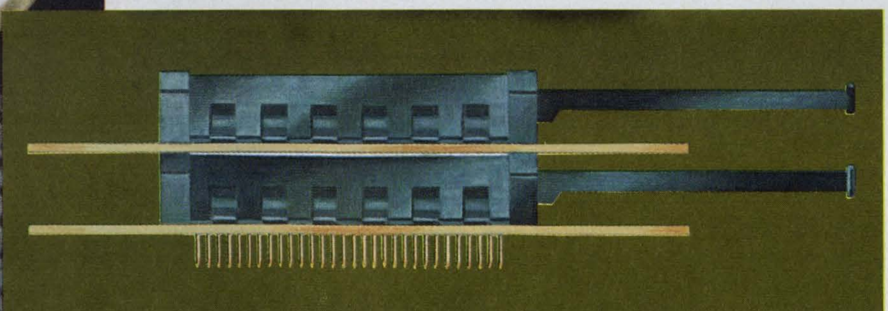
Extensive Product Line

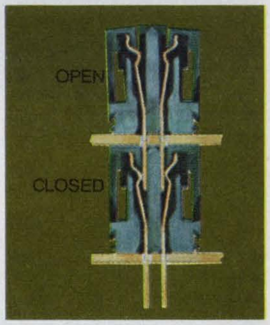
- mother board, daughter board, input/output, PC receptacle body styles
- 2-, 3-, and 4-row configurations
- 90° and straight PC, solderless wrap, crimp removable, willowy tail terminations

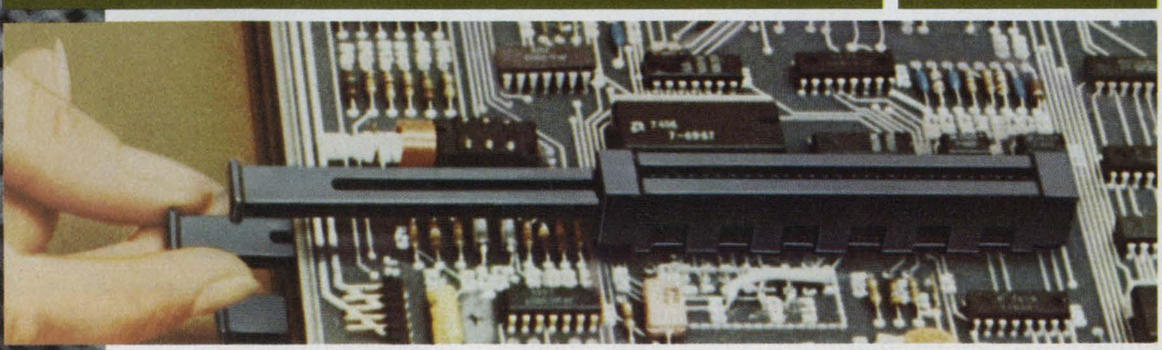
For complete information, contact The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix


AMP ZIF connectors
stack up savings in materials,
space and costs.
And that's what
progressive designers
are looking for.




OPEN
CLOSED



Speed up digital processors

by not using shift registers to do data scaling. Specialized scaling circuits can do the job faster and simpler.

Data shifting, an integral part of digital multiplication, division and scaling, is usually done with a straight shift register. Data are entered in parallel, shifted left or right, and outputted in parallel. However, these registers usually require one clock period for every position shifted, which makes complex calculations time-consuming. In the same clock period, a specialized scaling circuit, such as the Am25S10, can shift four bits of data 0, 1, 2, or 3 places (Fig. 1).

The high speed shifting of data is critical in many floating-point processors and data recorders, where real-time calculations must be performed on incoming data. By normalizing the data before performing calculations, many an algorithm can be accelerated.

With the right interconnections, the 25S10s can be cascaded for any word length and shift the word any number of places left or right. Shifting can be logical, with ZEROs pulled in at either or both ends; arithmetic, with the sign bit repeated during a shift down; or end around, with the data word forming a continuous loop.

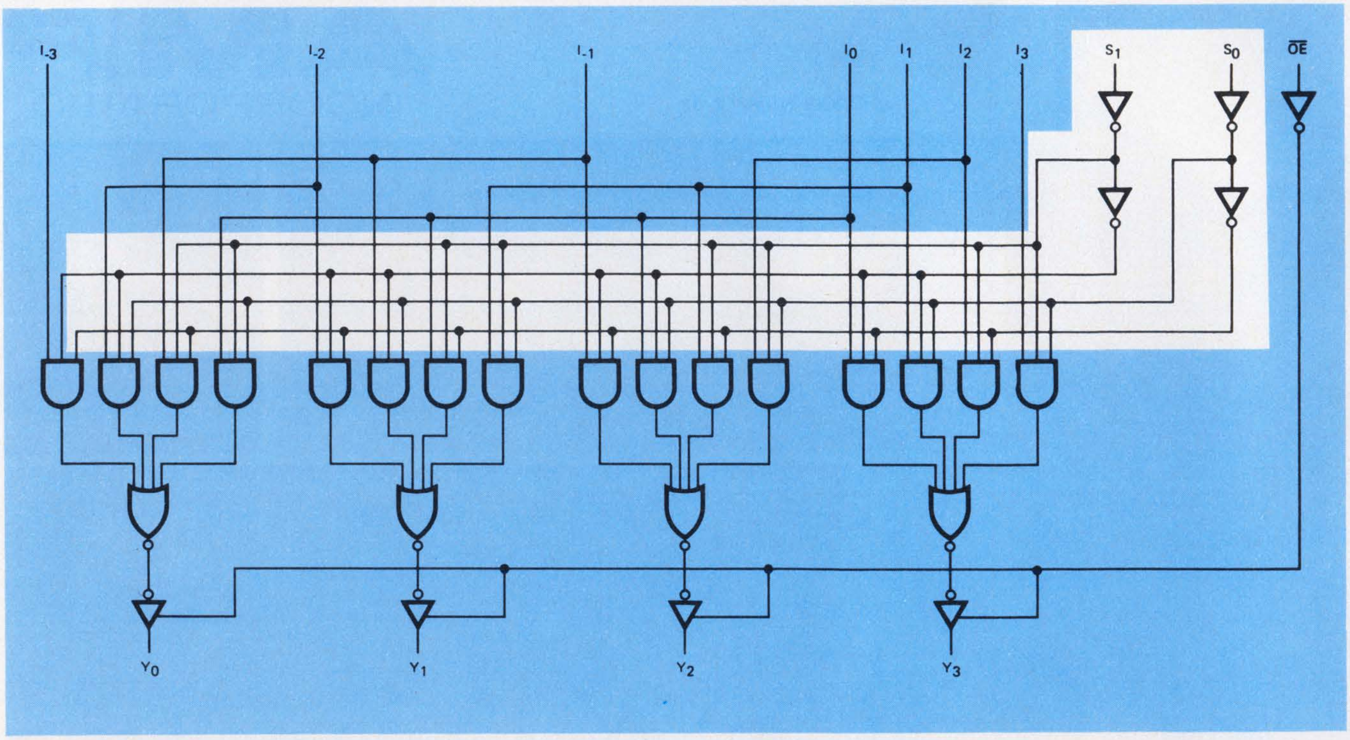
John Mick, Engineering Manager, Digital Bipolar Products, Advanced Micro Devices, 901 Thompson Place, Sunnyvale, CA 94086.

Get to know the Am25S10

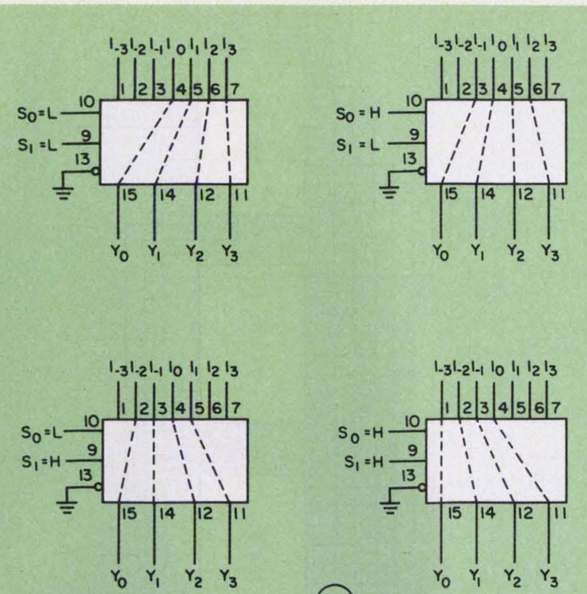
Working with the scaling circuits such as the 25S10 developed by AMD and second sourced by Signetics is relatively simple. Housed in a 16-pin DIP, the Schottky MSI circuit has seven data inputs, I_{-3}, I_{-2}, I_{-1}, I_0, I_1, I_2, and I_3; four three-state outputs, Y_0, Y_1, Y_2 and Y_3; one output enable line, $\overline{OE}$; two control lines, S_0 and S_1; and two power pins.

The three-state outputs allow several 25S10s to be bus-organized for shifts of more than three places, with only a single-level gate delay of less than 20 ns. In addition, input loading due to current sharing is usually only 1.5 standard Schottky loads—not up to four as might be expected with the internal gate arrangement.

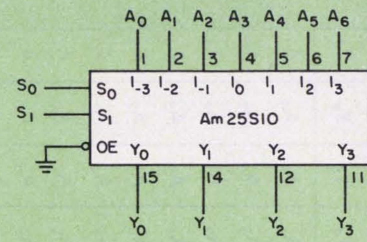
The $\overline{OE}$ line is an active-Low control—when Low, the data outputs follow the selected data inputs; when High, the outputs present a high impedance to the data bus. Under control of the two S lines, the I input



1. **Under the command of two control lines** the input word to the 25S10 can be shifted 0, 1, 2 or 3 places during a single cycle. It takes less than 20 ns for a signal to propagate through.



(a)

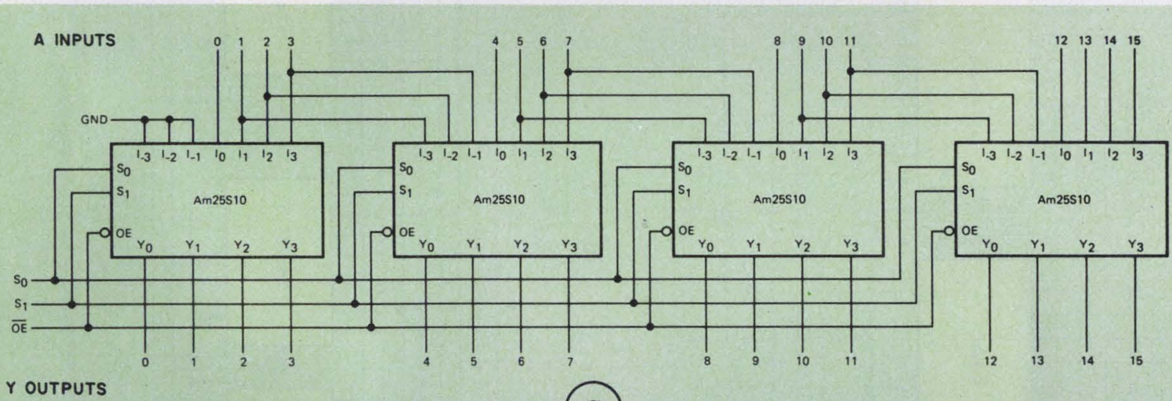


FUNCTION TABLE

S_1	S_0	Y_0	Y_1	Y_2	Y_3
0	0	A_3	A_4	A_5	A_6
0	1	A_2	A_3	A_4	A_5
1	0	A_1	A_2	A_3	A_4
1	1	A_0	A_1	A_2	A_3

(b)

2. **The four shift positions of the 25S10** depend on just the S_0 and S_1 control lines (a). By representing the 7-bit input as a single word, A_0 to A_6, the function table showing the next output can be drawn up (b).



(a)

FUNCTION TABLE

S_1	S_0	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}	Y_{15}
0	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}
0	1	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}
1	0	0	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}
1	1	0	0	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}

(b)

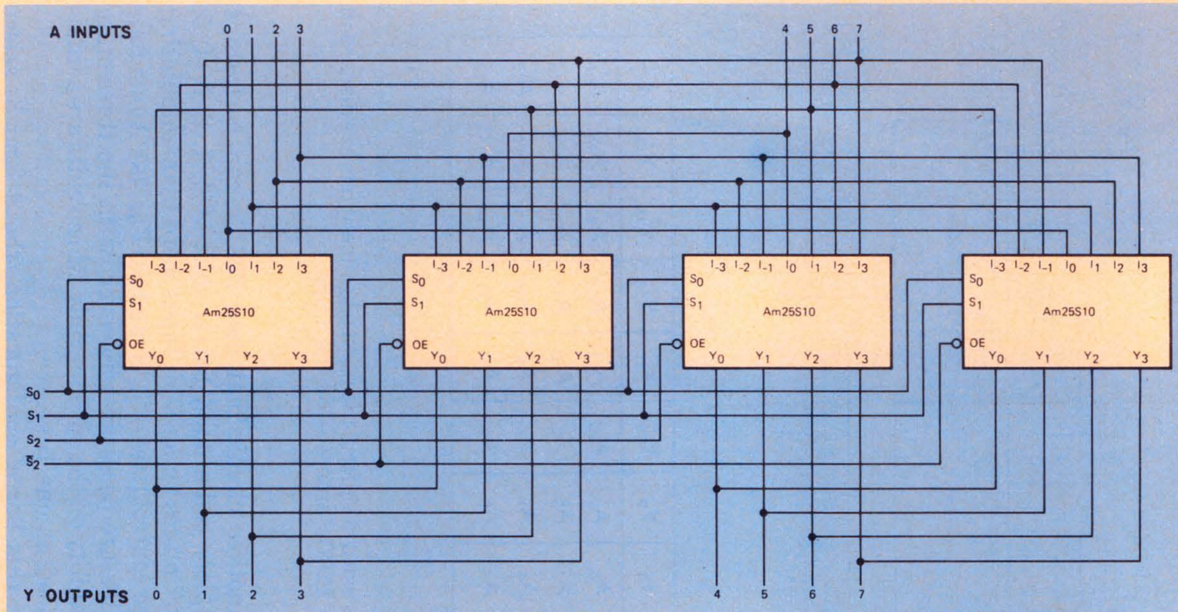
3. **Shifting a 16-bit word up to four places,** the scalers can be cascaded for almost any word length. When the data word is shifted, the most significant bits are discarded and ZEROs entered for the LSBs.

lines are routed to the output (Fig. 2a). If a 7-bit input word is used, A_0 to A_6, the circuit and its output can be represented by Fig. 2b.

If you cascade four 25S10s in the simple circuit of Fig. 3, a 16-bit input word can be shifted 0, 1, 2 or 3 places. As the shift is performed the most significant bits (A_{13}, A_{14} and A_{15}) are discarded and ZEROs are shifted in as least significant bits.

Another circuit that uses 25S10s can perform a complete end-around barrel shift of 0, 1, 2, 3, 4, 5, 6 or 7 places on an 8-bit input word by manipulating three control lines—S_0, S_1 and S_2 (Fig. 4a). Again four 25S10s are necessary; however, with the three-state capability on the outputs, only two circuits are actually used at one time.

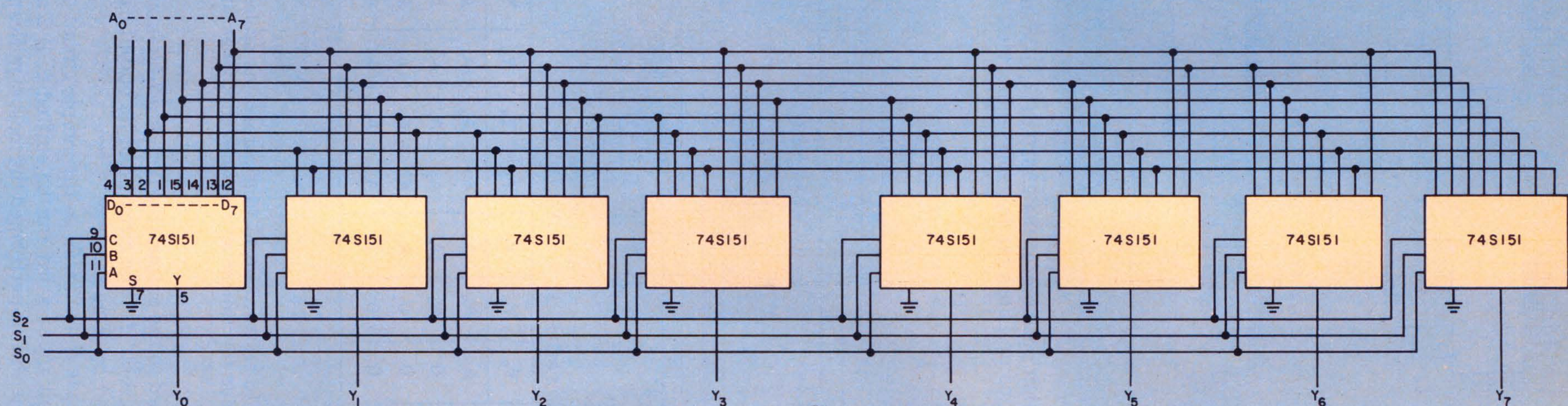
In this barrel configuration, the S_2 and $\overline{S}_2$ select



FUNCTION TABLE

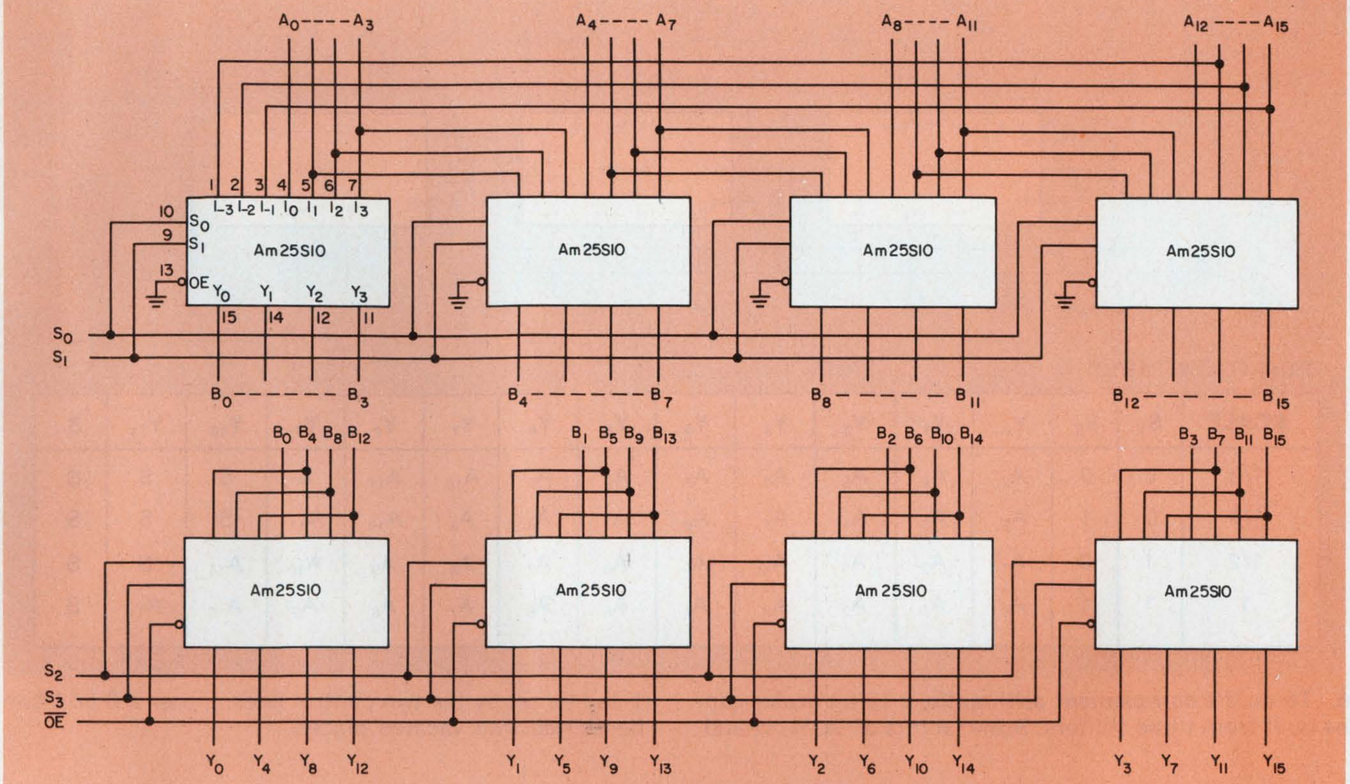
S_2	S_1	S_0	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7
0	0	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7
0	0	1	A_7	A_0	A_1	A_2	A_3	A_4	A_5	A_6
0	1	0	A_6	A_7	A_0	A_1	A_2	A_3	A_4	A_5
0	1	1	A_5	A_6	A_7	A_0	A_1	A_2	A_3	A_4
1	0	0	A_4	A_5	A_6	A_7	A_0	A_1	A_2	A_3
1	0	1	A_3	A_4	A_5	A_6	A_7	A_0	A_1	A_2
1	1	0	A_2	A_3	A_4	A_5	A_6	A_7	A_0	A_1
1	1	1	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_0

(a)



(b)

4. **An end-around barrel shifter** built from four scalers can handle an 8-bit data word and shift it 0, 1, 2, 3, 4, 5, 6 or 7 places, as shown in the function table (a). An equivalent wired shifter (b) has double the circuitry.



FUNCTION TABLE

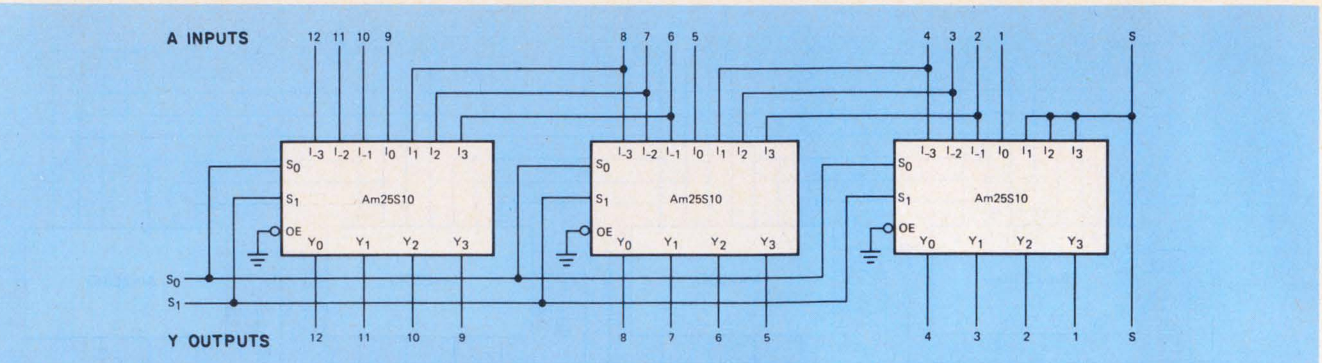
S_3	S_2	S_1	S_0	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}	Y_{15}
0	0	0	0	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}
0	0	0	1	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}
0	0	1	0	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}
0	0	1	1	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}
0	1	0	0	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}
0	1	0	1	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
0	1	1	0	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9
0	1	1	1	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
1	0	0	0	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7
1	0	0	1	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5	A_6
1	0	1	0	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4	A_5
1	0	1	1	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3	A_4
1	1	0	0	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2	A_3
1	1	0	1	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1	A_2
1	1	1	0	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0	A_1
1	1	1	1	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_0

5. **Performing a 16-bit, two-level barrel shift** requires just eight 25S10s. By using a two-level approach, four control lines determine over-all circuit operation to shift the word 0 to 15 places.

inputs determine which pair of 25S10s is selected. When S_2 is Low, IC_1 and IC_3 are on the bus and when High IC_2 and IC_4 are enabled.

Larger word lengths can be handled by using several 25S10s on each bit line and one-of-four or one-of-eight decoders to control the enable lines. If dedicated, hardwired multiplexers are used to perform the same function as shown in Fig. 4b, at least double the hardware would be necessary.

Another way to perform end-around shifting involves more than one level of shifters. A two-level, 16-bit barrel shifter can be built from eight 25S10s,



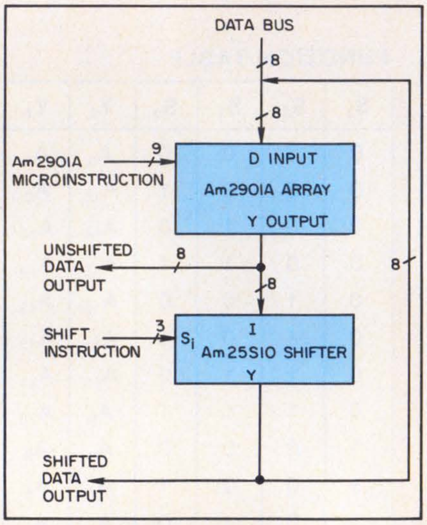
FUNCTION TABLE

SCALE	S_1	S_0	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	S
1/8	0	0	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	S	S	S	S
1/4	0	1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	S	S	S
1/2	1	0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	S	S
1	1	1	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	S

6. **To do 2's complement arithmetic,** a 13-bit scaler can be built from three shifters. Scale factors of ⅛, ¼, ½ and 1 can be set by the two control lines. Either a 0 or 1 can be shifted into vacated places.

Software commands for 2901A/25S10 network

2901A Source select		2901A ALU function		2901A Destination		25S10 Shift control	Function performed
Function	Octal code	Function	Octal code	Function	Octal code		
D, 0	7	OR	3	RAM A	2	1	Rotate register 1 position
D, 0	7	OR	3	RAM A	2	2	Rotate register 2 position
D, 0	7	OR	3	RAM A	2	3	Rotate register 3 position
D, 0	7	OR	3	RAM A	2	4	Rotate register 4 position
D, 0	7	OR	3	RAM A	2	5	Rotate register 5 position
D, 0	7	OR	3	RAM A	2	6	Rotate register 6 position
D, 0	7	OR	3	RAM A	2	7	Rotate register 7 position
D, 0	7	OR	3	RAM A	2	Ø	Rotate register Ø position



7. **Connecting an 8-bit barrel shifter to a 2900-based processor** requires that the input lines of the scalers be connected to the output port of the 2901A, and that the output lines of the 25S10 be connected to the data bus/input port of the 2901A.

which are connected to give four control lines, S_0 to S_3 (Fig. 5). The one-level method used in Fig. 4 would require 16 circuits to build a 16-bit barrel shifter.

If 2's-complement numbers have to be scaled, as in many mini or microcomputer applications, a 13-bit scaler can be built with just three 25S10s (Fig. 6). The sign bit is pulled in at the most significant end, and the least significant bits are truncated. Thus, a 13-bit number can be scaled to 1, 1/2, 1/4 or 1/8 its input value by shifting it 0, 1, 2, or 3 places.

Bit-slice processors take the best advantage of the improved speed contributed by the 25S10. Connecting an 8-bit barrel scaler as shown in Fig. 4 to a processor built around the 2900 series of bit slices is relatively straightforward (Fig. 7). The I lines connect to the 2901A output bus, and the Y-output lines connect to the data bus. The scalers are controlled by the microprogram memory directly or by one of the other control registers used in the processor.

Sample microinstructions for firmwave control are shown in the table for shifting a word in any of the sixteen 2901A internal registers. ■■

State of the art leadership in mass terminations ...that's what the BLUE MACS™ System is all about!

LEADERSHIP IN MASS TERMINATION DESIGN FLEXIBILITY begins with a complete package of BLUE MACS connector styles and sizes to meet your varied interconnect requirements. An expanded standard cable package that includes round conductor cable for intra-cabinet wiring, flat conductor cable for high flex life applications, and U.L. listed jacketed cable for external interconnect requirements. A tool package that includes hand and bench versions, cable cutters and separators, discrete wire fixtures and accessories.

LEADERSHIP IN MASS TERMINATION CONTACT RELIABILITY starts with our exclusive patented TULIP™ contact that provides 4 points of electrical contact per conductor for gas-tight, corrosion-free terminations. Comprehensive test information is available upon request.

LEADERSHIP IN LOWER INSTALLED COSTS begins with a one piece connector design that eliminates unnecessary handling to reduce installation time by as much as 65%. This one piece design incorporates mating grooves which assures positive cable to connector alignment, and it eliminates the operator variable when assembling the cable to the connector. Insulation displacing TULIP contacts let you simultaneously mass terminate up to 60 conductors in seconds —without wire stripping or soldering.

A colorful reference guide tells the full reliability story about our complete systems package. Ask your local Ansley distributor for a free copy of the BLUE MACS Wall Chart. Or write us, direct.

T&B/Ansley

The mass termination company.

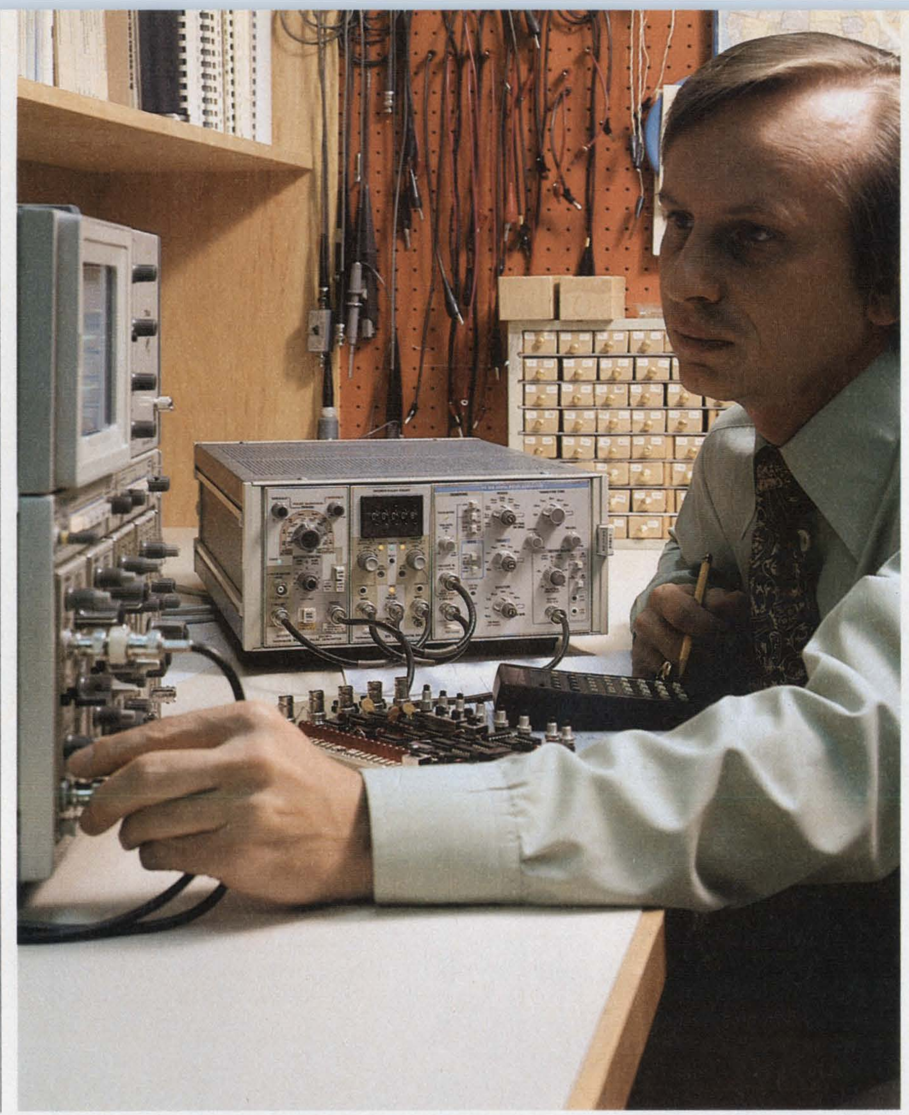
T&B/Ansley Corporation
Subsidiary of Thomas & Betts Corporation
3208 Humboldt St., Los Angeles, CA 90031
Tel. (213) 223-2331 • TWX 910-321-3938

CIRCLE NUMBER 39

Stocked and sold through authorized Ansley distributors.

International Offices: AUSTRALIA, Brookvale, (02) 938-1713 • **CANADA,** Iberville, Quebec, (514) 658-6611 • **SOUTH AFRICA,** Benrose, 24-8134 • **ENGLAND,** Luton, (0582) 597-271 • **WEST GERMANY,** Dreieichenhain bei Frankfurt, 06103-8 20 21 • **FRANCE,** Rungis, 687-23-85 • **JAPAN,** Tokyo, 03-354-9661 • **SWEDEN,** Upplands Vasby, 0760-86140 **ITALY,** Milano, 02-431216.

SEE US AT WESCON-BOOTHS 801-803



Think about expanding your pulse generation capabilities... think about TM500.

When testing 16-k dynamic RAMs, keep your eye on the temperature and your finger on your pattern generator. Minding both gives more accurate results.

Test a 16-k RAM inadequately, and you're on your way to a migraine headache. Two ways to get into big trouble: Forget about temperature effects, and ignore important test-pattern sequences. Analyze both, and you'll save your aspirins for later. Storage time is a case in point.

Charge storage on a 16-k MOS RAM is, of course, dynamic in nature, since the charge on the MOS capacitor eventually will leak off. Storage time is an intrinsic device parameter. Refresh time—more properly, refresh interval—specifies a maximum allowable interval. The interval separates two operations (on the same storage location) that will re-establish the full charge on a partially decayed HIGH level.

Performance varies with temperature

But remember: Storage time depends on temperature:

$$T_S = A \exp(-BT),$$

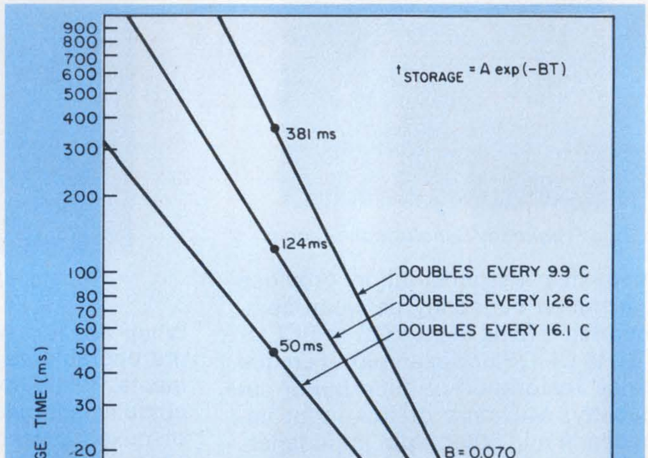
where T is the junction temperature in °C, B is a variable relating the magnitude of the generation-recombination current to the junction temperature (units of 1°C), and A is a scaling constant reflecting such variables as junction area, bulk-defect density, and sense-amplifier design.

Note that B is not a constant. Normally, it is assumed that the storage time doubles for every 10-C decrease in junction temperature—which is equivalent to assuming that B = 0.069. Data show that 0.055 is a typical value for B—but the number varies at least ±30% from the typical (Fig. 1).

The storage time at T_J = 25 C for the hypothetical device of Fig. 1 will lie somewhere between 50 and 381 ms. If room-temperature testing is to be attempted, the refresh interval should be set at 381 ms, since any lesser value won't guarantee the assumed minimum storage time of 2 ms at 100 C. Devices failing such a test won't necessarily be failures at 2 ms and 100 C, and would therefore have to be rescreened at 100 C.

The efficiency of the procedure depends upon the number of good devices found by the first screen, but in general the number of units requiring a second test is so great, you may as well go ahead and eliminate the first screen in favor of a 100% screen at the maximum-junction temperature.

Besides storage time, access time, power dissipation, and input/output levels all need to be verified over the temperature range. Access time and power dissipation are functions of transistor gain, which is temperature-dependent (through carrier mobility) and about 25% lower at 100 C than at 0 C. Therefore, access takes longer at elevated temperatures. The memory will dissipate more power at low temperature. However, note that much of the power required is capacitive and thus related to frequency rather than temperature.



1. **Storage time doesn't necessarily double** for every 10-C decrease in junction temperature, as the "conventional wisdom" states. Setting the correct refresh intervals during testing requires an accurate knowledge of the minimum storage time for the memory.

Robert W. Owen, Product Engineer-Mostek Corp., 1215 W. Crosby Rd., Carrollton, TX 75006.

Signal levels are functions of transistor-threshold voltage, which decreases about 2 mV for every 1-C increase in temperature. Input HIGH levels and output HIGH and LOW levels are normally the worst at low temperature and must be guardbanded if you test only at high temperature. (One 16-k RAM, the Mostek MK 4116, incorporates an integrated reference voltage for address and data inputs—which removes the threshold-voltage dependence and the temperature dependence along with it.)

A few timing parameters become worst-case as the memory becomes faster, and you must guardband these if you test only at high temperature. On balance, however—primarily because storage time varies radically with temperature—it is best to conduct tests at the maximum junction temperature only and guardband parameters that aren't worst-case.

Calculating temperature rise

The two junction temperatures singled out in Fig. 1 are not chosen at random. The equation describing temperature rise over an ambient is given by:

$$T_J - T_A = \Delta T = \theta_{JA} P_D,$$

where θ_{JA} is the junction-to-ambient thermal resistance (for a 16-pin ceramic DIP mounted in a socket on a double-sided PC board, the most widely accepted value is 70 C/W), and P_D is the power dissipation of the device under the conditions of interest.

To get ΔT, assume the following specified values

$$I_{DD}\ (\text{active}) = 35\ \text{mA},$$
$$I_{DD}\ (\text{stand-by}) = 1.5\ \text{mA},$$
$$V_{DD}\ (\text{maximum}) = 13.2\ \text{V},$$
$$t_{cycle} = 375\ \text{ns}.$$

Assume that the refresh test writes 16,384 bits at the 375-ns cycle rate, pauses in the stand-by condition for the refresh interval, then reads all bits again at 375 ns. With t(refresh) = 2 ms, calculate the rise in junction temperature as follows:

$$\text{duty factor (DF)} = \frac{2\ (16{,}384)\ 375\ \text{ns}}{2\ (16{,}384)\ 375\ \text{ns} + 2\ \text{ms}} = 0.86.$$

Therefore:

$$\Delta T = \theta_{JA}\ [P_D\ (\text{active}) \times (\text{DF}) + P_D\ (\text{stand-by}) \times (1 - \text{DF})]$$
$$= 70\ \text{C/W}\ [0.035 \times (13.2) \times 0.86 + 0.0015 \times (13.2) \times (1 - 0.86)]$$
$$= 28\ \text{C}.$$

With t(refresh) = 381 ms,

$$(\text{DF}) = \frac{2\ (16{,}384)\ 375\ \text{ns}}{2\ (16{,}384)\ 375\ \text{ns} + 381\ \text{ms}} = 0.03.$$

Therefore:

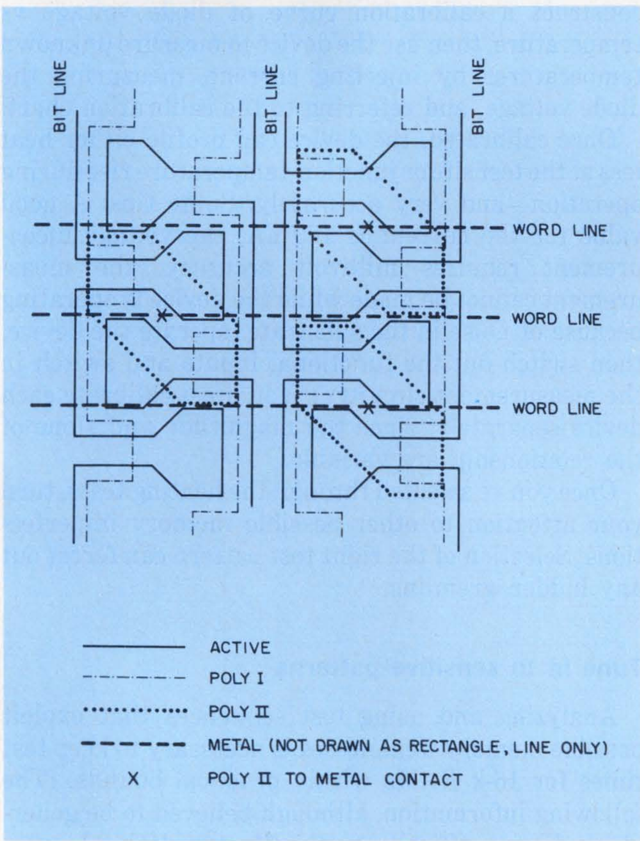
$$\Delta T = 70\ \text{C/W}\ [0.035 \times (13.2) \times 0.03 + 0.0015 \times (13.2) \times (1 - 0.03)]$$
$$= 2.3\ \text{C}.$$

The junction temperature of a device undergoing a 381-ms refresh test at T_A = 25 C will rise only 2.3° to 27.3°, while the same device executing a 2-ms refresh test at T_A = 70 C will rise to a whopping 98 C.

Strictly speaking, the foregoing calculations are true only if you allow the junction temperature to stabilize by running the refresh test in a continuous mode. The thermal mass of the device is not negligible. In fact, θ_{JA} is a function of time and has a time constant of approximately 60 s in most test situations.

Is it the pattern or the temperature?

Interestingly, much of the effectiveness of the N^2 pattern test is attributed to elevated junction temperatures occurring during the test interval. An N^2 pattern, with N equal to 16,384 and a cycle time of 375 ns, requires 100 s. The value of θ_{JA} after 100 s



2. **Cell layout of the MK 4116 16-k RAM** locates adjacent cells on the same row or on rows separated by one word line, but always on adjacent columns. The two-polysilicon-level construction may call for further testing, for instance, of cell-to-cell interactions.

Possible minimum test sequence for 16-k RAM

Test Description	Data Pattern	Function	Power Supplies V_{DD}	Power Supplies V_{BB}	Cycle Count
Maximum cycle	Diagonal	Functionality	13.2	−4.5	2N (t_{cyc} = 10 Ms)
	$\overline{\text{Diagonal}}$		13.2	−5.5	2N (t_{cyc} = 10 Ms)
	Diagonal		10.8	−5.5	2N (t_{cyc} = 10 Ms)
	$\overline{\text{Diagonal}}$		10.8	−4.5	2N (t_{cyc} = 10 Ms)
Load read	Parity and $\overline{\text{Parity}}$		10.8	−5.5	2N
			10.8	−4.5	2N
			13.2	−5.5	2N
			13.2	−4.5	2N
Load read	Checkerboard and $\overline{\text{Checkerboard}}$	Bit Interactions	10.8	−5.5	2N
			10.8	−4.5	2N
			13.2	−5.5	2N
			13.2	−4.5	2N
Walking diagonal	Diagonal	Functionality	10.8	−5.5	$2N^{3/2}$
			13.2	−4.5	$2N^{3/2}$
Dynamic refresh	Alternate Rows	Data retention	10.8	−5.5	1N + 2 ms
Dynamic refresh	$\overline{\text{Alternate Rows}}$	Data retention	10.8	−5.5	1N + 2 ms
Still refresh	All Highs	Data retention	10.8	−5.5	2N + 2 ms

of testing is about 80% of its final value. The junction rise for P_D = 462 mW is

$$\begin{aligned} T &= \theta_{JA} P_D \\ &= (0.8)\ (70\ \text{C/W})\ (0.462) \\ &= 26\ \text{C}, \end{aligned}$$

and this rise occurs during the test.

The storage time of the device may be reduced by as much as a factor of six, with the device speed approximately 10% less. You can attain these benefits, of course, without resorting to N^2 patterns: precalculate the final junction temperature and set the temperature chamber accordingly—an approach not without pitfalls.

If the test chamber is so constructed that heat is maintained throughout the test, you must consider the self-heating. If you hold the device in an elevated ambient before testing, then remove it and insert it into the test socket, you must then characterize the combined effects of heat loss in the socket and self-heating during the test.

The device itself can act as a temperature reference to accurately measure junction temperature. All signal inputs connect to pn^+ diodes, which can easily be calibrated. Notice that if diode current is held constant, diode voltage is linearly proportional to temperature. Calibrate an input on a reference device by stabilizing the device at an accurately measured reference temperature, injecting a constant current, and measuring the diode drop (from the input to the V_{BB} pin).

When you do so at several temperatures, you can construct a calibration curve of diode voltage vs temperature, then use the device to measure unknown temperatures by injecting current, measuring the diode voltage, and referring to the calibration chart.

Once calibrated, the device can profile either heat loss at the test site or junction-temperature rise during operation—and very accurately. Some tips: A good value for the current is 100 μA; the voltage measurement requires millivolt accuracy; the measurement cannot be made while the device is operating because of noise in the substrate (operate the device, then switch out the functional inputs and switch in the measurement circuitry). You must calibrate each device separately, since the magnitude and slope of the relationship are variable.

Once you've sweated through the heating tests, turn your attention to other possible memory imperfections. Selection of the right test pattern can ferret out any hidden gremlins.

Tune in to sensitive patterns

Analyzing and using test sequences that exploit possible memory weaknesses is necessary to keep test times for 16-k RAMs within practical bounds. (The following information, although believed to be general, applies specifically to the Mostek design.)

The 16-k is basically a synchronous machine built around a rectangular memory array, the coordinates of which are rows and columns (Fig. 2). The synchronous machine provides the timing control for the input latches, row decoder, sense amplifier, column decoder, write circuitry, and output latch.

Unlike earlier, asynchronous, RAMs, the 16-k nearly always fails digitally. That is, if a problem exists with the input latches, the wrong output will be generated (but not a "late" output, which is correct but delayed, for example, by poor input levels). Since there is no worst-case pattern for access time, the time is controlled by internal clock generators—which greatly simplifies the testing of gross functionality. This testing ensures cell uniqueness and output validity over the specified timing and power-supply ranges.

On the other hand, you must still check the memory array and sense amplifiers for pattern sensitivities. Consider the signal-detection capabilities of the sense amplifier and its precharge requirements. A probable worst-case pattern for a sense amplifier consists of a single bit of DATA in a field of $\overline{\text{DATA}}$.

If you run such a pattern in a "row-fast" mode, each sense amplifier will be required to perform some number of $\overline{\text{DATA}}$ reads and a single detection of DATA, and complete the scan by reading $\overline{\text{DATA}}$.

If the DATA bit occupies, at some time, each of the locations along the digit line, you will have checked the ability of the sense amplifier to pick a signal out of noise and to dispel completely any influence of preceding cycles on the present cycle. Note that this pattern requires only as many scans as there are bits per sense amplifier, and that you can check all columns simultaneously.

When considering the row-select function, here, too, noise-coupling considerations indicate that a worst-case pattern might be either a single DATA bit in a field of $\overline{\text{DATA}}$ or a solid field. Here also the word "field" has restricted meaning, applying only to all cells connected to a single row-select line.

Which pattern?

Several patterns check the fore-mentioned failure modes efficiently. One pattern, the $2N^{3/2}$ "moving-diagonal," requires 128 write-read scans through the entire array.

On the first scan, all bits are written to $\overline{\text{DATA}}$, except for the 128 bits along the major diagonal, which are written to DATA. The read scan verifies the correct operation of the array under these conditions.

On each succeeding scan, the position of the diagonal of DATA is shifted until, on the 128th scan, it has occupied every possible position in the array. Thus, each cell has been the only DATA cell in a row and column of $\overline{\text{DATA}}$. This pattern proves to be quite effective in screening the 16-k.

Refresh tests can be classified as either still or dynamic. For still tests, write all locations, pause for the refresh interval with $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ inactive (HIGH), and read all cells. The pause allows the cells to leak LOW, but also allows internal nodes (which are bootstrapped above V_{dd} by the trailing edge of $\overline{\text{RAS}}$ or $\overline{\text{CAS}}$) to decay so that you end up testing both the cells and the dynamic periphery.

Unfortunately, such a test normally isn't the worst case for the cell, for noise generated during active cycles can contribute to the loss of data in the cell.

The dynamic-refresh tests write data into some subset of the cells (normally half the cells). Then, during the refresh interval, they perform either read or write cycles on the cells not being tested to couple charge-degrading noise onto the unaccessed test cells. Both tests are necessary to guarantee functionality.

Be careful: Testing at maximum cycle time gives noise an opportunity to couple onto the row-select lines (which should be off to prevent a partially selected transfer gate), allowing cell data to leak onto the digit lines.

This test might perform a write scan with minimum precharge times (t_{RP}), and maximum active time (t_{RAS}), followed by a "read-modify-write" scan under the same basic timing conditions, which is then followed by a read scan to verify the "modify write" operation. This important test is often overlooked but is, in fact, the worst case for many of the internal circuits.

The patterns discussed provide a basic but adequate test sequence, a good starting point. The table summarizes a sequence that should provide a reasonable degree of confidence in any RAM that passes. Special timing modes and certain timing parameters are left unchecked, but you can easily add if desired.

The sequence requires $28N + 4N^{3/2}$ cycles, of which all but 8N can be at the fastest allowable cycle rate. The 8N are at the slowest allowable cycle rate (maximum cycle length). If the fastest cycle is 375 ns, and the slowest is 10 μs, then the sequence executes in just over 4.5 s, excluding tester overhead and power-supply settling times. ▪▪

Bibliography

Ahlquist, C.N., et al, "A 16,384-bit Dynamic RAM," *IEEE Journal of Solid-State Circuits*, Vol. SC-11, No. 5, October, 1976, pp. 570-573.

Barrett, C.R., and Smith, R.C., "Failure Modes and Reliability of Dynamic RAMs," *COMPCON Spring 1977 Technical Digest*, March, 1977, pp. 179-182.

Brown, J.R., Jr., "Timing Peculiarities of the 16-pin Multiplexed Address RAM," *Burroughs Technical Memorandum*, November, 1976.

Cocking, J., "RAM Test Patterns and Test Strategy," *1975 Semiconductor Test Symposium, Digest of Papers*, October, 1975, pp. 1-8.

Feldmann, D., and Healy, J.E., "Probleme bei der Freigabe-und Wareneingangspruefung von Halbleiterspeichern", *Elektro-Anzeiger*, No. 18, Sept. 24, 1976.

Foss, R.C., and Harlan, R., "MOS Dynamic RAM—Design for Testability," *1976 Semiconductor Test Symposium, Digest of Papers*, October, 1976, pp. 9-12.

Huston, R.E., "Testing Semiconductor Memories," *1973 Symposium on Semiconductor Memory Testing, Digest of Papers*, October, 1973, pp. 27-62.

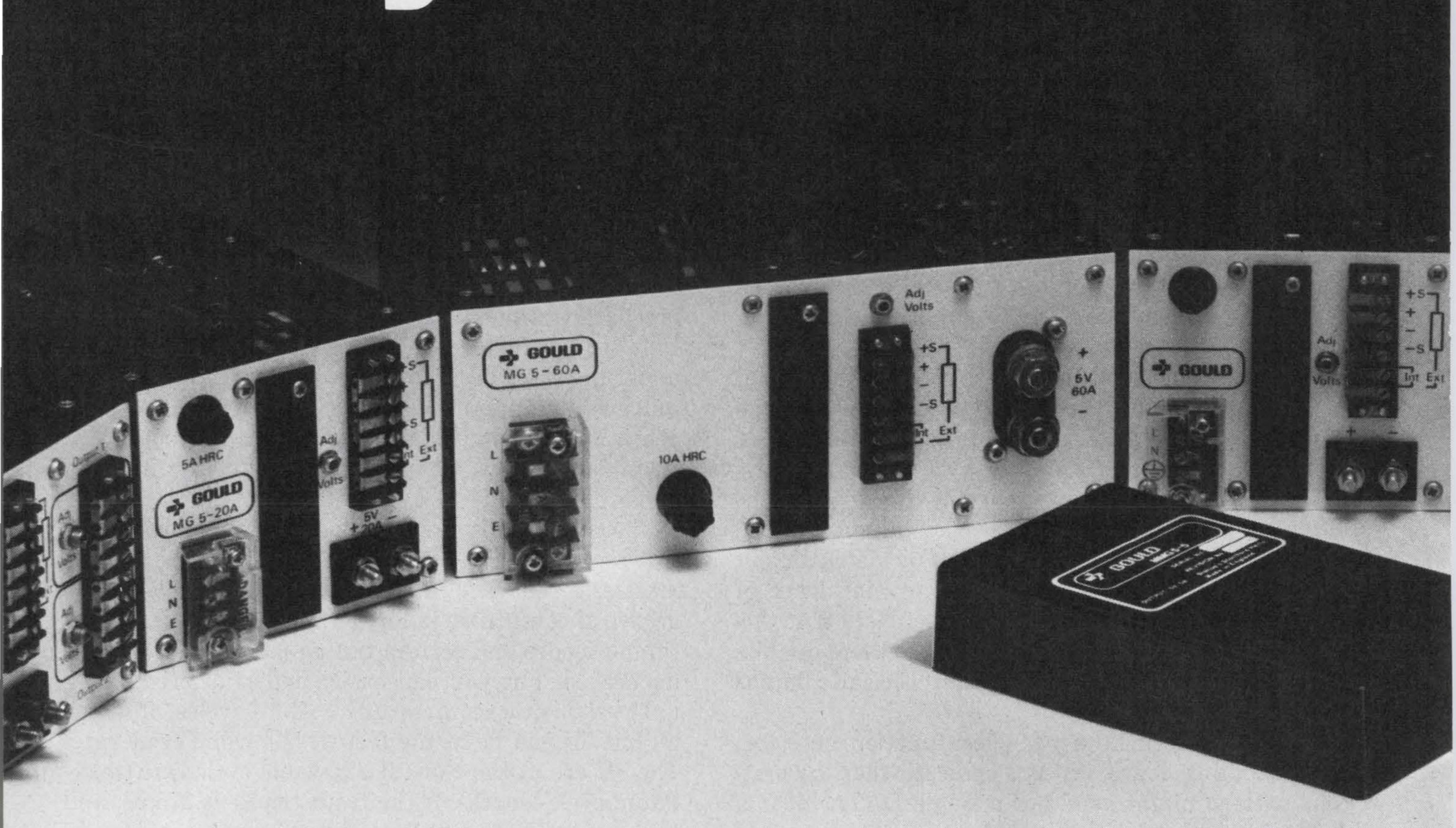
Kuo, C.K., et al, "16-k RAM Built with Proven Process May Offer High Start-up Reliability," *Electronics*, May 13, 1976, pp. 83-86.

Peck, D.S., and Zierdt, C.R., "The Reliability of Semiconductor Devices in the Bell System," *Proceedings of the IEEE*, Vol. 62, No. 2, February, 1974, pp. 185-211.

Schroeder, P.R., and Proebsting, R.J., "A 16-k × 1-Bit Dynamic RAM, *ISSCC Digest of Technical Papers*, February, 1977, pp. 12-13.

1977 Memory Products Catalog, Mostek, Carrollton, TX, pp. VII-1 through VII-15.

Why linear users



For better performance, more and more design engineers are switching to the smaller, lighter, more efficient switching power supplies.

Compared to linears, switchers cut energy consumption in half, reduce size and weight by four to five times, and offer unequalled brownout margin.

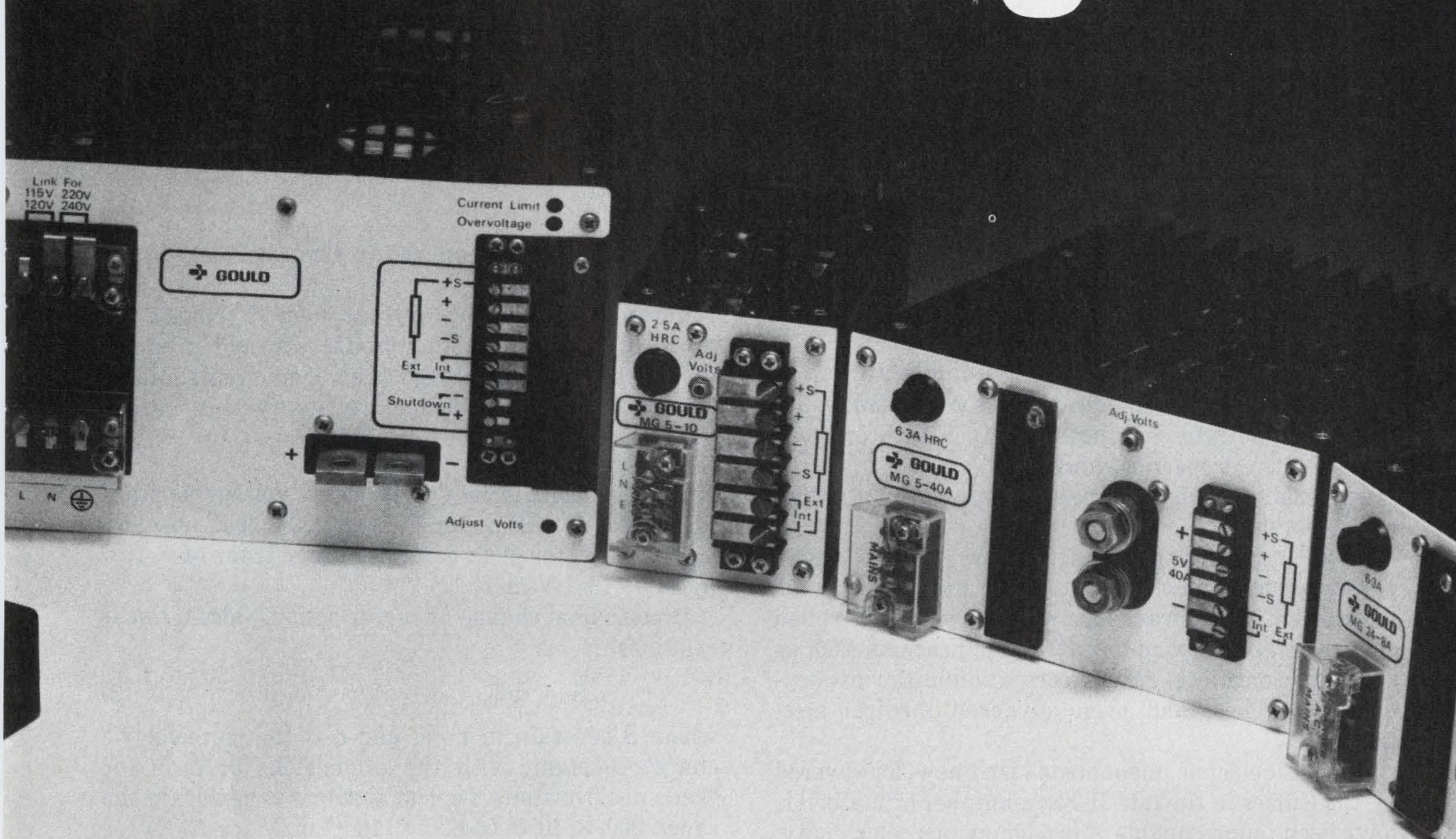
Now Gould makes it easy to make the switch.

Twenty-eight standard, single and multiple output switchers with power levels from 25-500 watts are available in a wide range of output combinations. And the line is about to expand to include 18 new models.

If standard units won't do, custom designs can be provided to your exact specifications. And, Gould engineers are experienced with UL 478, BS 800, VDE 0804, VDE 0875, and CEE 15.

More than 32,000 Gould switchers are in use around the world. Due to extensive testing and quality assurance, every

are switching.



Gould switcher has a 5 year warranty and field-proven MTBF capability in excess of 48,000 hours.

Even the most demanding production schedule can be met with the high volume manufacturing facilities that only a $1.5 billion electrical products company like Gould could offer. For after sales service Gould warranty repair centers are located worldwide.

For complete specifications on our entire switcher line or to arrange for a free evaluation unit, contact Gould, Inc., Power Supply Division, 4601 North Arden Drive, El Monte, CA. 91731, Telephone (213) 442-7755.

Gould. The power in switching power supplies.

GOULD

CIRCLE NUMBER 43

Get started with Gould switchers at WESCON booth 1849.

Consider piezoelectric ceramics:

Easily formed into complex shapes and chemically inert, they provide stable piezoelectric characteristics up to 180 C.

Piezoelectric properties of ceramic titanates make possible many new applications. Piezo-ceramic materials offer distinct advantages over other piezo-active substances. They are

- chemically inert in most environments,
- processable by standard ceramic technology,
- formable into complicated shapes with uniform piezoelectric properties, and
- operable at high temperatures because of a high Curie point.

These superior properties allow you to apply piezoelectricity not only to such narrow uses as instrument force transducers and crystal-controlled oscillators, but also to industrial applications such as ultrasonic cleaning, gas igniters, audible alarms, keyboard switches, and even advanced medical electronics.

The piezoelectric phenomenon isn't new. Discovered by the Curies in the late 1800s, a number of materials have been found capable of producing piezoelectricity. The most important include the two forerunners of ceramic titanates—Rochelle salt (sodium potassium tartrate) and natural crystaline quartz.

Single-crystal quartz, because of its high-temperature tolerance (usable to 573 C), stability, chemical inertness and physical ruggedness, is ideal for stable control of oscillator frequencies. However, to provide piezoelectric action, single quartz crystals must be oriented precisely, and thin platelets must be cut from the bulk crystal. Only untwinned, nearly perfect crystals can be used, and the world supply is limited. Material waste is high and only simple geometries—plates and discs—can be produced.

Rochelle salt ($KNaC_4H_4O_6 \cdot 4H_2O$) has a much higher piezoelectric voltage output. However, Rochelle salt's piezoelectric properties are sensitive to temperature. Water soluble, it can be destroyed in humid atmospheres—and its melting point is only 55 C.

Generator or motor action is produced

A piezoelectric material develops an electric charge that is proportional to a mechanical stress. Conversely, the material can convert an electrical field into a dimensional change.

For a stress, T, in Newtons/meter² (N/m²) the material's generator action produces a field strength, E, in volts/meter, measured as an open-circuit voltage that is linearly dependent on stress (within limits)

$$E = -g \cdot T, \qquad (1)$$

where g is the material's piezoelectric voltage constant measured in volt-meters/newton. Typical absolute values of "g" for piezo ceramics range from 14×10^{-3} to 44×10^{-3} V-m/N.

Dimensional change or motor action—also a linear relationship—is

$$S = d \cdot E, \qquad (2)$$

where S is strain in m/m and d is the piezoelectric charge constant, with the dimensions of m/V (or Coulombs/Newton). Typical absolute values lie in the range 200×10^{-12} to 600×10^{-12} m/V (or C/N) for piezo-ceramic materials.

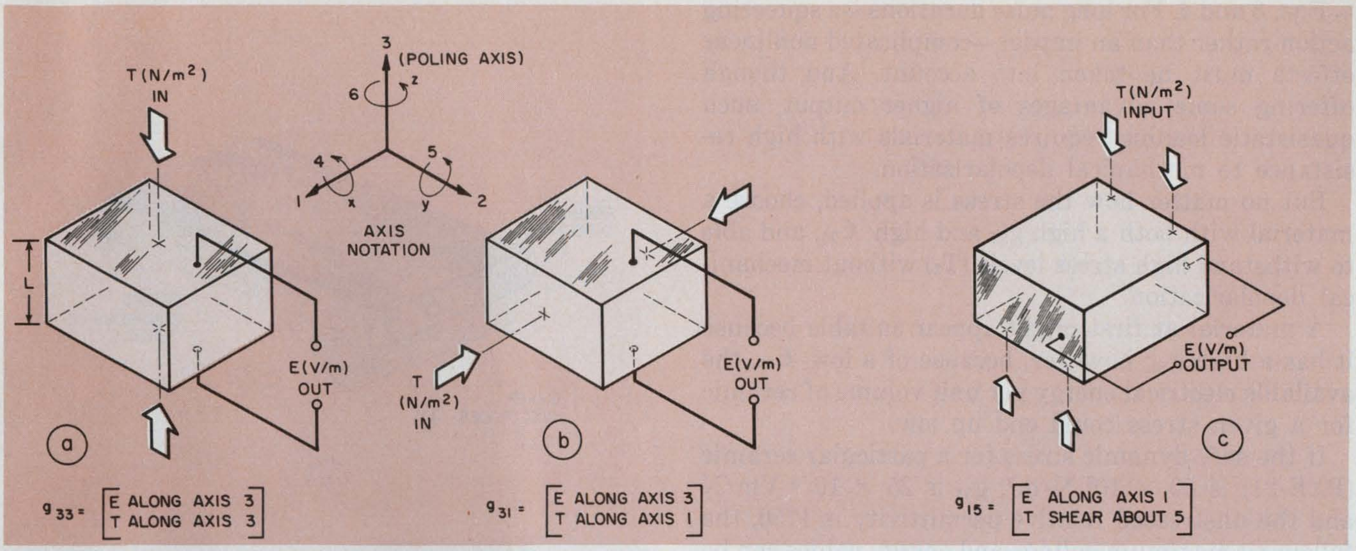
Piezo-ceramic material has no piezoelectric properties when first fabricated, because the electric-dipoles within grains are randomly oriented. The material must be polarized to align the dipoles in a "poling" operation. The polarization is done with an electric field of 10 to 30 kV/cm at an elevated temperature, but below the ferroelectric Curie temperature.

Because of the high voltage, the material is poled while immersed in silicon oil. The poling axis is in the direction of positive polarization (Fig. 1). The voltage is applied via electrodes of evaporated gold or silver, fired-on silver paint or electroless plated nickel, depending on cost and performance requirements. While poling makes the material behave like a single crystal, the piezo properties of bulk polycrystaline material are somewhat poorer than a true single crystal's.

Piezoelectric constants g and d are directionally dependent. Since the poling axis (direction 3) can differ from the direction of applied stress or applied field, you must employ a convention for describing this directional dependence. For example, g can have three values—g_{33}, g_{31} and g_{15} (Fig. 1). The first subscript is the direction of the generated electric field; the second, the direction of the applied mechanical stress. Since in ceramics, directions 1 and 2 are equivalent,

---

Dr. Thomas G. Reynolds III, Manager of Research and Engineering, and **David M. Tanka,** Applications Engineer, Ferroxcube Corp., Saugerties, NY 12477.



1. **The piezoelectric constants and the stress and voltage axes are directionally dependent.** Therefore they are indexed relative to the poling axis, which is by convention designated as "3." And since axes "1" and "2" are equivalent in piezo ceramics, convention dictates that only the "1" designation should be used for both.

only subscript 1 is used for both. And where shearing stress is involved, subscripts 4, 5 and 6 represent shear about the three axes.

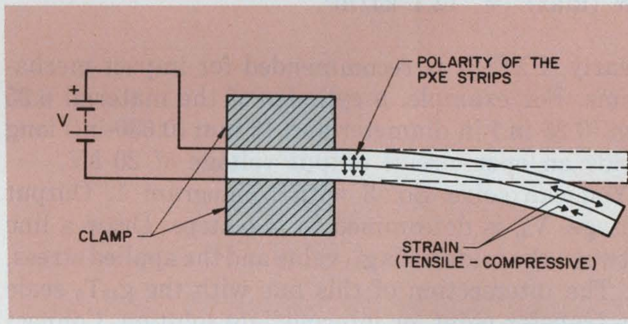
Avoid depolarization

Any stress that tends to destroy polarization must be guarded against—thermal, electrical or mechanical. Heat causes the ceramic's electric dipoles to return to their previously unaligned states. As the temperature approaches the Curie point, T_c, the material becomes completely depolarized and piezoelectric properties disappear. Prudent design thus requires that the continuous operating temperature of piezoceramic material should not exceed about 0.5 T_c, which limits operating temperatures to between 130 and 180 C.

Understandably, a large electric field opposite the direction of the original poling field can degrade the piezoelectric properties and even reverse the polarization. Depending on the material, duration of application and temperature, experience shows that 500 (PXE-5) to 1000 (PXE-43) V/mm is a safe upper limit for applied long-term fields.

Indeed, when applied mechanical stress becomes high enough, it too can cause depolarization. Again, depending on the material, temperature and the nature of the stress, the safe range is from 30×10^6 N/m^2 (4351 lb/in.^{2}) for a static load on a piezo-ceramic material such as PXE-21 to 130×10^6 N/m^2 for a dynamic load on PXE-4. (The PXE materials have been developed by N.V. Philips Gloeilampenfabrieken, the Netherlands. And, Vernitron Piezoelectric Division, Bedford, OH, makes a similar line of piezoceramic materials, designated PZT, as do many other companies.)

High electric-field generation for spark ignition of gases, flash bulbs or even gasoline engines usually depend on the g_{33} voltage constant.[1]



2. **The flexure mode, as in this bimorph configuration,** is used where larger deflections and smaller forces are involved than are possible with rings or discs.

For spark generation, therefore, use the following equations:

$$V_3 = -g_{33}T_3L_3, \qquad (3)$$

where

V_3 = voltage developed (V),
g_{33} = piezoelectric voltage constant (Vm/N),
T_3 = mechanical stress (N/m^2),
L_3 = length along E axis (m).

The electrical energy density, W, available for the spark is given by

$$W = \frac{1}{2}\epsilon_{33}\, g_{33}^2\, T_3^2, \qquad (4)$$

where ϵ_{33} is the permittivity (dielectric constant = $\epsilon_{33}/8.85 \times 10^{-12}$ F/m) of the unstressed ceramic. The energy density, J/m^3, is the energy available per unit volume of ceramic and includes the additional electromechanical energy released when the spark gap becomes conductive and discharges the electric field.

When an applied mechanical-stress pulse is measured in microseconds, apply the linear stress equations

—Eqs. 3 and 4. For long pulse durations—a squeezing action rather than an impact—complicated nonlinear effects must be taken into account. And though offering some advantages of higher output, such quasistatic loading requires materials with high resistance to mechanical depolarization.

But no matter how the stress is applied, choose a material with both a high g_{33} and high ϵ_{33}, and able to withstand high stress levels (T_3) without mechanical depolarization.

A material at first might appear suitable because it has a high g_{33}; however, because of a low ϵ_{33}, the available electrical energy per unit volume of ceramic for a given stress could end up low.

If the safe dynamic stress for a particular ceramic (PXE-21) is 50×10^6 N/m², g_{33} is 25×10^{-3} Vm/N and the unstressed relative permittivity is 1750, the following maximum voltage and energy values can be attained:

$$V_3 \text{ (max)} = 1.25 \times 10^6 \text{ V/m of ceramic length,}$$

$$W \text{ (max)} = 12.1 \text{ kJ/m}^3.$$

Clearly, PXE-21 is recommended for impact mechanisms. For example, a cylinder of the material 6.35 mm (0.25 in.) in diameter and 16 mm (0.630-in.) long yields an open-circuit output voltage of 20 kV.

You can solve Eq. 3 with Nomogram 1. Output voltage, V_3, is determined in two steps. Draw a line between the material's g_{33} value and the applied stress, T_3. The intersection of this line with the $g_{33}T_3$ scale is a transfer point, or intermediate solution. Connect the transfer point with the desired voltage to determine the length, L_3, of material needed.

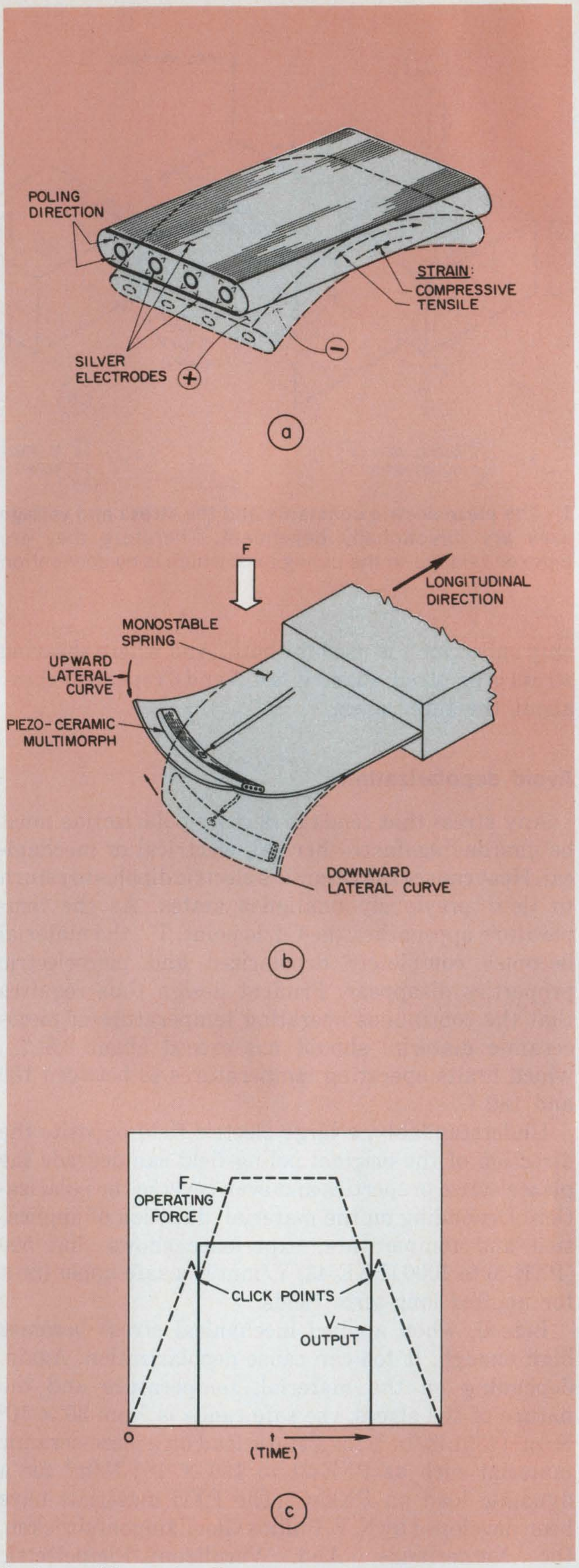
Since W is proportional to $(g_{33}T_3)^2$, for maximum energy density, the intermediate solution should be as close to the top of the scale as is consistent with the material's g_{33} and stress limits.

Small movements easily performed

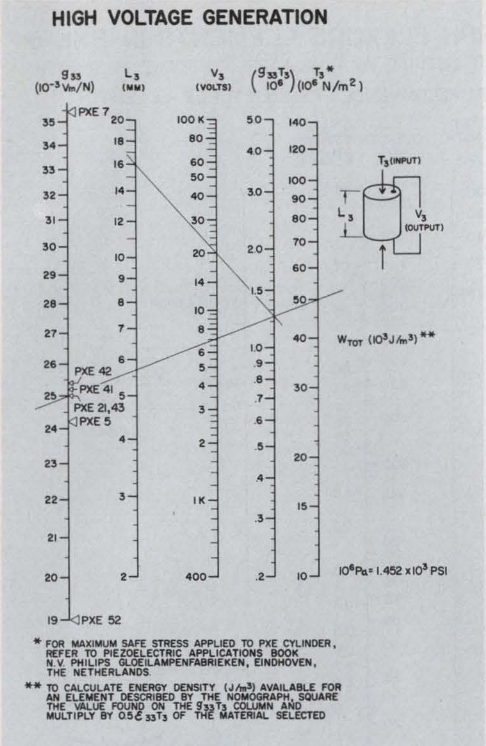
For small-displacement actuator devices, Nomogram 2 solves Eq. 2 for the "33" mode. Applications built with a stack of ceramic discs or rings include actuators for fuel metering and the positioning of optical components.

Consider a material with d_{33} of 384×10^{-12} m/V (PXE-5), which is readily available in many standard shapes and sizes. If the application requires a displacement (ΔL_3) of +20 μm, draw a line on the nomogram between d_{33} and the 20-μm displacement. The line intersects the voltage scale (V_3) at 53 kV. Choose a field strength, E_3, for the material—about 900 V/mm —and connect this value with V_3 to determine the total length of the ceramic element—about 60 mm.

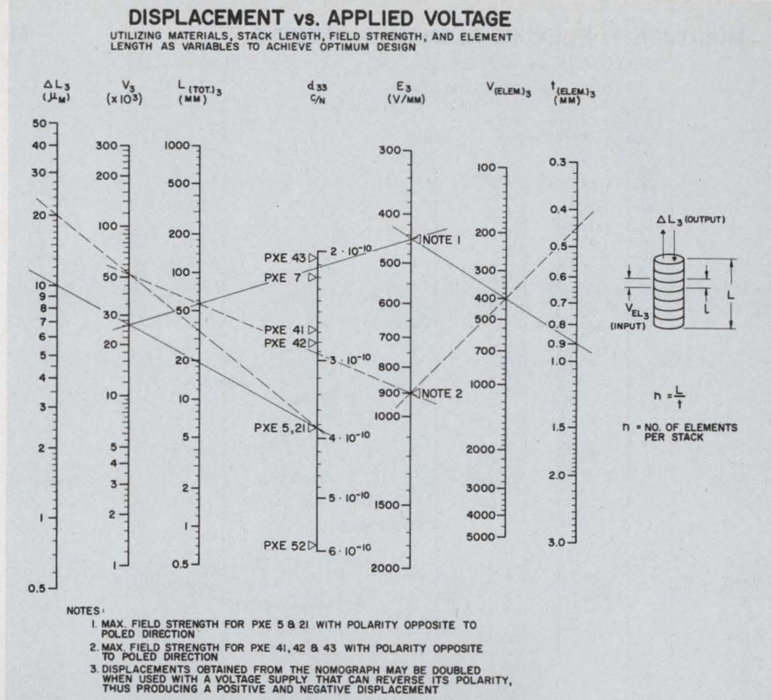
Note that since the electric field is applied in the same direction as the polarization, a field as great as 2500 V/mm may be applied before encountering dielectric breakdown problems in the ceramic. How-



3. **A multimorph flexure configuration,** for piezo ceramics (a), is simpler to fabricate than a bimorph. Such a piezo element can be used to build a snap-action switch, when bonded to a cantilevered spring of special design (b). The spring's snap action provides a step-voltage output (c) and also a tactile feel.



NOMOGRAPH 1



NOMOGRAPH 2

ever, since you must take care to prevent flashover along the ceramic's exposed surface areas, the applicable field is limited to approximately 900 V/mm. For an applied field opposite the poled direction, the maximum field is about 450 V/mm for PXE-5 to prevent depolarization.

The thickness of the individual ceramic discs can now be determined, depending upon the available voltage supply. Draw a line between E_3 and the voltage supply, or voltage level per disc, to obtain the disc thickness "l." For a 400-V supply, a stack of 130 elements, each 0.45-mm thick and operating at 400 V, will provide a 20-μm displacement.

A second example (solid lines) on Nomogram 2 shows the solution for a displacement of ± 10 μm. However, note that since the supply voltage now opposes the polarization for negative displacements, the field is kept at 450 V/mm (for PXE-5). Consequently, the ± 10-μm displacement can be obtained from a power supply of ± 400 V with a stack of 65 elements, each 0.9-mm thick.

Piezo ceramics can be bent

For applications such as high-voltage generation you use high impact forces on ceramic discs or rings, which in compression or tension have high elastic stiffness. Conversely, such stiff structures can supply large forces for small displacements when high voltages are applied. However, for small forces and large displacements flexure elements must be used.

The simplest flexure element—a bimorph (Fig. 2) consists of two thin strips of piezo-ceramic material bonded together, each strip operating in the "31" mode. With the two strips poled in opposite directions, one portion expands and the other contracts when a voltage is applied. The cantilevered structure bends to produce a relatively large displacement.

A similar structure—a multimorph (Fig. 3a)—is made of one monolithic ceramic element. Holes through the ceramic's center are silvered and serve only to pole the element. Silvered electrodes on the top and bottom surfaces enable the upper and lower portions to be polarized in opposite directions. The electrodes on the top and bottom surfaces then become the input or output ports.

Although performance may be slightly less than with an equivalent bimorph, the unit is much simpler to produce, and the problem of establishing a good, rigid bond between layers is eliminated.

Typical applications that employ flexure elements include sound-generation devices and microphones; small vibratory motors and fine-movement actuators; instrument transducers such as accelerometers, stress and strain gauges, and liquid-level sensors; and circuit components such as switches.

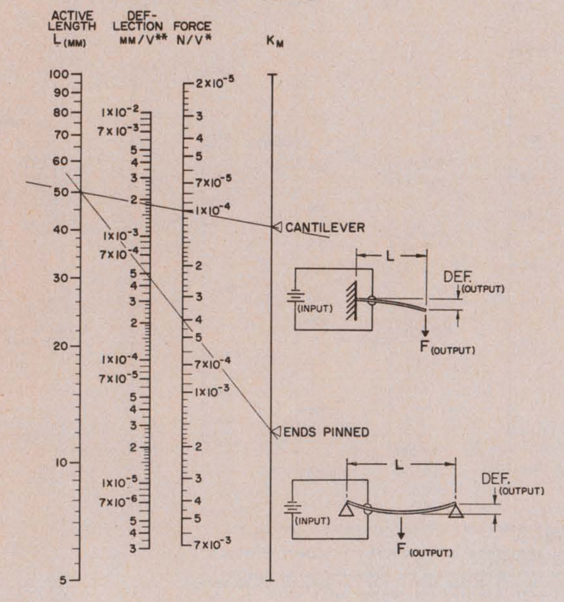
Because of low elastic stiffness, flexure elements can have very low resonant frequencies. Elements 80-mm long can resonate as low as 60 Hz. But how they are mounted, and how rigidly, strongly affect the resonance frequency and output of flexure elements.[3]

To aid in designing for "motor" applications, Nomogram 3 provides output force (N/V) or output deflections (mm/V) as a function of the mounting method and the active length (L) of the element. As illustrated by the example sketched on the nomogram,

MULTIMORPH FLEXURE ELEMENTS IN PXE 5

*DEFLECTION vs. APPLIED VOLTAGE

**FORCE vs. APPLIED VOLTAGE



* FORCE (F) = 0 ** DEFLECTION (DEF.) = 0

MAXIMUM RECOMMENDED APPLIED VOLTAGE: 220 V (HIGHER VOLTAGE MAY CAUSE PARTIAL DEPOLING)

NOMOGRAPH 3

for an active length of 50 mm with a cantilevered configuration, you can obtain a deflection of 1.8×10^{-3} mm/V. With a supply voltage of 20 V applied to the outer electrodes a deflection of 0.04 mm (0.0015 in.) can be obtained. Higher drive levels can produce larger displacements, and nonlinear effects tend to increase the displacement.

However, an ends-pinned configuration reduces the deflection to 0.45×10^{-3} mm/V: For maximum deflection, therefore, with no applied force, the cantilevered approach is more desirable. On the other hand, for a force output the ends-pinned configuration is better—about 4×10^{-4} N/V vs 1×10^{-4} N/V for the cantilever.

For generator applications, work with Nomograms 4 and 5. Use Nomogram 4 for force inputs. For example, the open circuit output of a 50-mm multimorph operating as a cantilever is 710 V/N. With an upper safe limit of 0.034 N, an open-circuit output voltage of 24 V can be obtained.

For larger forces, the ends-pinned configuration offers mechanical advantages. Although the specific output drops to 180 V/N, the maximum allowed force is a much higher 0.13 N, so the maximum output voltage force is still approximately 24 V.

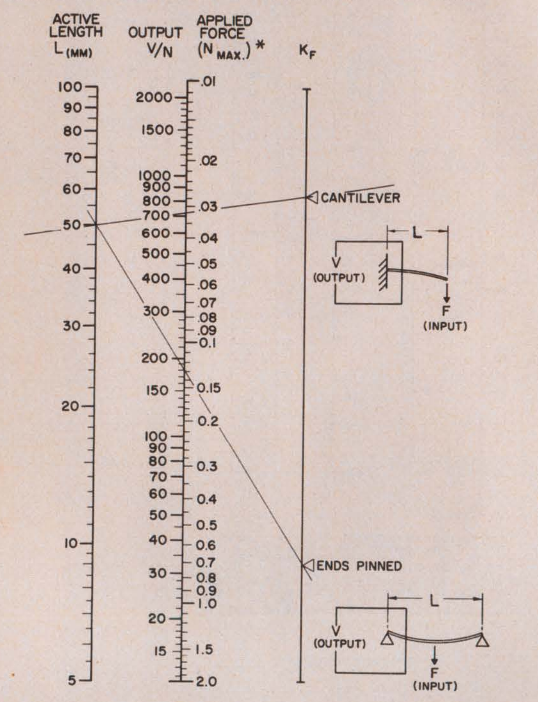
Use Nomogram 5 for deflection-input designs. The procedure is similar to that of Nomogram 4.

Note that the actual output voltage available from a piezo element depends on the capacitance of the piezo-ceramic material, C_t, and the shunt capacitance of any associated circuitry, C_s:

MULTIMORPH FLEXURE ELEMENTS IN PXE 5

OPEN CIRCUIT OUTPUT VOLTAGE / APPLIED FORCE vs. LENGTH

* MAXIMUM RECOMMENDED APPLIED FORCE vs. LENGTH



THE OPEN CIRCUIT OUTPUT VOLTAGE DERIVED FROM THE NOMOGRAPH ASSUMES THE MULTIMORPHS OVERALL AND ACTIVE LENGTH TO BE IDENTICAL AND CAN BE USED TO GOOD APPROXIMATION. HOWEVER, VIEWING THE MULTIMORPH UNDER ACTUAL OPERATING CONDITIONS, THE OVERALL LENGTH EXCEEDS THE ACTIVE LENGTH AND THE OUTPUT VOLTAGE MAY BE CALCULATED TO A CLOSER APPROXIMATION BY FIRST CALCULATING THE CHARGE OUTPUT/APPLIED FORCE: $(q_F)\,\mu C/N$

$q_F = .74 \times 10^{-3}\ L^2$ (CANTILEVER)

$q_F = .18 \times 10^{-3}\ L^2$ (ENDS PINNED)

L = ACTIVE (FLEXED) LENGTH OF MULTIMORPH (MM). THEN DIVIDING THE CHARGE OUTPUT BY THE TOTAL CAPACITANCE OF THE ELEMENT (C_T) PLUS THE SHUNT CAPACITANCE (C_S) OF ANY ASSOCIATED CIRCUITRY:

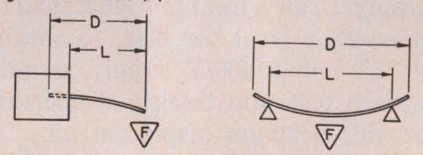
$$V = \frac{q_F}{C_T + C_S} \qquad C_T = 52 \times 10^{-12} L$$

V = VOLTAGE

D = TOTAL LENGTH OF THE MULTIMORPH (MM)

C_T = CAPACITANCE (F)

C_S = CAPACITANCE (F)



CANTILEVER ENDS PINNED

* PARTIAL DEPOLING MAY RESULT IF VALUE IS EXCEEDED

NOMOGRAPH 4

$$V = \frac{q}{C_t + C_s}, \qquad (5)$$

where "q" is the charge output per unit of input (force or deflection). The parameters for Eq. 5 and their application are explained on Nomograms 4 and 5.

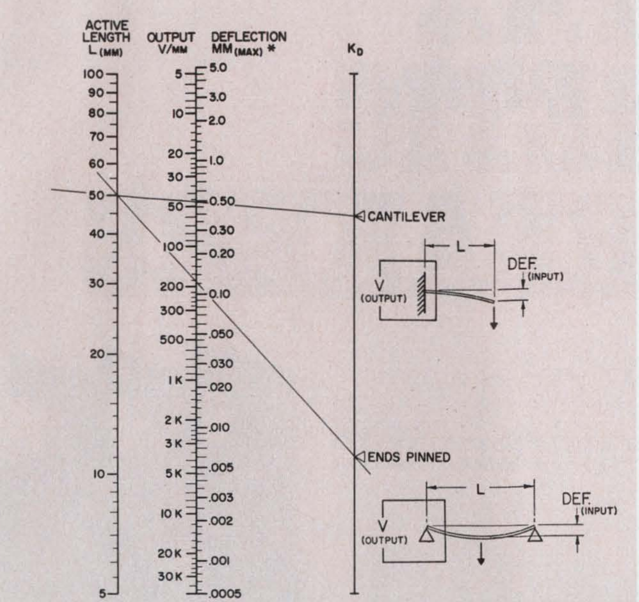
Piezo ceramics function as switches

The flexure mode can be applied to designing keyboard switches. A piezoelectric keyboard switch can eliminate the problems of contact resistance and bounce-in conventional contact switches, while provid-

MULTIMORPH FLEXURE ELEMENTS IN PXE 5

OPEN CIRCUIT OUTPUT VOLTAGE / DEFLECTION vs. LENGTH

*MAXIMUM RECOMMENDED DEFLECTION vs. LENGTH



THE OPEN CIRCUIT OUTPUT VOLTAGE DERIVED FROM THE NOMOGRAPH ASSUMES THE MULTIMORPHS OVERALL AND ACTIVE LENGTH TO BE IDENTICAL AND CAN BE USED TO GOOD APPROXIMATION. HOWEVER, VIEWING THE MULTIMORPH UNDER ACTUAL OPERATING CONDITIONS, THE OVERALL LENGTH EXCEEDS THE ACTIVE LENGTH AND THE OUTPUT VOLTAGE MAY BE CALCULATED TO A CLOSER APPROXIMATION BY FIRST CALCULATING THE CHARGE OUTPUT/AMOUNT OF DEFLECTION (q_D) µC/MM

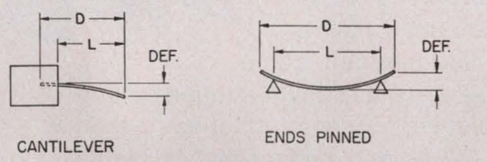
$$q_D = 5.7 / L \quad \text{(CANTILEVER)}$$

$$q_D = 23 / L \quad \text{(ENDS PINNED)}$$

L = ACTIVE (FLEXED) LENGTH OF MULTIMORPH (MM). THEN DIVIDING THE CHARGE OUTPUT BY THE TOTAL CAPACITANCE OF THE ELEMENT (C_T) PLUS THE SHUNT CAPACITANCE (C_S) OF ANY ASSOCIATED CIRCUITRY:

$$V = \frac{q_D}{C_T + C_S} \qquad C_T = 52 \times 10^{-12} L$$

V = VOLTAGE
D = TOTAL LENGTH OF THE MULTIMORPH (MM)
C_T = CAPACITANCE (F)
C_S = CAPACITANCE (F)



* PARTIAL DEPOLING MAY RESULT IF VALUE IS EXCEEDED

NOMOGRAPH 5

ing the tactile feedback not usually found in capacitor-type switches.

Designed properly, a piezoelectric switch can generate a substantial voltage, about 5 V, which is compatible with high-impedance circuitry. The switch consists of a piezoelectric element bonded to a monostable spring. An extruded ceramic multimorph element (Fig. 3a), when flexed, operates in a "31" mode, with longitudinal tensile strain on the upper and compressive strain on the lower section. Voltage appears between upper and lower silver electrodes. ■■

References

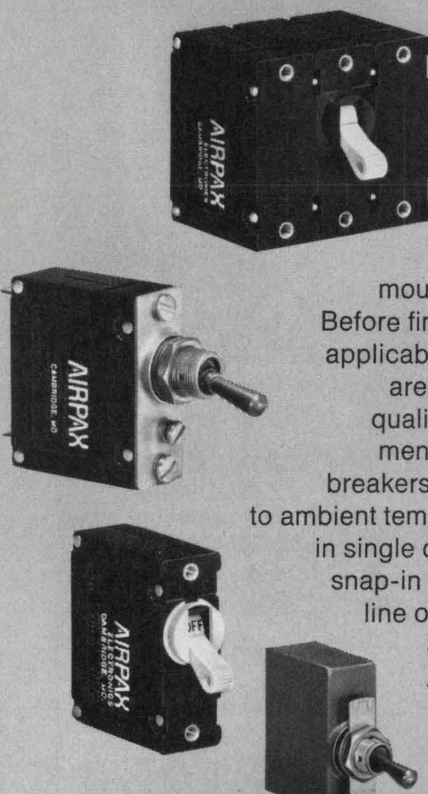
1. Germano, C.P., "Flints That Don't Wear Out," *Electronic Design*, June 21, 1974, pp. 88-90.

2. "Piezoelectric Ceramics, Component and Materials," Ferroxcube Corp., Saugerties, NY.

3. *The Step Response of Piezoelectric Flexure Elements*, Technical Information 018, September, 1976, N.V. Philips Gloeilampenfabrieken, Eindoven, the Netherlands.

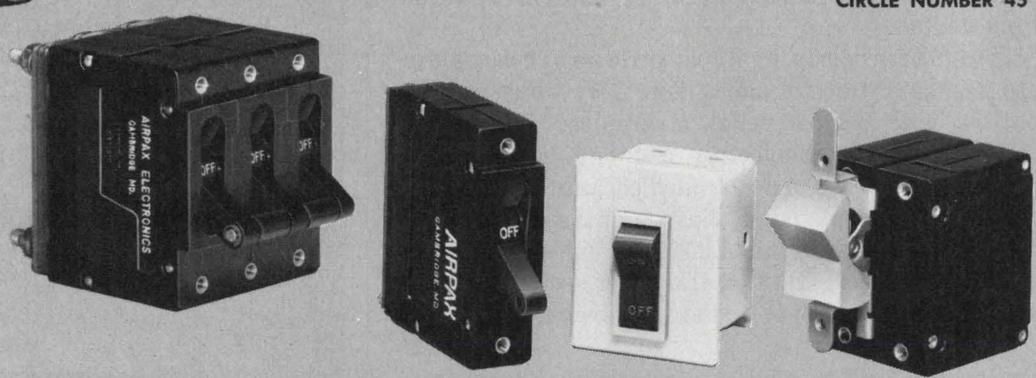
AIRPAX MAGNETIC CIRCUIT BREAKERS

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



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

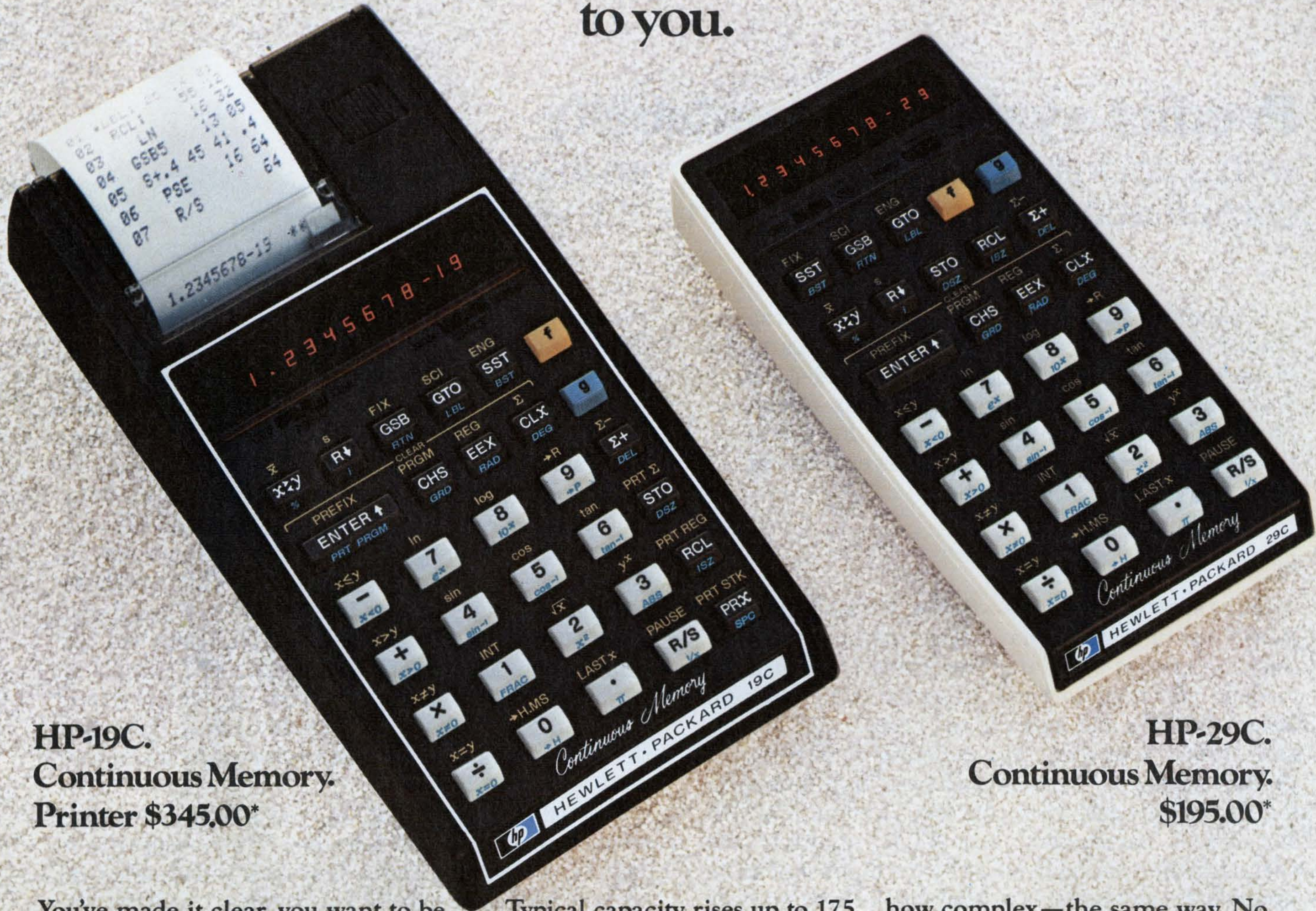
CIRCLE NUMBER 45



AIRPAX™

THE PRO IN PROTECTION

Hewlett-Packard's newest programmables are dedicated to you.



HP-19C.
Continuous Memory.
Printer $345.00*

HP-29C.
Continuous Memory.
$195.00*

You've made it clear, you want to be able to solve your problems your way. Our newest programmables let you do just that, at a price you can comfortably afford.

Their secret: continuous memory plus fully merged keycodes. The combination lets you store up to 175 keystrokes' worth of your programs and 16 registers' worth of your data for as long as you wish.

You're in the driver's seat. You decide what you want to store and how long you want to store it.

Continuous memory means the HP-19C and 29C are never "off."
Their 98-step program memories, 16 of 30 storage registers, and displays and formats stay "on" all the time even when turned off. You don't have to re-enter.

Fully merged keycodes increase capacity and efficiency.
All prefix functions and operations merge so one memory location can hold up to four keystrokes. Programs require fewer steps.

Typical capacity rises up to 175 keystrokes and beyond. Your sophisticated needs (today's and tomorrow's) are accommodated.

Speaking of sophistication, both the HP-19C and the HP-29C provide you with three levels of subroutines, 10 decision tests, 10 labels, conditional and unconditional branching, indirect addressing and insert/delete editing.

This latter feature, which lets you add or delete program steps without reloading, is another example of our personal approach. We know you like to try out alternatives, so we made it easy.

Our HP-19C is the world's first handheld printing programmable.
Add a whisper-quiet thermal printer to the programming features described above, and you have an exceptionally capable handheld calculator.

Both are easy to use.
Our straightforward parenthesis-free RPN logic system lets you run through all problems—no matter how complex—the same way. No false starts. No wrong turns. RPN makes the control you want easier to get.

(800) 648-4711. The toll-free number to call for details and the name of a nearby dealer (unless you're in Nevada, in which case you can call 323-2704 collect). Or send the coupon.

HEWLETT hp PACKARD

Dept. 232W, 1000 N.E. Circle Blvd., Corvallis, OR 97330

HEWLETT-PACKARD
Dept. 232W
1000 N.E. Circle Blvd.
Corvallis, Oregon 97330

Please send me complete details on the HP-29C and the HP-19C.

NAME ______________________

ADDRESS ______________________

____

CITY ______________________

STATE ____________ ZIP ________

*Suggested retail price, excluding applicable state and local taxes— Continental U.S., Alaska & Hawaii.
Displays photographed separately to simulate typical appearance. 616/47

CIRCLE NUMBER 46

Predict system dependability

with a pocket calculator. A programmable unit speeds computations of reliability and maintainability models.

A handheld programmable calculator can rapidly predict dependability of electronic systems. Carefully prepared, a calculator program, once loaded onto a program card, can provide calculations almost as precise as even a large-scale computer. Furthermore, the calculator is easier to use and less expensive than any computer, large or small.

Set up system models

Three subsystem models—Series, Parallel and Any-R-of-N configuration—have been programmed for a scientific pocket calculator (see Table 1). To use the models, you need to know the mean time between failure (MTBF) and mean time to repair (MTTR) for each system component. You can either rely on figures vendors supply or, if you have access to trouble reports for the components, you can easily compute MTBF and MTTR parameters. For MTBF, multiply the operating time period in hours by the number of units sampled, then divide this product by the total number of failures. To obtain MTTR, average the "out-of-service" times.

By applying the models, you can predict MTBF and MTTR for the total configuration, as well as for every underlying subsystem. Not only that, you can also determine availability, reliability and failure probability from MTBF and MTTR.

Availability, A, is defined as the probability of finding the subsystem working at any arbitrary future time. Reliability, R(t), is the probability of completely successful operation in time period, t. The probability of n failures occurring in t is designated P(n).

To generate a model, convert the hardware configuration into a reliability "bubble" diagram, which shows how individual elements affect a subsystem's over-all reliability. The bubble diagram is a network of connected circles, showing MTBF and MTTR figures within the bubbles. In Table 1, Example 1, a single element has an MTBF of 500 hours and an MTTR of 3 hours. To assemble single elements into first-level subsystems, use the three types of models: Series, Parallel and Any R of N.

In a Series connection, should any one element fail, the whole subsystem will cease to function. In a Parallel connection, the entire subsystem is considered operational if any one of the elements is working. However, an Any R-of-N connection is more versatile than the Series or Parallel configurations. In an N-element arrangement, the subsystem functions as long as R or more of its elements work.

When R=1, the Any-R-of-N connection is equivalent to a Parallel connection. Only one shunted element is required to maintain an operational sybsystem. In Example 8, R=1 and the results approximate those for the Parallel connection in Example 7. When R=N, "Any" and Series correspond. Example 4 produces the same results as the Series connection in Example 3. A unique example of the "Any" arrangement, where R=2 and N=3, which can't be duplicated by either the Series or Parallel models, is illustrated by Example 9.

Proceeding in this manner, you join primary elements into first-level subsystems. Then, repeat this process, assembling these first-level subsystems in turn to form higher-level subsystems, until the reliability diagram comprises the total system. Continue the same Series, Parallel, and Any R-of-N reduction strategy through each phase of the system.

Realistic assumptions are needed

To derive equations you can solve, several realistic assumptions, which apply to most encountered systems, must be made for the three models:

1. Equipment is either up (operational) or down (failed)—No in-between condition is allowed. When any module malfunctions, repair or replace it.
2. The state of one unit is unaffected by the states of its adjacent elements.
3. Redundant elements can be switched into place as a failure occurs, before the over-all system is considered to have failed.
4. Exponential service times are assumed, as is standard in the derivation of many analytical models.

In this last case, the probability of MTBF and MTTR time periods is assumed to follow a negative exponential distribution. In other words, the number of failures and repairs occurring in a unit time obeys the Poisson distribution; therefore, the variance is equal to the mean.

Assume widely fluctuating failure and repair times, with variance commensurate with MTBF and MTTR.

Ronald Zussman, Senior Consultant, Securities Industry Automation Corp., 55 Water St., New York, NY 10041.

Table 1. Examples of reliability models

Example No.	Reliability models	MTBF	MTTR	A	R(8760)	P(1)	P(2)
1	500 3	500.00	3.00	0.994036	0.000000	0.000000	0.000004
2	9000 2	9000.00	2.00	0.999778	0.377822	0.367746	0.178970
3	Series 9000 2 — 9000 2	4500.00	2.00	0.999556	0.142749	0.277885	0.270475
4	Any 2 of 2 (same diagram as example 3)	4500.00	2.00	0.999556	0.142749	0.277885	0.270475
5	Series 9000 2 — 9000 2 — 500 3	450.00	2.90	0.993594	0.000000	0.000000	0.000001
6	Parallel 500 3 500 3	42,166.67	1.50	0.999964	0.812413	0.168776	0.017531
7	Parallel 500 3 500 3 500 3	4,713,462.96	1.00	1.000000	0.998143	0.001855	0.000002
8	Any 1 of 3 (same diagram as example 7)	4,629,629.63	1.00	1.000000	0.998110	0.001889	0.000002
9	Any 2 of 3 (same diagram as example 7)	13,888.89	1.50	0.999892	0.532208	0.335675	0.105858
10	Parallel 500 3 9000 2	905,600.00	1.20	0.999999	0.990373	0.009580	0.000046
11	Any 3 of 4 #5 #5 #5 #5	5,818.97	1.45	0.999751	0.221924	0.334089	0.251472
12	Series #3 — #7 — #11	2,536.23	1.76	0.999307	0.031621	0.109216	0.188613

Table 2. SR52 coding form

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	46	LBL	025	44	SUM	050	75	—
	18	C′		00	0		04	4
	22	INV		02	2		17	B′
	57	fix		02	2		95	=
	04	4		17	B′		55	÷
005	46	LBL	030	20	1/x	055	04	4
	17	B′		42	STO		17	B′
	42	STO		00	0		65	x
	01	1		03	3		03	3
	09	9		81	HLT		17	B′
010	36	IND	035	46	LBL	060	95	=
	43	RCL		12	B		81	HLT
	01	1		85	+		46	LBL
	09	9		01	1		14	D
	56	rtn		17	B′		55	÷
015	46	LBL	040	95	=	065	53	(
	11	A		55	÷		43	RCL
	46	LBL		01	1		85	+
	13	C		17	B′		01	1
	57	fix		95	=		17	B′
020	02	2	045	20	1/x	070	54	)
	42	STO		49	PROD		94	+/−
	00	0		00	0		85	+
	01	1		04	4		01	1
	20	1/x		01	1		95	=
075	49	PROD	100	47	CMs	125	02	2
	00	0		01	1		55	÷
	05	5		42	STO		53	(
	05	5		00	0		07	7
	17	B′		04	4		17	B′
080	75	—	105	42	STO	130	75	—
	01	1		00	0		06	6
	95	=		05	5		17	B′
	94	+/−		86	rset		85	+
	92	STO		46	LBL		42	STO
085	00	0	110	15	E	135	00	0
	04	4		57	fix		08	8
	55	÷		00	0		01	1

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
	05	5		42	STO		95	=
	17	B′		00	0		42	STO
090	65	x	115	06	6	140	00	0
	03	3		81	HLT		01	1
	17	B′		42	STO		81	HLT
	95	=		00	0		65	x
	42	STO		07	7		53	(
095	00	0	120	81	HLT	145	43	RCL
	03	3		57	fix		55	÷
	81	HLT		02	2		02	2
	46	LBL		42	STO		17	B′
	16	A′		00	0		54	)
150	45	y^x		85	+		95	=
	08	8		01	1		42	STO
	17	B′		17	B′		01	1
	65	x		95	=	205	00	0
	08	8	180	42	STO		94	+/−
155	17	B′		00	0		22	INV
	29	x!		04	4		23	1n x
	65	x		03	3		65	x
	53	(		17	B′	210	43	RCL
	06	6	185	81	HLT		01	1
160	17	B′		46	LBL		00	0
	75	—		19	D′		45	y^x
	01	1		42	STO		00	0
	54	)		00	0	215	17	B′
	29	x!	190	09	9		55	÷
165	55	÷		00	0		00	0
	07	7		46	LBL		17	B′
	17	B′		10	E′		29	x!
	29	x!		42	STO	220	95	=
	95	=	195	00	0		22	INV
170	42	STO		00	0		57	fix
	00	0		09	9		81	HLT
	03	3		17	B′			
	55	÷		55	÷			
	53	(	200	03	3			
175	43	RCL		17	B′			

These distributions help in the formula derivations because of their inherent memoryless property, since at any instant, the remaining time to failure or repair is independent of what has preceded.

To estimate total system dependability, apply the models repeatedly to primary elements, first-level subsystems, second-level subsystems, and soon. Repair and failure rates of all elements and subsystems are presumed to have Poisson distributions. But don't go overboard. Although this is a fairly good estimate, it is not always precisely the case, especially for high-level subsystems containing low levels of redundancy.

While your calculator might be accurate to 12 places, your assumptions and input data are probably not as accurate. Therefore, don't carry MTBF and MTTR figures to more than a few decimal places. Round them off.

Also, of course, while you rely on the three subsystem models, don't get carried away. Applying them demands thought and proficiency, and the resulting predictions require proper interpretation.

Equations for three models

The formulas for computing total system dependability can be solved on any scientific pocket calculator. But solving them on the SR52, or another programmable type, not only enables you to complete the analysis much faster, but also reduces the risk of error. If you use an SR52, the following material will serve as a background, since you need only to follow the "User Instructions" detailed in this article. For other programmable calculators, you have to recode the equations. Those with manual calculators will have to grind through the formulas step-by-step.

Consider the Series model first. The inverse of total MTBF is the summation of the inverses of unit MTBFs:

Table 3. SR52 user instructions

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1.0	Series Connection		START	1.
1.1	Enter MTBF & MTTR for each series element.	element MTBF	MTBFs	Cumulative subsystem MTBF
1.2	Repeat steps 1.1 & 1.2 for each series element. Cumulative result is displayed after each entry. After each element is added, you may interrupt the loop to compute the following:	element MTTR	MTTRs	Cumulative subsystem MTTR
1.3	Availability		A	Availability
1.4	Reliability	t	R(t)	Reliability
1.5	Probability of n failures. Step 1.4 must precede the first use of P(n)	n	P(n)	Probability of n failures
2.0	Series Connection for calculation of MTBF only. MTTRs are unknown.		START	1.
2.1	Enter MTBF for each series element. Repeat step 2.1 for each element. Cumulative results are displayed after each entry. After each MTBF is entered, you may request the following:	element MTBF	MTBFs	Cumulative subsystem MTBF
2.2		t	R(t)	Reliability
2.3	Step 2.2 must precede the first use of P(n)	n	P(n)	Probability of n failures
3.0	Parallel Connection		START	1.
3.1	Enter MTTR & MTBF for each parallel element	element MTTR	$MTTR_p$	Cumulative subsystem MTTR
3.2	Repeat steps 3.1 & 3.2 for each parallel element. Cumulative results are displayed after each entry. After each element is added, you may interrupt the loop to compute the following:	element MTBF	$MTBF_p$	Cumulative subsystem MTBF
3.3	Availability		A	Availability
3.4	Reliability	t	R(t)	Reliability
3.5	Probability of n failures occuring in time period t	n	P(n)	Probability of n failures
4.0	ANY R-of-N Connection			
4.1	R elements required	R	ANY	
4.2	N elements available	N	RUN	
4.3	Assume all elements identical. Enter MTTR & MTBF only once.	element MTTR	RUN	Cumulative subsystem MTTR
4.4		element MTBF	RUN	Cumulative subsystem MTBF
4.5	Availability		A	Availability
4.6	Reliability	t	R(t)	Reliability
4.7	Step 4.6 must precede the first use of P(n)	n	P(n)	Probability of n failures

$$\frac{1}{MTBF_T} = \sum_{i=1}^{N} \frac{1}{MTBF_i}, \text{ for N units.}$$

Therefore,

$$MTBF_T = \frac{1}{\sum_{i=1}^{N} \frac{1}{MTBF_i}}.$$

Multiplying unit availabilities results in total availability:

$$A_T = \prod_{i=1}^{N} A_i.$$

And once $MTBF_T$ and A_T are determined, total MTTR can be found from

$$MTTR_T = \left(\frac{1-A_T}{A_T}\right) MTBF_T.$$

For a Parallel connection, adding the inverses of MTTR for each unit results in the inverse of total MTTR:

$$\frac{1}{MTTR_T} = \sum_{i=1}^{N} \frac{1}{MTTR_i}, \text{ for N units.}$$

Therefore,

$$MTTR_T = \frac{1}{\sum_{i=1}^{N} \frac{1}{MTTR_i}}.$$

Unavailability (U) is $1-A$. Parallel total unavailability is the product of unit unavailabilities:

$$U_T = \prod_{i=1}^{N} U_i$$

$$(1 - A_T) = \prod_{i=1}^{N} (1 - A_i)$$

$$A_T = 1 - \prod_{i=1}^{N} (1 - A_i)$$

Once you know $MTTR_T$ and A_T, you can compute total MTBF:

$$MTBF_T = \left(\frac{A_T}{1 - A_T}\right) MTTR_T.$$

For an Any R-of-N configuration, the entire connection is operational provided R units of the N available are working. Assume all units have identical MTBF and MTTR values, which are indicated with the subscript i. Use the following formulas to calculate total MTBF and MTTR:

$$MTTR_T = \frac{MTTR_i}{N - R + 1}$$

$$MTBF_T = MTBF_i \left(\frac{MTBF_i}{MTTR_i}\right)^{N-R} \left[\frac{(N-R)!\ (R-1)!}{N!}\right]$$

These two equations are derived with the assumption that $MTTR_i$ is much smaller than $MTBF_i$, as is generally the case. Once $MTTR_T$ and $MTBF_T$ have been computed, solve for total availability:

$$A_T = \frac{MTBF_T}{MTBF_T + MTTR_T}$$

The equations for reliability and failure probabilities—R(t) and P(n)—are the same for all three models. For reliability during t,

$$R(t) = e^{-t/MTBF_T}.$$

For the probability of n failures in a time period t,

$$P(n) = \frac{e^{-\bar{N}} N^n}{n!},$$

where

$$N = \frac{t}{MTBF_T}$$

represents the average number of failures during time period t.

To appreciate the effects various configurations have on dependability parameters, examine the reliability bubble diagrams and results for a set of 12 illustrative examples tabularized in Table 1. The period during which reliability and failure probabilities were calculated was arbitrarily selected as one year of continuous operation (365 days×24 hours/day=8760 hours).

Both examples 1 and 2 may be thought of as either Series or Parallel configurations, consisting of only one element. In both cases, availability exceeds 99%. On the average, these elements will be up (available) more than 99 hours out of every 100 operating hours. However, this is not always a good indicator of dependability. The reliability and failure probabilities in Example 1 are almost zero—i.e., this element is certain to have more than two failures per year.

The element in the second example is much more dependable. It has a 37.78% probability of zero failure, a 36.77% probability of one failure, and a 17.90% probability of two failures per year. Failure probabilities higher than two can also be determined, by entering n, then depressing the key labeled P(n).

Units are strung together in Examples 3, 4, and 5. Where as the Series model may always be applied to such string connections, Any N of N can only be used when all components are identical. Series dependability is always less than for the weakest link in the chain. Observe that the resulting dependability parameters in Example 5 are all less than their respective counterparts in Example 1.

Paralleled elements are represented in Examples 6, 7, 8, and 10. If they aren't all identical, you must use the Parallel model. When they are, either the Parallel or Any 1-of-N models apply. The dependability of a network of parallel elements is always greater than any one of them.

The resulting $MTBF_T$ in Example 6 is 4.8 years. In Example 7, it is 538 years. Yet, in both illustrations, the primary elements have an MTBF of only 500 hours.

Examples 9 and 11 have been computed with the Any R-of-N model. Compare Example 9 with Example 8 and note the decreased dependability. This occurs in Example 9 because two elements are required to be operational instead of only one. The network in Example 11 is a second-level subsystem configured with the first-level subsystems of Example 5.

The reliability diagram in Example 12 is a third-level subsystem. As an exercise, you should redraw it with 17 primary elements.

Occasionally, you will encounter a configuration that cannot be accurately represented by any of the models. Consider an Any Two Required of Three Available condition, where all three elements are different. When such situations occur, the models can always be applied to determine upper and lower bounds on dependability. One assumption will be optimistic, the other, pessimistic. Carrying both limits through the remaining calculations establishes two sets of results. The system's actual dependability lies somewhere between these values.

To code the SR52 calculator, see Table 2. With this coding procedure, you can obtain a program card that, when inserted into the calculator, prepares it to perform the computations described in Table 3.

Ten user-defined functions can be executed by pressing the top row of keys on the SR52 calculator. A great deal of thought has gone into their assignment to provide for maximum user convenience. In this article user function keys are named and referenced as follows:

Key	*Name*	*Key*	*Name*
A	$MTBF_s$	A'	START
B	$MTTR_s$	B'	-
C	$MTTR_p$	C'	A
D	$MTBF_p$	D'	R(t)
E	ANY	E'	P(n)

Program the TI-58 or TI-59 calculators with the keystroke modifications listed in Table 4. ■■

Table 4. Keystroke modifications for TI-58 and TI-59 calculators

SR52 Coding	TI-58, TI-59 KEY
rtn	R/S
HLT	R/S
x!	Implemented in master library module Pgm. 16

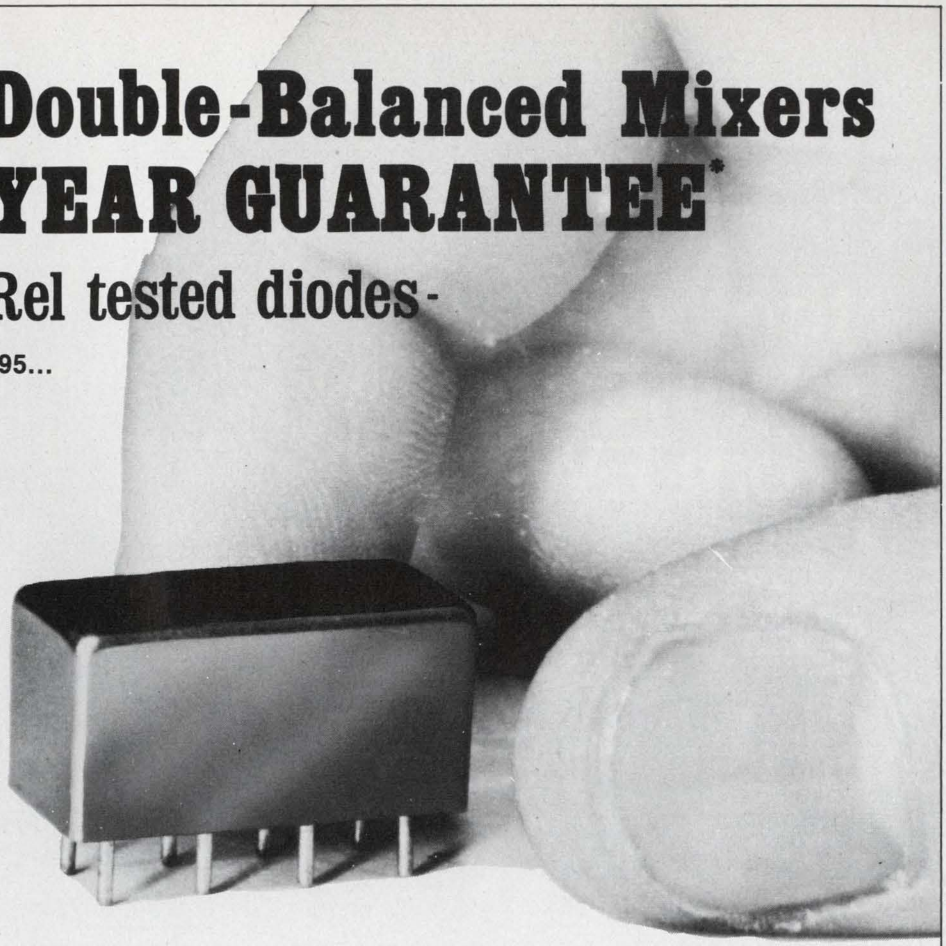
The only Double-Balanced Mixers with a 2-YEAR GUARANTEE*

featuring Hi-Rel tested diodes-

Introduced in 1971 at $7.95... still only

$7.95

(500 pieces)
$9.95 (1-49)



***including diodes!**

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

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

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

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

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

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

MODEL SRA-1

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

Conversion loss (dB)		**Typ.**	**Max.**
One octave from band edge		5.5	7.0
Total range		6.5	8.5
Isolation (dB)		**Typ.**	**Min.**
Lower band edge to	**LO-RF**	50	45
one decade higher	**LO-IF**	45	35
Mid range	**LO-RF**	45	30
	LO-IF	40	25
Upper band edge to	**LO-RF**	35	25
one octave lower	**LO-IF**	30	20

Min. Electronic attenuation (20 mA) 3 dB

Signal, 1 dB compression level + 1 dBm

Impedance all ports 50 ohms

HTRB Tested (High Temperature Reverse Bias)

WE'VE GROWN *Customer acceptance of our products has been so overwhelming, we've been forced to move to larger facilities — THANKS.*

International Representatives: ☐ **AFRICA:** Afitra (PTY) Ltd. P.O. Box 9813, Johannesburg 2000, S. Africa. ☐ **AUSTRALIA:** General Electronic Services, 99 Alexander Street, New South Wales, Australia 2065. ☐ **ENGLAND:** Dale Electronics, Dale House, Wharf Road, Frimley Green, Camberley Surrey. ☐ **EASTERN CANADA:** B.D. Hummel, 2224 Maynard Avenue, Utica, NY 13502 (315) 736-7821. ☐ **FRANCE:** S.C.I.E. - D.I.M.E.S. 31 Rue George - Sand 91120 Palaiseau, France. ☐ **GERMANY, AUSTRIA, SWITZERLAND:** Industrial Electronics GMBH 6000 Frankfurt/Main Kluberstrasse 14 West Germany. ☐ **INDIA:** Gaekwar Enterprise, Kama Mahal, M.L. Dananukar Marg, Bombay 400 026, India. ☐ **ISRAEL:** Vectronics, Ltd., 69 Gordon Street, Tel-Aviv, Israel. ☐ **NETHERLANDS, BELGIUM, LUXEMBOURG:** Coimex Veldweg II, Hattem, Holland. ☐ **NORWAY:** Datamatik AS, Ostensjoveien 62, Oslo 6, Norway. ☐ **SINGAPORE & MALAYSIA:** Electronics Trading Co. (PTE) Ltd., 87 Bukit Timah Road, Singapore 9, Malay Peninsula. ☐ **SWEDEN:** Integerad Electronik AB, Box 43, S-18251, Djursholm, Sweden.

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

World's largest supplier of Double-Balanced Mixers

Mini-Circuits

MINI-CIRCUITS LABORATORY

A Division Scientific Components Corp

OUR NEW ADDRESS AND PHONE NO. IS:

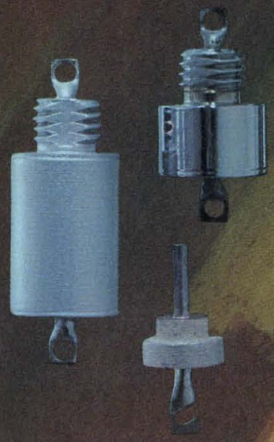
2625 EAST 14th STREET
BROOKLYN, NEW YORK 11235
(212) 769-0200

DOMESTIC TLX 125460 • INTERNATIONAL TELEX 620156


BELL INC.

Make us your headquarters for

EMI/RFI FILTERS

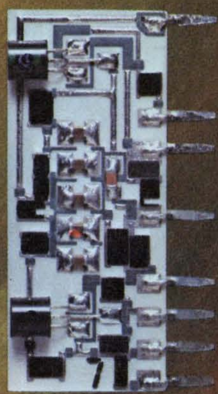


Passive Filter Headquarters:

Centralab Los Angeles is a one-stop source for reliable miniature ceramic low pass Feed Thru's/Filters. They're cost effective from 30 KHz to beyond 1 GHz. Threaded or solder mount for easy installation. Proven in AC as well as DC applications. Monolithic and multi-element. Standard products or computerized custom designs, including multi-circuit custom packages. Call Rich Colburn at (213) 240-4880.

Active Filter Headquarters:

That's Centralab Milwaukee. Solve design problems and cut costs with our thick film hybrids. Band pass, low pass, high pass and band reject. Cost effective for low to medium frequencies. Let us put our design and manufacturing expertise to work for you. Call Don Weiland at (414) 228-2872.



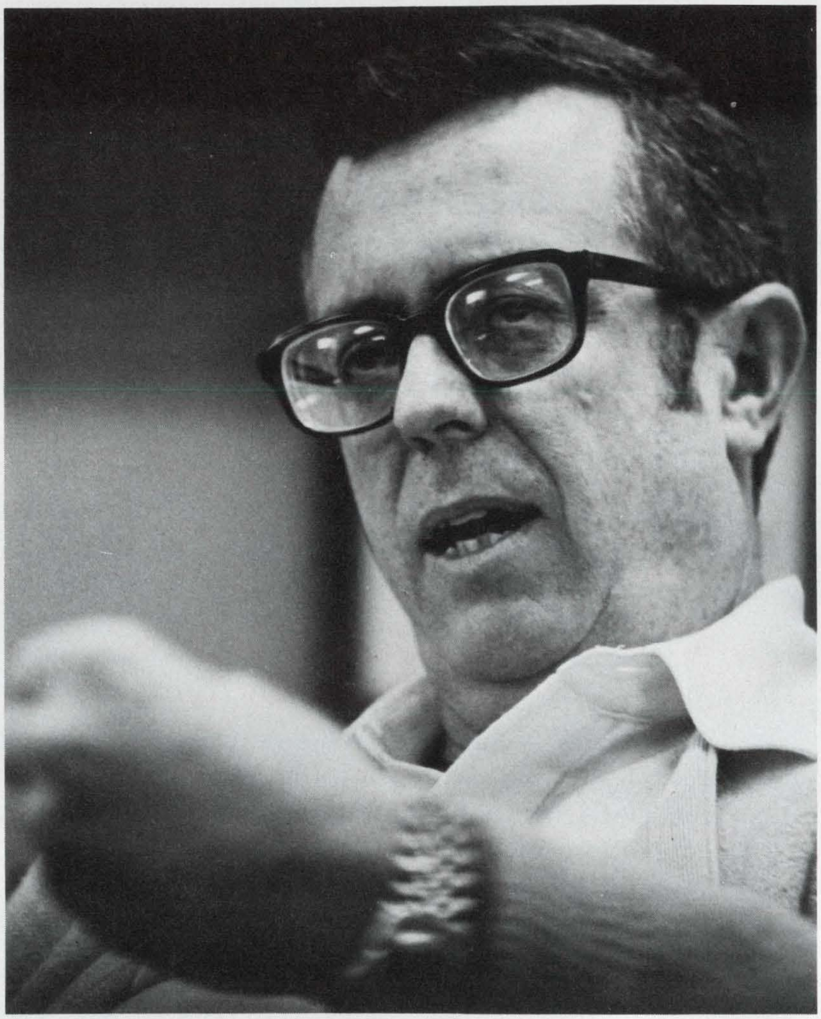
CENTRALAB
Electronics • GLOBE-UNION INC.

4561 Colorado Blvd., Los Angeles, California 90039
5757 North Green Bay Ave., Milwaukee, Wisconsin 53201

CERAMIC CAPACITORS • FILTERS • POTENTIOMETERS • SWITCHES
THICK FILM CIRCUITS • TRIMMER RESISTORS

SEE OUR COMPLETE CATALOG IN EEM; PAGES 317 to 335; AND GOLD BOOK PAGES 103 to 121; OR CONTACT US DIRECTLY.

Fred Bucy of TI Speaks on Managing Innovation



Like motherhood and apple pie, innovation is something everybody favors. What most people don't know is that you can actually plan and organize for it.

But no system ever created an innovation. People make innovations. So you have to create an environment in which people will be stimulated to innovate. And that environment must pervade your company because innovators are where you find them. Your R&D organization is not the sole source.

To stimulate innovation, you need a system. But you mustn't let it become too rigid or you'll discourage innovation instead of encouraging it.

The system we use at TI is one we call OST—for Objectives, Strategies and Tactics. It's designed to help us nurture and manage innovation.

It starts with the idea that innovation or invention is a very tender thing. You have to bring it up very carefully. It can starve if it isn't quickly nourished. And innovations perish without champions.

So we make initial resources available quickly and easily. Being able to allocate resources properly is the real key to the system. When a fellow comes up with a new idea, a new product, or a new solution to something, we can get the resources to him. Nothing is more discouraging than having a good idea and not being able to get the funding for it. The best way to motivate innovators is to provide resources to help them carry out their ideas.

This is far more important than it appears. You must have a source of "strategic" funding—money that's discretionary to your current operations. Such funds must be kept separate from day-to-day business requirements.

If you leave this allocation to individual managers, you force them into conflicts between today's profitability and tomorrow's growth. For the same reason, you must segregate the reporting of strategic and operating expenses so that you don't unwittingly penalize managers who carry out strategic programs. Unlike operating expense, strategic expense is desirable in business.

Further, you have to be wary of the old problem that resources do tend to gravitate away from embryonic ideas toward well developed products.

We have two basic ways to provide funds for innovations—the IDEA program and the Wild Hare program.

Under the IDEA program, we distribute modest sums of money to a large number of IDEA program representatives throughout the company.

When an engineer says, "I have an idea for doing such-and-such, and I think I can prove its feasibility in six months," he merely has to convince the IDEA man, who has authority to provide funding right away, without further approval.

The engineer will have a timetable in which to prove that he's making progress. At some point he may need an extension. And at some point he may develop his idea to the point where it enters into competition with other ideas for further funding.

In many cases the engineer who develops the original idea may continue in his own job while he's developing the idea. He may tell his boss that he has the funding to carry out a new idea and he needs some time to work on it. They'll work out a way to give him the time to work on the idea.

To help him develop his idea and for many other reasons, we challenge an ancient management principle. We believe that a man's responsibility can and should exceed his authority.

I know that many management texts take it as gospel that if you give a man responsibility, you must give him authority to go with it. Of course, that's frequently true. You can't give a man responsibility for running a production line or a lab without giving him authority over that line or lab.

But we believe deeply that if a man sees an opportunity to be pursued outside his immediate area, he has the responsibility to do something about it. Maybe he should bring it to the attention of his peers, his boss, or a committee. He should not sit back and say, "That's not my job; I'm not responsible." The same rule applies in corporate or civic ethics. If you see something wrong, you are obligated to do something about it, even if it's not in your area, and even if you don't have the authority.

So, if a man is given responsibility for developing a new idea, he may have to call on resources in other departments—where he has no authority. He may be asking for the services of people who "outrank" him . . . but I should add that rank doesn't play much of a role at TI.

We may have a situation where, so to speak, a sergeant needs services from a captain. Well, with our OST system we give him the funds to buy those services. He can say, "I need this and I have the money to pay for it." And that happens frequently.

Sometimes a man's idea is such that he can't pursue it while he's working at his regular job. He may need full time to develop the idea. In this case he obviously must be relieved of his regular duties. And this raises another question.

The normal boss wants to keep his productive people because they make him look good. He's reluctant to lose an innovative man—even for a relatively short time. He needs an inducement to support the innovator even if he'll move to a new effort.

Most of the time this isn't a problem because the innovator is in his own group and it's most likely that the idea will be in his own area of interest. So there's real incentive. He has a great deal to gain from supporting the fresh idea, as it might help him gain additional resources to make his business a success.

But if the engineer comes up with an idea that's not related to the boss's current business, the engineer may be transferred, perhaps temporarily, to, say, the Corporate Engineering Center. In the Corporate Development organization, he may work on products related to any of TI's businesses or to new businesses. If his idea proves successful, he may move with it as it goes into further development and into production. In such a case, the original boss should get the satisfaction of knowing that one of his people played an important role in helping the company grow.

In our Wild Hare system, we're looking for ideas that are more nebulous. We're working long shots. We're trying for a "hole in one."

One example is our development of charge-coupled devices. We did not invent them, but we did recognize their potential and funded them with an expectation of a payoff in several years—not immediately.

It's very difficult to set checkpoints when you're trying to get innovation. You can't command invention. So we can't have rigorous milestone reviews in our Wild Hare program. We have to give people the latitude to pursue something over an extended period.

In our Wild Hare program we may be making large investments, but they'll be spread over a long period of time. Since these are important programs, possibly with long-range impact, we don't fund them as quickly as we do the IDEA programs.

Now, as you can imagine, when thousands of people in a corporation are encouraged to innovate, we must often face the problem of deciding what business we're really in, especially when we examine some of the Wild Hare proposals. And that's precisely one of the functions of the OST system.

It turns out that we usually don't have to worry about that problem since most of the fellows working here are not likely to come up with an invention in, say, biology. But every once in a while somebody comes up with an idea that makes us evaluate the merits of entering a new business.

A new business can sometimes be an outstanding payoff of the OST system which, remember, is first and foremost a philosophy. It's a philosophy that keeps pointing to the fact that we are in the business of innovation. The philosophy is a foundation on which we build a structure to nurture innovation.

There are two critical aspects to this philosophy. First, we try to make the status quo uncomfortable. And second, we don't punish innovators for unsuccessful programs. That's very, very important.

We always stress the probability of success. IDEA projects may have one chance in, say, 20 or 25. Wild Hare projects may have even lower probabilities for success. If a program has a 50-50 chance, it will probably be supported by general OST strategic funds.

As you can imagine, the system isn't flawless. One of the problems we run into is the fact that bright innovators tend to be promoted to the ranks of management, and then get buried in administrative details. Of course we reward innovators with money and prestige. But there seems to be greater social prestige for the manager.

It's often difficult to get the innovator to realize that his biggest contribution is to remain the creative genius, rather than to get into the management progression. That idea can be frustrating to the genius because he thinks he has to carry everything all the way through.

Who is Fred Bucy?

He's very much a Texan. J. Fred Bucy, whose parents, grandparents, and great-grandparents were Texans, was born in the High Plains of Texas, in Tahoka, just south of Lubbock. His wife, Odetta, is from Grassland, a suburb of Tahoka.

He went to school in Texas, earning his BS in Physics in 1951 at Texas Tech University in Lubbock and his MS Physics, two years later when he was 25, at the University of Texas in Austin.

Then, of course, he came to work in the Central Research Lab of Texas Instruments, starting in geophysical instrumentation. He left the lab to carry one of his ideas through production at TI's plant in Houston. His responsibilities increased and in 1961 he was made general manager of the Houston operation. In 1963 he was made vice-president and put in charge of TI's military business. He continued his rise and, in 1967, he was given charge of the company's semiconductor activities; in 1972 he was made executive vice-president; then chief operating officer in 1974 and president in 1976.

Bucy is a hard worker. In his spare time he works. But he enjoys working. He started working 18 hours a day when he was 13 and he still does. But it does take work and time to manage a company that wants to keep growing from its 1976 sales peak of almost $1.7 billion. Bucy would be happier if there were more hours in the day and more days in the week.

He does unwind aboard his double-ended, gaff-rigged ketch, the "Tumbleweed." But he takes his briefcase with him. His pleasure in the boat is largely vicarious because his family is more often there without him than with him. The usual occupants include his 27-year-old son, J. Fred, III, the boat's captain when he's not operating his own business (The Car Doctor ... "I make house calls"), his wife, and his two daughters, Roxanne, 24, and Diane, 21.

Bucy does find time for other activities. He is particularly active working through the Defense Science Board on the question of export of technology. And he serves as a Regent of Texas Tech. He also spends much of his spare time reading—all kinds of things, with emphasis on political science and history, biography and autobiography, lots of technical material and some fiction.

The fellow who can generate a new idea, convert it to a product, push it through production and get it into the field—that fellow is pretty scarce. But nobody likes to give his baby away. So you have to protect the creative guy by rewarding him sufficiently so that he remains motivated to stay in his position.

The genius who comes up with the basic concept is probably not the individual who can get a product through a production line. Sometimes we let an innovator find out for himself. Then we can get him to return to what he really loves and does best.

Of course, you have to make sure that the innovator's salary, bonuses and recognition will be an adequate reward. In fact, we have what we call the TI Fellow Awards for the truly outstanding innovators. We present these at our Strategic Planning Conferences and publish them throughout the company. So our innovators do get recognition from their peers. The innovator can become a Fellow instead of a vice-president. And this is one way we cope with the fact that his neighbors don't know if he has made important innovative contributions to the corporation, but they sure know if he's a vice-president. It doesn't seem to be enough that he may make as much money as a vice-president. There's great social value in the fact that a business card says he's a vice-president.

Unfortunately, vice-presidents tend to become buried in administrative work. The OST system is dedicated in large measure to making the manager spend a lot of time thinking about the nature of our business and how to improve it instead of spending all his time on current administrative duties. We try to get all our managers to spend a significant part of their time thinking about innovation and strategic planning because that's what we're all about.

We have a "two-hat" system for our managers. A manager must be a short-term operating manager and he must develop long-term strategic skills. He should develop the self-discipline needed to divide his time wisely between today's demands and tomorrow's needs. He must not let himself be consumed by today's business requirements.

The manager has to keep thinking about the future—about new products, new management techniques, new everything.

Without new products, we cease to grow. Without innovation in management, our overhead continues to grow. So we always worry about how to become more productive in everything we do.

You have to realize that the OST philosophy doesn't apply only to engineering. It might involve a new product, a new process, a new marketing technique, even—and especially—a new management technique. Productivity is the key.

Here's the best example: Between 1970 and 1976 we doubled our billings with an increase of only 16% in people. We didn't do that just by making everybody work hard. It was done by people thinking about their jobs and being innovative in what they're doing. Being more productive is getting more out with less effort. And that's part of the OST system.

We have a very simple measure of this productivity. It's called the People Effectiveness Index, which is simply our billings divided by total payroll. We try to make that improve every year.

Of course, no system is perfect. It's easy to fall into the trap of thinking that a system exists independent of people. And it's easy to let the system cover too much. That can lead to a heavy paperwork burden. Or the system can become too mechanistic, giving people the feeling that the system controls events. You must continue to refine and improve any system.

OST really started in the early days of our company. When we had a sales volume of substantially less than $200 million, it was possible for the president and the vice-presidents to get together and operate the OST system among themselves. They could follow what was important and get things started.

One of the early Wild Hares—long before we invented that name—was the silicon transistor. When we introduced that in 1954 we were enjoying a volume of somewhat over $24 million.

Pat Haggerty, who was then chairman of the board, sold the board on the idea of developing the silicon transistor. We could do things very informally at that time because lines of communication were short.

But Mr. Haggerty and others like him recognized the fact that, as we got bigger, we would need a system to help us see where the new opportunities were and to allocate the proper resources to help us take advantage of them.

He wanted to institutionalize what was already being done informally. "How are we going to handle this," he asked, "when we get to be a half-billion-dollar corporation, or a billion dollar corporation?"

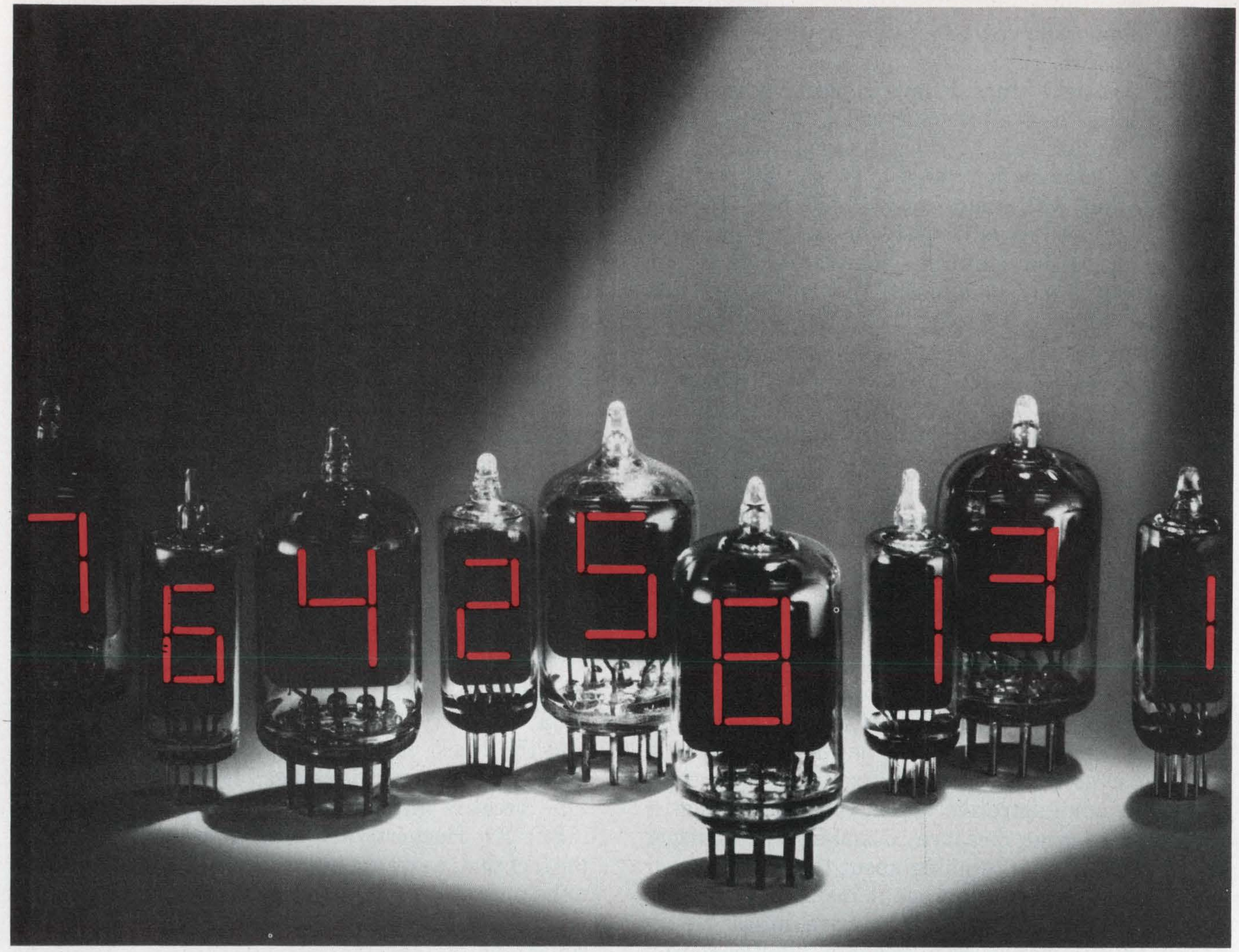
We started formalizing the system in the early 1960s and we've been developing it ever since. Though it's now in an advanced state, we still come up with improvements.

If we didn't do that, the system would stagnate and die. What worked well with one size corporation may not work well at another level. To be useful, OST must be a living thing, a way of life, a philosophy that's ingrained in all your people. You can't just say, "Today is OST day."

OST is not merely a way to fund new ideas—though that's an important role. It can be, and often is, a meeting on a production line, where a group of people get together and talk about how to improve an operation. We do get inputs right from the people working directly on the line.

One of the best examples of ideas from the production floor I heard recently during a visit to Italy, when a girl from the production floor came out with a better layout of the product line she worked on.

Our effectiveness depends very much on our innovative skill. We want to use every technique to improve that skill. That's our life blood. ■■



RCA NUMITRON Digital Display Devices – Retain brightness even in direct sunlight.

RCA Numitron Digital Display Devices are the designer's answer to high ambient light conditions. And, with normal indoor lighting, numerals are legible to 40 feet or more with almost any color filter desired.

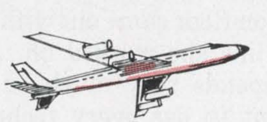
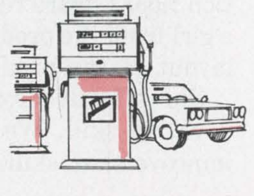
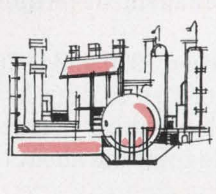
In addition to their astonishing brightness, they offer equipment designers the following unique benefits:

- Color filter selection is practically unlimited since the output spectrum is broad and continuous.
- Brightness is completely controllable. Numitrons maintain uniform brightness from segment to segment, even at reduced voltages.
- High reliability and rugged construction provide a mean life expectancy of more than 100,000 hours.
- Low voltage operation (4.5 volts nominal).
- Compatible with IC decoder/drivers such as the RCA CD2500E family.
- Freedom from induced or radiated interference.
- Planar construction gives uncluttered wide-angle viewing.
- Ambient operating temperatures range from -50°C to +125°C.

RCA Numitrons will open new markets for your products. Their applications keep growing throughout industry. Remember, Numitrons are designed and manufactured by RCA . . . the quality and ruggedness are built-in.

Get your free copy of "RCA NUMITRON Display Devices" containing complete technical information. Contact your RCA District Manager or Numitron Distributor or write RCA Numitron Merchandising, RCA Distributor and Special Products Division, 2000 Clements Bridge Road, Deptford, N.J. 08096.

RCA NUMITRON Display Devices


The CRADLE that'll ROCK the industry

At last: Guardian's high quality in telephone type relays...at Guardian's low price.

Interchangeable with most miniature, enclosed cradle type relays you are now using . . . will handle dry circuit to 5 amp DC loads.

Interchangeable because they have the same form. The same fit. The same function.

Interchangeable, but **better:** With a one piece core and yoke for improved magnetic efficiency and stability. With one piece bobbin and terminal assemblies for rigid, built-to-take-it coil terminations. With polycarbonate insulation to virtually eliminate moisture absorbtion and insure stability of spring-set adjustment.

What else do you get besides sensible basic design and superb efficiency? You get a choice of PC or solder lug terminals. A choice of contact material. A choice of mating sockets and mounting hardware.

That's why your choice should bear the Guardian name. And why **you** should join the swing to the cradle that's rocking the industry.

Your Guardian Angel has a free technical application bulletin waiting for you. Send for your 1555 Series data today.

UR Recognized under the component program of Underwriters Laboratories, Inc.

GUARDIAN®

GUARDIAN ELECTRIC MANUFACTURING CO. • 1572 W. Carroll Ave. • Chicago, IL 60607 • 312/243-1100

CIRCLE NUMBER 271

The new DAC standard. Analog Devices' complete 10-bit monolithic DAC.

Less than a buck a bit.

You can pay at least twice as much for a 10-bit IC D/A converter and still not get the degree of accuracy and stability of our new AD561. Selling for less than $10, the AD561 sets a new standard of price and performance for the other guys to shoot for.

As for accuracy, the AD561 is guaranteed to ±½LSB max of 10-bits (or even ±¼LSB—and that's 11-bits). Monotonicity is guaranteed over the full operating temperature range. The excellent stability is made possible by a unique buried zener voltage reference and Analog Devices' proprietary thin film resistor process. And for settling time, there's nothing faster: less than 250ns for the worse case transition; that's fast enough to build a 5 μsec ADC. Current-to-voltage conversion with an op amp is direct and simple: trimmed application resistors mean no calibration trimmers are needed.

How did we achieve this breakthrough? With the industry's most advanced monolithic processing and our pioneering technique of laser wafer trimming. The kind of advances that have quickly pushed us to the top and made us the leading supplier of D/A and A/D converter components.

The AD561 joins another group of Analog Devices' pacesetters: a series of monolithic CMOS converters that also set new performance standards. At the same time they set a lot of microprocessor users free of analog interface problems. One is the 10-bit successive approximation AD7570 ADC. Another is the multiplying 10-bit DAC, AD7522, the only device that can be loaded in either parallel or serial modes.

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

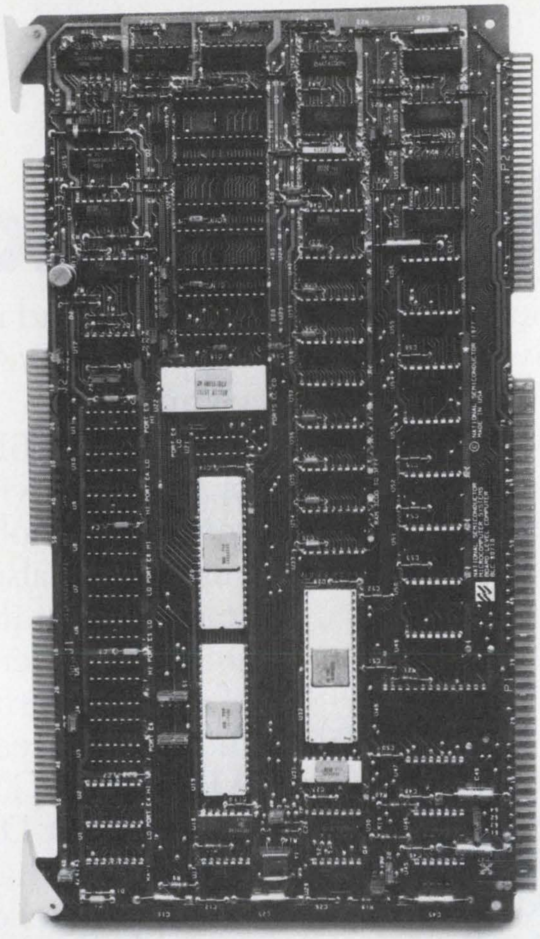
Find out how you can cut in half the cost of your 10-bit IC D/A converters and still get true, 10-bit performance by writing for our data sheet. Contact Analog Devices, the real company in precision measurement and control.

ANALOG DEVICES

The real IC converter company.

CIRCLE NUMBER 272

Analog Devices, Inc., Box 280, Norwood, Massachusetts 02062 East Coast: (617) 329-4700, Midwest: (312) 894-3300, West Coast: (213) 595-1783, Texas: (214) 231-5094, Belgium: 031 38 27 07, Denmark: 02/84 58 00, England: 01/94 10 46 6, France: 686-77 60, Germany: 089/53 03 19, Japan: 03/26 36 82 6, Netherlands: 076 14 21 50, Switzerland: 022/319704 and representatives around the world.



ACTUAL SIZE

100% off.

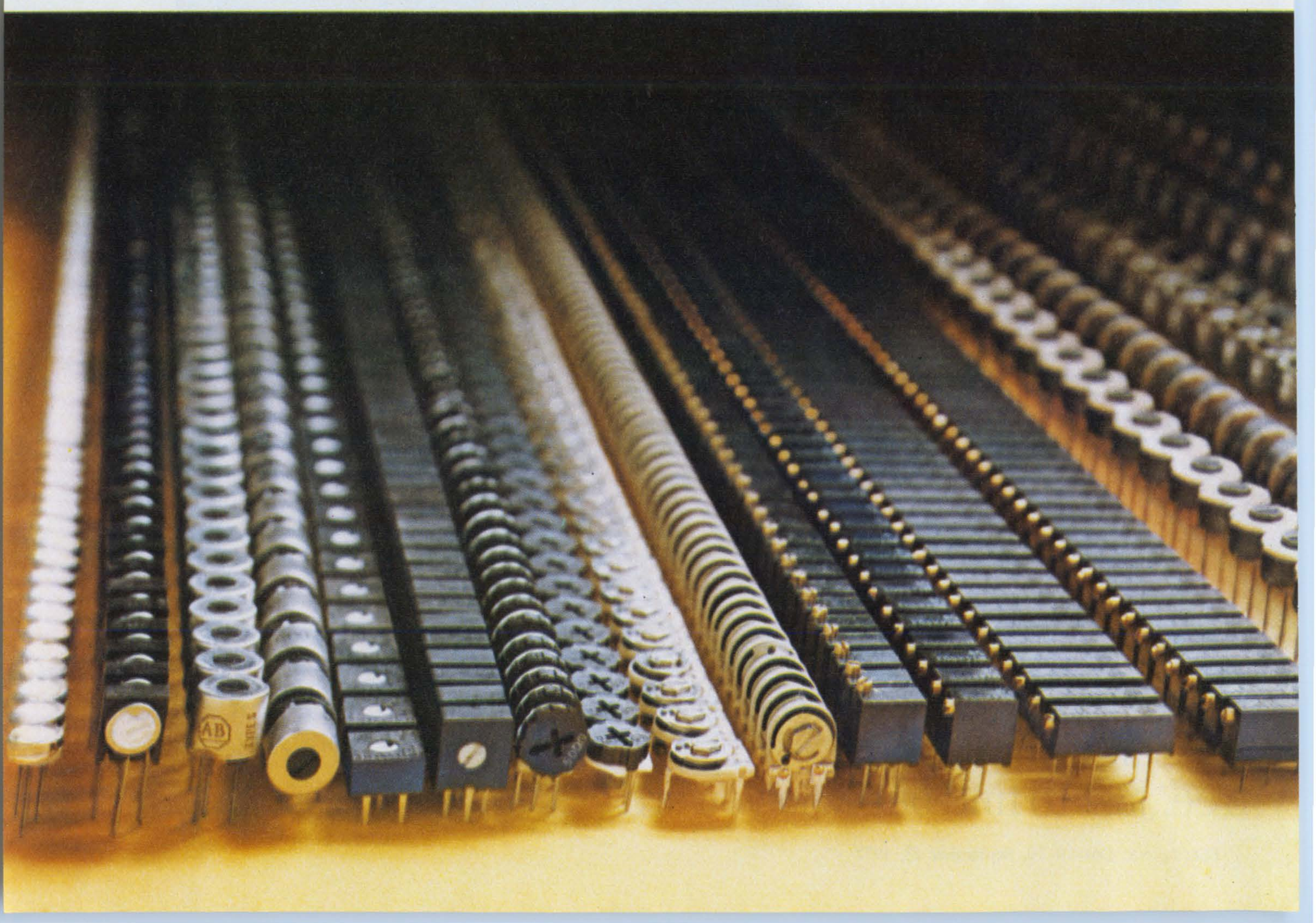
If your project group is using the Intel SBC 80/10—and you're the first one in your group to call us at 800-538-1866 (in California, 800-672-1811)—we'll give you this calculator free. Just to find out who you are.

Offer expires October 15.

Allen-Bradley Trimmers:

We have what you need.

Our distributors have them when your need is now.



CERMET TRIMMERS

Type A: ¼" diameter, single turn, 10 ohms to 2 megs ±10%, 0.5W at 85°C, immersion sealed, 3 terminal options, Publication 5238. **1000 piece price $1.12 to 1.68.**

Type S: ⅜" dia., single turn, 50 ohms to 1 meg ±10%, 0.5W at 85°C, immersion sealed, top or side adjust, Publication 5208. **1000 piece price $1.15 or 1.40.**

Type E: ⅜" square, single turn, 10 ohms to 2 megs ±10%, 0.5W at 70°C, immersion sealed, 13 terminal options, Publication 5219. **1000 piece price $0.49.**

Type D: ⅜" diameter, single turn, 10 ohms to 2 megs ±20%, 0.5W at 70°C, dust cover, 6 terminal options, Publication 5240. **1000 piece price $0.42.**

Type 90: Approx. 7⁄16" square, single turn, 100 ohms to 2 megs ±20%, 0.5W at 70°C, open frame, 2 terminal options, Publication 5242. **1000 piece price $0.55.**

Type MT: ⅜" square, 20 turn, 10 ohms to 2 megs ±10%, 0.5W at 70°C, immersion sealed, 3 terminal options, Publication 5241. **1000 piece price $1.18.**

Type RT: ¾" long, 20 turn, 10 ohms to 2 megs ±10%, 0.75W at 70°C, immersion sealed, 3 terminal options, Publication 5237. **1000 piece price $0.65 or 0.93.**

CARBON COMPOSITION TRIMMERS

Type Y: ½" dia., single turn, 100 ohms to 5 megs ±10% or 20%, 0.25W at 50°C, dust/splash resistant, 5 styles, non-linear tapers, Pub. 5209. **1000 piece price $0.90 to 1.59.**

Type F: ½" dia., single turn, 100 ohms to 5 megs ±10% or 20%, 0.25W at 70°C, immersion sealed, 6 styles, non-linear tapers, Pub. 5234. **1000 piece price $1.00 to 1.62.**

Type O: ½" dia., single turn, 100 ohms to 5 megs ±10% or 20%, 0.40W at 70°C, immersion sealed, 4 styles, non-linear tapers, Pub. 5235. **1000 piece price $1.20 to 1.58.**

Type FD: ½" dia., 2 sec., 1 turn, 100 ohms to 5 megs ±10% or 20%, 0.25W at 70°C, immersion sealed, 4 styles, 5 tapers, 2 atten. Pub. 5231. **1000 piece price $2.65 to 4.10.**

Type BT: ½" dia., 2 section, 1 turn, for 75 ohm Bridged-T pad applications, dust/splash resistant, side and top adjust versions. Pub. 5236. **1000 piece price $2.49.**

Type N: 1¼" long, 25 turn, 100 ohms to 2.5 megs ±10% or 20%, 0.33W at 50°C, immersion sealed, Publication 5206. **1000 piece price $2.50 or 2.65.**

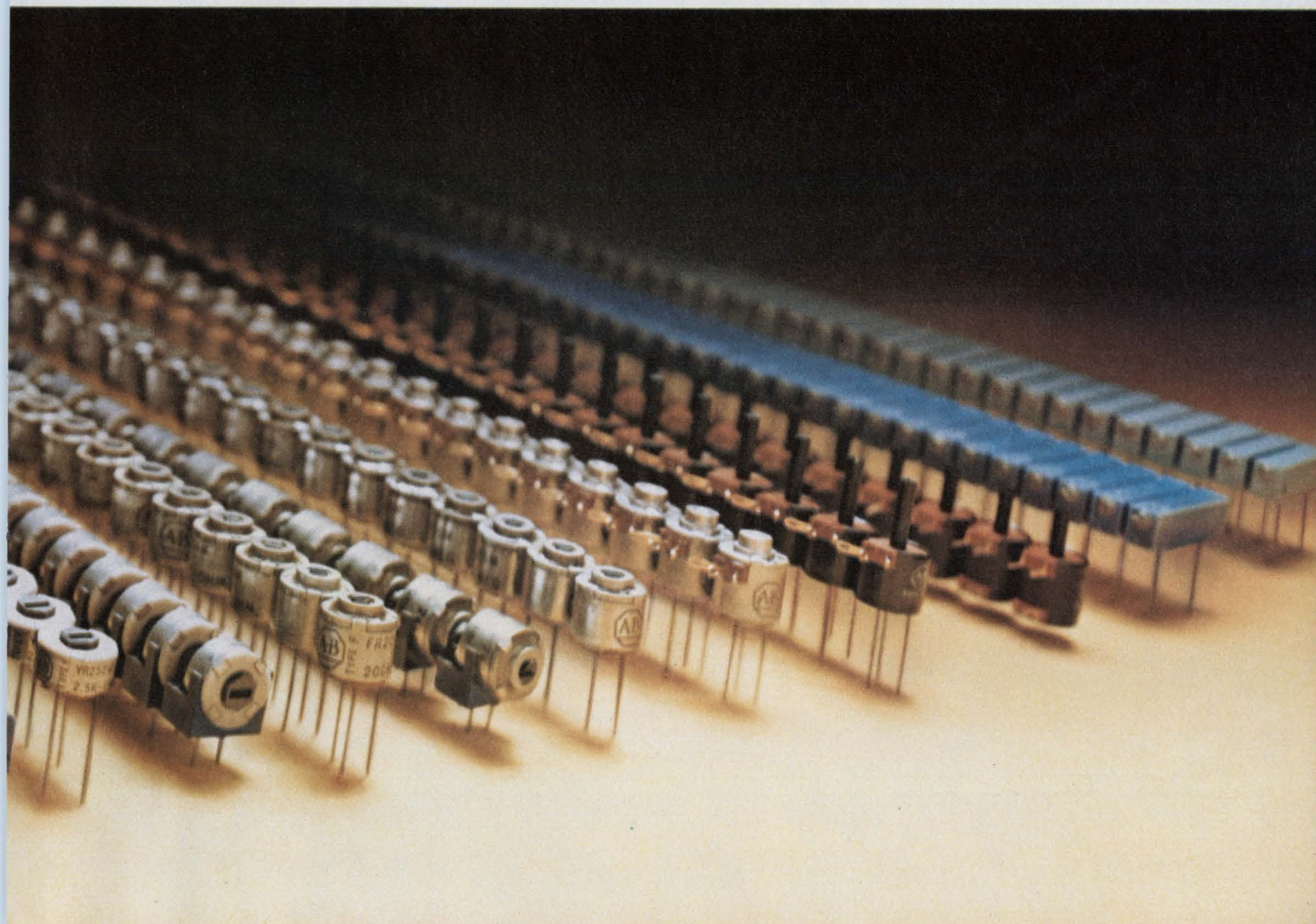
Type R: 1¼" long, 25 turn, 100 ohms to 2.5 megs ±10% or 20%, 0.25W at 70°C, immersion sealed, bushing mount option, Pub. 5205. **1000 piece price $2.87 to 3.73.**

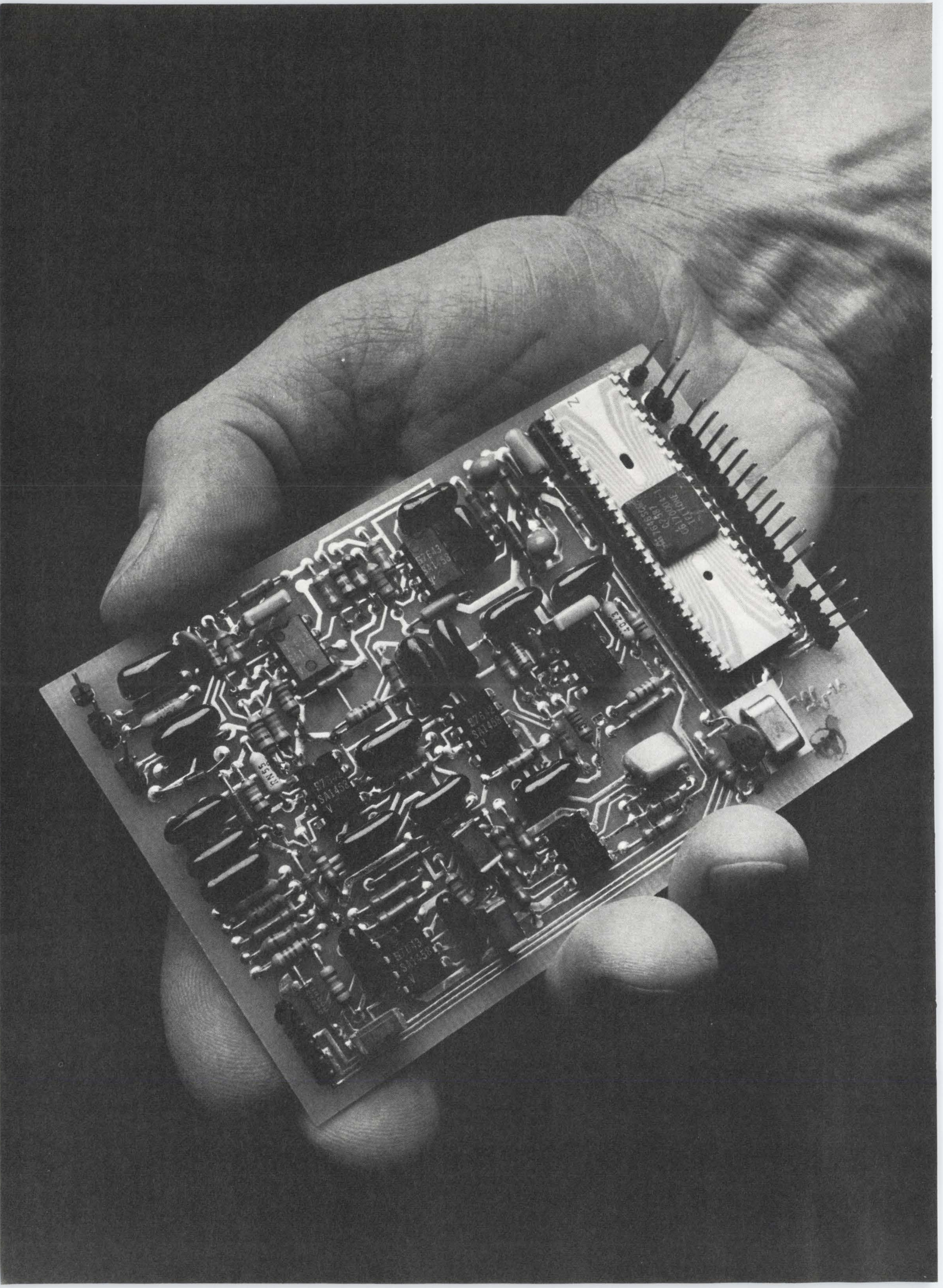
Quality in the best tradition.

ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

CIRCLE NUMBER 273

EC120





New MINIATURE HGW RELAYS from CLARE

Ideal when PCB space is limited
These new miniaturized mercury-wetted relays offer space-saving solutions for many applications in telecommunications, industrial controls, and computer peripherals. As systems become more sophisticated . . . and space comes at a premium . . . Clare's HGW series can fill the bill without filling unnecessary space.

Yes—smaller size
No—loss in contact rating
Although package size has been reduced, the contact ratings of the new HGW series offers the 100 VA rating and multi-billion operation reliability found in our popular HGSM series. So good things really do come in small packages. The voltage rating is 500 volts max. Current rating is 2 amps max switched, 5 amps max carry only. Contact resistance or impedance is 12 to 25 milliohms (within ±2) over the life expectancy of 20 x 10^9 operations at rated load with proper contact protection.

Choice of Form C or 2 Form C
Form C—HGWM. This form offers single side stable and bistable functions . . . with an insulation resistance of 1000 megohms.
2 Form C HGW2MT. This form offers the single side stable function with a common open time of 50 microseconds minimum. Insulation resistance is 10,000 megohms.
Both forms—have an operating and release time of 1.25 milliseconds maximum, switching up to 200 Hz . . . mount on standard 0.100″ grid patterns . . . are available with electrostatic shields.

For more information
The HGW relay series is available for immediate delivery through Clare's nationwide distributor network. For specific information and data, contact your local Clare Representative, or C.P. Clare & Company, 3101 W. Pratt Avenue, Chicago, Illinois 60645. Phone: (312) 262-7700.

C. P. CLARE & COMPANY
GENERAL INSTRUMENT CORPORATION

CIRCLE NUMBER 275

Switch to the LICON® LPB line...a spur to your imagination!

Your design ideas really *will* track better when you keep Licon LPB's in mind. With Licon's vast array of choices and options you're sure to find the switch you need quickly, save design time, and avoid frustration.

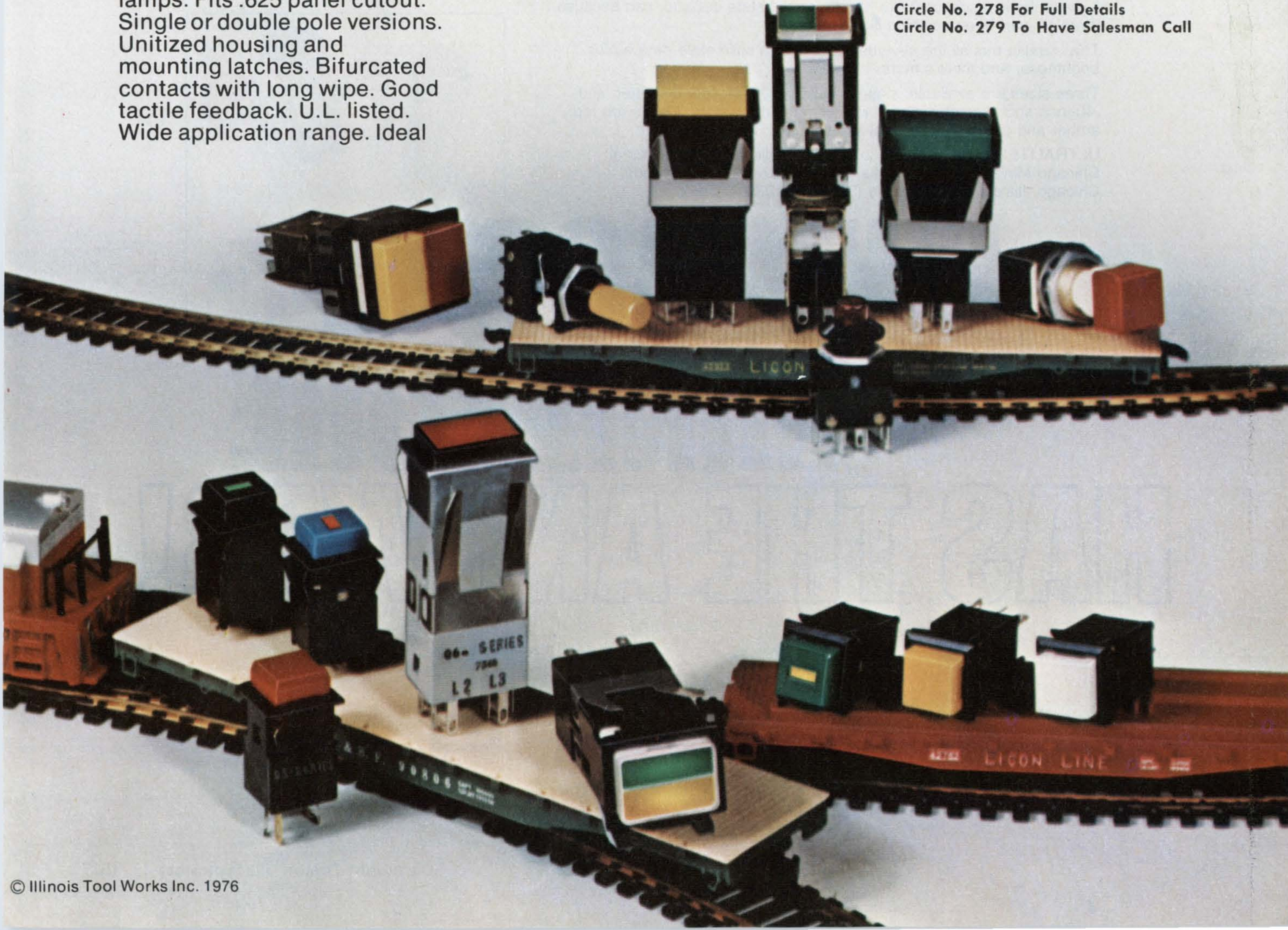
Take our Series 05 LPB's for example. These economical lighted or non-lighted low-level switching devices are available in seven lens cap colors, plus clear. Centrally-located red, yellow or green LED display, too. Excellent illumination with LED's or inexpensive T 1¾ wedge base lamps. Fits .625 panel cutout. Single or double pole versions. Unitized housing and mounting latches. Bifurcated contacts with long wipe. Good tactile feedback. U.L. listed. Wide application range. Ideal for low energy digital electronics switching.

Our Series 06 LPB's feature Licon's ultra-reliable double-break Butterfly® switches. One or two-lamp illumination. Over 200 display options. One light full screen. Two-light vertical split, horizontal split, or full-screen illumination. Solid color, projected color, insertable legend or hidden display. Use standard T 1¾ flange base lamps. Fits .70 x .920 panel cutout. U.L. listed, C.S.A. certified, and meets 3 mm terminal spacing requirements. Wide application range. Both Series 05 and 06 LPB's have standard PC or .110 quick-connect terminals.

Many other brilliant choices available in our amazing array of lighted and unlighted switches. Switch to us for best answers. Call or write for our Licon Switch Catalog: Licon, 6615 West Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040. TWX 910-221-0275.

LICON
A DIVISION OF ILLINOIS TOOL WORKS INC.

Circle No. 278 For Full Details
Circle No. 279 To Have Salesman Call



YOU CHOOSE THE WINNER

PROCESSOR	6/16	NOVA 3/4	PDP-11/04
Data Type Lengths (bits)	4,8,16,	16	1,8,16
Instruction Word Length (bits)	16,32	16	16,32,48
General-Purpose Registers	16	4	8
Hardware Index Registers	15	2	8
Maximum Memory Available (KB)	64	64	56
Directly Addressable Memory(KB)	64	2	56
Automatic Interrupt Vectoring	Standard	N/A	Standard
Parity	Optional	Optional	N/A
Cycle Time (nanoseconds)	600	800	725

PRICE	6/16	NOVA 3/4	PDP-11/04
8KB Processor	$2200	$2600	N/A
16KB Processor	$2800	$3200	$3795
32KB Processor	$4000	$4400	$4995
Multipy/Divide Hardware	$ 950	$1400	$1820

Interdata's 6/16 wins the battle of the specs.

Not only do we cost less than the Nova 3/4 and the PDP-11/04, we have more features. Just compare: 16 general purpose registers on the 6/16 to simplify programming and reduce fetches . . . only 4 in the Nova and 8 in the 11/04; 15 hardware index registers on the 6/16 against 2 for the Nova and 8 for the 11/04; 64 KB of directly addressable memory instead of just 2 KB for the Nova 3/4 and 56 KB for the PDP11/04.

What's more; all these hardware features enhance the nimble 6/16's performance. Its cycle time is only 600 nanoseconds, compared to 800 for the Nova and 725 for the 11/04.

Interdata's comprehensive software drives this powerful hardware full out. You get the field-proven OS/16 MT2, a real-time, multi-tasking operating system providing instantaneous response to events, while allowing the user to minimize memory by storing non-critical functions on disks. And the 6/16 can be programmed in your choice of FORTRAN, BASIC or MACRO CAL.

All this and save money too, as much as one-third less than a PDP-11/04 and substantially less on a Nova 3/4 . . . with OEM discounts saving even more.

Get the whole story. Just fill in the coupon or call (201) 229-4040.

Send me 1977 specs on your Model 6/16

NAME __________ TITLE __________

COMPANY __________

ADDRESS __________

CITY __________ STATE ______ ZIP ______

PHONE __________

INTERDATA®

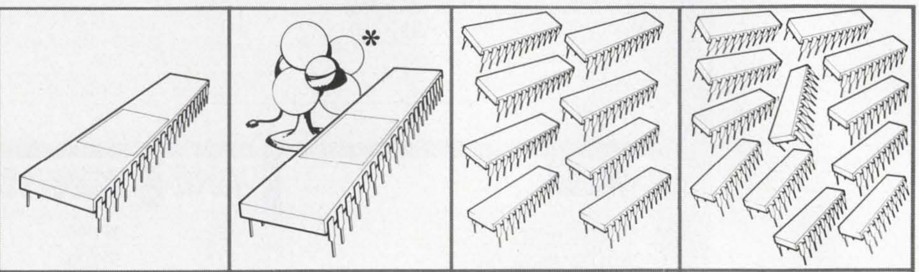
A UNIT OF

PERKIN-ELMER DATA SYSTEMS

Oceanport, New Jersey 07757, U.S.A. ED-9

CIRCLE NUMBER 51

Four ways to do 8 x 8 Multiplication



	MMI	TRW	AMD	TI
DEVICE	MMI 67558	TRW MPY-8	AMD 25S05 (FD 93S43)	TI (MSI) 74S274/5
ORGANIZATION	8 X 8	8 x 8	2 X 4	4 X 4
TYPICAL SPEED	100 NS	130 NS	75 NS	75 NS
POWER	1W	1.8 W	5W	5.4W
PACKAGE	40-PIN	40-PIN	24-PIN	20-PIN
NUMBER OF PACKAGES	1	1	8	12
TECHNIQUE	COMBINATORIAL (BOOTH)	COMBINATORIAL	COMBINATORIAL (BOOTH)	COMBINATORIAL (WALLACE)
ROUNDING	YES	YES	NO	NO
MFG. PROCESS	LS/TTL	TRIPLE DIFFUSION	S/TTL	S/TTL
SECOND SOURCE	YES	NO	YES	NO
DATA REP.	SIGNED and UNSIGNED	SIGNED ONLY	SIGNED ONLY	UNSIGNED ONLY
TOTAL $ — MIL	110	115	210	≈140
At 100 UP quantity — COM	64	70 (Fan not included.)	124	68

*300 fpm cooling required.

Europe
Monolithic Memories, GmbH
8000 Munich 80
Mauerkircherstr. 4
West Germany
Tel: (089) 982601, 02, 03, 04
Telex: (841) 524385

Far East
MMI Japan KK
Parkside-Flat Bldg.
4-2-2, Sendagaya Shibuya-Ku
Tokyo 151, Japan
Tel: (3) 403-9061
Telex: (781) 26364

United States
Monolithic Memories, Inc.
1165 East Arques Avenue
Sunnyvale, CA 94086
Tel: (408) 739-3535
TWX: 910-339-9229

(Second sourcing from ITT Semiconductor.)

For more information, phone, TWX or write.

Monolithic Memories

CIRCLE NUMBER 52

Three-digit bipolar voltmeter built with v/f converter and BCD counters

Convert voltage in the −10 to +10-V range to a frequency, count the pulses generated and provide the sign plus a three-digit BCD output with the circuit in Fig. 1. The v/f converter is a Burr-Brown VFC15 adapted to function over the voltage range with resistors R_1, R_2 and R_3. A reference voltage (V_{ref}) of 10 V must be applied to the converter's current input.

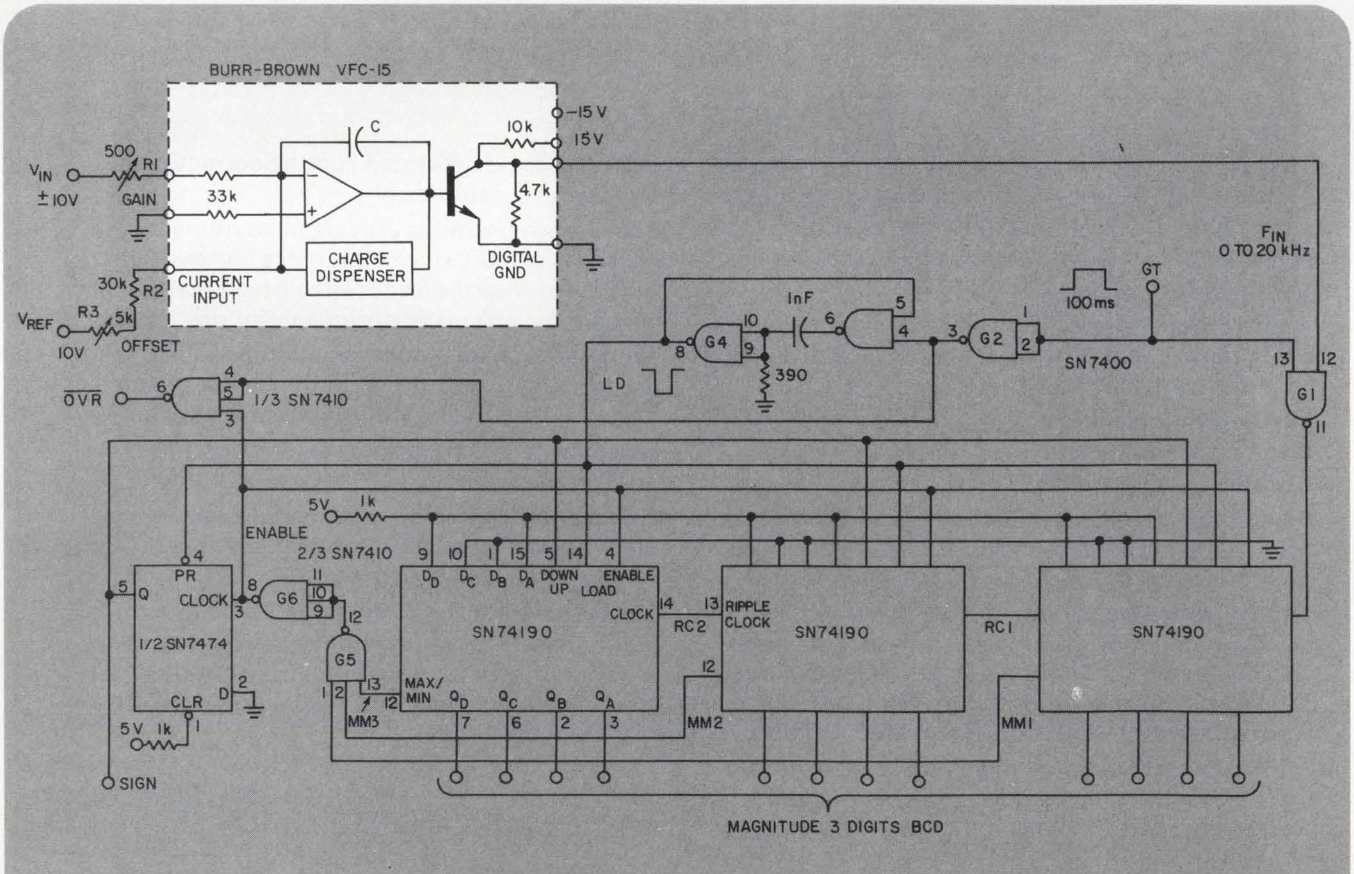
The v/f output frequency, which covers 0 to 20 kHz, feeds into three up/down SN74190 decade counters. The polarity sign is entered into a SN7474 flip-flop.

A measuring cycle begins at the positive edge of a 100-ms pulse fed to the input labeled GT. Gate G_1 allows the v/f output pulses (F_{in}) to enter the counter, and the pulse, LD, generated by the one-shot circuit, G_3/G_4, sets the BCD counters to 999 and the SGN output of the Sign flip-flop HIGH. A HIGH SGN sets the BCD counters to count down.

If the counters pass the 000 state, the Sign flip-flop is set LOW, and thereafter every clock-pulse increments the counters by one. After 100 ms, GT cuts off the F_{in} input to the counters, which then contain the value of the input voltage, V_{in}, in BCD code plus the sign of the input-voltage polarity.

If F_{in} is higher than the 20 kHz, the Enable signal generated via G_5 and G_6 blocks the counter at +999 and provides the $\overline{OVR}$ signal to indicate an out-of-range condition.

Pucka Stanislaw, 41-809 Zabrze, Sikorskiego 99, Poland CIRCLE NO. 311



1. A bipolar digital voltmeter measures ±10 V, which corresponds to the 0-to-20-kHz output from a v/f converter.

CIRCLE 251 FOR INFORMATION

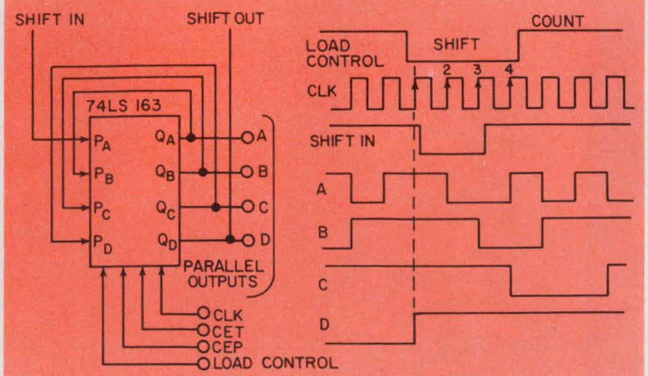
CIRCLE 252 FOR FREE DEMONSTRATION

Synchronous counter also shifts for serial/parallel conversions

Many logic circuits require that the output of a counter be converted to serial format. Also, a counter often must be loaded from a serial signal. Such parallel-to-serial and serial-to-parallel conversions, usually accomplished with a shift register, can be done without a shift register, if the counter is a synchronous, preloading type, such as the 74LS163.

When the 74LS163's load control is HIGH, it operates normally as a counter. However, when LOW, the counter can progressively transfer data at its preload inputs (P_A through P_D) to the outputs. Four clock cycles will load all stages of the counter with a serial input to P_A, and shift each of its stages progressively to the Q_d output (see figure).

Darryl Morris, Northeast Electronics, Airport Rd., Concord, NH 03301. CIRCLE NO. 312



Some counters can double as shift registers and simplify logic-circuit designs.

Demand power supply draws low standby current

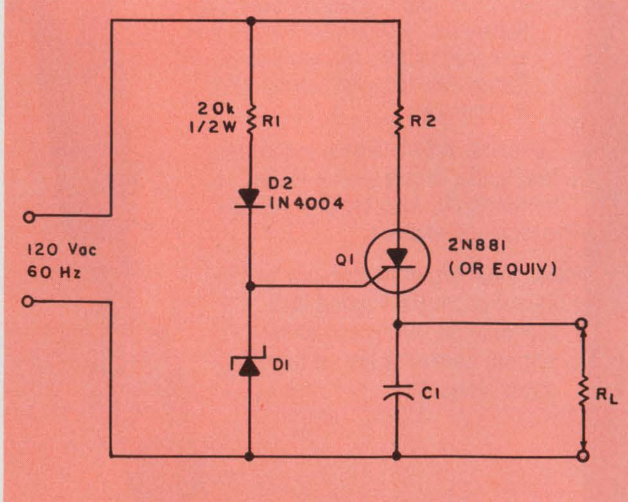
The inexpensive, simple power-supply circuit in the figure draws almost zero standby current and features a low component count and no power transformer.

Each positive half of a power cycle charges the storage capacitor, C_1, until its voltage equals the zener-diode reference voltage. At this point, the gate of the SCR reverse-biases and the SCR turns off at the end of a cycle. When the load draws current from the storage capacitor and the capacitor voltage falls below the zener voltage, the gate is forward-biased and the SCR turns on. When no load current flows, the output capacitor stays charged—the only current drain is through R_1 and the zener diode.

The circuit's relaxation-oscillator mode of regulation has one disadvantage: It imposes a low-frequency ripple on the output voltage. A large R_2C_1 time constant can limit this ripple. Of course, to minimize power loss, R_2 should be kept as low as possible.

George W. Masters, Teledyne Microelectronics, 12964 Panama St., Los Angeles, CA 90066.

CIRCLE NO. 313



Power is supplied on demand by this simple relaxation-oscillator power supply. The zener-diode reference, D_1, determines the output voltage and the time constant of R_2C_1 controls the amount of ripple.

Interface slows visual-display data for driving data-recording peripherals

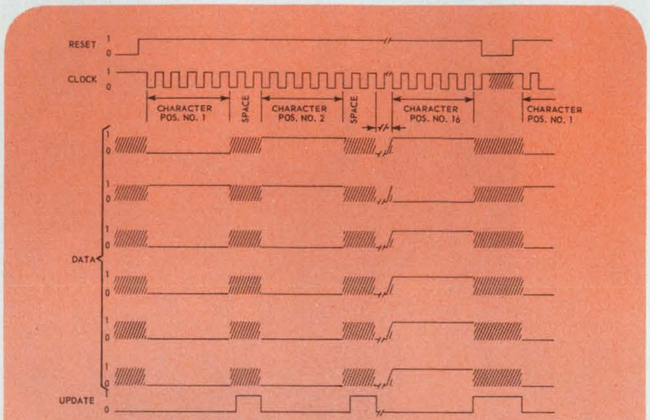
You can use the readout of data stored in a refresh-memory display to drive external data-recording devices such as paper-tape punches, incremental magnetic-tape recorders, impact printers and teletypewriters. But the data rate of a typical 16-character display, refreshed at 60 to 80 Hz, is 960 to 1280 char/s —too fast for such recording devices.

The timing diagram of such a refresh memory, 16-digit display (Burroughs Model SSD 1000-61) is shown in Fig. 1. To slow down the readout rate, the circuit in Fig. 2 reads out the first character from an initial frame of 16 characters, then reads the second character from a subsequent frame, and so on, until all 16 characters are clocked out.

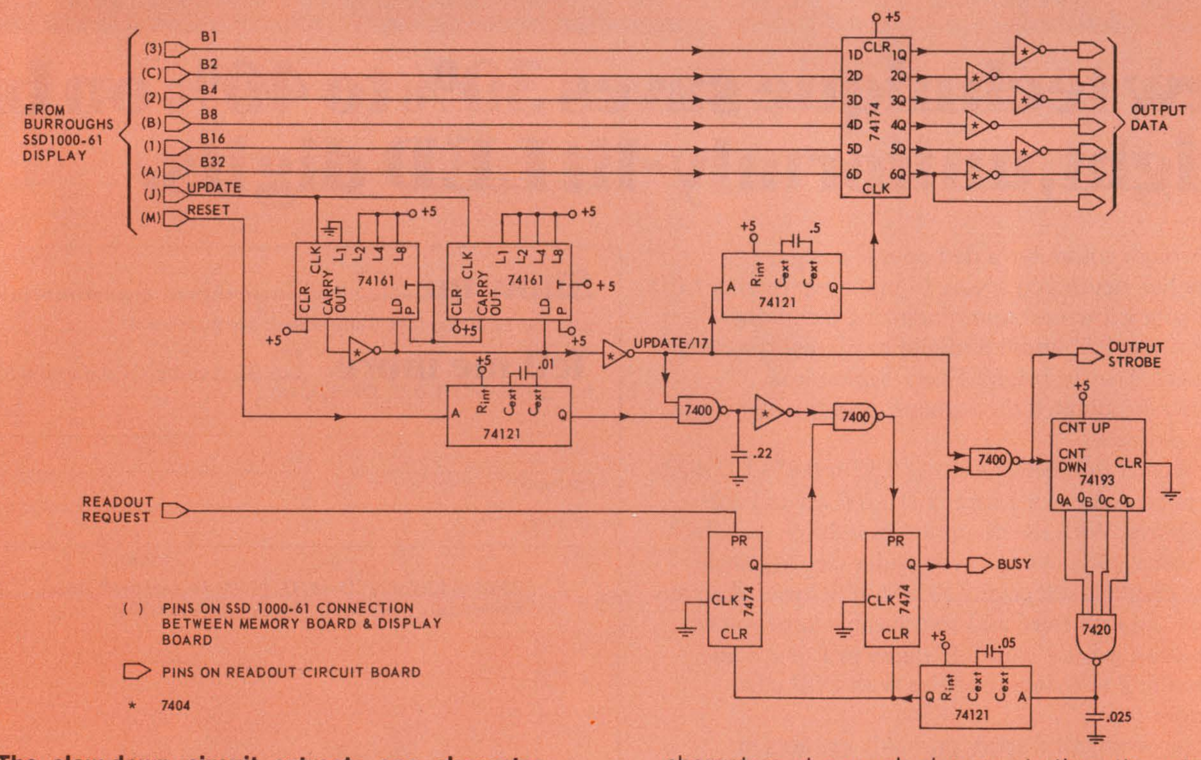
This sampling process uses a divide-by (16n + 1) circuit, where n is an integer between zero and 16 chosen to get the desired speed. For example, a divide-by-33 choice gives 29.1 to 39 char/s. In addition, the circuit provides the necessary counting, latching and gating to limit the output to 16 characters.

The refresh memory of the display, therefore, can become the storage medium for a single-task system, such as an automated weighing machine. The system can easily be constructed with a digital balance, a multiplexer to read digits from the balance into the display, a keyboard to enter identifying digits into the display, and the circuit in Fig. 2 to read data from the display to a paper-tape punch or incremental magnetic-tape recorder. Data on a tape can be processed subsequently as a batch job on a computer.

Stephen A. Oliva, Captain, U.S. Army, Armed Forces Radiobiology Research Institute, Bethesda, MD 20014. CIRCLE NO. 314



1. The Reset and Update pulses from the timing diagram of this visual-display refresh-memory system are used to synchronize the slow-down circuit for hard-copy readout.



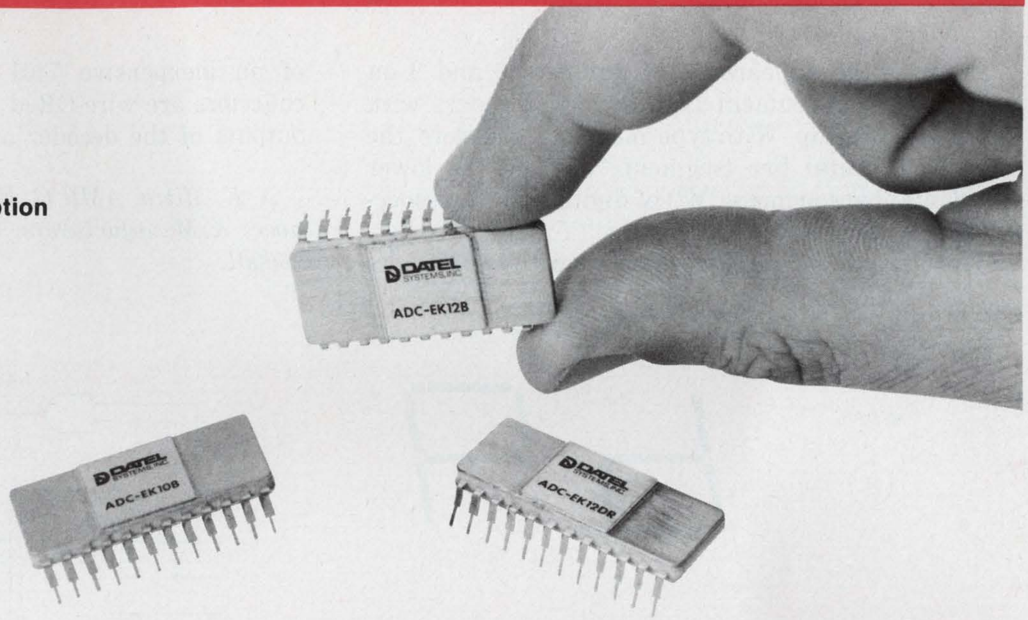
2. The slow-down circuit extracts one character each from one or more frames to obtain the 16 characters at a much slower rate than the original visual-refresh rate of 960 to 1280 char/s.

Datel's Monolithic Integrating Analog to Digital Converters

ADC-EK SERIES

FEATURES

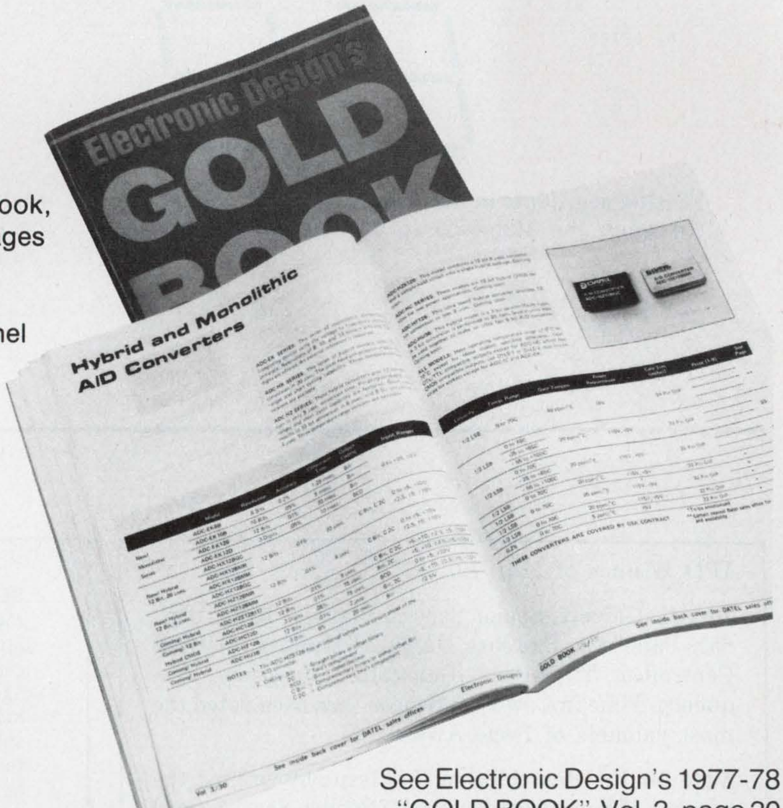
- ▶ Monolithic CMOS
- ▶ Binary or BCD Models
- ▶ 20mW Power Consumption
- ▶ To 12 Bit Accuracy
- ▶ No Missing Codes
- ▶ Priced from $11.50



You'll find complete specifications on this product and more than 300 data conversion circuits and systems in Gold Book.

Just check Gold Book's Volume 3. That's Datel's complete Engineering Product Handbook, in its own separate volume. More than 290 pages of D/A & A/D Converters, Multiplexers, Sample-Holds, Op Amps, Power Supplies, Digital Panel Meters, and Printers, Digital Panel Instruments, Data Loggers, Digital Cassette Recorders, and Data Acquisition Systems. Each fully detailed on individual data sheets.

And it's available to you in Gold Book.



DATEL SYSTEMS, INC.

1020 Turnpike St., Canton, MA 02021
Phone: (617) 828-8000

See Electronic Design's 1977-78 "GOLD BOOK"-Vol. 3, page 30

Santa Ana, CA (714) 835-2751, (L.A. Exchange) (213) 933-7256 • Sunnyvale, CA (408) 733-2424 • Gaithersburg, MD (301) 840-9490
OVERSEAS: DATEL (UK) LTD–TEL: ANDOVER (0264) 51055 • DATEL SYSTEMS SARL 620-06-74 • DATELEK SYSTEMS GmbH (089) 78-40-45

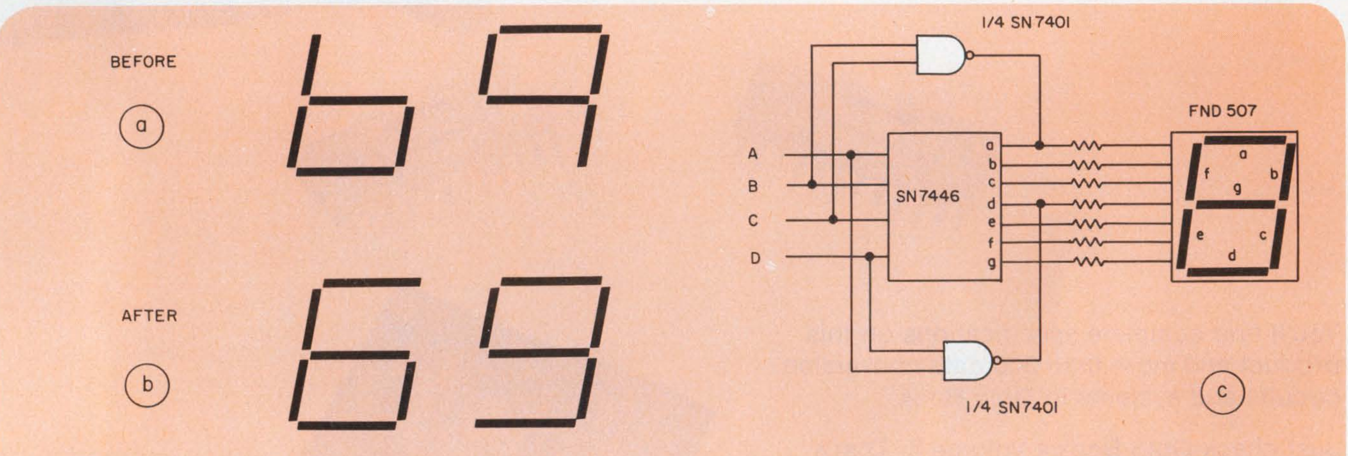
CIRCLE NUMBER 56

Add missing segments to 6 and 9 on standard seven-segment decoders

Improve the appearance of numbers 6 and 9 on standard seven-segment LED-display decoders with half a NAND chip. With type 7446/7447 decoders, the upper horizontal bar (segment "a") and the lower horizontal bar (segment "d") of digits 6 and 9, respectively, do not glow.

You can add the missing segments with two circuits of an inexpensive 7401 quad NAND. Their open collectors are wire-ORed to the "a" and "d" segment outputs of the decoder as shown in the figure.

A. K. Mitra, AMICO, Electrical & Electronic Engineers & Manufacturers, 20 Strand Road, Calcutta - 700001. CIRCLE NO. 315



Missing segments in numbers 6 and 9 (a) are added (b) when the standard seven-segment decoder is modified with two wire-ORed NANDs (c) to improve the appearance of the numbers.

IFD Winner of May 10, 1977

Rex C. Geivett, Senior Service Planner, IBM Corp., 6519 Pajaro Ct., San Jose, CA 95120. His idea "Crystal-Controlled Time-Base Generator Measures Frequency/Time in Low-Cost Scopes" has been voted the most valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number of your selection on the Reader-Service 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.

Datel's Low Cost, Digital Panel Printer

MODEL DPP-7

- **Thermal 7-Segment Printhead uses no ink, hammers, or printwheels.**
- **Panel-mounting, featherweight 2.3 lb. (1,1 kg)**
- **6-Digit and polarity sign formats available with optional hexadecimal.**
- **AC line power or +5, +12 or +28 VDC**
- **Includes all BCD TTL full parallel electronics plus input storage register for multiplexed bussing.**
- **Selectable positive/negative true data and controls logic coding.**

COVERED BY GSA CONTRACT

You'll find complete specifications on this product and more than 300 data conversion circuits and systems in Gold Book.

Just check Gold Book's Volume 3. That's Datel's complete Engineering Product Handbook, in its own separate volume. More than 290 pages of D/A & A/D Converters, Multiplexers, Sample-Holds, Op Amps, Power Supplies, Digital Panel Meters, and Printers, Digital Panel Instruments, Data Loggers, Digital Cassette Recorders, and Data Acquisition Systems. Each fully detailed on individual data sheets.

And it's available to you in Gold Book.

DATEL SYSTEMS, INC.
1020 Turnpike St., Canton, MA 02021
Phone: (617) 828-8000

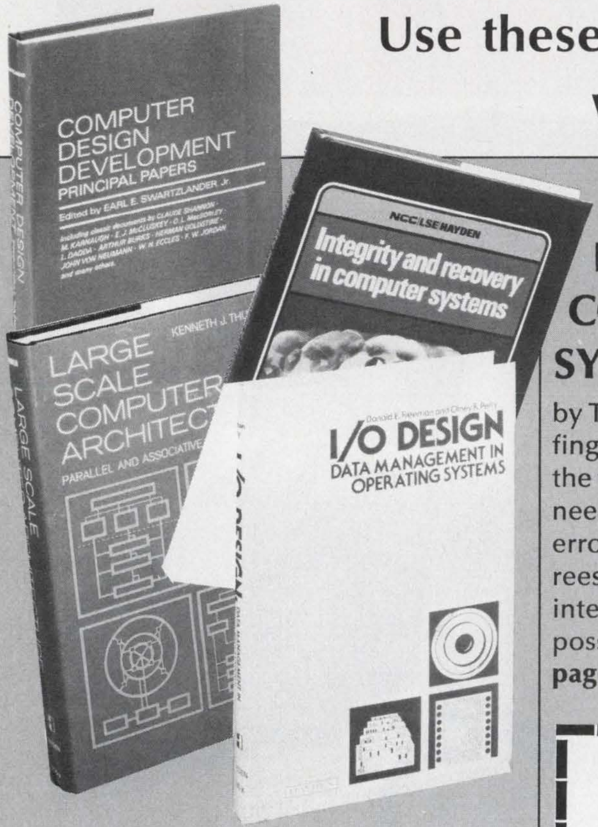
See Electronic Design's
1977-78 "GOLD BOOK"—Vol. 3 page 246

• Santa Ana, CA (714) 835-2751, (L.A. Exchange) (213) 933-7256 • Sunnyvale, CA (408) 733-2424 • Gaithersburg, MD (301) 840-9490

CIRCLE NUMBER 57

How they work on the job is the ultimate test

Use these fine books for 15 days without charge!



INTEGRITY AND RECOVERY IN COMPUTER SYSTEMS

by T. K. Gibbons. Places at your fingertips in step-by-step fashion all the techniques and strategies you need for locating and correcting errors and failures and for reestablishing complete system integrity and reliability as quickly as possible. **#5454-8, cloth, 144 pages, $9.95**

COMPUTER DESIGN DEVELOPMENT: Principal Papers

edited by Earl E. Swartzlander. Gathers together the original papers that heralded the major achievements in logic design, arithmetic algorithms, and computer arithmetic. The coverage progresses from basic design concepts to small subsystems to complete computing systems. **#5988-4, cloth, 320 pages, $13.95**

I/O DESIGN: Data Management in Operating Systems

by Donald E. Freeman and Olney R. Perry. Details the many I/O system and subsystem designs in use today allowing you to design your systems with more confidence and accuracy. **#5789-X, cloth, 384 pages, $17.50**

LARGE SCALE COMPUTER ARCHITECTURE: Parallel and Associative Processors

by Kenneth J. Thurber. A rare and comprehensive reference covering both general theory and practical applications of the main systems currently in operation. **#5775-X, cloth, 352 pages, $18.95**

ORDER FORM

15-Day money-back guarantee

Please send me the books checked below to read and use FREE for 15 days. At the end of that time, I will send payment, plus handling and postage, or return the book(s) and owe nothing. On all prepaid orders, publisher pays postage. Prices are subject to change without notice. Offer good in U.S.A. and Canada only.

☐ #5454-8 **Integrity and Recovery in Computer Systems** . . . . . $ 9.95
☐ #5789-X **I/O Design** 17.50
☐ #5775-X **Large Scale Computer Architecture** 18.95
☐ #5988-4 **Computer Design Development** 13.95

NAME ____________________
COMPANY ____________________
ADDRESS ____________________
CITY/STATE/ZIP ____________________

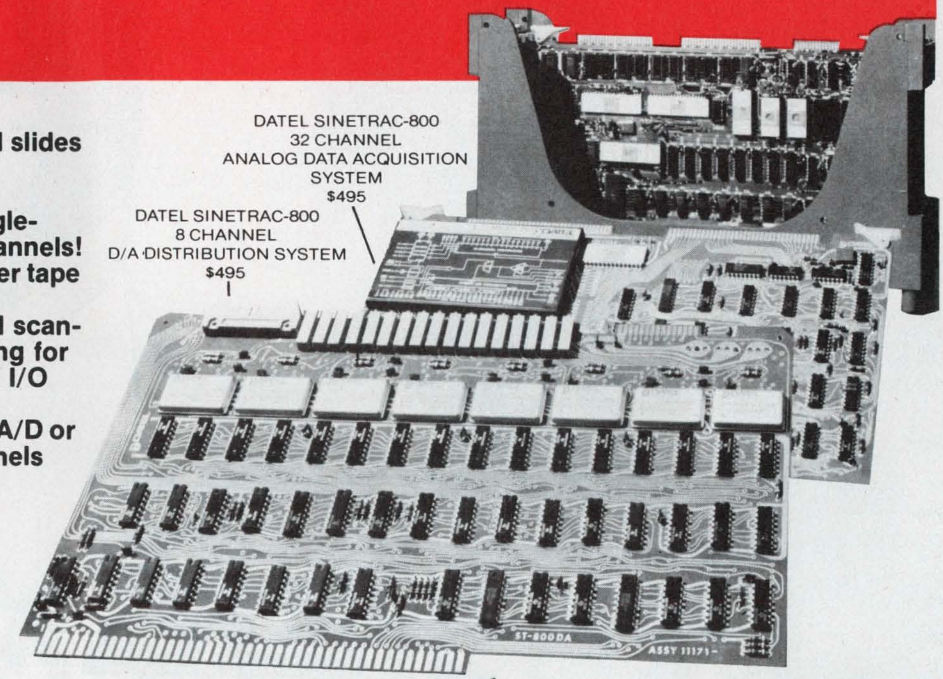
77-6

Send to: **Hayden Book Company, Inc.**
50 Essex Street
Rochelle Park, New Jersey 07662

You'll learn a lot from HAYDEN — your computer science publisher

Datel's 8080 A/D-D/A Advantage

SINETRAC 800



- **32 channel A/D - D/A input card slides directly into Intel's MDS-800 or SBC-80/10/20 Microcomputers.**
- **Only 2 cards needed for 80 single-ended or 64 differential A/D channels!**
- **Super-software supplied on paper tape with full listings in manuals.**
- **On-board channel counters and scan-timers reduce CPU housekeeping for fastest speed: True 40 kHz total I/O rate using DMA.**
- **Expandable in increments of 48 A/D or 8 D/A channels up to 256 channels each.**

COVERED BY GSA CONTRACT

You'll find complete specifications on this product and more than 300 data conversion circuits and systems in Gold Book.

Just check Gold Book's Volume 3. That's Datel's complete Engineering Product Handbook, in its own separate volume. More than 290 pages of D/A & A/D Converters, Multiplexers, Sample-Holds, Op Amps, Power Supplies, Digital Panel Meters, and Printers, Digital Calibrators, Data Loggers, Digital Cassette Recorders, and Data Acquisition Systems. Each fully detailed on individual data sheets.

DATEL SYSTEMS, INC.
1020 Turnpike St., Canton, MA 02021
Phone: (617) 828-8000

See Electronic Design's 1977-78 "GOLD BOOK"-Vol. 3, page 141

Santa Ana, CA (714) 835-2751, (L.A.) (213) 933-7256 • Sunnyvale, CA (408) 733-2424 • Gaithersburg, MD (301) 840-9490 • Houston, TX (713) 932-1130
OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264) 51055 • DATEL SYSTEMS SARL 620-06-74 • DATELEK SYSTEMS GmbH (089) 78-40-45

CIRCLE NUMBER 59

Mi chiquita, si...mi C-Meter, no.

Don't ask. This man isn't going to compromise. He knows that the pushbutton speed, high accuracy (0.1%), compact size and versatility (0.1 pf to 0.2 farads) make him faster on the draw than any reactionary still shaping up circuits by measuring resistors.

With the C-Meter®, you'll measure capacitors as standard operating procedure. You'll waste no time twiddling and nulling, and you'll cut the need for costly tight-tolerance capacitors or tweak pots. You'll be as speedy as Gonzales... and popular too. People just can't keep their hands off the C-Meter.

You owe it to yourself to try one. Our reps are friendly and stock them at **$289.**

Capacitors supplied by Apollo Electronics, Inc.

ECD CORP.
196 Broadway, Cambridge
Mass. 02139 (617) 661-4400

CIRCLE NUMBER 60

SALES OFFICES: AL, Huntsville (205) 533-5896; AZ, Scottsdale (602) 947-7841; CA, Costa Mesa (714) 540-7160; CA, Sunnyvale (408) 733-8690; CO, Denver (303) 750-1222; FL, Winter Haven (813) 294-5815; GA, Chamblee (404) 457-7117; IL, Elk Grove Vill (312) 593-0282; IN, Indianapolis (317) 293-9827; MD, Silver Spring (301) 622-4200; MA, Wakefield (617) 245-5940; MN, Minneapolis (612) 781-1611; MO, Kansas City (816) 358-7272; So. NJ/Philadelphia (215) 674-9600; NM, Albuquerque (505) 299-7658; NY, Great Neck (516) 482-3500, (212) 895-7177, Syracuse (315) 446-0220; NC, Raleigh (919) 787-5818; OH, Centerville (513) 433-8171; TX, Houston (713) 688-9971; TX, Richardson (214) 231-2573.

Powerful oscillators are very efficient, too

Gunn oscillators that produce a peak power of 120 W with an efficiency of 18% at 5 GHz (C band) have been developed by Standard Telecommunication Laboratories of Harlow, England.

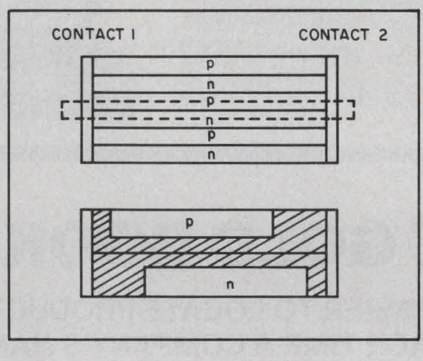
The devices are made from indium phosphide and have an active-layer thickness of 34 μm and a low-field resistivity of about 2 Ω-cm. The substrate of the indium slice is lapped until it is about 120 μm thick. Metal contacts of 90% silver and 10% tin are then evaporated on both sides and alloyed in hydrogen at 500 C. Standard photolithographic etching forms mesa devices.

The cathode has a current-limiting action as a result of the Schottky barrier formed at the metal-indium phosphide interface. The device must be operated in forward-bias conditions.

Peak powers of 100 to 120 W with 15 to 18% efficiency are produced in the 140 to 150-V bias range. For this bias-voltage range, the operating frequency decreases at about 3.5 MHz/V. The devices usually avalanche if the bias exceeds 160 V. The output frequency also decreases with increasing temperature. Typical values are 5.3 GHz, 5.1 GHz and 4.7 GHz at −40, 25 and 80 C, respectively.

Varactor has wider capacitance range

A varactor structure that yields a much greater variation of capacitance with voltage than a conventional varactor diode has been developed at Osaka University, Japan. The device consists of alternating layers of n-type and p-type silicon as shown in Fig. 1. A pair of n and p layers forms a unit structure indicated in Fig. 1 by broken lines and shown in detail in Fig. 2.



With contact 1 biased negatively with respect to contact 2, contact 1 is reverse-biased in the n region while contact 2 is reverse-biased in the p region. By suitably choosing the electron barrier heights, most of the voltage drop will occur across the reverse-biased junctions, where the depletion widths increase with bias voltage.

Because the junction between the n and p regions in each unit structure is also reverse-biased, a widening of the depletion region also takes place perpendicular to that which occurs at the metal-semiconductor interface. This bias voltage affects the depletion region in two dimensions and the larger variation of capacitance with bias voltage occurs.

Prototype 1.25-mm long × 0.14-mm wide devices have been made having a p-n junction diffusion potential of 0.52 eV. The capacitance/voltage curves of the Osaka diode (with a linear doping profile and gold contacts) reveals that the sensitivity of the capacitance to bias voltage variations (λ) lies between 0.4 and 0.6. In the curves the capacitance was normalized to its zero bias value.

In contrast, C/V measurements from a conventional varactor diode using the same materials show a lower γ, a higher capacitance and, unlike the new device, is not symmetrical about the zero bias point.

For frequency multiplication applications, the new varactor structure is more efficient as a result of its greater nonlinearity.

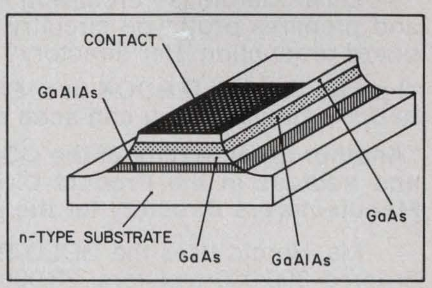
Superluminescent diode has narrow line width

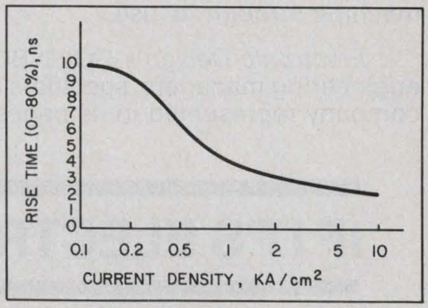
A superluminescent diode (SLD) for optical communication systems can be pulse-modulated up to 250 MBits/s. With a narrower spectral output than a LED, it can carry data over longer lengths of fibers.

For high-bit-rate optical systems, solid-state lasers provide the best performance because they have the narrowest spectral linewidth, but they are expensive. LEDs, on the other hand, provide a low-cost solution, but typical linewidths are only about 40 nm. The SLD, developed by researchers at the Munich University in West Germany, is an excellent compromise with its 10-nm linewidths.

The SLD is based on a mesa-type structure (Fig. 1). The substrate is n-type gallium arsenide and is 300 to 1000 μm long. It consists of four layers: (1) tellurium-doped, n-type gallium aluminum arsenide, (2) undoped gallium arsenide, (3) germanium-doped, p-type gallium aluminum arsenide, and p-type gallium arsenide.

The mesa stripe is made longer than the contact length, providing sufficient loss to prevent lasting action. Linewidths of 10 nm were obtained with current densities above 5 kA/cm². Rise times below 2 ns can be achieved above this level. The SLD light output vs drive current is highly nonlinear.





I PREFER THE GOLD BOOK *OVER EEM...*

IT'S EASIER TO HANDLE...EASIER TO LOCATE PRODUCTS AND PHONE NUMBERS ARE LISTED EACH TIME A COMPANY'S NAME APPEARS

Lillian Herold is Purchasing Manager, Kantz Electronics Industries, Clifton, New Jersey. Kantz designs and prepares prototype circuitry for printed circuit boards and provides manufacturing facilities for PC board production. Her directory? *Electronic Design's* GOLD BOOK.

"I prefer the GOLD BOOK over EEM because it's easier to handle. The print is easier to read, too, and it's better organized. You can scan quickly to find what you need.

"Another great feature of the GOLD BOOK is that phone numbers are listed with each company's name and address in the Product Directory. With EEM I have to take the extra step to refer back to the Manufacturers Directory for the phone listing."

Ms. Herold uses the GOLD BOOK about 15 times a week. Among other purchases, she has recently ordered 300,000 resistors, 20,000 sockets, solder bars, a wave soldering machine and an axial forming machine through its use.

Electronic Design's GOLD BOOK is working for advertisers because it's working for 90,000 engineers, engineering managers, specifiers and buyers — like Ms. Herold — throughout the U.S. and overseas. Is your company represented in its pages?

IF IT'S ELECTRONIC...IT'S IN THE GOLD BOOK!

"Last year, we repatriated $800,000 in tax-free profits from Puerto Rico. What a place for U.S. manufacturers."

In seven years, Harold R. Frank's magnetic tape head operation in Carolina, Puerto Rico, accumulated $800,000 in tax-free profits.

Read his story. See how you can repatriate your profits tax-free—from a plant in Puerto Rico. Then mail the coupon.

Harold R. Frank is President and Chairman of Applied Magnetics based in Santa Barbara, California. The company makes a wide range of sophisticated electronics products. And plans to manufacture two new product lines in Puerto Rico.

"So much has happened since 1969 when we opened Applied Magnetics of Puerto Rico.

"The Economic Development Administration (Fomento) helped us find a factory shell in the town of Carolina. We started out with 2,000 sq. ft. and only about a dozen workers.

"Today, that plant has 11,200 sq. ft. and we employ some 120 people.

100% tax exemption

"Of course, U.S. Federal taxes on corporate income simply don't apply in Puerto Rico. And all profits are free from Puerto Rican corporate income and property taxes as well as local license fees for your entire exemption period.

"So, in effect, we actually had a 100% tax-free situation until our exemption period was up. How successful have we been?

38% of worldwide profit

"Last year, our tax-free Puerto Rican operation contributed 38% *of our worldwide profit*—with only a small portion of our total space.

"Following procedures set down in Puerto Rican law and the U.S. Internal Revenue Code, we liquidated Applied Magnetics of Puerto Rico, Inc.

"That left us free to transfer the accumulated $800,000 in profits back to the parent company in California before our tax-exemption period was up. So we paid *no tax of any kind* on our repatriated income."

Note: Under the U.S. Tax Reform Act of 1976, you may repatriate profits free of taxes at the end of your exemption period of 10 to 30 years, or, pay only a 7% to 10% tax to Puerto Rico and repatriate your profits any time—without liquidating your company.

New product lines planned

"Now we have a disc head operation on the Island. Applied Magnetics Caribe, Incorporated.

"We're also equipped to manufacture computer memories. And plan to produce two new product lines—also with 100% tax exemption.

"But there's more to Puerto Rico than tax incentives.

Highly skilled workers

"With the help of grants from Fomento, we've trained our Puerto Rican workers to fashion components with tolerances as low as three-millionths of an inch.

"We found the workers quick to learn and sticklers for detail.

"Another plus about Puerto Rico is transportation.

"We ship almost completely by airfreight. We can choose from hundreds of flights leaving San Juan every week. And the Island itself is centrally located to service our customers on the U.S. mainland, Europe, and Japan.

"There's no question in my mind that manufacturing our products in Puerto Rico has been a rewarding experience."

For all the facts on what 100% tax exemption and repatriation of profits can mean to *your* bottom line, mail the coupon.

For immediate information

Call our industrial representative nearest you. New York: (212) 245-1200; Atlanta: (404) 577-7345; Boston: (617) 262-1310; Chicago: (312) 565-0910; Los Angeles: (213) 553-6393; Dallas: (214) 387-0267.

Tell me more—free!

Puerto Rico
Economic Development Administration
Dept. ED-4, 1290 Ave. of the Americas
New York, N.Y. 10019

I'd like full details on how I can keep *all* the profits I make and repatriate them tax free with a plant in Puerto Rico.

Please send me a free copy of your "Profile of Puerto Rico's Electrical and Electronic Industries." *Plus* "Tax Reform Highlights" (on repatriation of profits).

The products I might be interested in manufacturing in Puerto Rico are:

____

Name________________

Title________________

Company________________

Address________________

City________________

State________ Zip________

You're in good company in Puerto Rico, U.S.A. THE ALLEN GROUP • AMP • CENTRONICS • COIN ACCEPTORS • COMMUNICATIONS TECHNOLOGY • DIGITAL EQUIPMENT • DOCUMATION • DYNAMIC INSTRUMENT • ECONOMICS LABORATORY • GENERAL MONITORS • GOULD • GTE SYLVANIA • KELVIN ELECTRIC • MATSUSHITA ELECTRIC • MOTOROLA • POTTER INSTRUMENTS • RCA • TECHNICON • TRACOR • UNION CARBIDE

CIRCLE NUMBER 62

If you haven't had a Model 3500 demo yet here are 7 reasons why you should.

Data Precision's Model 3500 5½ digit multimeter gives you more at reduced costs.

1. BCD Output and Digital Control

Parallel BCD output and digital control signal capability at *no extra cost.*

2. Ratio Measurements

DC/DC and AC/DC ratio measurement capability at *no extra cost.*

3. High Normal Mode and Common Mode Rejection

Model 3500 performance is significantly more effective in rejecting normal mode and common mode signals up to 80dB NMRR and up to 160dB CMRR.

4. Hi-Frequency Measurements

The Model 3500 AC voltage measuring capability is specified up to 100KHz.

5. High and Low Range ACV Measurement Capability

Provides a measurement capability of AC voltages on 5 range scales, including the low scale with 1μV resolution and a high scale to 700 volts RMS.

6. Zero Stability

Model 3500 incorporates Tri-Phasic ™ autozeroing performance eliminating the need for zero adjustment between measurements on any range and any function.

7. Price

High quality performance and accuracy for $995 complete.

The Model 3500 has a 6 months basic DC accuracy of ±0.007% of reading ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 Megohms resistance, 20% overranging and an easy-to-read ½ inch planar display.

The Model 3500 also features our Tri-Phasic ™ conversion cycle, Ratiohmic ™ resistance mode, and Isopolar ™ referencing, circuit techniques that increase performance and decrease price.

To arrange an immediate demonstration or for technical data contact: Data Precision, Audubon Road, Wakefield, MA. 01880 (617) 246-1600. TELEX (0650) 949341.

DATA PRECISION

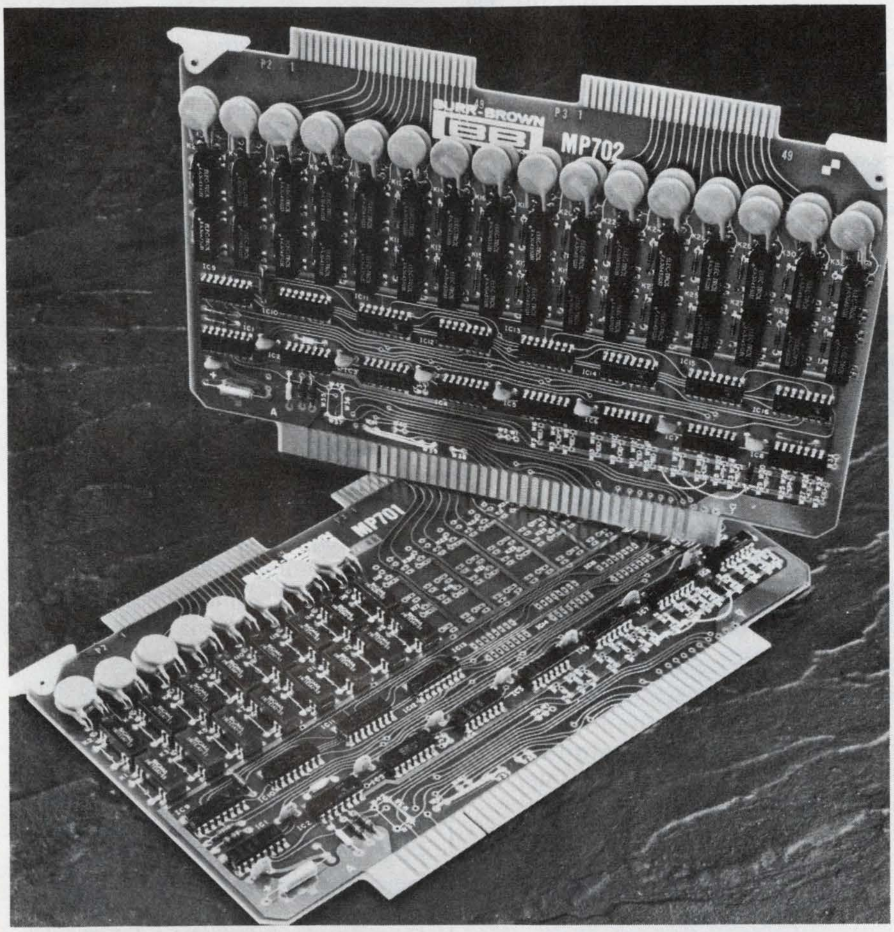
...years ahead

VISIT US DURING WESCON, BOOTH NUMBERS 1554 1556 1558

CIRCLE 241 FOR DEMONSTRATION

CIRCLE 242 FOR ADDITIONAL INFORMATION

Analog I/O cards for industry plug into Motorola 6800



Burr-Brown Research Corp., P.O. Box 11400, Tuscon, AZ 85734. C. R. Teeple (602) 294-1431. P & A: See text.

Burr-Brown, the first to make analog peripheral boards that are plug-compatible with Motorola's 6800 microcomputer systems, is now the first to orient such boards to industrial applications.

The MP701 is a 16-channel relay-output board, and the MP702, a 32-channel. The MP7608 is an eight-channel analog-input board. Both relay-output boards feature 300-V dc channel-to-channel isolation and 600 V dc isolation to the computer bus. All three boards operate directly from the 6800's +5 V dc and ±12 V dc power-supply buses.

Output power for both the MP701 and MP702 is rated at 10 VA per channel. A metal-oxide varistor protects the dry relay contacts when they switch inductive loads. The reeds are rated at 10^6 operations each.

The MP7608 features 12-bit a/d conversion accuracy. Normally, it is configured to accommodate direct voltage inputs from strain gauges and resistive temperature devices (RTDs). Sensing bridges and excitation voltages are provided on board.

The birdge-reference voltage is derived from the same source as the a/d converter reference—this reduces the effects of drift with time and temperature. Each channel is overvoltage-protected to 200 V.

Input-voltage bridges are replaced with precision-dropping resistors in a current-input option, the MP7608-I, which provides input for 4 to 20-mA loop signals. Fast-acting fuses protect the 250-Ω resistors from excess current surges that might affect their 0.01% accuracy. Inputs are RC-filtered to 10 Hz.

Both series of boards are memory-mapped and assigned specific addresses at the factory. The supporting 6800 software is claimed to be simple —only two instruction steps are required to change the state of as many as eight output channels, according to Burr-Brown.

Prices of the 16-channel MP701 output board are $295 in lots of 1 to 9 and $265 in 10 to 24 lots. The MP702 costs $475 and $425 in the same quantities. Both versions of the MP7608 cost $595 and $535, respectively. Delivery is from stock.

Other firms supplying analog I/O boards for microcomputers include Analog Devices and Datel.

Analog Devices markets its RTI-1200 and 1220 series boards for Intel and Prolog card cages. By October, Analog Devices expects to be shipping its RTI-1230 series for the Motorola bus.

Datel manufactures an ST-800 family of analog I/O cards for Intel systems and several others for minicomputer systems. Datel, too, expects to be shipping Motorola-compatible cards in the near future.

Burr-Brown **CIRCLE NO. 302**
Analog Devices **CIRCLE NO. 303**
Datel **CIRCLE NO. 304**

Current monitor guards up to 50-A-ac lines

Logitek, Inc., 42 Central Ave., Farmingdale, NY 11735. (516) 694-3080. From $105; 4 to 6 wks.

Type CA and 1A ac-current-monitor modules constantly oversee ac lines and test for overcurrents in the 10-A range for military use and in the 50-A range for industrial use. Accuracies of 1% and 5% are standard. Both types feature 2 and 10-A contacts. Fixed or field-adjustable trip settings are available.

CIRCLE NO. 308

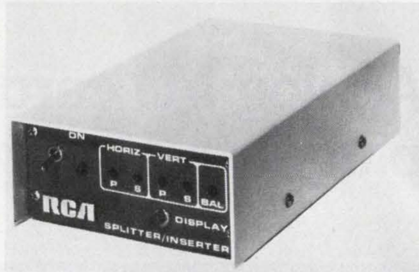
Tiny d/a converter follows A-law

Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. A. Chame (408) 246-9222. From $9 (100 qty); stock.

The DAC-87, a monolithic companding d/a converter, conforms to the CCITT exponential A-law characteristic. The unit features the dynamic range of a sign-plus-11-bit converter (66 dB) in a sign-plus-7-bit format. The device may be configured as an encoder, as a decoder, or may be time-shared as an encoder and decoder. The converter is meant for European A-law pulse-code-modulation systems. Significant features include: multiplying capability, true current-source outputs with −5 to +18-V compliance, 500 ns settling time and 141-mW consumption.

CIRCLE NO. 309

Display two cameras on one CCTV monitor



RCA, New Holland Ave., Lancaster, PA 17604. (800) 233-0153. $265; stock.

A closed-circuit-TV splitter/inserter, the TC1470, enables simultaneous display of video from two cameras on one monitor or recording of both on a single video tape recorder. The unit features front-panel-pushbutton selection of either the split or inserted display or either camera's full screen. With simple video wiring at the monitor you get a similar selection via the video cable. Front-panel screwdriver adjustments vary the horizontal and vertical size and position of the split/insert. The split or insert is outlined with black to provide clear visual separation and a front-panel balance control permits equalization of picture brightness. The master camera needs only a simple interlace because the splitter/inserter provides a vertical-drive output for the second camera.

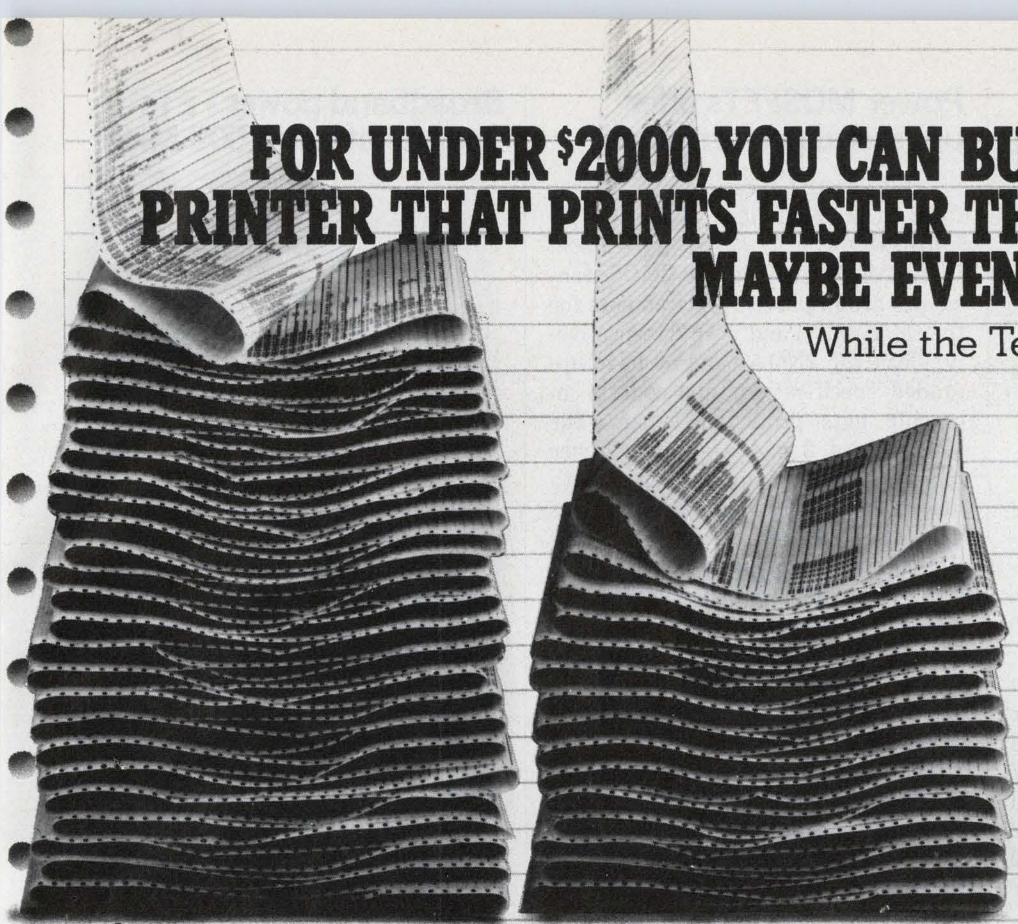
CIRCLE NO. 310

High-voltage op amp has speed, too

Burr-Brown, International Airport Industrial Park, Tucson, AZ 85735. D. Haynes (602) 294-1431. $70 (25-99 qty); stock to 4 wks.

At a gain of 100, the 3584 op amp boasts: 20-MHz min and 50-MHz typ gain × bandwidth; 150-V/µs typ slew rate; and 12-µs settling time to 0.1%. But the TO-3 hybrid must be compensated externally. The device operates with input power ranging from ±70 to ±150-V dc and swings its dc output between $\pm(V_{cc}-5)$ V. The unit's FET cascode input requires only 20-pA max-bias current. Other input specs include: 3-mV offset, 25-µV/°C input-offset drift and 110-dB CMR. Protected against output shorts; automatic thermal shut off.

CIRCLE NO. 320



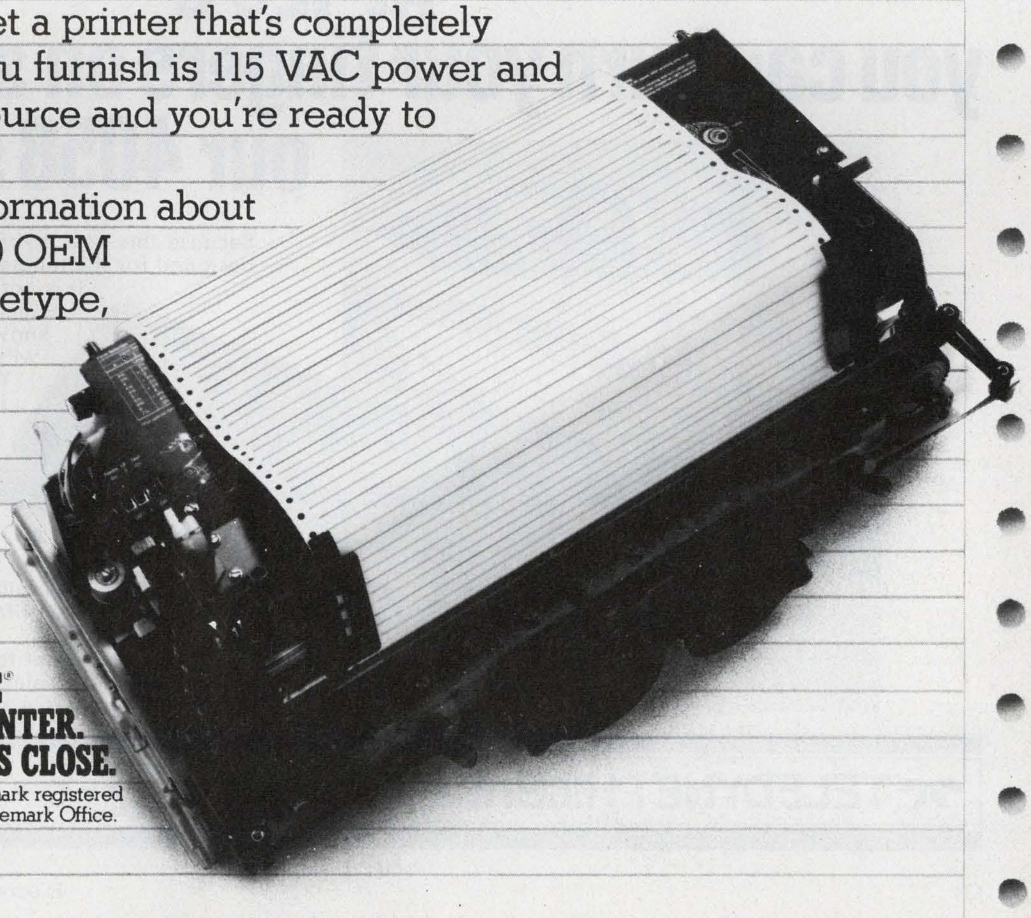
FOR UNDER $2000, YOU CAN BUY A 300 LPM PRINTER THAT PRINTS FASTER THAN 300 LPM. MAYBE EVEN 50% FASTER.

While the Teletype® model 40 132-column printers are rated at 300 lpm (monocase), that figure is somewhat misleading.

Actually, that's quite an understatement since the real printing speed lies somewhere between 300 and 500 lpm. We wish we could pin our speed down tighter, but throughput takes into consideration a couple of variables. Like different character type belts and an almost infinite number of data patterns.

But speed isn't all we offer for less than $2000. Because for that money you also get a printer that's completely operational. All you furnish is 115 VAC power and the serial signal source and you're ready to go on-line.

For more information about Teletype model 40 OEM printers, write: Teletype, Dept. 89-P, 5555 Touhy Ave., Skokie, IL 60076. Or call: 312/982-2000.

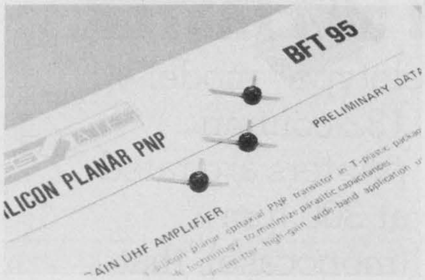


TELETYPE

THE TELETYPE® MODEL 40 OEM PRINTER. NOTHING EVEN COMES CLOSE.

CIRCLE NUMBER 65

Pnp transistors deliver linear outputs to 1 GHz



SGS-ATES Semiconductor, 79 Massasoit St., Waltham, MA 02154. Ruben Sonnino (617) 891-3710. \$4.80 (95) \$6.90 (96); samples from stock.

A pnp transistor, the BFT 96, is intended for common-emitter driver applications up to 1.5 GHz. It can deliver linear signals of up to 0.5 V across a 75 Ω load at 1 GHz. Housed in a T plastic package, the BFT 96 handles a collector-base voltage of −20 V, a collector-emitter voltage of −15 V and an emitter-base voltage of −3 V. Total dissipation is 500 mW, max.

CIRCLE NO. 321

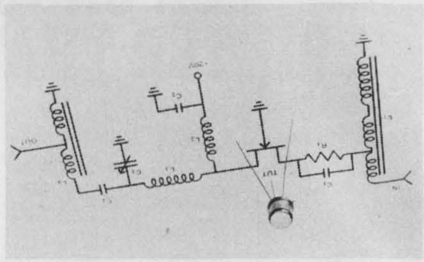
Power MOSFETs offer upgraded performance

Siliconix, 2201 Laurelwood Rd., Santa Clara, CA 95054. Jim Graham (408) 246-8000. From \$3.33 (100-qty); stock.

The 2N6657 and 2N6660 VMOS transistors are improved replacements for the older VMP 1 and VMP 2, respectively. Both the 2N6657 and 60 have upgraded specifications and contain an on-chip gate protection zener. (The VMP 1 and 2 had a separate zener mounted in the same package.) Both new units have lower input currents and lower ON resistances than their VMP series counterparts (100 nA vs 500 nA). The lower ON resistance 2.5 Ω max instead of 3 Ω results in a lower power dissipation. The 2N6660 can handle 6.25 W in a T0-39 package and the 2N6657 handles 25 W in a T0-3 package. Other features of the 2N6657 and 2N6660 are the high current handling capability (up to 3A), 60 V breakdowns, 10 ns switching times, and a complete lack of secondary breakdown or current hogging (in parallel configurations). Both the 2N6657 and 2N6660 operate over −65 to +150 C.

CIRCLE NO. 322

Broadband power FETs operate at up to 500 MHz

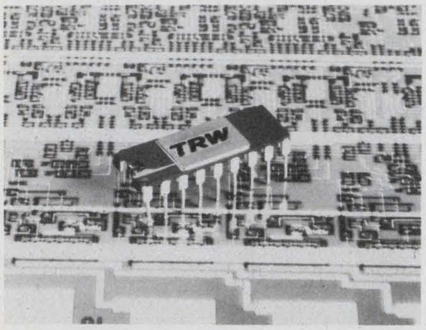


Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. Raymond Moore (617) 491-1670. From \$4.50 (100 qty); stock.

The CP640, CP650 and CP651 family of power FETs is useful at frequencies up to 500 MHz. They exhibit a third-order intermodulation intercept point greater than +40 dBm and a 50 Ω VSWR of less than 1.5:1 over the 0.5 to 50-MHz range. The smaller geometry unit, the CP643, has a g_m of 25,000 μmhos at a 25 mA drain current. The CP643 is useful as an i-f preamp where it presents a good termination for double-balanced mixers because of its constant 50 Ω input impedance over 1 to 108 MHz.

CIRCLE NO. 323

Speedy a/d converters provide 8-bit answers



TRW, One Space Park, Redondo Beach, CA 90278. William Koral (213) 536-1500. For 100 qty lots: $75 (1002J), $175 (1001J); 60 days.

Capable of operating at conversion rates of 1 μs and 400 ns, the TDC-1002J and the TDC-1001J are monolithic 8-bit a/d converters. The converters are bipolar units and are TTL compatible. Accurate within ±½ LSB, they require synchronizing clock signal, an accurate full scale reference voltage, and a compensating capaitor. Nine clock periods are required per conversion, with a typical clock frequency of 22.5 MHz. A status output indicates when the a/d converter is available for the next conversion. All output bits are available one clock period after the status signal indicates "ready to convert." Fanout capability is two Schottky-TTL output loads. Both a +5 and a −5 V supply are required. Input full scale range is from 0 to −0.5 V. An on chip operational amplifier is used to buffer the full scale reference input. The "start convert" input is a D-type, positive edge-triggered line.

CIRCLE NO. 324

High-speed counters handle inputs to 600 MHz

Plessey Semiconductors, 1641 Kaiser Ave., Irvine, CA 92714. Dennis Chant (714) 540-9970. From $16 (100-qty); stock.

Two high speed counters optimized for ECL and TTL interfacing, the SP8735B and SP8736B are ÷8 circuits. The devices have binary outputs that operate from dc to 600 MHz and 500 MHz, respectively, over a 0 to 70-C range. Both devices have an input dynamic range of 400 to 800 mV, a direct gating capability up to their maximum operating frquencies, and dissipate only 450 mW.

CIRCLE NO. 325

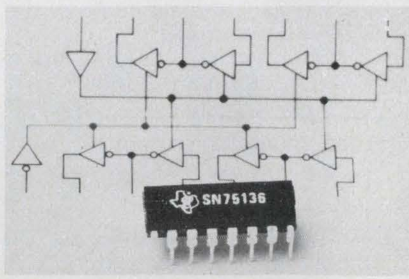
Get almost any voltage with settable regulators

Silicon General, 7382 Bolsa Ave., Westminster, CA 92683. J. Catrambone (714) 892-5531. From $1.10 (100-qty); stock.

The SG1532/2532/3532 series of precision but general purpose voltage regulators, provides performance improvements over the older SG723. The regulators retain all the versatility of the SG723 but have an input voltage range of 4.5 to 50 V, and open-collector outputs on the SG1532 (cerdip package) permit use of external pnp power transistors for high-current regulators with only a 2-V input-output differential. Reduction of sense voltage from 650 mV in the SG723 to 80 mV in the SG1532 can save significant power. A 10-A regulator would dissipate 6.5 W in the current sense resistor when using the SG723 while the loss is only 0.8 W with the SG1532. A band-gap reference provides both a low 2.5-V reference level, as well as a greatly reduced noise voltage over the conventional zener diode used in older designs. Line regulation for the SG1532 is 0.01%/V, max. Useful output current exceeds 100 mA. Available in 14-pin cerdip and 10-pin TO-96 cans for −55 to +125 C (SG1532) and 0 to +70 C (SG2532/3532).

CIRCLE NO. 326

Quad bus transceiver provides three-state I/O



Texas Instruments, P.O. Box 5012, Dallas, TX 75222. Dale Pippenger (214) 238-2011. From $1.76 (100 qty); stock.

Three-state outputs for both driver and receiver are included in the SN75136, a quadruple bus transceiver. The outputs of the circuit provide the high switching speeds of totempole TTL circuits while offering the bus capability of open-collector gates. Other features include party line, or databus operation, a single 5-V supply requirement, pnp inputs for minimal input loading and a 40-mA driver sink capability. 16-pin DIP.

CIRCLE NO. 327

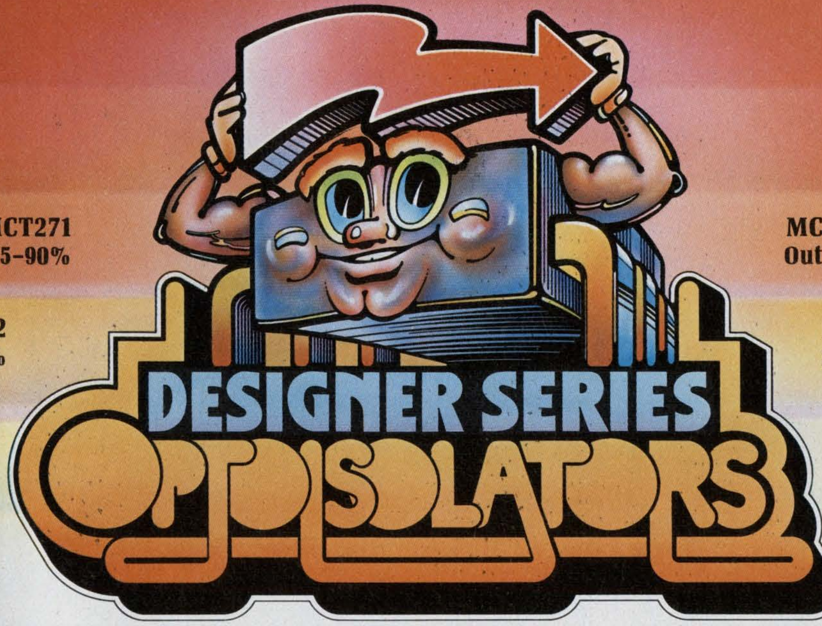
Now it's possible to specify the optoisolator you need–in a standard product.

MCT271
Controlled Gain 45-90%

MCT272
Controlled Gain 75-150%

MCT273
Controlled Gain 125-250%

MCT274
Controlled Gain 225-400%



MCT275 High Voltage
Output (80 volts)

MCT276 High Speed
2.5 μseconds

MCT277 TTL/Temperature
Compensated 100% min.

MCT2E General Purpose
2500 V rms, Isolation

INTRODUCING THE NEW "DESIGNER" SERIES OF OPTOISOLATORS FROM MONSANTO.

The new MCT270 "designer" series from Monsanto introduces a new approach to your design requirements. It lets you control the important design parameters so you can specify what you need without a special order. Standard products, off the shelf, where you have the flexibility of selecting the best product for your application.

CONTROLLED GAIN.

Choose from four ranges of Current Transfer Ratio, so that you know in advance what the gain of that design stage is going to be. Not just a "typical" rating, but a distinct "min-max" specification. From a 45% transfer ratio to a 225% minimum. All are UL recognized at 2500 volts, rms.

HIGH SPEED.

If your circuit design requires high speed in a transistor output optoisolator, you can get the MCT276. It has a gain ranging from 15% to 60%, with a fast 2.5 μseconds maximum turn-on/turn-off speed. And, you guessed it—UL recognized to 2500 volts, rms.

HIGH VOLTAGE OUTPUT STAGE (80 VOLTS).

When a high output blocking voltage is needed, specify the MCT275. Current transfer ratio is between 70% and 210%. Again, it's UL recognized to 2500 volts, rms.

TEMPERATURE COMPENSATED, TTL COMPATIBLE.

Your application may require reliable operation over a wide temperature range. If so, you need an optoisolator that's specified that way. That's our MCT277. It features a minimum 100% current transfer, with a 15 μsecond maximum rise and fall time. And those specifications hold from 0°C to 70°C. You can get the reliable operation you need, across the temperature range you need. It too is UL recognized.

GET OUR "DESIGNER" KIT.

You'll want to find out more about this exciting new option for your designs. Send for our free literature kit, containing complete specifications, applications information, and ordering information. Write, Monsanto Commercial Products Co., Electronics Division, 3400 Hillview Ave., Palo Alto, CA 94304. Telephone: (415) 493-3300.

Monsanto
the science company

CIRCLE NUMBER 68

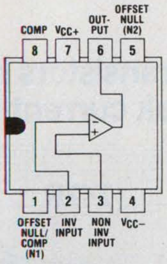
Low cost. Low noise. Low power. From the leader in BIFET op amps, Texas Instruments.

Now there are three BIFET op amp families to serve virtually all of your operational amplifier requirements. The new TL061 and TL071 families join the TL081 family to offer you the most comprehensive line of BIFET op amps available. Each family has its own identical specifications so you can standardize your requirements regardless of application.

You'll find low-cost general purpose BIFET op amps priced to replace bipolars. Low noise audio devices with low harmonic distortion. And a totally new concept, a BIFET op amp with low power consumption and low supply current. Four singles, four duals and four quads. Six pinouts in three series plus a whole lot more.

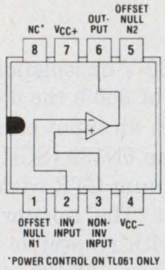
Check the prices and specifications. You'll find them more than competitive. But more important, you'll find all twelve BIFET op

TL080



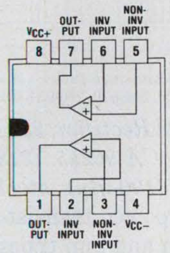
Uncompensated with offset control.
Pin equivalents:
LM301A, LM308, μA748

TL061 TL071 TL081



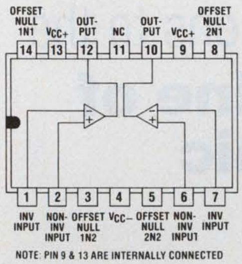
Compensated with offset control.
Pin equivalents:
μA741, LF355, CA3140

TL062 TL072 TL082



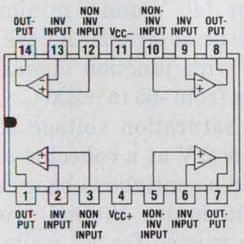
Compensated with no offset control.
Pin equivalents:
MC1458, RC4558

TL083



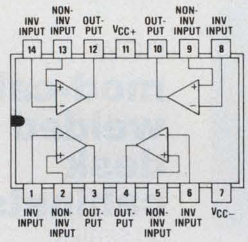
Compensated with offset control.
Pin equivalents:
μA747

TL064 TL074 TL084



Compensated with LM324 pinout.

TL075



Compensated with RC4136 pinout.

amps available off the shelf from TI and your TI distributor.

TL081 Series

Five general purpose devices with identical specifications that allow you to standardize your op amp requirements in one family to replace such widely used bipolars as μA741, MC1458, LM308, LM324, μA747, RC4558 and RC4136.

TL071 Series

Low noise and low harmonic distortion make the TL071 series ideal for high fidelity and audio pre-amp applications. Equivalent input noise voltage is typically 18 nV/$\sqrt{Hz}$ with a low harmonic distortion of .01%.

TL061 Series

A totally new BIFET op amp series ideally suited for battery-powered and similar applications requiring a minimum of power consumption. Now you can get BIFET dc specs and ac specs better than μA741 and MC1458 bipolar op amps at less than one tenth the power–0.25 mA max I_{CC} per amplifier.

Priced to replace bipolars.

You'll find prices as low as 33 cents each for the TL081 in 100 piece quantities; 47 cents for the TL071 and TL061. Twelve devices in three BIFET families offering low cost, low power, low noise. To learn more about how these new BIFET devices can serve all of your op amp requirements, contact your authorized TI distributor or the leader in BIFET op amps, Texas Instruments.

	BIFET op amp specifications.	TL081	TL071	TL061
I_{IB}	Input bias current (nA max)	0.4	0.2	0.4
V_{IO}	Input offset voltage (mV max)*	15	10	15
B_1	Unity gain bandwidth (MHz)	3	3	1
SR	Slew rate (V/μs)	13	13	3.5
V_n	Equivalent input noise voltage (nV/$\sqrt{Hz}$ max)	47	18	–
I_{CC}	Supply current (mA max)	2.8	2.5	0.25

*A & B versions available with 6 mV and 3 mV respectively for all three families.

Texas Instruments Incorporated
Inquiry Answering Service
P. O. Box 5012, M/S 308
Dallas, Texas 75222

Please send me a copy of the new BIFET op amp brochure.

Name__________ Title__________

Company__________

Address__________

City__________ State__________ Zip__________

ED

TEXAS INSTRUMENTS
INCORPORATED

CIRCLE NUMBER 70

93177

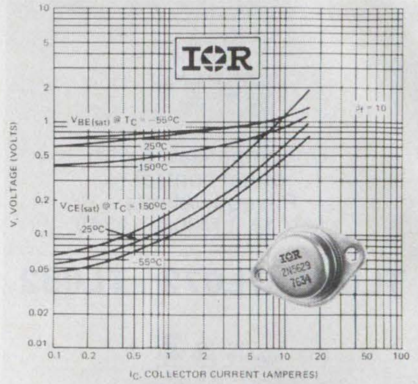
Isolators require only 0.5 mA for 400% CTR

Spectronics, 830 E. Arapaho Rd., Richardson, TX 75081. (214) 234-4271. From $1.65 (1000-qty); 30 days.

The 6N138 and 6N139 optoisolators feature high gain at low input currents, TTL compatible outputs and 800% current transfer ratios (CTRs). And, their input currents are only 0.5 mA while providing 3000-V-dc isolation voltages. With a CTR of 300% the 6N138 (SCH 4370) requires an input current of 1.6 mA, while the 6N139 (SCH 4371) has a 400% minimum CTR with a 0.5-mA input current. The isolators are pin-compatible with respective HP 6N138 (5082-4370) and 6N139 (5082-4371) isolators. 8-pin DIP.

CIRCLE NO. 328

Power transistors handle 20-A peak current



Typical Saturation Levels – $\beta f = 10$
2N5629, 2N5630, 2N5631 (NPN)

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 322-3331. From $3.20 (100-qty); stock.

Six 20-A power transistors, including both npn and pnp types, are available with collector-emitter ratings of 100, 120 and 140 V. Units designated 2N5629 (npn) and 2N6029 (pnp) are rated for 100 V with a minimum dc current gain of 25; the 2N5630 (npn) and 2N6030 (pnp) are rated for 120 V and a minimum gain of 20; and the 2N5631 (npn) and 2N6031 (pnp) are rated for 140 V and a minimum gain of 15. All units offer 20-A peak collector current with junction operating temperature from -65 to +200 C. Collector-emitter saturation voltage for all six devices is 2 V at a collector current of 16 A and a continuous base current of 4 A. Maximum thermal resistance, junction-to-case for all units is 0.875 C/W. TO-3 case.

CIRCLE NO. 329

Transistors operate from 200 MHz to 4 GHz

California Eastern Laboratories, One Edwards Court, Burlingame, CA 94010. (415) 342-7744. For 10 to 99 qty: $17 (chip), $77 (packaged); stock.

A general-purpose transistor, the NE645, is designed for use from 200 MHz to 4 GHz. The NE645 has a 0.8 dB noise figure and a 21 dB gain at 500 MHz, 1.3 dB noise and 14 dB gain at 1.5 GHz, and 2.7 dB noise and 8 dB gain at 4 GHz. Ideal for i-f amplifiers, the transistors require from 1.5 to 30 mA and can meet the requirements of MIL-STD-750/883.

CIRCLE NO. 330

Calibrator stores tolerance limits

John Fluke Mfg. Co. Inc., P.O. Box 43210, Mountlake Terrace, WA 98043. (206) 774-2211. $6495; 60 days.

The 5100A calibrator stores the tolerance limits of a unit under test and flashes its display if an out-of-tolerance voltage from the calibrator is required to correct the reading of the UUT. A single "edit" control provides continuous adjustment over the output range of the calibrator and activates all error, tolerance, and limit calculations.

The calibrator handles meters with dc accuracies specified to ±0.01% and ac accuracies of ±0.1% from 50 Hz to 50 kHz. A wideband frequency module extends frequency range to 10 Hz to 10 MHz.

Current outputs, both ac and dc, are from 5 μA to 2 A. Resistance values for ohmeter calibration are from 1 Ω to 10 MΩ in eight discrete decade sizes—no intermediate values are available.

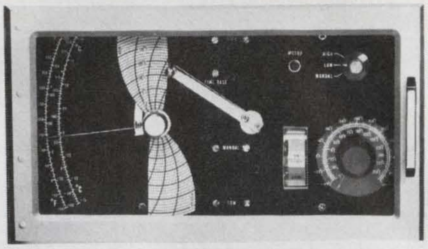
In calibrating resistances, the 5100A can compensate for lead resistances, storing this information and substracting it from measured data. This allows precise measurements of resistance without the inconvenience of four-wire hookups. However, four-terminal resistance measurements can also be made, if desired.

The 5100A can also be programmed for entry limits. If an operator tries to call up a voltage higher than the stored limit, the instrument indicates an error and locks at the last voltage output within limits. This prevents damage to the unit under test, as well as injury to the operator.

Additional safety features include separate low and high-voltage supplies. The high voltage supply is turned on only when necessary; lower output voltages are derived from the separate low-voltage supply instead of by division from the higher-power section.

CIRCLE NO. 307

Programmer/temperature controller in one unit

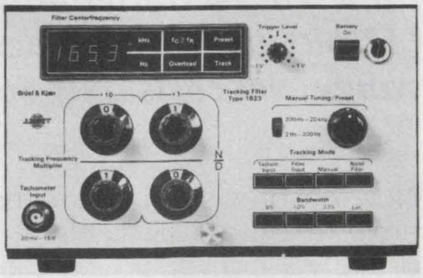


Victory Engineering, Victory Rd., Springfield, NJ 07081. (201) 379-5900. $625.

The Model 4000 is a self-contained dual-function instrument that automatically controls temperature in a continuous temperature-time program. The unit comes with a proportional temperature controller in either a horizontal or vertical configuration. A program is introduced by a 6-in. rotating cam which is easily shaped by the user to the desired configuration. Temperature control is achieved by the solid-state proportional controller which responds to the sensor and the set-point. The sensor may be either an RTD or a thermocouple, while the set-point is determined manually with a 1-k pot or by a 200-Ω slidewire which is positioned by the program cam.

CIRCLE NO. 331

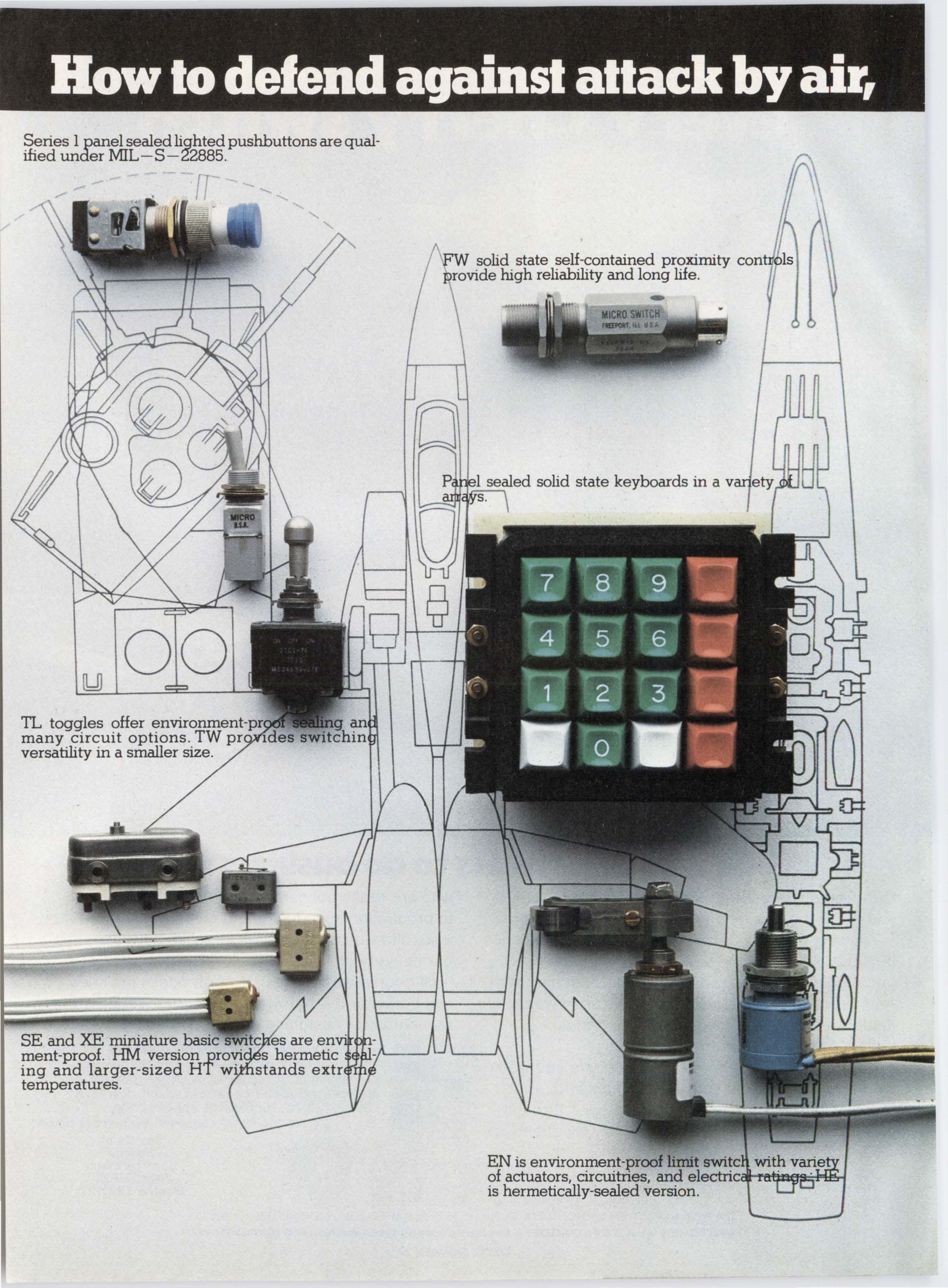
Portable comparator rapidly sorts resistors



Associated Testing Labs., 23 Vincent St., Wayne, NJ 07470. (201) 473-6455

A portable, solid-state resistance comparator rapidly sorts semi-precision resistors for incoming inspection. The Model DLRC-9A comparator features analog output for recording, low test currents, two or four wire (Kelvin) measurements and four-place limit-set controls. Also, the instrument offers three state readout of limit—MIN, PASS and MAX. Strobed status-lamp outputs (TTL compatible) are included for use with automatic handlers.

CIRCLE NO. 332


How to defend against attack by air,
Series 1 panel sealed lighted pushbuttons are qualified under MIL—S—22885.
FW solid state self-contained proximity controls provide high reliability and long life.
MICRO SWITCH
FREEPORT, ILL. U.S.A.
Panel sealed solid state keyboards in a variety of arrays.
7 8 9
4 5 6
1 2 3
0
MICRO
U.S.A.
TL toggles offer environment-proof sealing and many circuit options. TW provides switching versatility in a smaller size.
SE and XE miniature basic switches are environment-proof. HM version provides hermetic sealing and larger-sized HT withstands extreme temperatures.
EN is environment-proof limit switch with variety of actuators, circuitries, and electrical ratings; HE is hermetically-sealed version.

Programmable source spans 1 mHz to 50 MHz

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $5500; 30 days.

Capable of generating sine, triangle, and square waves from 1 mHz to 50 MHz, the 8165A can store and recall up to 10 complete instrument settings via front-panel controls or an IEEE-488 interface.

While store-and-recall of frequency and amplitude has been available in other instruments, it has not been as complete, nor available in a function generator. A similar such source, Exact Electronics' Model 757 (ED 10, May 10, 1977, p. 102), lacks such features, but its price is much lower ($1450), and its frequency range wider (0.1 mHz to 50 MHz).

Complete operating mode settings, function parameters, and output mode settings are recalled by pushing two buttons, or by addressing one of 10 storage registers via the interface bus. Built-in batteries maintain data storage up to 6 months when the instrument is turned off.

Pulses or ramps with 20 to 80% duty cycles are generated from 1 mHz to 19.99 MHz, with pulse transition times less than 5 ns. Source impedance can be set at 50 or 1000 Ω.

Phase-locking to a 10-MHz crystal reference achieves output frequency stability of $\pm 1 \times 10^{-5}$ of the programmed value. Frequency resolution is four digits—1 μHz in the 1 mHz to 9.999 mHz range, for example.

Output amplitude of the 8165A can be set from 10 mV peak-to-peak to 9.99 V peak-to-peak from 50 Ω into a 50-Ω load. In the 1000-Ω, current-source mode, the 8165A can deliver 20 V peak-to-peak into a 50-Ω load. Amplitude accuracy is 2% of the programmed value.

Offset is variable from zero to ±5 V from 50 Ω into a 50-Ω load, or double that in current-source operation. Offset accuracy is within ±1% of programmed value.

In the trigger mode, a single cycle of the selected waveform is triggered with an external signal. Gating is synchronous and the waveform always begins at zero phase.

In the counted burst mode, the 8165A generates a predetermined number of waveforms from 1 to 9999, independent of the frequency of the selected waveform.

The 8165A can be swept in two modes. In the VCO mode, an external voltage from 10 mV to 9.999 V controls the internal oscillator. In the sweep mode, the internal oscillator is swept logarithmically over a selected sweep time. In either case, the sweep is over three decades from the main frequency. Triggering can be internal or external.

The carrier of the 8165A can be frequency modulated using a rear-panel BNC by an external ac or dc signal. For a change of 1% in carrier frequency, a voltage of 1 V peak-to-peak is required. Modulation can be varied from 100 Hz to 20 kHz.

Hewlett-Packard **CIRCLE NO. 305**
Exact **CIRCLE NO. 306**

Synthesizer tunes continuously

Comstron·SEG, 200 E. Sunrise Highway, Freeport, NY 11520. (516) 546-9700. $1595.

Model 1010 five-digit, bench frequency synthesizer covers 1 Hz to 10 MHz and is controlled by a single front-panel knob that provides continuous tuning like a standard dial-tuned signal source. The unit provides 1-Hz resolution to 100 kHz and 100-Hz resolution to 10 MHz, as well as a metered output leveled to 0.25 dB over the full range. It has a precision output attenuator adjustable over a 60-dB range in 10-dB steps.

CIRCLE NO. 333

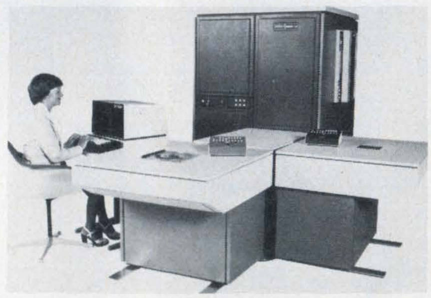
Processor measures & controls mixed signals

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. About $6000; 60 days.

Model 2240A Measurement and Control Processor allows the user to acquire a mix of both digital and analog data and to control digital and analog outputs. The unit is the first in a line of such devices using silicon-on-sapphire technology and taking advantage of the HP-IB (IEEE-488) Interface Standard. The 2240A's digital and analog capabilities include multiplexing and conversion of analog input signals, multiple analog output signals, multiple digital signal event monitoring, frequency counting, event counting, digital signal outputs and stepper motor control outputs. Analog input signals are automatically corrected for temperature offset and drift.

Booth No. 2051 **CIRCLE NO. 334**

LSI test system aims at high throughput

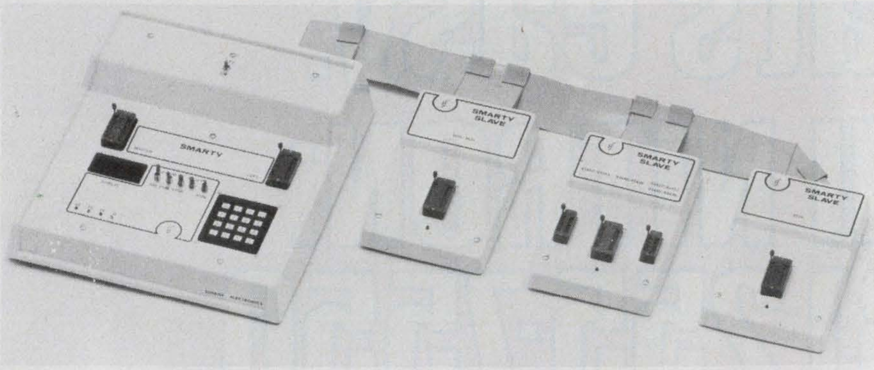


Fairchild Camera and Instrument Corp., 1725 Technology Dr., San Jose, CA 95110. (415) 962-3617. Start at $169,500 (30 pins); 60-90 days.

Sentry V automatic test system is said to increase throughput by as much as 200%. The unit handles μPs peripheral chips, bit slices, phase-locked loops, RAMs, ROMs, shift registers, universal asynchronous receiver/transmitters (UARTs) and digital hybrids in such technologies as NMOS, PMOS, CMOS, SOS, ECL, TTL and I^2L. Sentry V is source-program compatible with the Sentry II and VII, Sentry 600 and Sentry 610, thereby minimizing programming costs.

CIRCLE NO. 335

PROM programmer has slave unit capability



Sunrise Electronics, 228 North El Mulino, Pasadina, CA 91101. Anna Erickson (213) 963-8775. From $1495; 30 days.

A μP-based PROM programmer/emulator offers slave expandability, an optional cassette data storage unit, multiformat load and dump features, built in PROM simulator and a resident editor. The Smarty uses the 1802, an 8-bit CMOS μP and has a 1 k × 8 data RAM, a 128 byte scratch pad, parallel and serial data interfaces.

Handling the 2704/2708 PROMs, the unit also has a hexadecimal keyboard, display and indicators. The system software includes fault tolerant input/output subroutines for BPNF, hexadecimal, packed binary, ASCII/hex or user defined format.

The software can ignore rubouts, invalid characters and comments and permits the user to load highly flawed, first attempt tapes. Editing commands include: find, delete, move, insert and replace. To put the unit in the programming mode requires four keystrokes and when slaves are connected two additional keystrokes specify which slave and PROM type are to receive the programming.

Data in the data RAM can be dumped onto punched paper tape, cassette, disk or other media under keyboard control. The system software provides multiformat input and the parallel and serial I/O buffers permit interfacing with any kind of peripheral.

The system has sockets for 4 kbytes of program memory although only 1 k is used in the basic machine. By adding several slaves of the same type the Smarty can program large quantities of PROMs in minimum time. A Smarty and eight slaves will verify erase, program and verify programming of nine 2708 PROMs in three minutes.

CIRCLE NO. 336

Fluxmeter takes ±0.2% dc readings

RFL Industries, Boonton, NJ 07005. (201) 334-3100. $1470; stock.

Model 803 fluxmeter provides ±0.2% (dc mode) readings of both total flux and flux density of ac and dc or permanent-magnetic fields, with ranges from 100 to 200 × 10^7 Maxwell-turns. A peak-reading sample-and-hold mode is also incorporated. Manual or automatic reset is continuously variable from 1 to 10 s. An analog output is included and a BCD output is available as an option.

Booth No. 1357 **CIRCLE NO. 337**

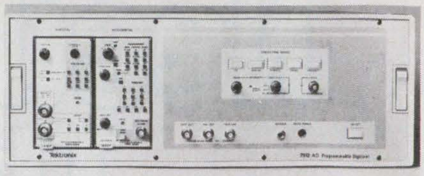
Unit converts capacitance to frequency

Valhalla Scientific, 7707 Convoy Ct., San Diego, CA 92111. (714) 277-2732. $175; stock.

The Model 2020 provides an output frequency directly equivalent to the capacitance under test. The unit handles between 1 pF and 200,000 μF. The frequency may be displayed on any conventional frequency counter. A 4.7-μF capacitor will generate an output signal frequency of 47,000 Hz accurate to within ±2% of range. Dynamic range is 0 to 200% of full-scale range.

CIRCLE NO. 338

High-speed digitizer works on IEEE bus



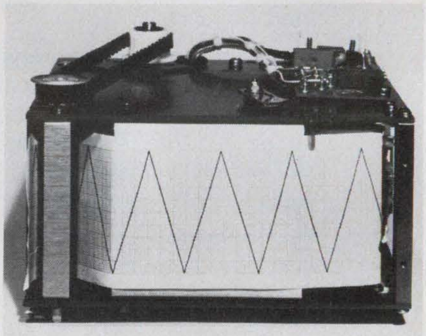
Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. 16 wks.; Approx. $22,000.

Model 7912AD high-speed waveform digitizer offers fully programmable operation and compatibility with the IEEE-488 bus. The unit captures transients to 1 GHz (fully programmable to 200 MHz) with automatic waveform digitizing. Included are built-in data manipulation and self-diagnostic capability. Operation is similar to an oscilloscope except that acquired waveforms are normally output as digital information for waveform processing.

Booth No. 2038

CIRCLE NO. 339

OEM recorder ignores battery voltage changes



Astro-MED, Atlan-Tol Industrial Park, West Warwick, RI 02893. (401) 828-4000. $425; 30 days.

This single-channel battery-powered OEM recorder retains its accuracy of 0.5% of fs despite the drop-off of battery voltage and changes in load. The 102 XLA DCH is said to regulate chart movement to within 2% of the set speed and will control gain of the galvanometer to better than 1%. A battery output voltage from a peak of 13.9 down to 10.5 V (almost depleted) will not affect the operation of the amplifier or the chart paper speed. Weighing only 4 lb, the unit consumes only 6 W. Channel width is 50 mm, with the writing on thermal paper by a stylus that operates directly from the 12-V power source without an inverter. Dimensions are 4 × 6 × 6-¼ in.

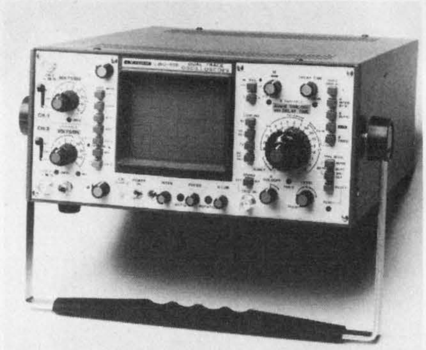
Booth No. 1253 **CIRCLE NO. 340**

Tracking filter goes where you go

B&K Instruments, 5111 W. 164th St., Cleveland, OH 44142. (216) 267-4800. $3552; 150 days.

Type 1623 tracking filter is completely portable, operating from internal battery power. Specs include three selectable filter bandwidths, 6%, 12%, and 23%; and a frequency range of 2 Hz to 20 kHz. The unit is tunable from practically any periodic signal, with filter frequency/tuning signal-frequency ratio adjustable between 99/1 and 1/99. **CIRCLE NO. 341**

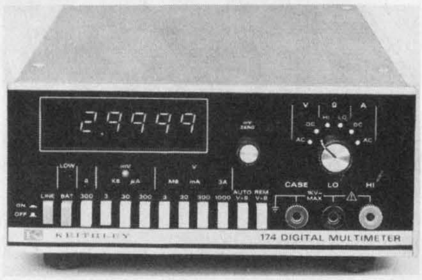
25-MHz dual-trace scope delays sweep 1 μs to 5 s



Leader Instruments, 151 Dupont St., Plainview, NY 11803. (516) 822-9300. $1400; stock.

The Model LB0-515, dual-trace, 25-MHz bandwidth oscilloscope features a continuously variable delay from 1 μs to 5 s. The instrument offers 5 mV/div vertical sensitivity and allows viewing the leading edge of pulses. The overall accuracy level for automatic trace and reset modes is ±3%. Also included are beam rotator for stray magnetic-field correction; trigger for Channel 1 and 2 with a polarity inversion switch for Channel 2; X10 magnification and a rise time of 14 ns. **CIRCLE NO. 342**

Sensitive DMM shows 100 nV/digit

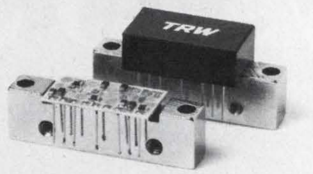


Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139. (216) 248-0400. $995; 60 days.

Sensitivity is the standout feature of the Model 174 4-½-digit DMM. Dc sensitivity is 100 nanovolts/digit on a high-resolution, 30,000-count display. Automatic zeroing and standardization occurs during each a/d conversion for stable, accurate readings. Dc voltage measurements range from 100 nanovolts/digit to 1200 V full scale. Choice of automatic or manual ranging is available on most ranges.

CIRCLE NO. 343

Incredible performance... at unbelievable prices!

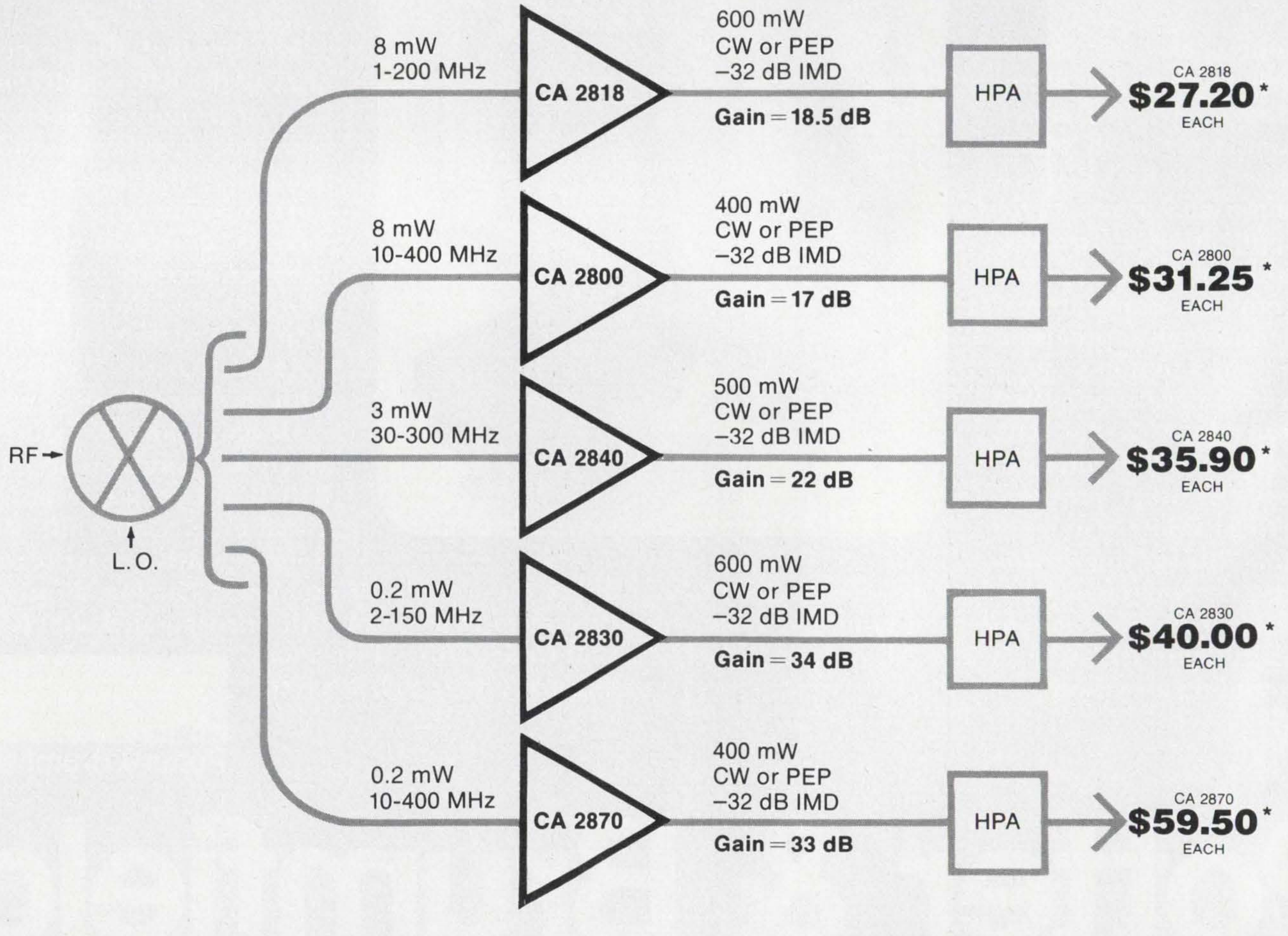


TRW hybrids shatter the price/performance barrier for RF output power, linearity and dynamic range!

You'll have to see it to believe it! And we're ready to show you proof. Take a look at some of our typical applications. Look at the gain quoted for each.

Then take a look at the price. Now, in your production units, you can get the performance you'd only expect from precision laboratory gear.

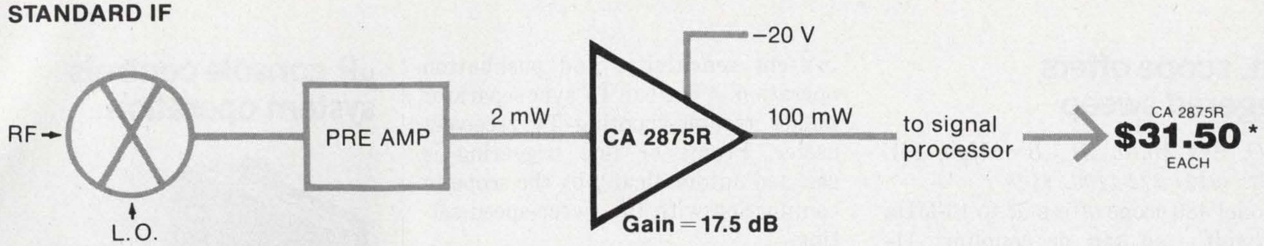
TRANSMITTER DRIVERS:



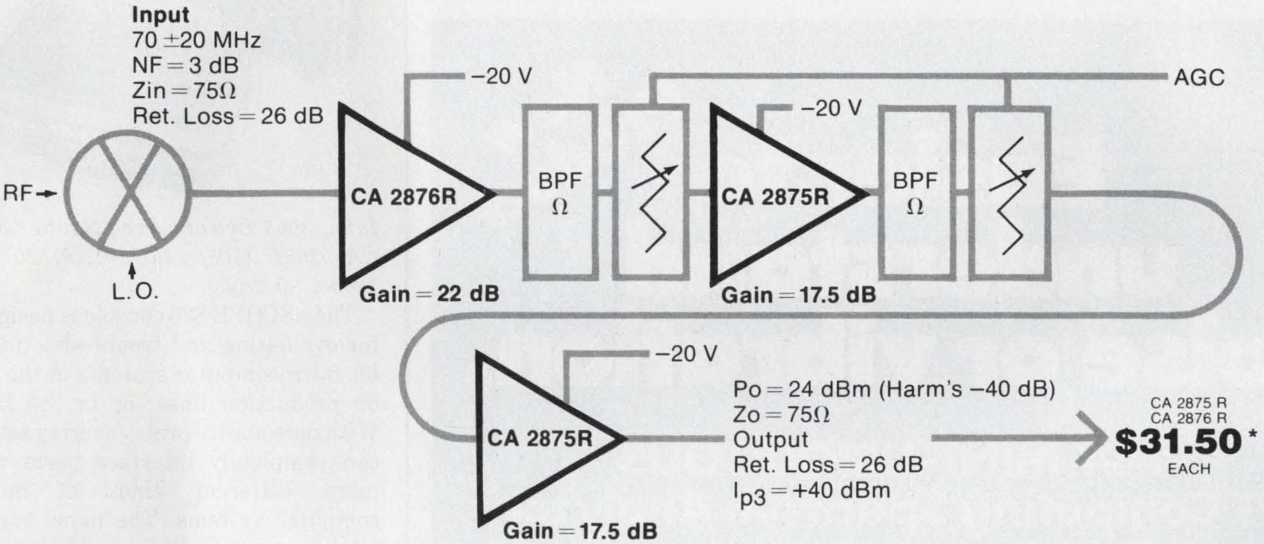
RECEIVER APPLICATIONS:

40 MHz to 100 MHz IF amplifier.

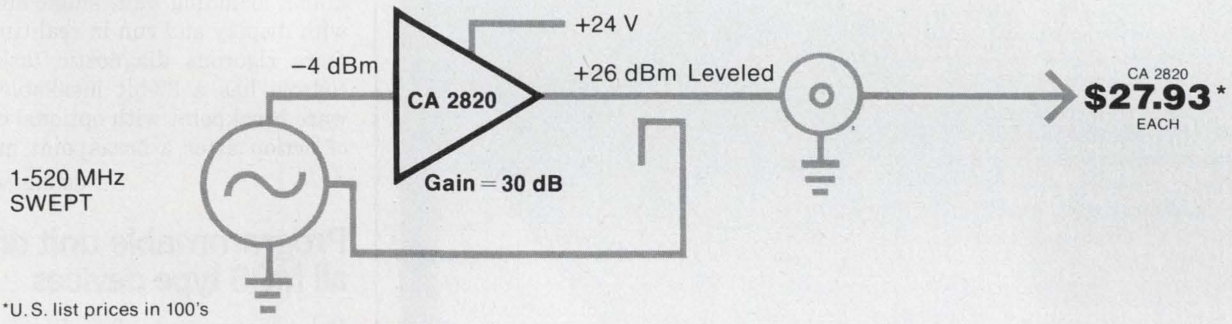
STANDARD IF



HIGH PERFORMANCE IF



INSTRUMENTATION APPLICATIONS:



*U.S. list prices in 100's

These applications are only the beginning. TRW RF linear hybrids can revolutionize design after design...with incredible performance at unbelievable prices. Let us prove it. To get complete data sheets, send us the coupon.
To find out how you can get a free sample and test fixture, call Dan Brayton at (213) 679-4561.

TRW RF SEMICONDUCTORS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

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

☐ *Please send me your new RF linear catalog.*
☐ *Please have an applications engineer contact me.*

(Phone)

Name

Position

Company Name

Address

City State Zip

5-in. scope offers triggered sweep

EICO, 283 Malta St., Brooklyn, NY 11207. (212) 272-1100. $425.

Model 480 scope offers dc to 10-MHz bandwidth, ac and dc coupling, 11-position calibrated attenuator, 10 mV/cm sensitivity, and pushbutton operation. A built-in TV sync separator makes trouble-shooting TV receivers easier. Frame or line triggering is selected automatically by the scope in conjunction with the sweep-speed setting.

CIRCLE NO. 344

µP console controls system operation

Intel, 3065 Bowers Ave., Santa Clara, CA 95051. (408) 246-7501. $1520 w/o probe; 90 days.

The µSCOPE 820 console is designed for evaluating and troubleshooting 8-bit microcomputer systems in the lab, on production lines, or in the field. With personality probe/overlay sets, it can completely interface users with many different kinds of microcomputer systems. The panel can be used to monitor, display and alter register, memory and I/O values of the system under test. It also gives complete control over microprocessor operations including halt, single-step, run with display and run in real-time. For more rigorous diagnostic tasks, the console has a 32-bit maskable hardware breakpoint with optional courses of action after a breakpoint match.

CIRCLE NO. 345

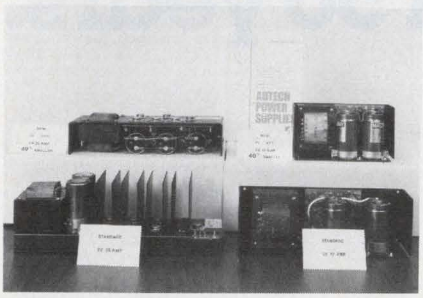
Programmable unit drives all MOS type devices

Pulse Instruments, P.O. Box 655, San Pedro, CA 90733. (213) 541-3204. $295; stock to 4 wk.

The PI-451 Programmable MOS/CCD Driver plugs into a Tektronix TM-500 mainframe and shifts TTL signal levels to ±25-V outputs, driving practically all MOS devices and other capacitive loads. The output high and low levels are independently adjustable, by front-panel controls or input voltage program. Digital programming is available, too. Output transition times are variable from 2.5 ns/V to 2.5 µs/V. Output-polarity inversion and output pulse-width controls are also provided.

CIRCLE NO. 346

Linear supplies cased in small volume



Adtech Power, 1621 S. Sinclair St., Anaheim, CA 92806. K. Nelson (714) 634-9211. See text.

The EMPS family of series-regulated dc supplies provides: a 5-V at 40-A supply in the same package volume as conventional 5-V at 25-A units; a 5-V at 25-A supply in a slightly smaller package than former 5-V at 18-A units, and a 5-V at 18-A supply in the same package size as present 5-V at 12-A units. Sixteen models are available in single, dual and triple outputs. The units are convection cooled for full-power rating at 50-C ambient. Forced-air cooling extends full-power rating to 60 C. The following protection is standard: overload via automatic-recovery foldback-current limiting, reverse-polarity and inductive load. Crowbar-type overvoltage protection is optional. Prototype units are now available with full-production quantities expected in October. Efficiencies (measured with a wattmeter) at nominal line and full load, range from 55 to 68%. MTBF: 60,000 hr. Regulation: ±0.05% for line or load. Ripple: 5-mV pk-pk. Tempco: 0.02%/°C.

Booth No. 1073

CIRCLE NO. 347

Open-board supplies develop three outputs

Wall Industries, 175 Middlesex Tpke., Bedford, MA 01730. L. Bennett (617) 275-0708. $68 (unit qty); stock to 2 wks.

Two triple-output dc power supplies are mounted on open boards. Model A12T300 develops ±12 V at 300 mA and ±5 V at 2 A while model A15T300 develops ±15 V at 300 mA and +5 at 2 A. Regulation is 0.05% for line and 0.1% for no load to full load. Input can range from 105 to 125 V ac. Options in ac inputs are available. The units operate from −25 to +71 C.

CIRCLE NO. 348

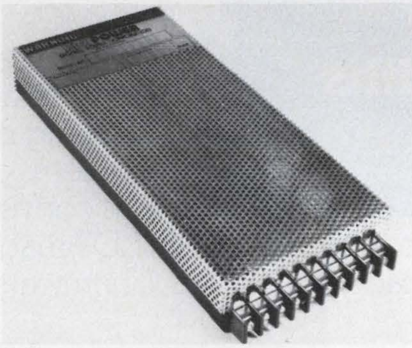
50-W switchers take nominal 45-V-dc input

Abbott Transistor Laboratories, 5200 W. Jefferson Blvd., Los Angeles, CA 90016. A. Hilbert (213) 936-8185. $310 (unit qty); stock to 10 wks.

The DC50 series of three switching regulated power modules operate from dc input power of 41 to 52 V. A single output of 5 V dc and dual outputs of ±12 and ±15 V dc together deliver a 50-W total. Full power is available at 55-C ambinets with 50% derating NCC dc d at 71 C. Line and load regulation is less than 0.5% and pk-pk ripple is less than 100 mV. Standard features include overvoltage protection, short-circuit protection, over-temperature shut-down and remote error sensing. Efficiency can go up to 80%. 5.5 × 9.4 × 2 in.

CIRCLE NO. 349

Five small switchers pour out 150 W



Digital Power, 2060 The Alameda, San Jose, CA 95126. R. Fain (408) 246-4337. From $187 (1000 qty).

Two single and three triple output models in the DS series feature 150-W outputs in 90 in^3. Efficiencies can go up to 90%. Single-output models pass 5 V at 30 A, or 12 V at 12 A. All three triple-output models offer 5 V at 24 A; auxiliary outputs are ±12 or ±15 V at 3 A, or +12 V at 4 A, −12 V at 1 A. All models include current-foldback short-circuit protection, overvoltage protection on all outputs, overtemperature protection, and a soft start that limits inrush current. EMI filtering on inputs and outputs is standard. Ripple and noise 50-mV pk-pk on the 5-V output and 1% on auxiliary outputs; voltage regulation is 0.1% with a transient response of 250 μs. 1.75 × 5 × 11.25 in.

CIRCLE NO. 350

Multi-output switchers power loads up to 750 W

Pioneer Magnetics, 1745 Berkeley St., Santa Monica, CA 90404. A. Hagiwara (213) 829-3305. $695 (unit qty); 45-90 days.

Three families of multiple-output switching power supplies, the PM2675, PM2676 and PM2677 deliver 375, 600 and 750 W, respectively. They provide regulated output at full-rated load with inputs ranging from 92 to 138 V ac for the 115-V-ac input units, and 184 to 250 V ac for the 208/220-V-ac-input units. The supplies continue to operate for several minutes with inputs as low as 60% of nominal. If the input voltage fails entirely, the output voltage will hold up for 30-ms min. The main output delivers 250 W for the PM2675, 500 W for the PM2676 and 600 W for the PM2677. Three additional channels are also included in each unit. Channels two and three of any of the models can handle 150 W or 10 A. Channel four passes 75 W or 5 A. Outputs range from 2 to 48 V. The switchers also feature isolated outputs, independent from each other except for the 50-W-min load required by the main channel. Other features include overload, short-circuit and reverse-voltage protection on each output, automatic over-temperature shutdown, an ac-input fuse, overvoltage protection on the main channel and remote sensing. The supplies operate at full power from 0 to 50 C and derated to 80% at 70 C. 5 × 8 × 11 in.

CIRCLE NO. 356

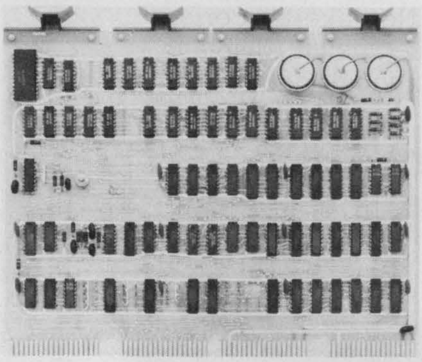
Remote operation with switching regulators

β Industries, 3811 N. 34th Ave., Phoenix, AZ 85017. B.A. Barney (602) 278-7516. $150 (unit qty).

Output voltages from 5 to 24 V dc, at efficiencies of up to 80%, can be delivered by the BPS series of Mini-Switchers. Four models, covering the input range of 15 to 40 V dc at 6 to 15 A, are available in small (3.25 × 3.5 × 4.88 in.), lightweight (2-lb) packages. Ripple and noise are typically 50 mV rms over a 30-MHz bandwidth. The output has built-in overvoltage protection and is adjustable to ±10% of the stated voltage.

CIRCLE NO. 357

Battery-powered board tells time and date



Digital Pathways, 4151 Middlefield Rd., Palo Alto, CA 94306. (415) 493-5544. $325 (TCU-50), $495 (TCU-100); (1-qty).

Calendar and real-time clock functions for the PDP-11 and LSI-11 computers are provided by the TCU-100 and TCU-50 timing control units. The units keep track of the correct date and time, even when the computer's power is turned off. A read instruction given by the PDP-11 operator allows the TCU-100 to present the date (month and day) and time (hr, min, sec). The TCU-50 performs the same function in the LSI-11 computer. Both units can operate without computer power for up to three months on their built-in rechargeable batteries. They are contained on edge-connector circuit boards that plug into one of the computer's accessory slots. Units are shipped working and preset to the correct date and local time at the customer's location.

CIRCLE NO. 358

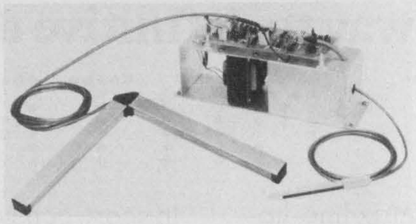
Double-sided floppy stores 1600 kbytes

General Systems International Inc., 1440 Allec St., Anaheim, CA 92805. (714) 956-7183. P&A: See text.

The FDD 200 double-sided floppy disc drive can handle 1600 kilobytes of data, unformatted, with data transfer operations controlled by interface-specified control commands. Software interlock, to safeguard against operator error during data transfer, is a $25 option added to a basic price of about $400 in OEM quantities.

CIRCLE NO. 359

Digitizer tracks by sensing sound



Science Accessories Corp., 970 Kings Highway West, Southport, CT 06490. (203) 255-1526. $800.

The Model GP-101 sonic digitizer package consists of a stylus or a cursor, an electronics package, and a sensor L-frame. Two sensors are mounted in the rigid L-frame, which can be as long as 60 in. The assembly can be moved without recalibration or realignment of its right angle. Output of the GP-101 is two gating signals that are true from the time the supersonic pulse is generated by the stylus or cursor until the pulse is received by each of the sensors.

CIRCLE NO. 360

Nonimpact head prints 10 columns

Gulton Industries Inc., 212 Durham Ave., Metuchen, NJ 08840. (201) 548-2800. $35.65 (100-499); stock to 8 wks.

The only moving part of the DM1050 10-column dot-matrix thermal printhead is the advance mechanism. The printhead can handle speeds up to 7 lines per second with 5 × 7 characters on standard 90 C heat-sensitive paper. It is furnished with a soldered ribbon cable and mounted on a standard heat sink designed for ganged assembly to extend the number of columns. MTBF is rated 10 million character lines minimum at maximum rated operation.

CIRCLE NO. 361

Stand-alone terminal is microprocessor based

Omron Electronics, 432 Toyama Dr., Sunnyvale, CA 94086. (408) 734-8400. $7200 (1-qty); 60 days.

The 8035 intelligent terminal is an 8080-microprocessor-based unit with stand-alone capability. Incorporated into the system are a CRT terminal, IBM 3740-compatible dual floppy-disc subsystem, complete operating software and an RS-232C interface. A 120-char/s printer can be added as an option. The operating system software package, called FDOS is composed of an editor, assembler and debugger. FDOS includes full file management routines to handle file creation, deletion and modification. Up to 4-Mbits of memory is provided by the dual-drive floppy-disc subsystem. In communications applications the system operates at rates up to 9600-baud.

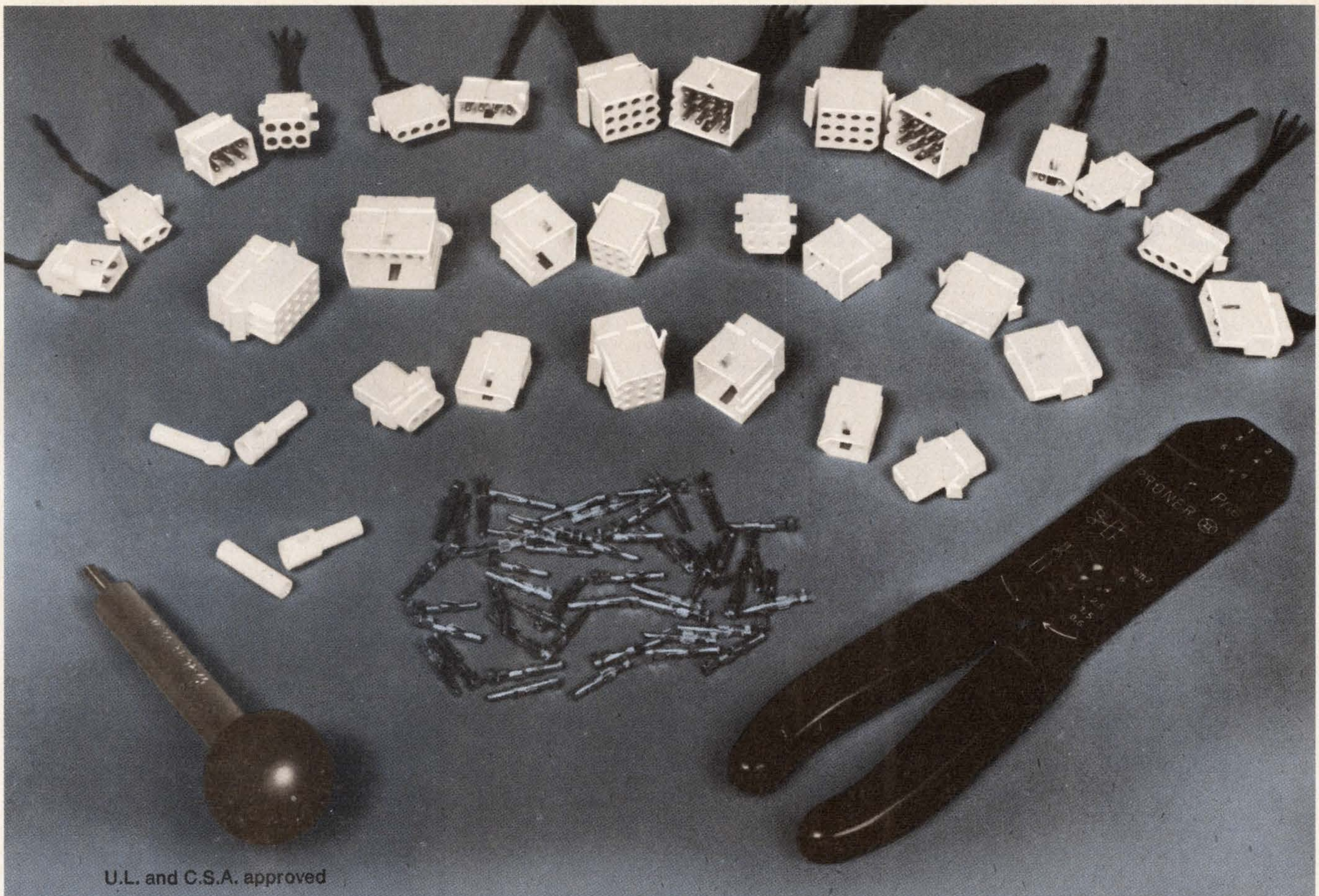
CIRCLE NO. 362

Store video signals in graphic memory

Vidco, P.O. Box 25452, Portland, OR 97225. (503) 292-4104.

Analog signals are converted to digital by the Model 300-YT Graphic Memory. The digital signals are then stored in an MOS memory where they are available for continuous television display or video recording. Thirteen inputs can be accepted and displayed simultaneously by the unit. Front-panel switches allow selection of one or any combination of the inputs for immediate display. The unit provides four display modes: Store-information is continuously accumulated in memory until commanded otherwise. Auto-erase: at the end of each sweep the display is erased and a new sweep starts at the next trigger. Single-sweep: sweep will run at trigger input and lock-out until reset. Wipe: old information is cleared away as new information is written into the display. Options to meet special requirements are available.

CIRCLE NO. 363



MALCO'S THRIFT-MATE T.M.

...cuts your price not your performance

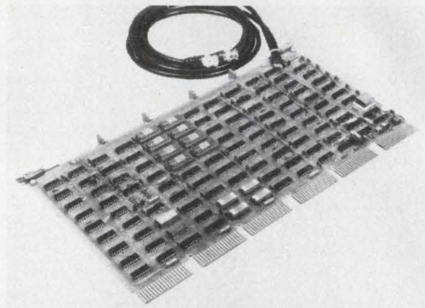
Thrift-Mate is a high-performance, hard-shell plug and receptacle, perfect for low-cost, rapid assembly applications. You can get Thrift-Mate immediately for cable-to-cable, free hanging or panel mount applications. Also in strip form for automatic or semi-automatic crimping of wires to terminals. Thrift-Mate is intermateable/interchangeable with hard shell connectors available from other manufacturers.

Let Malco help you save money without sacrificing performance. Write Malco, 12 Progress Drive, Montgomeryville, Pennsylvania 18936.
Phone: (215) 628-9800.

MALCO
A Microdot Company

CIRCLE NUMBER 88

Control 32 CRT stations with PDP plug-in board



Echolab, 213 Middlesex Tpke., Burlington, MA 01803. Don Brickman (617) 273-1512. $1785 (OEM-qty).

A plug-in peripheral device, the CVD-11, allows a PDP-11 computer to handle a cluster of up to 32 remote CRT stations. Each device consists of a controller card that plugs into a hex slot and two small remote interfaces. The controller card contains the electronics to support two remote CRT stations, including independent display memories, character generators, TV sync generator and Unibus interface. A remote CRT station, which may be up to 1000 ft away, connects to its controller with a single coaxial cable. This is made possible by the remote interface which multiplexes a CRT monitor, a parallel-encoded keyboard and a serial printer to the coax cable. The display is 1920 characters in an 80×24 format, and the 128 character ASCII set is standard, with special characters available.

CIRCLE NO. 364

Nova memory card holds all 128 kwords

Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. Jim Carver (214) 242-0444. $7275 (unit qty); stock.

An add-in memory card for the Data General Nova 3, the MK8003, provides up to 128 k × 17 bits on a 15 × 15-in. card. The memory card is compatible in both hardware and software with the Nova 3/4, 3/12, or 3/D, and allows the user to place the maximum addressable memory for the Nova 3 series in only two card slots, freeing additional slots for I/O.

CIRCLE NO. 365

Single line terminal can replace CRTs

Computerwise, 4006 E. 137th Terrace, Grandview, MO 64030. Richard Hawkins (816) 765-3330. $595 (1-qty).

A single-line, 32-character data display terminal designated the Transactor I, comes with a 53-key TTY-style keyboard. Designed for low cost, small size applications, the unit is intended to replace CRT terminals. The display is a gas-discharge type with a 5×7 dot matrix for easy reading. Interfacing to existing computers is possible through either an RS-232 or 20-mA current loop. Switches allow the user to select the following operating modes: 110-9600 baud rate, full or half duplex, even/odd/no parity, five to eight data bits, and one or two stop bits. The unit is packaged in either a 6 in. (H)×15 in. (W)×11 in. (D) aluminum case or a molded plastic case.

CIRCLE NO. 366

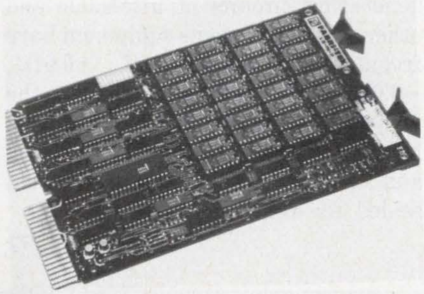
Flexible disc drive uses band-driven design

Micro Peripherals, 8724 Woodley, Sepulvada, CA 91343. Keith Ullal (213) 894-4076.

The band-driven design concept, similar to the type used in IBM devices, is available on the Series B82 flexible disc drive. For single density drive, the unit provides up to 6.4-Mbits per disc, and 12.8-Mbits for double density. Up to 1.6-Mbytes can be stored on an industry standard 8-in. diskette. The band-driven concept provides friction-free operation and very high head speeds. Average access time is 91 ms, and track-to-track access time is 3-ms. Both hard or soft sector format operation can be provided, allowing the unit to read or write any IBM-compatible diskette having the appropriate format. Electronics for the drive is packaged on a single card and it can operate either from ac or dc.

CIRCLE NO. 367

Add-in memory provides 32 k on a single board

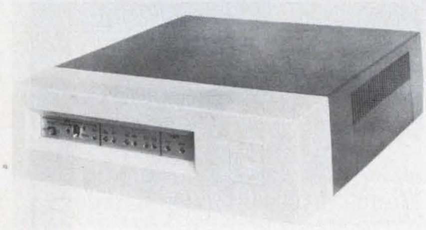


Fabri-Tek, 5901 S. Country Rd., Minneapolis, MN 55436. John Underwood (612) 935-8811. $1085 - 16-kword (1-qty); 10 days.

A semiconductor add-in memory for the DEC LSI-11 and PDP 11/03 microcomputers is designated the LS-IN-11. Up to 32 k words can be provided on a single board using 8 k or 16 k dynamic MOS N-channel chips. The unit is available in 8, 16, 24 or 32-k memory versions and memory segments are switch selectable in 4-k increments from 0 to 32-k. A 2-wide connector system is used, as compared to a 4-wide type employed by other manufacturers. The 8.5× 5.187×0.375 in. board plugs into a single chassis slot and is hardware and software compatible with the computer.

CIRCLE NO. 368

Single-card data set runs up to 1800 b/s



General DataComm Industries Inc., 131 Danbury Rd., Wilton, CT 06897. (203) 762-0711.

The GDC 202S/T FCC-registered data set is a single-card unit that transmits and receives asynchronous serial data at up to 1200 b/s over the switched network and up to 1800 b/s over private lines. It features local and remote diagnostics such as local self test, remote test, and analoop test, and manual or automatic answer. A 5 b/s reverse channel and local copy on the primary and secondary channels are options.

CIRCLE NO. 369

Rugged computers work in severe environments

Honeywell Information Systems, 200 Smith St., Waltham, MA 02154. (617) 890-8400.

Level-6 minicomputers will be available in ruggedized form for special factory, environmental and military applications. All features and performance of present Level-6 units are preserved in the ruggedized version. Protection against shock, vibration and RFI/EMI are added. The Model RL6 (Ruggedized Level 6) processor has completed environmental testing related to ground, mobile and shipboard applications as specified in MIL-E-5400 and MIL-E-16400. Level-6 processors contain either core or MOS memory of from 8 k to 64 k words, CRT or teleprinter console, and controllers for a variety of peripherals, including synchronous and asynchronous communication lines.

CIRCLE NO. 370

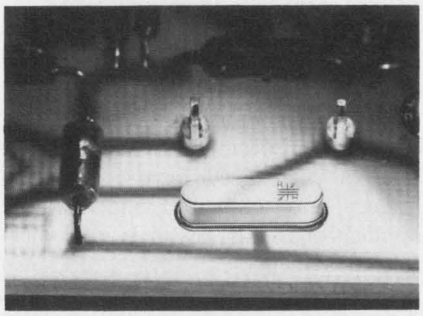
Bypass leased line with remote entry terminal

Randel Data Systems, 365 Maple Ave., Torrance, CA 90503. (213) 320-8550. $4950 (1-qty); 60 days.

Remote sites can communicate with a central computer without using leased lines, through the FDSR diskette terminal. Link 100, 200 or 500 small business computers can interface with the terminal which has a file capacity of over 311,000 characters, organized as 2431 addressable lines of 128 characters each. Information is stored during the business day on a flexible disc. As necessary, the remote site calls the Link computer's location and confers with it at high speed. Access time is typically 0.3 s, and is 0.6 s maximum from keyboard or CPU to any line.

CIRCLE NO. 371

Sealed quartz crystals have tight tolerances



Reeves-Hoffman, 400 W. North St., Carlisle, PA 17013. Dave Lind (717) 243-5929.

Quartz crystals for use in signal generating circuits of ultrasonic and other security systems equipment have frequency tolerances of +0.01%, −0.015%. The crystal is available in the frequency range from 17 to 150 kHz. Measuring 0.5-in. long, 0.14-in. wide, and 0.173-in. high, they are coldweld sealed for reliability.

CIRCLE NO. 372

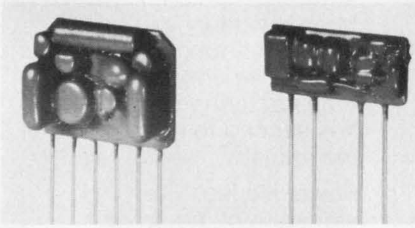
Diffuse-scan photosensor sees over 6-ft range

Micro Switch, 11 W. Spring St., Freeport, IL 60132. (815) 235-5731. $118 (unit qty).

The MLS9A, a diffuse-scan, self-contained photoreceiver works at 850 operations/min and has a 6-ft range. The target returns the light beam to the photoreceiver without the need for a retroreflector. Moreover, in a retroreflective mode, the range is 50 ft. UL-listed, the control operates on standard ac line voltage from −40 to 70 C, and is made with monolithic ICs. Operational features include adjustable sensitivity, false-pulse protection and slide-switch-mode selection for dark operate/light operate. Two optional programmable-logic cards can provide up to five additional functions.

CIRCLE NO. 373

Time-delay packaged for relays and PCs



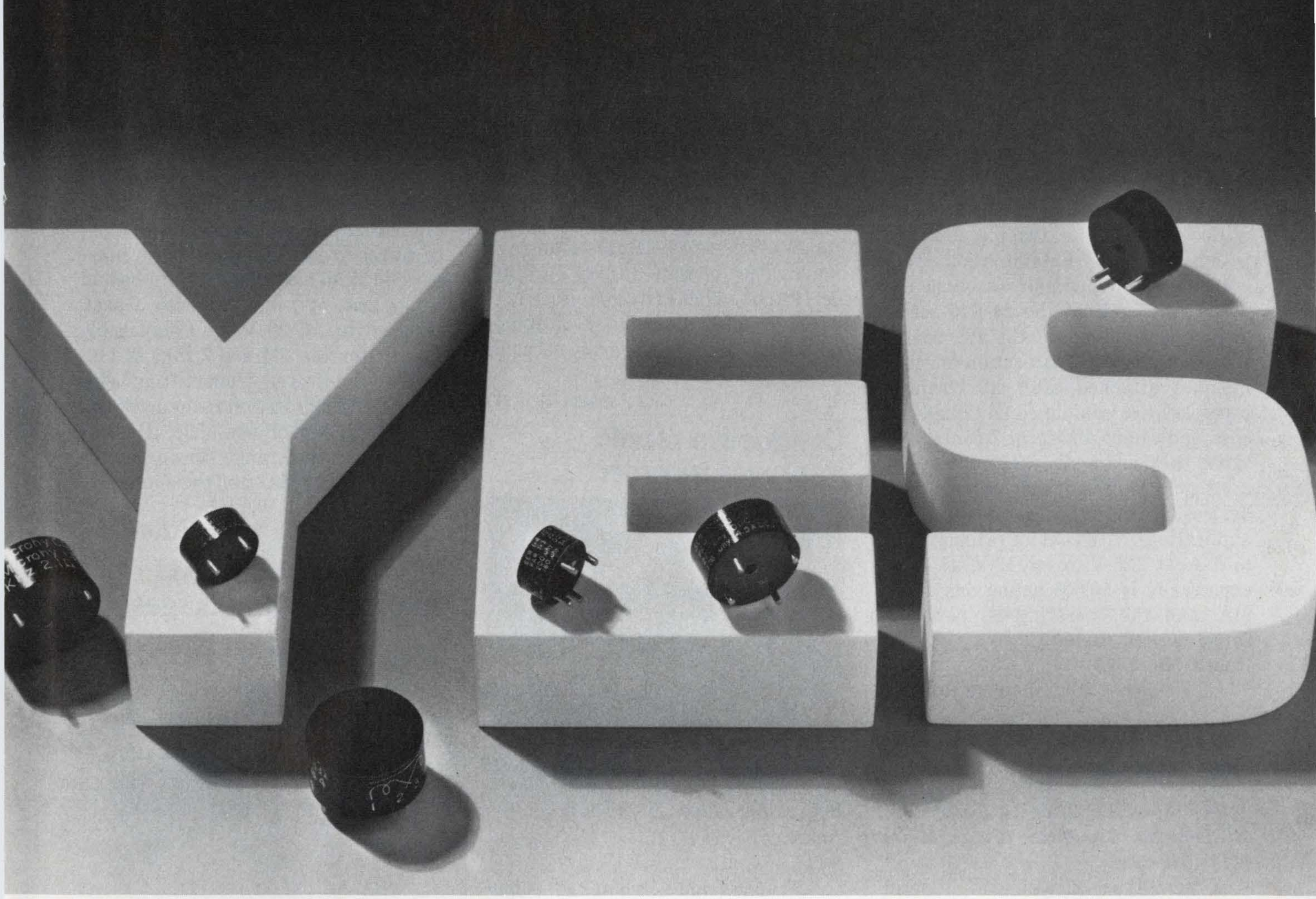
Instrumentation & Control Systems Inc., 129 Laura Dr., Addison, IL 60101. (312) 543-6200. About $5: ON delay, $8: OFF delay (OEM qty); stock.

The Icsotimer, a miniature time-delay circuit, is compactly molded and easily adapted to PC designs or readily incorporated into relay packages. Time delay is adjustable from 0.1 to 300 s. Its all-solid-state hybrid network can switch standard relays and contactors with an accuracy of ±2% under fixed conditions. The circuit is available in ON and OFF-delay timing functions for input voltages of 120, 240 V ac, and 120, 24, 48 V dc.

CIRCLE NUMBER 374

Need power-switching inductors for switching regulators?

TRW / UTC has a stock answer.



Introducing the SR series, a family of miniature high-performance, power-switching inductors.

Our SR Inductors reduce size and weight. Now you have off-the-shelf power-switching inductors with performance advantages over your in-house capabilities.

Low temperature rise and low loss characteristics combine to give the SR series high performance with maximum reliability. With an inductance range of 8 to 10,000 UHy, a DC current range from .8 amps to 15 amps, SR Inductors have low losses in the 3 to 100 KHz frequency range, making them ideal for use in switching regulators and AC filter-choke applications.

Compact and easy to install, the SR family has pin terminals for mounting on PC boards. Available with double windings, which when brought out to four terminals permit series, parallel, center-tapped or transformer connections.

Available from stock in three sizes. Type SRA measures 7/8-in. OD by 7/16-in. height; SRB measures 1-3/16-in. OD by 9/16-in. height; and SRC measures 1-3/8-in. OD by 3/4-in. height.

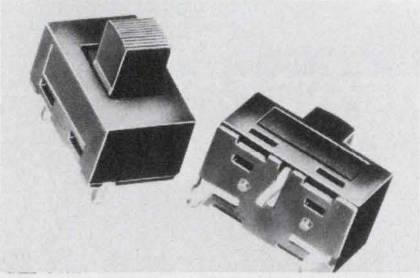
Check your authorized TRW/UTC local distributor for immediate off-the-shelf delivery or contact TRW/UTC Transformers, an Operation of TRW Electronic Components, 150 Varick Street, New York, N.Y. 10013. Area Code: 212 255-3500.

TRW UTC TRANSFORMERS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

CIRCLE NUMBER 95

Two-piece slide switch simplifies soldering



Chicago Switch, 1714 N. Damen Ave., Chicago, IL 60647. (312) 489-5500. $0.52 (spst) in (1000-qty); stock.

Wave-soldering operations are simplified by using a two-piece switch which prevents contamination from entering the upper half. Only the exposed base half of the 24-X40 series switch is soldered to the PC board, while the upper snap-action mechanism is attached after all cleaning processes are completed. Available in spst, spdt, dpdt and form-Z configurations, they are made with contacts of hard gold over a nickel barrier. The devices are designed for low energy applications with contact ratings of up to 1-A at 125-V ac or 12-V dc. Life expectancy is 50,000 actuations at 10 mA, and the operating temperature range is −40 to 100 C.
Booth No. 1403

CIRCLE NO. 375

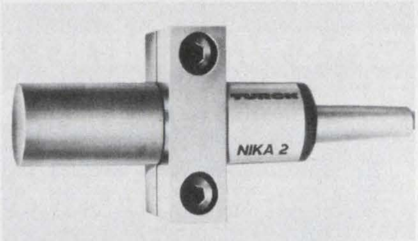
New relay data sheets offer detailed info

International Rectifier, 233 Kansas St., El Segundo, CA 90245. Martin Mintz (213) 678-6281.

A new type of technical bulletin provides users of solid state relays with detailed information on thermal characteristics, repetitive surge, fuse selection and duty cycle. Bulletin 500-11 is specifically for Crydom Series 3 relays, which are 2-A, 120 and 240-V-ac PC board mount devices. One area covered in depth by the bulletin is the overload capability of the devices. Conventional surge curves show only how much current can be handled on a non repetitive basis. The new data show a series of curves relating peak surge current and overload time to the allowable number of surges. Other curves simplify fuse selection and provide data on devices that operate with less than 100% duty cycles.

CIRCLE NO. 376

Proximity-sensor line features cost economy

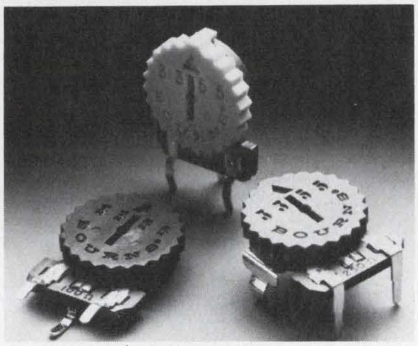


Turck Multiprox, 9710 10th Avenue N, Minneapolis, MN 55441. (612) 374-5000. From $16 (OEM qty.).

Six low-cost inductive proximity sensors and switches are completely encapsulated in tubular plastic housings (0.43-in. dia) and include removable mounting brackets. Switching ranges are to 0.078 or to 0.196 in. Two lower-range units may be flush-mounted in metal. They operate at from 5 to 24 V dc. Output switches handle either 12 or 24 V dc with a normally open npn output as standard (normally open pnp is also available).

CIRCLE NO. 377

Conductive plastic improves trimmer

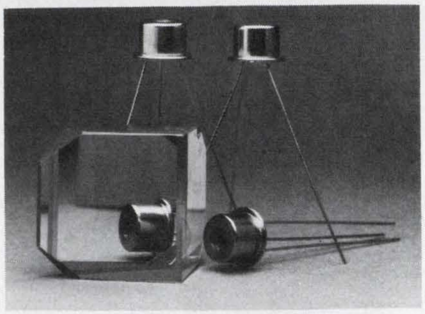


Bourns Inc., 1200 Columbia Ave., Riverside, CA 92507. (714) 781-5140. See text.

An open-frame trimming potentiometer, Model 3355, provides performance specifications never before available in the under 20¢ industrial market, according to Bourns. Said to be the first conductive-plastic element on a plastic substrate, the unit has a contact-resistance variation of 1%; similar carbon units have 3 to 6%. Temperature coefficient is 500 ppm/°C compared to almost 1000 ppm/°C for competitive trimmers. And the conductive-plastic greatly reduces the tendency to develop holes in frequently set spots. The new trimmer has a resistance range of 100 Ω to 5 MΩ, is made of flame-retardant materials and is board washable, despite its open frame.

CIRCLE NO. 378

Visible to infrared covered by detector

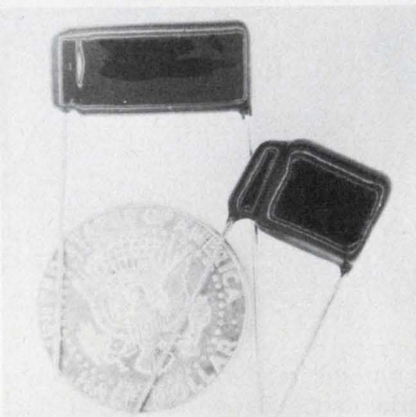


Dexter Research Center, 7300 Huron River Dr., Dexter, MI 48130. (313) 426-3921. $60 (100-qty); stock.

The 1M and 2M thermopile detectors provide spectral sensitivity from the visible to the far infrared. Both devices are hermetically sealed in either argon or nitrogen gas at atmospheric pressure, in TO-5 packages. The 1M has an active area of 1-mm dia with a peak responsivity of 25 V/W. Comparable figures for the 2M are 2 mm and 18 V/W. An infrared transmitting window is incorporated into the package, providing a field of view of 98°. Operating temperature range for the detectors is −65 to +85 C, and the maximum irradiance is 0.1 W/cm².

CIRCLE NO. 379

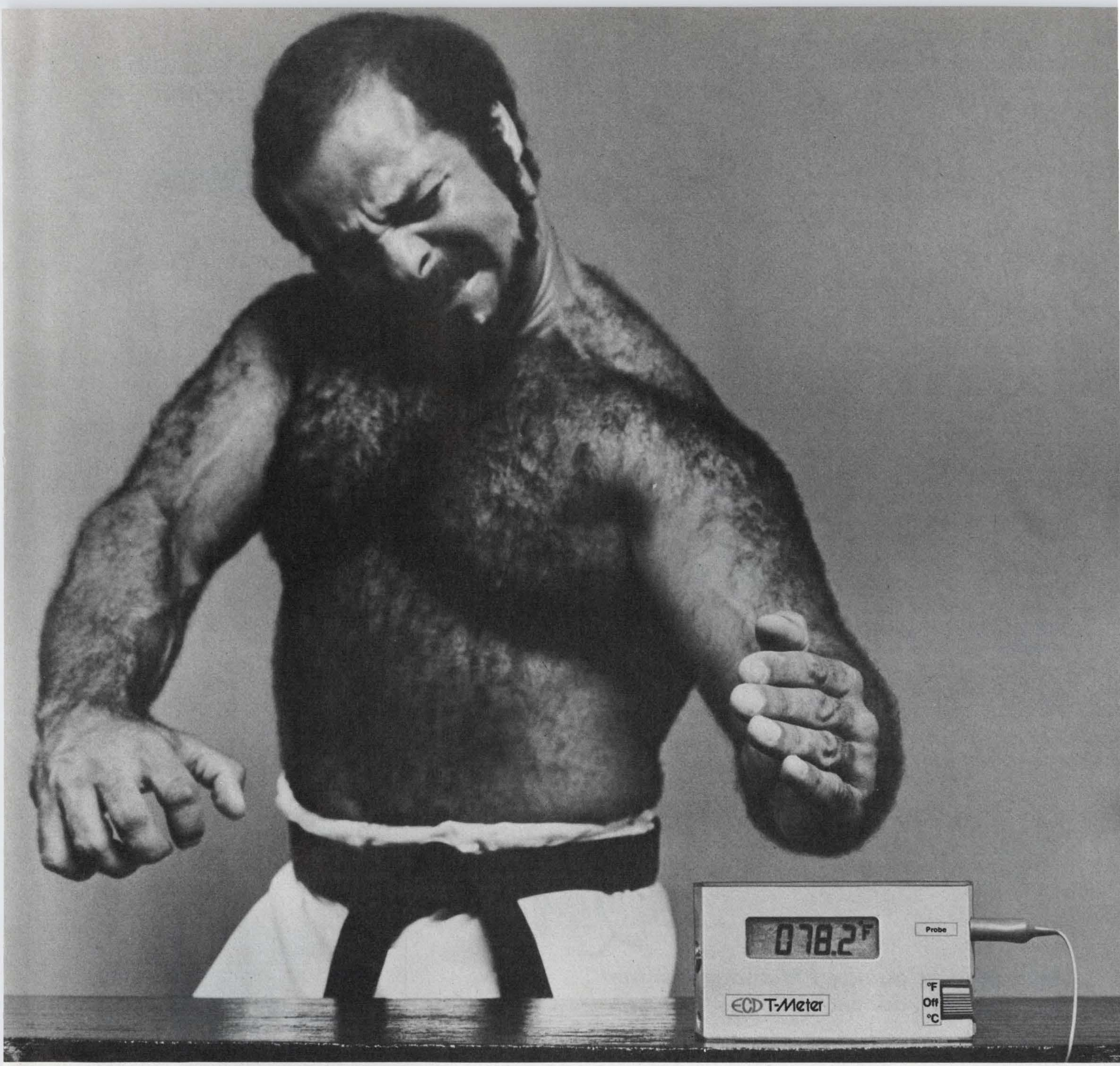
RC network series in epoxy dipped packages



TRW, 301 W. "O" St., Ogallala, NE 69153. (308) 284-3611. 8-10 wks.

Resistance values of up to 800 Ω, and capacitance values to 1 μF come in two-lead epoxy dipped packages. Designed as contact protectors for electromechanical switching systems, the packages contain a resistor and capacitor in series. The resistors have power ratings from ¼ to ½ W, with a range of 100 to 800 Ω. The capacitors are metallized Mylar with voltage ratings from 100 to 400-V and capacitance values from 0.22 to 1.0-μF.

CIRCLE NO. 380



T-METER™ MEANS TOUGH

This digital thermometer is virtually indestructible...drop proof, shock proof, water proof, chemical proof, you name it. We have hurled it against stone walls, immersed it in boiling water for an hour, and submerged it for a week in a salt water fish tank without harming it. Its electronics are cast in silicon. Its teflon-coated probes and cables resist chemicals. It is so rugged that we confidently offer a 3 Year Full Warranty.

Tough, accurate, and versatile, spanning −100°C to 200°C and −150°F to 400°F, the T-Meter (with standard probe) achieves ±0.5°C (±0.9°F) accuracy over −55°C to 125°C (−67°F to 257°F). Optional high accuracy probes for special applications achieve ±0.1°C (±0.15°F), covering the MIL range in 20°C increments. You can supplement the standard 3′ probe with lengths of 10′, 25′, and 100′. And you can special order lengths to 3,000′!

Tough as nails and nuisance-free, this fully guaranteed pocket-sized time-saver will cut your costs in a host of practical applications. Our reps stock T-Meters at **$239.** Standard probe, $25. General purpose high accuracy probe, $30. Others available.

ECD CORP.
196 Broadway
Cambridge, MA 02139
(617) 661-4400

CIRCLE NUMBER 97

SALES OFFICES: AL, Huntsville (205) 533-5896; AZ, Scottsdale (602) 947-7841; CA, Costa Mesa (714) 540-7160; CA, Sunnyvale (408) 733-8690; CO, Denver (303) 750-1222; FL, Winter Haven (813) 294-5815; GA, Chamblee (404) 457-7117; IL, Elk Grove Vill (312) 593-0282; IN, Indianapolis (317) 293-9827; MD, Silver Spring (301) 622-4200; MA, Wakefield (617) 245-5940; MN, Minneapolis (612) 781-1611; MO, Kansas City (816) 358-7272; So. NJ/Philadelphia (215) 674-9600; NM, Albuquerque (505) 299-7658; NY, Great Neck (516) 482-3500, (212) 895-7177, Syracuse (315) 446-0220; NC, Raleigh (919) 787-5818; OH, Centerville (513) 433-8171; TX, Houston (713) 688-9971; TX, Richardson (214) 231-2573.

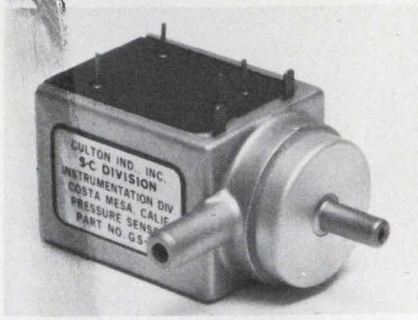
Ceramic caps handle 12 kVA of rf power

JFD, 15th Ave at 62nd St., Brooklyn, NY 11219. Gerald Kron (212) 331-1000.

Small ceramic capacitors in the UFP line can handle rf power levels of 12 kVA. The power handling capability is attributed to use of Hi-Q ceramic materials, glass encapsulation and monolithic construction using high conductive noble-metal electrodes. Capacitance values of 3.5 to 3,000 pF, with tolerances of ±0.25 and ±0.5 pF in the lower values, are available. Higher value capacitors have tolerances of from 5 to 10%. Small value capacitors—up to 150 pF—can handle up to 4,200-V peak, while a 300-pF device can typically handle 2,800 V. Temperature coefficient, in the temperature range from −55 to +125 C is 90 ± 20 ppm/°C.

CIRCLE NO. 381

Control tape loop with pressure transducer

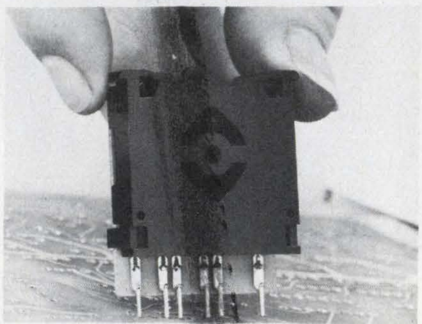


Gulton SCD, 1644 Whittier Ave., Costa Mesa, CA 92627. Jim Pancake (714) 642-2400. $55 (1-qty); 4 wks.

The length of the tape loop in high-speed tape transports can be controlled by a transducer that senses differential air pressure. In the GS-503 pressure transducer, high level output dc signals result from differential pressures of ±2 PSID. Holes in the "slack" tape chamber allow the pressure to be sensed as the tape moves along, and the transducer outputs a signal to control the rotation of the tape reels. A solid state dc-dc converter in the transducer allows operation from 9 to 15 V dc sources. It is constructed with a die-cast case which includes pressure fittings that accept standard ¼-in. dia. tubing.

CIRCLE NO. 382

Thumbwheel switch mounts on PC board

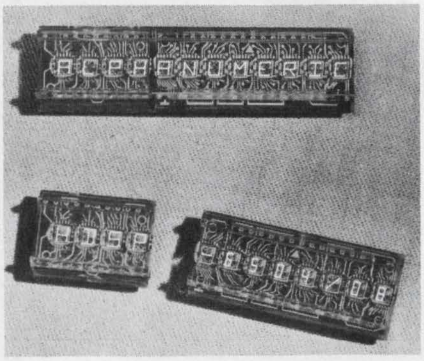


EECO, 1441 E. Chestnut Ave., Santa Ana, CA 92701. (714) 835-6000. $0.09 per pin (500-qty); 5 wks.

Optional pin terminals on the 1800-series thumbwheel switches allow them to be mounted on PC boards. Pin-terminal models are available in the following codes: 1-pole decimal BCD, BCD with complement, BCD complement only, BCD with diode provision and special 2-pole repeating codes. Dimensions of the pins are 0.025 in. square by 0.16 in. long, and board connections can be made by either hand or flow soldering.

CIRCLE NO. 383

LED 16-segment display generates 64 ASCII set



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 91304. (415) 493-1501. $38: HDSP-6058, $19: HDSP-6504 (100 qty); stock.

HDSP-6504/6508 four and eight-character LED alphanumeric displays have a 16-segment font plus a centered decimal point and colon. The complete 64-character ASCII set can be displayed. Character spacing is four characters per in. Red gallium-arsenide-phosphide LEDs are magnified by an internal lens which produces a character size of 0.150 in. Characters drawing as little as 1-to-1.5-mA average current per segment can be easily read at a distance of more than 6 ft. The DIP units can be stacked end-to-end for applications that require additional characters.

CIRCLE NO. 384

Mercury tilt switch handles 4 A at 28 V

Kahl Instrument, P.O. Box 1166, El Cajon, CA 92022. (714) 444-2158.

Electrical contact is made by the 03EA135 tilt-sensitive switch when it is turned beyond a preset angle. The device is normally off in the vertical position and rotation about its cylindrical axis does not affect contact closure. In the on mode, an inversion of 180° from its initial position will not change the contact state. The hermetically sealed switch can handle 4 A at 28 V dc or 2 A at 220 V, 60 Hz. A typical tilt angle for contact is 45°, but other angles are possible by varying the amount of mercury. Made from specially selected alloys, the switch is packaged in a glass envelope, measuring about 0.7-in. diameter and 0.85-in. high.

CIRCLE NO. 385

Hall-effect sensors shrunk to ¾ in.

Micro Switch, 11 W. Spring St., Freeport, IL 61032. (815) 235-5731. $2.10: 3AV $2.20: 4AV (100 qty).

Vane-operated position sensors, 3AV/4AV, are now only about ¾-in. long and include a standard 0.040-in. square Hall-effect IC chip on one side of the gap and a powerful rare-earth magnet on the other. The miniature vane sensors can function from zero speed to 100,000 operations per second. They are unaffected by dust, dirt or ambient light. Operate and release points are carefully controlled to tight tolerance. The vane sensor may be used as a limit switch by operating with a single large vane; as a tachometer sensor by using a toothed wheel, and as a machinery-synchronizing element by using a cam. The sensors may be interfaced directly with discrete transistors, μPs, IC logic and SCRs. An 8-or-20-mA output eliminates the need for amplifiers in most applications. The 3AV needs a supply voltage of 4.5 to 5.5 V dc, and operates from 0 to 50 C. The 4AV series also uses 4.5 to 5.5 V dc, but three models of the series need 6 to 16 V dc, and the series operates from −40 to 85 C.

CIRCLE NO. 386

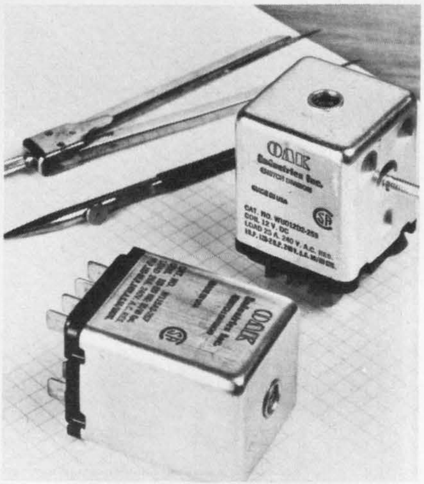
Load cell is accurate and compensated

Celesco, 7800 Deering Ave., Canoga Park, CA 91304. Philip Gindes (213) 884-6860. $110 (1-qty).

With an accuracy of 0.1% of full scale, the MB-101 series of load cells comes in seven models in ranges from 2.5 to 25 lb. The compensated temperature range for the device is from 30 to 130 F. Temperature effect on zero balance and temperature effect on output are both spec'd at ±0.0008% of full scale per °F. The unit contains a four-arm Wheatstone bridge of etched-foil strain gages and can be supplied in either tension or compression. Deflection is approximately 0.002 in., with creep of less than 0.03% after 20 min., at full load. Overall operating temperature range is from −65 to +275 F.

CIRCLE NO. 387

Relay series offered in power, low-level models



Oak Switch, Crystal Lake, IL 60014. Dodi Almcrantz (815) 459-9000.

Two types of relays are offered in the type W series—a power contact type and a low-level model—with a combination of both contacts also available. Both styles are designed to operate at dc voltages of 6, 12, 24, 48 and 110, or ac voltages of 6, 12, 24, 115 and 220. Mounting options are plug in socket, or standard quick-connect terminals. The standard contact material is silver, with silver-cadmium-oxide or gold plate available as options. Power types have life expectancies of 10 million mechanical operations at 25 A resistive and inductive loads, ac and dc. Coil dissipation is 2.5-W dc and 7.5-VA ac, and operate and release time is nominally 25 ms.

CIRCLE NO. 388

Low-profile relays for dry-circuit systems

Omron, 233 S. Wacker Dr., Chicago, IL 60606. Frank Schwartz (312) 876-0800. $4.85-$6.30 (100-qty).

Twenty-four models of low-profile relays designed to minimize contact resistance are offered in the LZN series. Though designed for dry-circuit applications in communications systems, the unit can switch up to 3 A at 24 V dc. Operating voltages of 6, 12, 24 or 48 V dc are available in two formats —dpdt or 4pdt. Typical power consumption in continuous operation is 300-mW for dpdt and 480-mW for 4pdt. Maximum operating time is 10 ms. All models measure 0.453 in. (H) by 1.201 in. (L) and fit PC boards mounted on 0.5-in. centers. The width varies with the contact configuration, being 0.87 in. for double-pole models, and 0.965 in. for four-pole units.

CIRCLE NO. 389

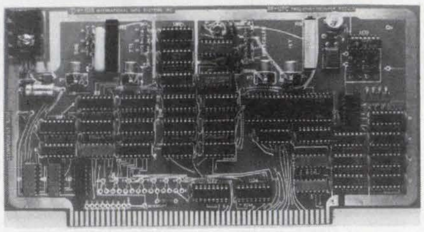
Complete microcomputer has printer and discs

INEX, 150 S. 600 E., Salt Lake City, UT 84102. Doug Hancey (801) 363-1177. $13,250; 90 days.

The "Total" microcomputer system, designed for use in stand alone applications, consists of a M6800 processor with up to 52 kbytes of RAM, an 80 × 25 character display monitor, a matrix line printer and a dual floppy-disc system. The system allows the user to program in Extended disc Basic, and the disc operating system software includes a macro-assembler, editor, I/O handlers and variable length file handling.

CIRCLE NO. 390

Frequency counter plugs into S-100 bus systems



International Data Systems, 400 N. Washington St., Suite 200, Falls Church, VA 22046. (703) 536-7373. $179 (kit); stock.

Precise frequency and period measurements controlled by a microprocessor are possible using the 88-UFC, a nine-decade universal frequency counter module. The counter includes provisions for four signal sources and the signal to be measured is selected under software control. Three of the inputs are general purpose and accept analog or digital signals. The fourth input accepts TTL level signals. One of the general purpose inputs includes a prescaler extending its range typically above 600 MHz. The other three inputs will typically count to 65 MHz, with 60 MHz guaranteed. An onboard crystal timebase is selectable under software control for count intervals from 100 ns to 1 s. For period measurement functions either half-cycle or full cycle measurement and the unit of measure may be selected under software control. Provisions are included for interrupts generated upon completion of a frequency count or period measurement. This option may be enabled or disabled under software control. Software is included to provide totalizing/accumulation, period measurement, time interval measurement, frequency measurement, and more, as well as storage for subsequent retrieval in ASCII, binary, or BCD.

CIRCLE NO. 391

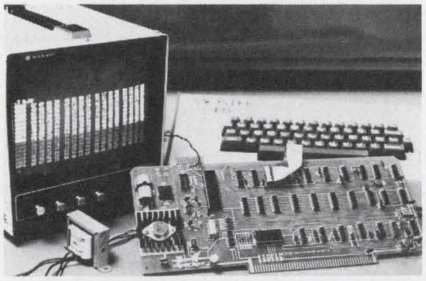
Expanded SBC 80/20 board holds double the memory

Intel, 3065 Bowers Ave., Santa Clara, CA 95051. Rob Walker (408) 246-7501. $895 (80/20); $995 (80/20-4); 30 days.

The SBC 80/20-4, an updated SBC 80/20, provides twice as much resident memory as the original model. It has 4 kwords of read/write memory and up to 8 k of nonvolatile program storage. Also, the program memory capacity of the original SBC 80/20 has been doubled. Users now have the option of storing up to 8 kbytes of program along with 2 k of data, at no increase in price.

CIRCLE NO. 392

μP-based terminal fits on single circuit board



Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. (214) 242-0444. $195; stock.

Built around the MK 3870 single-chip microcomputer, the Video Adaptor Board (VAB-2) forms the heart of a simple video terminal. When connected to an ASCII keyboard, video monitor and power transformer VAB-2 forms a complete video terminal. The board offers a screen format of 16 lines of 64 characters (5 × 8 dot matrix), and a ROM character generator for 96 characters, including lower case letters. Full cursor controls are provided, including screen-clear, erase to end of line/screen, and direct cursor addressing. Output is EIA composite video and data rates of both 110 and 300 baud are supported with either 20 mA current loop or RS-232 interface compatibility. The VAB-2 operates from a 5 V dc on-board power supply and measures 14 × 5 in.

Booth No. 1608-10 CIRCLE NO. 393

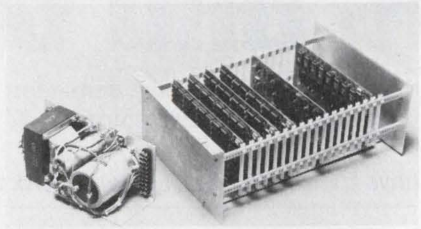
16 kbyte memory board mates with S-100 bus

Solid State Music, 2102A Walsh Ave., Santa Clara, CA 95050. Dan Burgoon (408) 246-2707. $525 (kit); $625 (assembled); stock.

A 16 k static RAM board, Model MB-7, allows for system expansion beyond 64 k and is fully buffered. The board, compatible with the S-100 bus, uses 32 4-k RAMs with 200 ns access times. Automatic memory unprotect and protect features allow the user to protect memory in 4 k blocks with automatic unprotect at power-on. The SOL microcomputer compatible memory disable allows the ROM monitor of the SOL to initialize the system at power-up or reset.

CIRCLE NO. 394

Rackmount computer has 18 slot chassis



Vector Graphic, 790 Hampshire Rd. A-B, Westlake Village, CA 91361. Carol Ely (805) 497-0733. $225 (chassis); $90 (supply); stock.

A rack-mount version of the Vector 1 microcomputer includes card cage and 18-slot motherboard assembled and tested with 18 connectors, card guides and locking buttons for 18 cards. The motherboard is fully shielded to reduce noise on the bus. A heavy duty modular power supply is also available. The 18 A at 8 V, 2.5 A at ±16-V unit provides sufficient unregulated power for all 18 boards. Primary taps on the transformer permit line voltage of 110, 120, and 130 V.

CIRCLE NO. 395

Disc operating system aids PACE development

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Bob Pecotich (408) 737-5000. $4500; 30 days.

The IPC-16P/840, a disc-operating system (DOS) for the PACE microprocessor, simplifies the assembly, editing and execution of programs. Including a dual-floppy disc drive in a stand-alone enclosure, an interface circuit subsystem card, a ROM card containing firmware, the system comes with complete operating software on a diskette. The software includes a comprehensive file management capability, support for assembly programs, editors, linking loaders, utility programs and diagnostics. The system may be installed on any IPC-16P PACE microprocessor development system with 12 kwords of RAM and heavy-duty power supply.

CIRCLE NO. 396

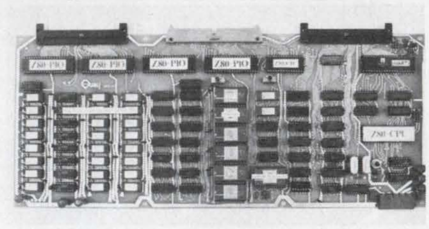
EPROM programmer kit uses system software

Mini Micro Mart, 1618 James St., Syracuse, NY 13203. Maury Goldberg (315) 422-4467. From $24.95; stock.

The 3164-1, an EPROM programmer kit, is intended to program the 2708 series of EPROM. The newer (2 k × 8) Intel and TI devices can also be accommodated. Originally designed to function with the company's series of RM 8080 and Z-80 systems, the programmer is equally effective on any system that has available three latched parallel I/O ports. The programmer is software driven from the user's processor. Some software routines are included and are intended to run with a system monitor provided by the company. The user may need to tailor the software to his own operating system. A power supply kit is also available. The supply provides the regulated +12, +5, and −5 V, and a source of dc for program pulses in excess of 25 V dc.

CIRCLE NO. 397

Microcomputer board designed around Z80



Quay Corp., P.O. Box 386, Freehold, NJ 07728. R. Maly (201) 681-8700. $500 (100-qty); stock.

The 90 MPS, a single-board Z80-based microcomputer includes 6 kbytes of memory. Of the 6 k, 4 k is dynamic RAM, 1 k is static RAM, and the other 1 k is a monitor held in 2708 UV PROM. Two Z80 parallel I/O chips provide four parallel I/O ports. Also on board is a UART with RS-232C and 20-mA current-loop interfaces, a 2.5-MHz crystal clock, a Z80 counter/timer circuit, and a PROM programmer for 2708 type UV PROMs. The microcomputer measures 16.175×6.875 in. All I/O is via three 60-pin flat-ribbon connectors. The dynamic RAM can be expanded to 65 k and a total of 7 k of 2708 UV PROM can be installed on the board. Sockets are also provided to permit two more Z80 PIO chips. An option for 4 MHz operation is also available.

CIRCLE NO. 398

Meet our better half.

The New TI .156″x .200″ H4 Series Edgeboard Connector.

Our better half from T.I. It's the edgeboard connector half of a PC board/edgeboard connector system. And definitely today's best value.

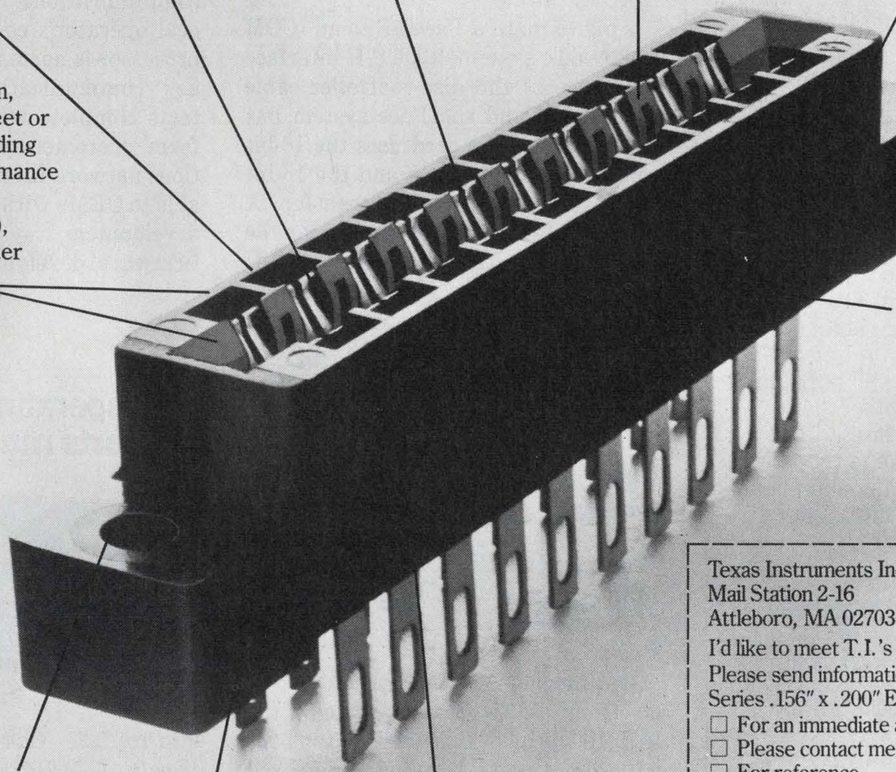
Its minimum 75 microinches wrought-gold inlay provides greater reliability at contact mating surfaces to make our better half better.

Its bifurcated contacts provide greater connection reliability to make our better half better.

Its between-position polarizing key system allows more efficient use of the connector to make our better half better.

Its off-the-shelf availability through our extensive nationwide distribution network makes our better half better.

Its construction, designed to meet or exceed demanding military performance specifications (MIL-C-21097), makes our better half better.



Its functional and dimensional interchangeability with common one-piece edgeboard connectors gives you price and delivery advantages and makes our better half better.

Texas Instruments Incorporated
Mail Station 2-16
Attleboro, MA 02703

I'd like to meet T.I.'s better half.
Please send information on your new H4 Series .156″ x .200″ Edgeboard Connector.

☐ For an immediate application.
☐ Please contact me directly.
☐ For reference.

Name ______
Title ______
Company ______
Area Code ______ Phone ______ Ext. ______
Address ______ Mail Station ______
City ______ State ______ Zip ______

ED

Its termination and mounting flexibility, including both solder tail and solder eye terminations, as well as flush or earless mounting, make our better half better.

Its glass-filled thermoplastic polyester contact housing meets U.L. Flammability Classification 94V-0 to make our better half better.

Its practical design coupled with our low, low prices (as exemplified by our low cost IC's) make our better half better.

TEXAS INSTRUMENTS
INCORPORATED

Interface board joins Pace to floppy drive

Abler Data Service, 740 Garvens Ave., Brookfield, WI 53005. Joseph Abler (414) 786-2448. $300 (board); $200 (PROM); stock.

Able to mate a Pace μP to an ICOM floppy disc system, a DOS-II interface card accepts the disc-controller cable on one end and the Pace system bus on the other. The card uses the 16-bit commands of the Pace and the 16-bit data words to speed the transfer. A typical IBM format diskette can be read or rewritten in 75 s. DOS-II monitor listings are included. The controller can support from one to four drives. An optional PROM-based bootstrap and the monitor on diskettes are also available.

CIRCLE NO. 399

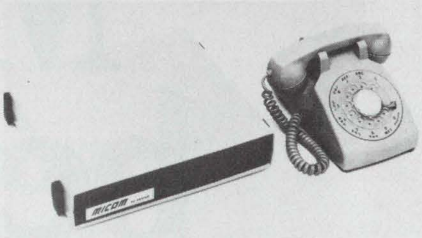
Video interface board mounts in S-100 bus

Vectron, P.O. Box 20887, Dallas, TX 75220. John McCrady (214) 350-5291. $185 (assembled and tested), $155 (kit); stock.

Requiring just the unregulated 7 V dc from an S-100 bus system, the SCT-100 provides a video output for data display on a terminal. The board includes both ASCII and Baudot serial interfaces, and requires only the addition of a standard ASCII encoded keyboard and a TV monitor. Designed around the 3870 single-chip microcomputer, the board includes full X-Y cursor control (both absolute and relative), screen clear, clear to end of line, page mode and autoscroll, 96 displayable characters, 16 line by 64 character display, plus multiple baud rates up to 300 baud. For stand-alone applications an on-board rectifier and filter permits the operation of the board directly from an external 6.3 V ac, 1 A transformer.

CIRCLE NO. 403

Communication processor handles up to 9 channels



Micro Systems, 9551 Irondale Ave., Chatsworth, CA 91311. Roger Evans (213) 882-6890. From $880; 45 days.

The 20 Series communications processor is a completely self-contained communications-oriented microcomputer system. Built around the Z80, the 20 Series consists of the CPU, up to a 19-k RAM buffer storage, up to 8-k PROM control firmware, up to nine communications interfaces, and integral operator's console. The 20 Series processor is normally supplied in turnkey communications controller systems complete with firmware to perform customer-specified communications network functions. It is also available to OEMs with a complete program development system to facilitate firmware development.

CIRCLE NO. 404

Disc operating system supports multiple users

muPro, 424 Oakmead Pkwy., Sunnyvale, CA 94086. Don Pantle (408) 737-0500. P&A: See text.

The muPro-80D a multitask disc operating system can support multiple users. Combined with the firm's MUTE software, the system keeps costs low because a single microcomputer and floppy disc can be used with multiple terminals rather than having multiple microcomputers. The system consists of a dual disc drive and the company's μPro-80 computer. The full system with enough memory (48k) to handle two terminals costs $9750. Another 16 k of memory costs $800 and permits the system to be used with four terminals. Delivery is 30 days.

CIRCLE NO. 405

NOW, LEAR SIEGLER AND BURROUGHS ARE ON SPEAKING TERMS.

You're probably very happy with your Burroughs mainframe.

But you'd undoubtedly like to have the versatility and dependability of Lear Siegler terminals. If only they were compatible with your present system.

Now they are. Complete with standard Burroughs polling and address line disciplines.

What's more, the ADM-2B's forms mode capability is compatible with the TD-820.

The ADM-2B gives you full text editing capabilities. Including erase to end of line/field/page. Insert and delete character and line. Blinking and blanking fields. And tabbing.

Just flick a switch and you can convert the ADM-2B to a standard ADM-2 with Burroughs line discipline.

Line diagnostic mode is switch selectable — which makes it extremely valuable for troubleshooting.

Of course, there's all the support that Lear Siegler is famous for. Throughout the United States and in many foreign countries.

$2485.

That's the full price. Including serial printer port. Numeric keypad. 24x80 character screen. 16 function keys. 110-9600 baud. RS232 interface. Burroughs two-wire direct connect is available as an option.

The fact is, Lear Siegler's new ADM-2B terminal gives you the best of both terminals. So you can use it right alongside your present Burroughs terminals and mainframe.

So rest easy, Burroughs users. Because now Lear Siegler speaks your language.

For more information contact: Lear Siegler, Inc., E.I.D./Data Products, 714 N. Brookhurst St., Anaheim, CA 92803; (800) 854-3805. In California (714) 774-1010.

LSi®

THE ADM-2B. SMART TERMINAL. SMARTER BUY.

CIRCLE NUMBER 107

µP development system also programs PROMS

Microkit, 11205 S. La Cienega Blvd., Los Angeles, CA 90045. Bob Schaaf (213) 641-7700. P&A: see text.

The Microemulator, an in-circuit emulator/EPROM programmer, can handle the 2704 and 2708 EPROMs. The unit extends the editing, assembling and debugging capabilities of the company's 8080/6800/ Z-80 product development systems. A cable from the Microemulator plugs directly into a prototype's CPU socket and allows debugging of the prototype in its own environment. Programs residing in the microcomputer's RAM memory can execute and access the memory and I/O devices, emulating actual usage. In addition to basic monitor commands, provision is made for single step and trace execution, hardware breakpoints and 2708/2704 EPROM programming. The complete system package consisting of an M8-40 Microemulator and M8-41 debug and EPROM programmer costs $1250.

CIRCLE NO. 406

Disc controller connects 4 drives to HP terminals

Microcomputer Systems, 440 Oakmead Parkway, Sunnyvale, CA 94086. (408) 733-4200. $1595 (unit qty); stock.

A terminal-resident, microprogrammed disc controller interfaces the HP 2645A, 41A, 49A intelligent terminals with up to four Ampex DM 440 series disc drives. These drives provide 40 Mbytes of on-line disc storage. The heart of the disc interface is the MSC-264X, a 13 × 4-in. microprogrammed controller. In addition to the I/O commands necessary for terminal-to-disc data transmissions, the controller is equipped with firmware diagnostic routines.

CIRCLE NO. 407

Debug tool handles both hardware and software

RCA, Box 3200, Somerville, NJ 08876. (201) 685-6000. $1600; stock.

The Cosmac micromonitor permits in-circuit debugging of any CDP1802 microprocessor system's hardware and software in real time. The CDP18S030 Micromonitor includes a built-in keyboard, display, and status indicator lights, as well as software debugging routines. A self-test card simulates a user system to allow verification and assurance of Micromonitor operation. A single cable connects between the CPU of a system under test and all the interfaces. Controlled by its own built-in microprocessor, the Micromonitor uses the CPU, power supply, clock, memory, etc. of the system under test to run a user program. It can be operated either from its own keyboard or from an external terminal if a hardcopy record is desired. Remote operation from a floppy disc file possible when the Micromonitor is used with the Cosmac Development System II (CDP18S005). The Micromonitor provides 43 commands that permit the user to examine or modify memory and all CPU registers and flags. Break conditions can be programmed for: external flag lines, auxiliary break input, idle, interrupt response, or memory read/write. Three modes for running programs are available. One mode provides for real-time running, starting at a specified address or continuing from a break. Another mode provides for single or a specified number of instruction cycles. The third mode provides for a single or a specified number of machine cycles to be executed.

Booth No. 707-709

CIRCLE NO. 408

ROM-based Basic does floating point math

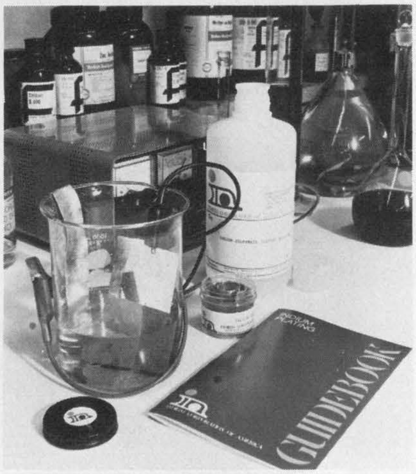
Electronic Arrays, 550 E. Middlefield Rd., Mountain View, CA 94043. John Lipnisky (415) 964-4321. $95 (1 to 24 qty); stock.

The EA3280 LLL 8080 Basic interpreter is solid-state software. It is a set of two (4 k × 8 ROMs) containing a 6 k Basic routine with floating point, TTY I/O, memory check and ODT-80 monitor routines. It is a high-level, easy-to-use language for use in an 8080 microprocessor system. The EA3280 chip set comes with an application note, assembly listing and user's guide.

CIRCLE NO. 409

PACKAGING & MATERIALS

Try out indium plating with experimental kit



Indium Corporation of America, P.O. Box 269, Utica, NY 13503. (315) 797-1630. $95 (unit qty).

An experimental indium plating kit tests indium plating on sample or prototype parts or surfaces. Each kit includes one liter of indium sulfamate bath, two anodes (1 × 12 × 0.030 in.) of 99.99% pure indium metal, and the new Indium Plating Guidebook. Indium is an excellent plating material for surface protection and hardening, decorative finishing, corrosion and wear-resistance of electrical contacts, and much more.

CIRCLE NO. 410

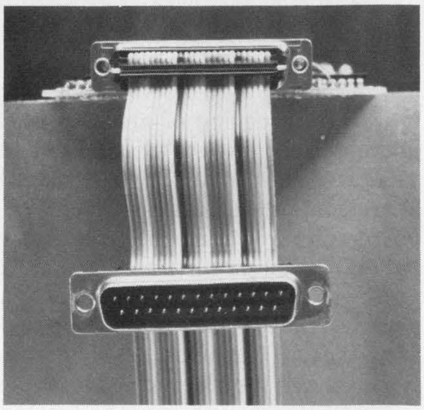
NiCd battery replaces rectangular 9 V dry cell

Sanyo Electric, 51 Joseph St., Moonachie, NJ 07074. H. Tamada (201) 641-2333. $9.95 (unit qty). See text.

A 9-V nickel-cadmium battery is offered in the popular rectangular case and a compact recharger accommodates it. The Model 6N-75P has a nominal capacity of 75 mAh. It can be recharged as many as a thousand times. The recharging unit ($5.50) holds a single battery, which recharges in 7 to 8 h.

CIRCLE NO. 411

D-shelled connectors mass terminate speedily



ITT Cannon Electric Div., 666 E. Dyer Rd., Santa Ana, CA 92702. (714) 557-4700. $5.67: 25 pins (500 qty.); 10 to 12 wks.

Mas/Ter-D pin-and-socket connectors for high-speed mass termination with 25 and 37-position contact arrangements are fully intermateable and intermountable with the Cannon D-subminiature series. This system terminates round-conductor flat cable or discrete wires. Connectors handle the wire ranges 22 through 24 AWG and 26 through 28 AWG, solid and stranded. Copper-alloy contacts are plated with gold over nickel; insulation is glass-reinforced thermoplastic, meeting the flammability requirements of UL 94 V-O. The steel shells are cadmium, chromate conversion plated. The connector has a dielectric-withstanding voltage of 1000 V ac, an insulation resistance of 1000 MΩ minimum and contact resistance of 15 m Ω after environmental testing. The operating temperature is −55 to 105 C.

CIRCLE NO. 412

Silicone-rubber contacts actuate CMOS circuits

Tecknit, 129 Dermody St., Cranford, NJ 07016. R. Ventimiglia (201) 272-5500.

Switch contacts, called ESCONs, made from high-temperature cured silicone rubber filled with conductive particles, provide a resistance of less than 300 Ω. The contacts can operate with high-impedance circuits (CMOS) to turn on 20-to-100-μA logic circuits. Silver-filled ESCONs are available for high-current (15-to-30-mA) applications. The typical silver contact has a nominal contact resistance of less than 0.3 Ω. ESCON was developed for the pushbutton switches used in digital electronic watches.

CIRCLE NO. 413

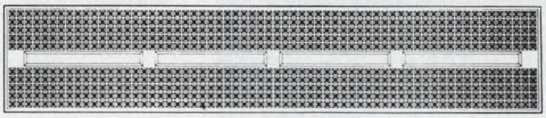
Special Bonus Offer!

A P Terminal and Distribution Strips for Faster and Easier solderless circuit building and testing. No special patch cords are required, and any solid wire up to No. 20 AWG can be used for connection. Strips accept all components with leads up to .032″ diameter, and hardware and mounting templates are provided with every strip. Terminals are non-corrosive nickel/silver.

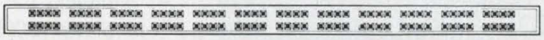
For the name of the distributor nearest you call Toll-Free 800-321-9668.

Send for our complete A P catalog The Faster and Easier Book.

Faster and Easier is what we're all about.



Buy this Model 264L **TERMINAL STRIP,** with 128 five-tie-point terminals, #923261 for only **$12.50.**



And get this Model 212R **DISTRIBUTION STRIP,** with 24 four-tie-point terminals, #923277 **FREE** of added cost.

Free offer also applies to other sizes.

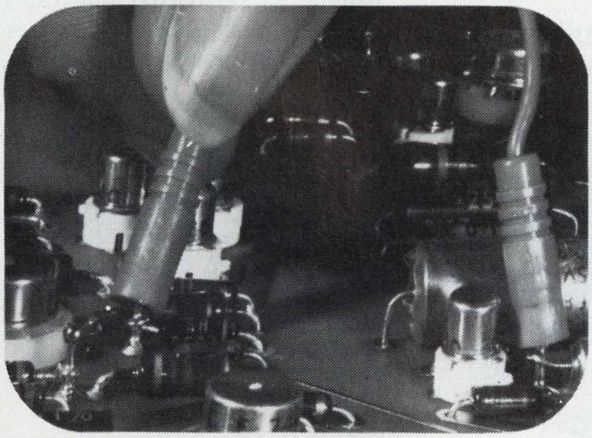
Look for the Special Bonus Offer Display at your A P distributor.

*Special bonus offer expires 12/31/77

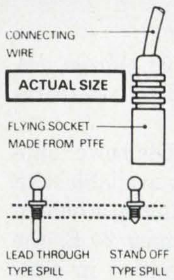
A P PRODUCTS INCORPORATED

Box 110 • 72 Corwin Drive, Painesville, Ohio 44077 • 216/354-2101 TWX: 810-425-2250

CIRCLE NUMBER 120



award winning OXLEY Snaplox®



Snaplox® connector/test point extends Oxley's wide range. Clicks on/off but pulled beyond generous angle, detaches without damage. Ball-ended spills (stand-off or lead-through) available in various executions. PTFE insulated flying socket spherical spring contact, in eleven colours. Request information.

See Snaplox

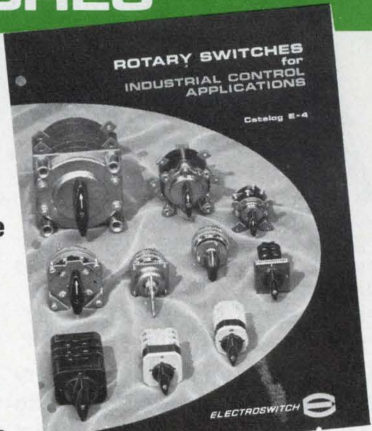
STAND 1016/8 WESCON

Oxley Incorporated PLAZA SUITE 900, 3250 WILSHIRE BOULEVARD LOS ANGELES, CALIFORNIA 90010. PHONE (213) 383-8270 TWX 1 910 321-2903

OXLEY Oxley Developments Co. Ltd.
ULVERSTON · CUMBRIA · LA12 9QG · ENGLAND
CABLES OXLEY ULVERSTON · TELEX 65141 · TELEPHONE 0229 52621

CIRCLE NUMBER 121

NEW CATALOG! POWER ROTARY SWITCHES



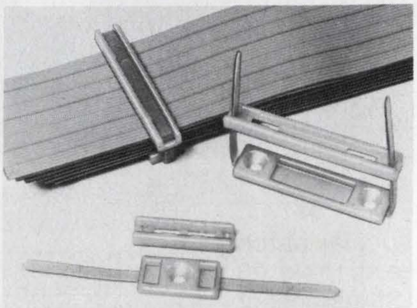
- Complete line of switches for Industrial Control Applications
- 17 basic switch models
- Ratings from 10A to 200A . . . from 240V to 600V
- Up to 75 poles! up to 16 positions!
- Myriad of standard & optional features

Request Catalog E-4

ELECTRO SWITCH
Weymouth, Massachusetts 02188
Telephone: 617/335/5200 • TWX: 710/388/0377

CIRCLE NUMBER 122

Cable clamps bundle flat cables

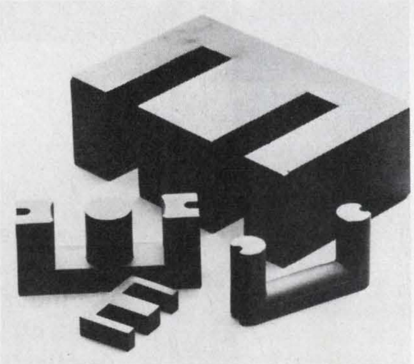


T&B/Ansley Corp., 3208 Humboldt St., Los Angeles, CA 90031. (213) 223-2331. From $0.12 (1000 qty).

Self-locking Blue Macs cable clamps bundle flat flexible cables without special tools. Made of nylon, the clamps are adjustable, reusable and releasable for the easy removal or addition of cables. The clamps mount 1-to-3-in.-wide flat cables in a neat, low-profile arrangement. Clamps are available with screw or adhesive-mounting bases for bundling cable from 0.5-to-1-in high.

CIRCLE NO. 414

E cores automatable with round center legs



Stackpole Carbon Co., St. Marys, PA 15857. (814) 781-1234. $210-to-$450/1000; 4 to 5 wks.

E cores for switch-mode power supply applications are now available with round center legs for automatic bobbin winding. Made of ceramag 24 B, the new cores may be specified in sizes ranging from 35 to 70 mm. The material is popular for the energy-saving power supplies because of its low core loss and high-permeability characteristics.

CIRCLE NO. 415

New literature

Packaging systems

A 60-page catalog covers microelectronic packaging systems and hardware. Mupac, Brockton, MA

CIRCLE NO. 416

Synchro converters

A 30-page catalog describes synchro converters, displays and encoders. Computer Conversions, East Northport, NY

CIRCLE NO. 417

GGG substrates

Material advances in gadolinium gallium garnet (GGG) substrates for magnetic bubble memory devices are described in a four-page brochure. Union Carbide, San Diego, CA

CIRCLE NO. 418

Capacitor motors

Capacitor motors and their performance as a function of capacitance are featured in the current issue of *Motorgram.* Bodine Electric, Chicago, IL

CIRCLE NO. 419

Test instruments

Digital multimeters; communications and CB instruments; oscilloscope and power supplies; transistor and tube testers, and TV and radio service equipment are described in a series of five bulletins. Sencore, Sioux Falls, SD

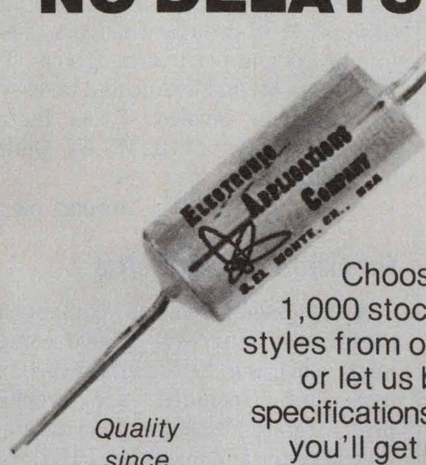
CIRCLE NO. 420

Active filters

Electrical specifications complete with tabulated amplitude and phase data and mechanical dimension drawings of 10 active filter families are given in a 36-page catalog. Frequency Devices, Haverhill, MA

CIRCLE NO. 421

REED RELAYS — NO DELAYS



Choose from over 1,000 stock reed relay styles from our catalogs, or let us build to your specifications. Either way, you'll get delivery in 2 weeks for thousands, and sooner for smaller quantities. And at good prices.

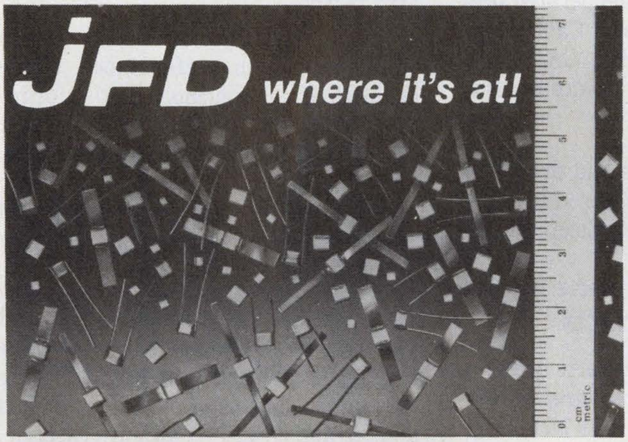
Quality since 1959

EAC

Electronic Applications Company
4918 Santa Anita Avenue
El Monte, CA 91734

Telephone:
213/442-3212

CIRCLE NUMBER 124



MICROCERAM®/CERAMIC MICROWAVE CAPACITORS

Microceram represents a major advance in the state-of-the-art of multilayer capacitors. Precise shape factor and technical performance data make Microceram units ideal for microwave circuitry applications. Their high Q performance persists even at high frequency, high power, high current and high ambient temperatures. Available as chips, pellets and leaded devices.

Delivery of standard values of 'A' and 'B' case sizes is from stock to 7 weeks, ARO.

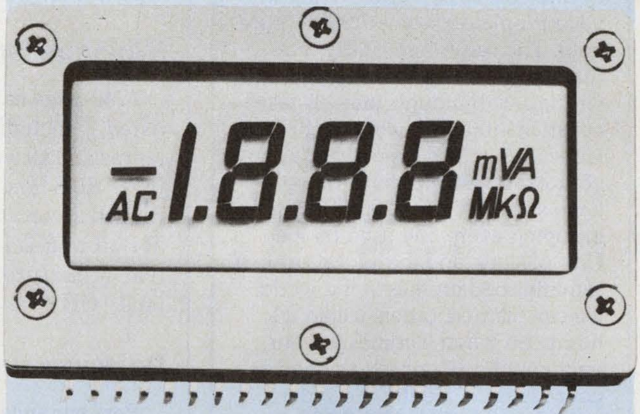
JFD ELECTRONICS COMPONENTS CORPORATION
15th Avenue at 62nd Street, Brooklyn, N.Y. 11219
212-331-1000 TWX 710-584-2462

CIRCLE NUMBER 125

New for OEM...EPSON's FEM

LIQUID CRYSTAL DISPLAY

2½'' × 1½''



with an integral one-chip

C-MOS LSI A-D CONVERTER

The world's largest manufacturer of Liquid Crystal Displays for hand-held calculators now offers the full-size panel display Model LD-E702 for OEM.

Compare these value features:

- ☐ Four numerals, each 10mm high X 5.5mm wide.
- ☐ AC or − displayed before numerals.
- ☐ m, V, A, M, K, and Ω after numerals.
- ☐ C-MOS LSI combines linear/digital C-MOS plus oscillation/driving circuits for LCD.
- ☐ Several hundred hours operation when DMM or DPM is battery driven.

EPSON products are made by Shinshu Seiki Co., Ltd., Japan

Write or call for complete information

EPSON

EPSON AMERICA, INC.
23844 Hawthorne Blvd., Torrance, CA 90505
Telephone (213) 378-2220 · TWX 910 344-7390

CIRCLE NUMBER 126

NEW LITERATURE

Memory products

The newest edition of National's 550-page Memory Data Book covers memory and memory-related products. To order send a check for $4 (CA residents include 6% sales tax) to Marketing Services Dept., National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051.

INQUIRE DIRECT

Miniature lamps

A 40-page catalog has 70 new lamps listed, including 38 halogen-cycle lamps and 19 wedge-base lamps. Drawings, data and specifications are arranged according to bulb size from 7/16 dia up to 2-1/16-in. dia. General Electric, Miniature Lamp Products, Cleveland, OH

CIRCLE NO. 422

Dc power supplies

Performance capabilities of the company's high-reliability, low-voltage dc power supplies are outlined in a brochure. Elexon Power Systems, Santa Ana, CA

CIRCLE NO. 423

Voltsensors

A data sheet covers the Model 425-252 and 415-215 line-operated precision dc voltage monitors. Calex Manufacturing, Pleasant Hill, CA

CIRCLE NO. 424

Coaxial relays

Specifications, charts and drawings of coaxial relays are featured in a 28-page catalog. Magnecraft Electric, Chicago, IL

CIRCLE NO. 425

Data, memory products

Data and memory products are covered in an eight-page brochure. Ampex International, Reading RG1 7XY, England

CIRCLE NO. 426

Rotary solenoids

The Magton family of dc voltage rotary solenoids is described in a six-page brochure. Technical drawings are included. Oak Switch Div., Crystal Lake, IL

CIRCLE NO. 427

Card-edge connectors

Design, construction, specifications and dimensional drawings of card-edge connectors are given in a six-page brochure. Eby Co., Philadelphia, PA

CIRCLE NO. 428

Interface circuits

A 576-page linear-IC catalog, "The Interface Circuits Data Book," provides information on line drivers, receivers and transceivers, memory drivers, MOS-interface drivers, sense amplifiers and peripheral drivers. The book costs $4.75. Postage and taxes will be added to invoice. Texas Instruments, P.O. Box 5012, MS 54, Dallas, TX 75222.

INQUIRE DIRECT

Precision components

A 208-page precision components catalog contains over 25,000 components covering 24 different product categories. Included are working prints, reference tables, gear data and metric terms and formulas. PIC Design Div. Benrus, Ridgefield, CT

CIRCLE NO. 429

Temperature controllers

The full line of LFE temperature controllers, sensors and accessory equipment is described in a 32-page catalog. It also features an applications guide. LFE, Process Control Div., Waltham, MA

CIRCLE NO. 430

Recorder

A six-page brochure describes the Brush 2800 high performance, eight-channel, direct-writing recorder for industrial, scientific and biophysical use. Gould, Instrument Systems Div., Cleveland, OH

CIRCLE NO. 431

Terminals

Hundreds of terminals, splices and disconnects are covered in a 60-page catalog. In addition to photographs, the catalog has dozens of drawings, charts and graphs. ITT Cannon Electric, Solon, OH

CIRCLE NO. 432

Optical waveguides

Specifications and characteristics for four Corguide optical fibers are included in a six-page bulletin. Corning Glass Works, Corning, NY

CIRCLE NO. 433

Data-entry terminals

Five specification guides cover source-data-entry terminals. Incoterm, Wellesley Hills, MA

CIRCLE NO. 434

Bulletin board

Microcomputer Rentals has expanded its line of **microcomputer-hardware-development equipment** with the addition of the Intel Intellec MDS.
CIRCLE NO. 435

The Electronic Product Associates Micro-68b floppy-disc system includes a disc-status-monitoring panel and write-product switches. The disc includes an interface to plug into the 6800 Exorcisor or the 8080 S-100 bus.
CIRCLE NO. 436

Teledyne Relays' JM640 solid-state-relay series has received QPL approval to MIL-R-28750. **CIRCLE NO. 437**

Optron has been granted **JAN TX approval** for its JEDEC 4N22, 23 and 24 devices. **CIRCLE NO. 438**

Wintek has lowered the price on its **16-kbyte Wince RAM module** to $399 from $889. **CIRCLE NO. 439**

DEC's Computer Special Systems Group has reduced prices from 13 to 22% for its **TJU45 and TWU45 nine-track magnetic tape subsystems** for PDP-11 computers. **CIRCLE NO. 440**

Precision Monolithics has reduced prices of its **8-bit d/a converters** in 100-999 qty as follows: DAC-08AQ from $20 to $17; DAC-08Q from $7.95 to $6.75; DAC-08HQ from $9.95 to $8.20; DAC-08EQ from $5.50 to $3.95; and DAC-08CQ from $4.50 to $3.45.
CIRCLE NO. 441

Shugart Associates has reduced prices 15% on its **SA400 minifloppy disc drive.** The price drops from $250 to $215 (500 OEM qty).
CIRCLE NO. 442

Hewlett-Packard low-noise microwave-transistor prices have been reduced up to 37%. **CIRCLE NO. 443**

Prices have dropped about 12% on selected **Hewlett-Packard multiprogrammer-system components.**
CIRCLE NO. 444

Motorola has a **mil-temp version of its M6800.** It is identical to previous M6800 products in electrical and software specifications. **CIRCLE NO. 445**

Vendors report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

San Fernando Electric Manufacturing Co. Inductors and monolithic ceramic capacitors. **CIRCLE NO. 446**

Scan-Data Corp. Optical character recognition systems, key entry systems, data center services, field service engineering. **CIRCLE NO. 447**

SRC Laboratories, Inc. Photomultiplier tubes. **CIRCLE NO. 448**

Western Union International. International and domestic record communication services. **CIRCLE NO. 449**

Engelhard. Ores, minerals and metals. **CIRCLE NO. 450**

SRI. Research and development.
CIRCLE NO. 451

Medgeneral. Medical electronics.
CIRCLE NO. 452

Data 100 Corp. Multifunction terminal systems. **CIRCLE NO. 453**

Pathcom. CB radios. **CIRCLE NO. 454**

Unitrode. Power semiconductors.
CIRCLE NO. 455

Burndy. Connectors and IC sockets.
CIRCLE NO. 456

International Laser Systems. Pulsed Nd:YAG and GaAs systems.
CIRCLE NO. 457

Solid State Scientific. Rf transistors, CMOS ICs, LEDs. **CIRCLE NO. 458**

Incoterm. Computer display terminals, software and systems, peripheral equipment. **CIRCLE NO. 459**

Battelle. Research and development.
CIRCLE NO. 460

Advanced Micro Devices. Bipolar/LSI μPs; MOS/LSI memories.
CIRCLE NO. 461

(continued from page 16)

this chemical and its promoters shows it to be a fraud. The chemical plainly does not work. It has no objectively beneficial effects. The theory on which its use has been based is anti-scientific garbage. Many, many times the chemical has been shown to be absolutely, completely useless.

Every five years or so, a new fraud in the treatment of crippling or fatal diseases hits the world press. A standard tactic used by unethical promoters is to accuse the medical establishment of repression. Gradually real evidence comes in; the new wonder drug is firmly discredited; and the promoters retire with their millions, or find a new chemical.

The only defensible argument for allowing the use of laetrile is that it makes some people feel better. This is a more difficult question in philosophy than can be profitably argued in an electronics magazine, but I put it to you that the effects of laetrile can be duplicated by distilled water and so depend on psychological effects. Is it really in our best interest to allow the use of a chemical whose effectiveness depends on the ignorance of the patient? What are the consequences of having irrational behavior becoming more dominant in our societies?

A final word on the ethics of editorials. You seem obsessed with professionalism this last year. A professional engineer is supposedly trained in the scientific method. This means he should know something about the nature of science, the role of theory, and the importance of evidence. Except on the aforementioned utilitarian grounds, a scientist must remain skeptical. You have disgraced yourself as a spokesman of science. Remember your editorial five years from now.

Vaso Bovan
Engineering Science
University of Western Ontario
London, Canada

If we accept the premise that you are qualified to evaluate laetrile, then your editorial should have concluded with an invitation to the medical community to evaluate fiber optics, bubble memories and single-chip microprocessors!

And if you are saying that every new advance should be universally adopted upon announcement, then where would be the responsible, methodical testing that gave us *proven* semiconductors and other components that could safely carry living men to the moon and back?

The only cancer patient I know of who took laetrile was not helped in any way. She died a few months afterward.

"Why beholdest thou the mote that is in thy brother's eye, but considerest not the beam that is in thine own eye?" (Matt 7:3)

Jay C. Sinnett
Wakefield, RI 02879

Your editorial is an example of unprofessional journalism at its extreme. Your conclusions are without fact, and you, as an electronics-engineering journalist, are not competent to pass the judgments reflected there.

There is no scientific evidence that laetrile is a vitamin. By what authority do you call it vitamin B_{17}? Second, are you aware that laetrile releases concentrations of cyanide, a highly toxic substance, into the bloodstream? Third, there are no controlled studies to show that laetrile has analgesic properties.

As for its acceptance in 26 countries, dictatorship is accepted in many more. Do you recommend dictatorship for the US?

Further, there are drugs that are partially effective in treating human cancers. No such drugs have failed to demonstrate tumor reduction in laboratory animals. Medical researchers consider it unethical (and properly so) to conduct clinical trials of drugs on humans without first having some success in using the curbs on laboratory animals and in demonstrating what risks, if any, are likely in using the drugs on humans.

I feel that you have become a victim of the so-called "Freedom of Choice" movement, which is being promulgated by laetrile profiteers. Do you know of the millionaires that have been made by laetrile promoters? I certainly hope that your technical articles, upon which I depend, are researched more carefully than this editorial.

Incidentally, a recent issue of *Consumer Reports* contains an excellent summary of a more rational view of laetrile and its quackery.

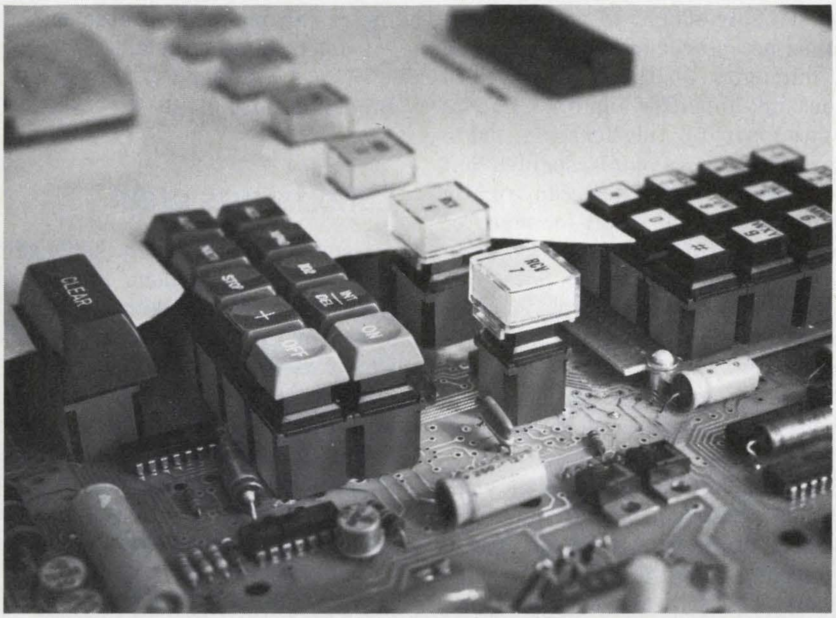
A. Brinton Cooper, III, Ph.D.
Bel Air, MD 21014

Three points: First, you're not qualified to judge the technical merits/demerits in the laetrile controversy.

While you're certainly entitled to take a personal position on emotional grounds, voicing your feelings as you have done before all but the most skimpy evidence has been brought in

(continued on page 190)

KEYBOARD SWITCHES
for INSTRUMENT PANELS



Now is the time to stop hand wiring to *expensive* panel-mounted switches.

Mechanical Enterprises' keyswitches are available at about *half-the-cost.* And, they are *self-supporting* on the PC board without the need for metal sub-plates.

Our switches feature –

- Sealed contacts or inexpensive gold bar mechanical contacts
- 3/4" or 5/8" spacing, or stand-alone
- Selection of legending systems including doubleshot keytops
- Lighted models in three lens styles, all relampable from front
- Single or double pole, NO or NC
- Momentary or alternate action
- Wave solderable
- 20 million cycle life at TTL loads with guaranteed low bounce

Please phone for a free sample with keytop.

Mechanical Enterprises, Inc.

8000 Forbes Place Springfield, Virginia 22151 (703) 321-8282 TWX 710-832-0942

Germany - NEUMULLER GMBH, MUNICH / U.K. - TEKDATA Ltd., STOKE-ON-TRENT / France - TEKELEC AIRTRONIC, SEVRES / Switzerland - DIMOS, AG ZURICH

CIRCLE NUMBER 142

ALCOKNOB
HIGHEST QUALITY
INSTRUMENT KNOBS

Remember that knobs are the most visible part of your equipment. Therefore, field acceptance of your product depends largely upon its' appearance.

ALCO has become a leading source in the USA for anodized aluminum knobs offering a wide variety of styles in five basic diameters.

Our knobs are better because they are totally machined with no compromise, even on the knurls. This offers a new dimension in appearance.

All knobs illustrated in our catalog are generally "off-the-shelf" in production quantities. However, we'll be glad to quote on custom knob designs too!

We urge you to call Customer Service at (617)-685-4371. Our salespeople know how to tend to your immediate needs. Also ask for our 24-page catalog and free sample!

ALCO ELECTRONIC PRODUCTS, INC.
1551 OSGOOD STREET NORTH ANDOVER MA 01845 U.S.A.

Tel: (617) 685-4371 TWX: 710 342-0552

A SUBSIDIARY OF AUGAT® INC

CIRCLE NUMBER 143

MODEL 612

Paper Tape Transmitter

50-9600 baud
RS 232 / Current loop or parallel outputs available
5-8 level tape, 7-11 frames per character
Stops and starts on character at all speeds
Uses manual control or x-on, x-off
90-260 volt, 50-60 Hz power
Even or odd parity
Desk top or rack mount

Addmaster Corporation
416 Junipero Serra Drive San Gabriel, California 91776
Telephone: (213) 285-1121

CIRCLE NUMBER 144

(continued from page 188)

and weighed is beneath someone in your position of editorial responsibility.

Second, you do an injustice to the medical profession by claiming that it has selfishly sought to prevent widespread acceptance of things beneficial to humanity ("...those who allowed thousands to suffer and die...") There is no support for this nonsense, and to the contrary, it cannot be doubted that the medical profession can rightly claim its share of credit for many of the blessings of good health we enjoy today. The list is very long, but surely you have heard of Jenner, Pasteur, Reed, Fleming, Banting, Salk, etc. Once again, your attack demeans your office and your publication. (And where were *you* when the FDA banned thalidomide?)

Third, and most important, the engineering profession should *emulate* the medical profession, not denigrate it! It's nice to have the great interests of all mankind at heart, but charity begins at home! I most respect the medical profession for looking out for #1, and despite occasional grumblings from the general populace (such as your editorial), most everyone else does, too. It's high time engineers snap out of it and stand up for their own interests. Before you lash out at the medical profession again, you tell me this:

How many engineers show up at work to find a waiting room full of clients? And how many engineers have an income even close to the median income for physicians? How many physicians were laid off their jobs this year? And how many physicians are still unemployed from the year before? Do physicians worry about wage-busting, as engineers do? How about physicians past their 30's...do they worry about becoming obsolete, of being replaced by interns fresh out of med school? How many engineers increase in value with age the way physicians do.? WHERE'S OUR LOBBY IN CONGRESS?

"Professionalism"? It's just a fancy word for plain old *Respect!* The medical Profession? Hell! Plumbers are more professional than engineers!

Respect is the issue. Respect comes down to dollars and cents. I'd rather be a rotten S.O.B. with a good, steady income and some solid security than that really hard-working Nice Guy who's out of a job, broke, and standing in the unemployment line.

You bet I want *that* kind of professionalism! Would it be so bad if engineers had at least *some* say about what happens to them? About how fast the job market is being flooded with new engineers? And especially about how fast the semiconductor manufacturers can make them obsolete?

I don't think so at all!

Mitchell D. Brody, Ph.D.
Brookline, MA 02146

Editorial was great

I appreciate your remarkable editorial on professionalism and laetrile. Never before have I seen you write so clearly on so heated an issue. I applaud wholeheartedly.

There isn't much I can add to the penetrating assessment, except to call attention to the underlying (and false) philosophical premise without which elitism would receive little intellectual support. That premise is: the anti-conceptual view of man.

We are told by doctors who want to ban laetrile that people won't follow their medical advice voluntarily. That is an open admission of professional failure. I wonder if it has occurred to those doctors that their medical judgment might receive far greater respect from the public if those doctors were not so reckless in their advocacy of physical force and so eager to avoid having to reason with people. It is as if laymen are viewed in the same category as laboratory animals—not just physically, but mentally too.

Originally a substance could be banned only if it was extremely dangerous—too dangerous to be used, even in small quantities. Laetrile certainly doesn't fall into that category. Even if laetrile consumption were as harmful as staying in the sun too long or eating uncooked meat, it still would be nowhere near as dangerous as implied by attempts to ban it.

Today, of course, substances can be banned if there is a statistically measureable probability, no matter how small, that laboratory animals will get cancer when forced to ingest massive doses. In other words, big doses carry slight risks, which hardly justifies depriving people of their right anf responsibility to weigh risks and benefits for themselves. If the risk is only slight with huge doses, how much less will the risk be in the much smaller quantities actually used by humans? Is this risk great enough to offset the benefits? A ban implies that no individ-

(continued on page 192)

Free!

Axial–Radial

Miniature aluminum electrolytic capacitor catalogs.

Capacitance values from .47 mfd through 10,000 mfd and voltages from 6.3V. to 450V. are readily available. Operating temperatures are from −40°C to +85°C at full rated voltage.

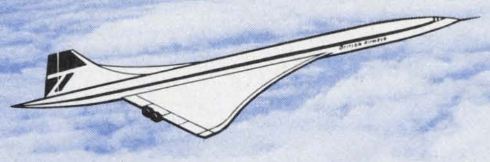
OTHER PRODUCTION ITEMS: Computer Grade Aluminum Electrolytics, Ceramic Capacitors, Film Capacitors, Oil Filled Capacitors—without P.C.B., Metallized Paper Capacitors, and Wax Paper Capacitors.

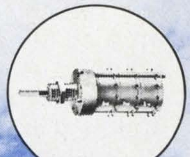
nichicon **The pulse of the industry.**

NICHICON AMERICA CORPORATION
Division of NICHICON CAPACITOR LTD., Kyoto, Japan
6435 N. Proesel, Chicago, Ill. 60645 (312) 679-6530

CIRCLE NUMBER 147

CONCORDE NEEDED THE FINEST ...*THEY CHOSE JANCO!*





JANCO ROTARY SWITCHES

The reliability, performance, and long life of Janco Rotary Switches has been demonstrated over and over again since 1947. Today, as Janco continues to extend the frontiers of its technology around the world and beyond...we are prepared to offer a down-to-earth solution to your switching problem, too!

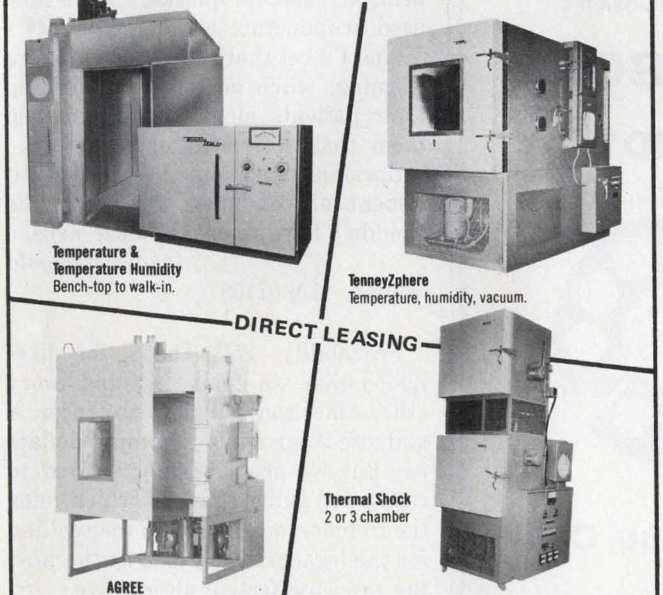
JANCO CORPORATION

3111 Winona Ave., Burbank, California 91504
Phone 213-845-7473 • TWX 910-498-2701

CIRCLE NUMBER 149

Environmental Control?

We've been doing it for 45 years with. . .



Write or call for further information on any of your environmental testing requirements.

Tenney ENGINEERING, INC.

1090 Springfield Rd., Union, N. J. 07083 (201) 686-7870
Oldest and largest manufacturer of Environmental Equipment

742A

VISIT OUR WESCON BOOTH NO. 101
CIRCLE NUMBER 148

Built to last

Our new 3½-digit LED autopolarity digital VoltOhmyst® is quality-constructed for long, hard service.

- Fast and accurate measurement of ac and dc volts, current, and resistance.
- Built-in analog panel meter for peaking and nulling.
- Hi- or Lo-power ohms selector.
- 120V/240V ac or battery operation with built-in charger.
- RF shielded, with rugged vinyl-clad case.

WD-750A
$267.00

VIZ Test Instruments Group
of VIZ Mfg. Co.
335 E. Price St.
Phila, PA 19144

Formerly RCA Instruments

© VIZ 6730

CIRCLE NUMBER 150

(continued from page 190)

ual has the mental capacity to resolve such questions, not even with advice sought from a doctor.

At first glance, the "big dose, small risk" rule doesn't seem to apply to laetrile, since laetrile isn't a cancer cause and may even be beneficial in cancer treatment. If our premise is to do everything possible to fight cancer, then we ought to legalize laetrile immediately. Yet, incredibly, opponents of laetrile are using that same premise to urge a ban. They are trying to extend the premise to include psychological as well as physiological factors, as if man's mental condition (including one's opinions of doctors and laetrile) were as unconsciously determined as his physical condition. The unreality of that view of man is matched only by the destruction it brings when people try to make it real.

D.W. Johnson
Huntington Beach, CA

It's a brave stand you've taken. I predict you'll get a lot of heat.

Whether one agrees or disagrees with the proponents of laetrile, the crux of the matter is, as you've said, that it is "resisted with a passion." The medical profession and its cohorts would be a lot more credible if they maintained their cool.

Wasn't it less than a decade ago that Chinese doctors in this country were being arrested for quackery when they used acupuncture on their patients?

And I'll bet that for centuries before Fleming, witch doctors were feeding their patients molds (uggh!) to help them shake off infections.

Speaking of acupuncture, if a practitioner could combine it with voodoo, he wouldn't have to make house calls.

Dan Sheingold
Waban, MA 02168

Probability .25!! That's the likelihood that we engineers (and every other American) will develop cancer. A statistic so given as this must deflate us—but we are justifiably elated to read your gutsy editorial which joins the thunderous grassroots roar calling for the legalization of laetrile therapy, the proven-effective alternative.

Damn the cancer Establishment—its orthodox "cures" defy rational critique. Surgery, radiation and chemical poisoning (chemotherapy) serve only to disfigure the hapless patient while influencing the spread and/or development of cancer elsewhere in the body. Correction—this witchcraft also serves to fatten the Establishment's pocketbooks and destroy the patient financially if not physically. Who's kidding whom?

It's high time we expose the phonies in the American Cancer Society, FDA and AMA and demand of our legislators that freedom in medical therapy be a reality, now! With one thousand cancer deaths per day, we haven't a moment to lose.

Henry E. Zeuli
Medford, MA 02155

Your laetrile editorial is the best piece of writing I've ever seen in Electronic Design.

One of the foremost experts on laetrile is Dean Burk, Ph.D., a founder of the National Cancer Institute who served as its chief chemist and head of the Cytochemistry Section. In addition to his observation that laetrile kills cancer cells "like flies" under the microscope, Dr. Burk states that positive, statistically highly significant, anticancer activity by laetrile in animal-tumor systems has been observed with a wide variety of animal cancers by at least five independent institutions. These include (1) Southern Research Institute, Birmingham, AL; (2) Scind Laboratories, Univ. of San Francisco; (3) Pasteur Institute, Paris; (4) Institute von Ardene, Dresden, Germany; (5) Sloan-Kettering Institute for Cancer Research, New York.

Although Sloan-Kettering has been testing laetrile since 1972, it has refused officially to release the experimental data. However, Dr. Kanematsu Sugiura, who conducted this research at Sloan-Kettering, stated the following in a letter to us:

"I have tested the effect of laetrile isolated from apricot pits on the growth of spontaneous mammary cancers in mice many times and on the development of lung metastases. I found that prolonged intraperitoneal injections of 2000 mg/kg/day of laetrile inhibited the growth of small tumors (less than 1.5 cm. in diameter), in many cases temporary. Laetrile had a strong inhibitory action on the development of lung metastases—approximately 80% against approximately 20% in control mice. The general health and appearance of laetrile-treated animals with large tumors were better than those of the control animals with large tumors."

Laetrile Case Histories, a book by John Richardson, M.D., contains im-

(continued on page 194)

(continued from page 193)

pressive case histories, verified by meticulous medical documentation. Over 800 American doctors are using laetrile and 50,000 Americans are taking it. Laetrile (amygdalin) has been recognized as nontoxic by the medical pharmacopoeias since 1834 and is on the FDA's GRAS list, being less toxic than white sugar. It is an essential vitamin (B_{17}) with a strong ability to prevent sickle-cell anemia, as well as cancer. In the country of Hunza, where the people eat large quantities of apricot seeds, cancer is totally unknown.

Dr. Linus Pauling has called the FDA "derelict" in its ban on Vitamin B_{17} since "nothing is wrong with it as a treatment or dietary supplement."

Numerous cancer patients attribute their recoveries to laetrile (generally coupled with an anti-cancer diet).

Arlin J. Brown
Director

Arlin J. Brown Information Center, Inc. P.O. Box 251
Fort Belvoir, VA 22060

The editor's turn

As I indicated, I don't know if laetrile works. My point, though, is that if *we* are to be professionals it should not be at the expense of the public. But many readers saw a different message.

It's apparent that the facts obtained by some readers are not the facts I obtained. First, as to laetrile's effectiveness. I have read many reports of humans who feel they have been helped by it.

In a case this April, Judge Mark Constantino (of Federal District Court in Brooklyn, NY) gave permission to Dr. Baldassare Cumella to import 375 grams of laetrile for his patient Joseph Rizzo. Dr. Cumella said that, after 30 days of laetrile treatment, 69-year-old Rizzo no longer suffered pain from his incurable cancer of the pancreas and had regained enough strength to take short walks. Further, his jaundice and itching had diminished, the swelling of his ankles had disappeared and his hemoglobin count had doubled. Dr. Cumella reported that he had not seen so noticeable or rapid an improvement in his 30 years of experience.

What about the vitamin-deficiency diseases cited by Mr. James and Dr. Risk? That's precisely the point. Most of the pioneers in vitamins were denounced in their day. A suggestion that there could be another cause—a nutritional deficiency—was clearly absurd since science had already proven that germs and poor hygiene were the cause of disease.

According to *The Vitamin Pioneers* by Herbert Bailey (Pyramid Books), almost all these pioneers were ridiculed for years by the medical establishment. In many cases, their findings were suppressed. Even today, the amply documented findings of Drs. Wilfrid and Evan Shute about the astonishing value of Vitamin E in treating burns and cardiovascular diseases are routinely ignored and even suppressed by the medical establishment.

As to the medical pioneers cited by Dr. Brody, I never suggested that no medical researcher had ever made an important contribution to mankind. But Dr. Brody's examples can prove instructive.

Edward Jenner's discovery of vaccination against smallpox was at first attacked by the medical profession of the late 18th century, especially by the celebrated surgeon, J. Ingenhousz.

Louis Pasteur's early work, the work that established his reputation, was aimed at conquering diseases of wine, silkworms and chicken. His work was treasured, as it was a treasure for three important industries. Only later did Pasteur develop an inoculation to stop rabies.

Walter Reed found the source of yellow fever, which was an epidemic among soldiers in Cuba during the Spanish-American War. The U.S. government didn't want its soldiers dying before they ever saw combat.

Sir Alexander Fleming's penicillin, Sir Frederick Grant Banting's insulin and Jonas Salk's vaccine against infantile paralysis all furnished new products and new markets for the pharmaceuticals industry. Of course, their contributions weren't opposed. They made money.

I believe that the essential controversy lies between the views I tried to express and the views in the final paragraph of Dr. Brody's letter.

He argues that the medical profession is to be admired because it takes care of its own financial interests first and, if necessary, the public be damned. I feel we ought to be better than doctors and, as professionals, place humanity's interests first. I know that engineers often get a raw economic deal, and I feel we should fight for a better deal. But I don't feel we should block technical or human progress to protect our economic interests.

George Rostky
Editor-in-Chief

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 circulated free of charge to those individuals in the United States and Western Europe who function in design and development engineering in companies that incorporate electronics in their end product and government or military agencies involved in electronics activities. For a free subscription, use the application form bound in the magazine or write for an application form.

If you do not qualify, paid subscription rates are as follows: $30.00 per year (26 issues) U.S./Canada/Mexico, $40.00 per year (26 issues) all other countries. Single copies are $2.50 U.S. and all other countries. The Gold Book (27th issue) may be purchased for $30.00 U.S./Canada/Mexico, and $40.00 all other countries.

If you change your address, send us an old mailing label and your new address; there is generally a postcard for this 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 our 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.

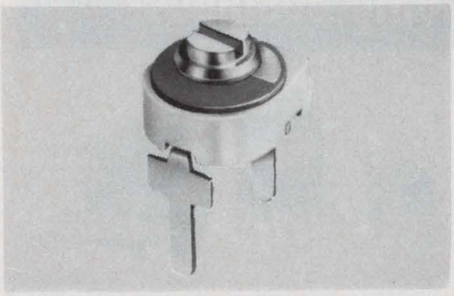
Individual article reprints and microfilm copies of complete annual volumes are available. Reprints cost $6.00 each, prepaid ($.50 for each additional copy of the same article), no matter how long the article. Microfilmed volumes cost $23 for 1976 (Vol. 24); $30 for 1973-75 (Vols. 21-23), varied prices for 1952-72 (Vols. 1-20). Prices may change. For further details and to place orders, contact Customer Services Dept. University Microfilms, 300 N. Zeeb Rd., Ann Arbor, MI 48106. (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 St.
Rochelle Park, NJ 07662

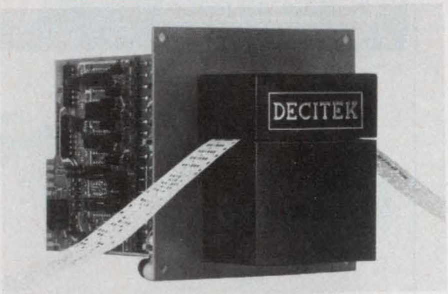
quick ads

New and current products for the electronic designer presented by their manufacturers.



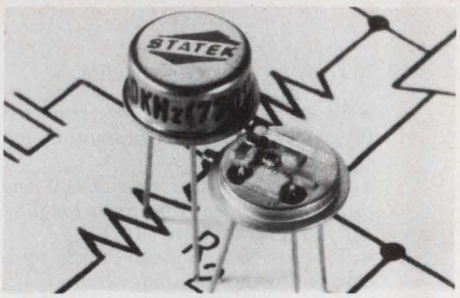
MINIATURE CERAMIC TRIMMER CAPACITORS 9371 series of ceramic trimmer capacitors are compact, economical and rugged. They are 50% smaller than other trimmers of this type yet provide high capacitance values. Available in 4 capacitance ranges, 1.5 to 4, 3.0 to 10, 3.5 to 18 and 5.0 to 25 pf with Q's > 300 at 10 MHz. They have an overall diameter of .225" with .215" above board height. JOHANSON MANUFACTURING CORPORATION, Rockaway Valley Road, Boonton, N.J. 07005 201-334-2676

TRIMMER CAPACITORS 181



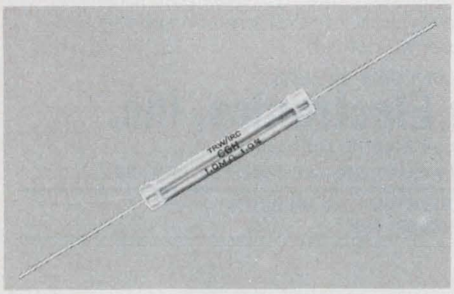
Low-cost tape reader is fast—up to 300 cps—and quality-built. Dual sprocket drive, a state-of-the-art fiber optic light source and photo transistor read head. Simplicity of design makes it easy to adapt to specific OEM requirements. Decitek, 250 Chandler Street, Worcester, MA 01602 (617) 798-8731

SAM® TAPE READER 184



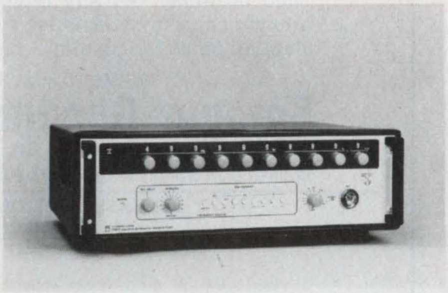
CMOS Crystal Oscillators in Low profile TO-5. Frequency range is 10 kHz to 300 kHz (divided outputs to 1 kHz, low as one cycle per month available). Low milliamp current consumption. Accuracy ±0.01%. Shock 1000 g. Hybrid thick and thin film chip and wire design is rugged and ideally suited for portable equipment. Details in Gold Book & EEM * STATEK CORP * 512 N. Main, Orange, Ca. 92668 * (714) 639-7810 * Telex 67-8394.

CRYSTAL OSCILLATOR 187



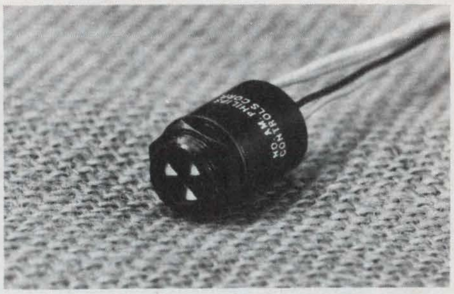
CGH Metal Glaze Resistors from TRW operate in high ambient temperatures with excellent high voltage load stability. These thick film resistors are particularly suited for precision high voltage and high impedance applications such as voltage multipliers, X-ray equipment, and high voltage power supplies where precision tolerances and TCs are required. TRW/IRC Resistors, an operation of TRW Electronic Components, 401 N. Broad St., Phila., Pa. 19108. (215) 922-8900.

CGH HIGH VOLTAGE 182



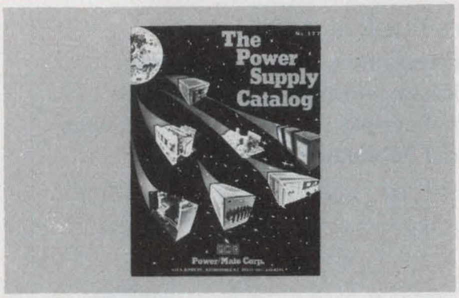
FREQUENCY SYNTHESIZERS. GenRad offers the best combination of low-phase noise, fast switching speed and price. Frequency range is dc to 500 MHz. Important features: non-harmonic spurs > 80 dB down; a-m, fm and pm capabilites; built-in search sweep; programmable (BCD parallel) frequency control; and optional resolution to 0.1 Hz. GenRad, 300 Baker Ave., Concord, MA 01742, (617) 369-8770.

FREQUENCY SYNTHESIZERS 185



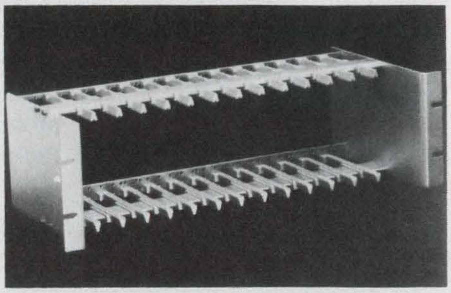
ELECTRIC RESET "BITE" INDICATOR Meets M83827/02. Monitors systems or components. Pinpoints malfunctions by providing automatic and permanent (until reset) warning of fault condition. Miniature size. Can be compactly grouped. 3 to 28V dc. 40 ms response. Wire leads or turret terminals. North American Philips Controls Corp., Cheshire, Conn. 06410.

"BITE" INDICATOR 188



Free New '77 catalog contains over 34,500 quality power supplies from the world's largest manufacturer, Power/Mate Corp. Power Supplies for every application including submodulars, open frame, varirated, encapsulated, laboratory & system. All units UL approved and meet most military and commercial specs for industrial and computer uses. Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601 (201) 343-6294

POWER SUPPLIES 183

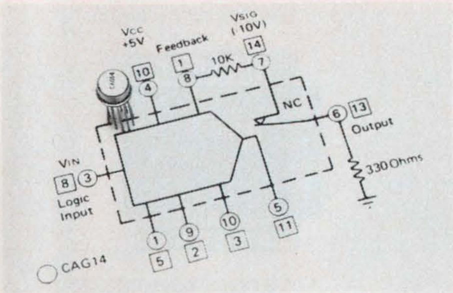


VARIABLE SPACED CARD FILE KIT Cambion's card files in kit form feature simplicity, easy shipping, storage, assembly —and durability. Intermix wire-wrap® cards with cards spaced close together. Kit has instructions, hardware and everything for assembly of a file of max. 27 positions. Edge card connectors with mounting hardware for interboard connection also available. For literature, write: Cambridge Thermionic Corporation, 445 Concord Ave., Cambridge, MA 02138. Phone: 617-491-5400.

CAMBION 186

3S-WICK® De-solder Braid. Spirig produces the vacuumized (pat. pend.) solder removal wick in unequalled technology to meet any standards worldwide. 3S-Wicks unique three dimension combination solves all electronics desoldering problems. 3S-Wick pat. pend. Spirig also produces pencil soldering irons. Dealers and distributor inquiries welcomed. USA: Spirig-Signalarm, PO Box 3128, Springfield, Mass. 01101, (413) 788-0224 Internat: Spirig, PO Box 160, CH-8640 Rapperswil, Switzerland TX 75400

3S-WICK DE-SOLDER BRAID 189

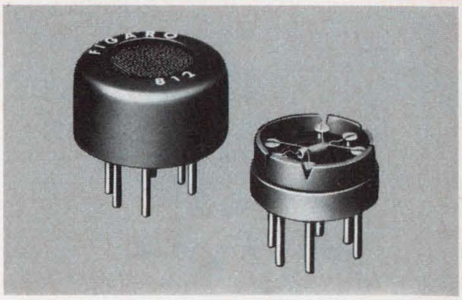


ULTRA HIGH SPEED FET ANALOG GATE The CAG14 is a SPST switch and driver circuit, for use as a high speed store and hold or general purpose Analog Gate. It features a turn-on time of 20 nanoseconds, 5 times faster than a comparable monolithic analog switch, and low ON resistance, typically 35 ohms, which remains constant with voltage. The space advantage cuts costs in handling, stock and inventory. Price: 1-49, $42.; 50-99, $35. Teledyne Crystalonics, 147 Sherman St, Cambridge, MA 02140 (617) 491-1670

ANALOG GATE **190**

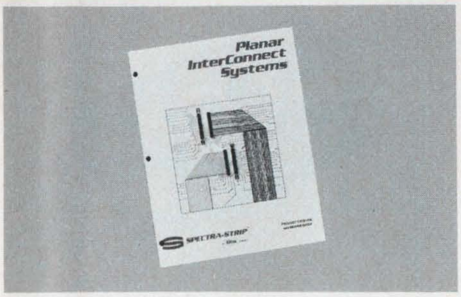
FREE HIGH VOLTAGE CAPACITOR CATALOG. Complete source listings for over 1000 power, pulse, high voltage, and special purpose capacitors and high voltage power supplies in glass, plastic and CP72 styles. Special low inductance types for laser and high energy applications. Many "custom" designs are standard with us. High reliability, long life, moderate cost, and fast delivery assured. To get your catalog, just drop us a line. Condenser Products Corporation, P.O. Box 997, Brooksville, FL 33512.

HIGH VOLTAGE CAPACITOR CATALOG **193**



FIGARO GAS SENSOR TGS is a gas sensitive semiconductor. When combustible gas is absorbed on the sensor surface, a marked decrease of electrical resistance occurs. Major features of the sensor include high sensitivity, long term reliability and low cost. The applications are: GAS-LEAK ALARM, AUTOMATIC FAN CONTROL, FIRE ALARM, ALCOHOL DETECTOR, etc. Figaro Engineering Inc., North America Office-3303 Habor Boulevard, Suite D-8, Costa Mesa, Calif. 92626 Tel: (714) 751-4103 Telex: 678396

GAS SENSOR **196**



SPECTRA-STRIP'S NEW PLANAR PRODUCT CATALOG & DESIGN GUIDE. AT LAST a complete catalog and design guide for planar connectors, ribbon and flat cables, flex circuits and planar interconnects. 86 pages on new products, connector applications, custom product designs, ultra flexible and high temperature cables, IDC connector designs and low cost interconnects. For your FREE copy write: Spectra-Strip Marketing Services, P.O. Box 415, Garden Grove, CA 92642

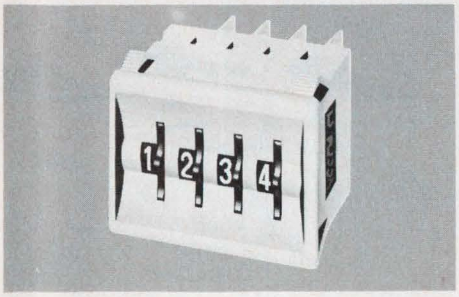
PLANAR CATALOG **191**

HANDSOME, RUGGED ENCLOSURES Custom-crafted laminated Formica®-Mahogany-Formica® construction, internally reinforced corners, rich wood grain or solid color exteriors. Superb workmanship, competitive prices, any quantity. W. A. Miller Co., Inc., 307 Mingo Loop, Oquossoc, Maine 04964. Phone: 207/864-3344

ENCLOSURES **194**

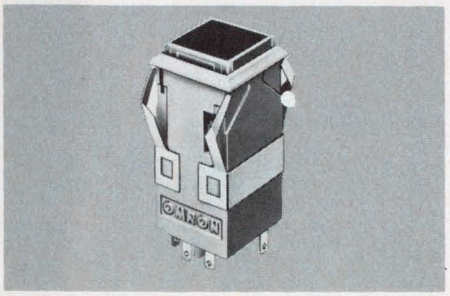
MAGNETIC SHIELDING Take advantage of Eagle's 23-year background in shield design and production. Custom and standard models. Full service includes design, engineering, fabrication, heat treating, finishing, testing. Also wide selection of sheet and foil so you can form your own shields. For helpful design and cost data, request Bulletin E-77. Eagle Magnetic Co., Inc., Box 24283, Indianapolis, IN 46224, 317-297-1030.

MAGNETIC SHIELDING **197**



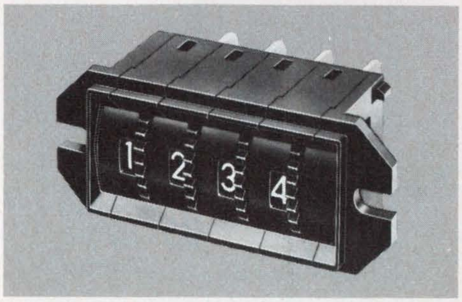
OMRON ECONOMY THUMBWHEEL SWITCHES. Cuts cost and assembly time with standard-size, snap-together, modular construction, plus snap-in mounting. Black or beige housings. Decimal or binary codes, with or without repeating terminals. Service life exceeds 100,000 mechanical operations. Continuous current of 1A at 28 VDC. Typical 4 digit assembly units measures 1.7" width × 1.3" high × 1.6" depth. OMRON ELECTRONICS, INC., 233 S Wacker Dr., Chicago, IL 60606. (312) 876-0800.

URT ECONOMY THUMBWHEELS **192**



OMRON LIGHTED PUSHBUTTONS. Mechanical contacts or solid state Hall-effect outputs, choice of momentary or alternate action, SPDT or DPDT, for direct power switching or input to solid state switching. Available in solid state, gold alloy and silver alloy contacts. Standard T-1 3/4 incandescent bulb replaces with power on, no tools needed. Snap-in mounting, long life of 5 million mechanical operations. OMRON ELECTRONICS, INC. 233 South Wacker Drive, Chicago, Ill. 60606. Phone (312) 876-0800.

A3P LIGHTED PUSHBUTTONS **195**



OMRON MINI-SLIM THUMBWHEEL SWITCH. World's smallest, yet very reliable . . . uses least panel space without sacrificing readability. Snap-together modules—0.630" high × 0.236" wide × 0.827" deep—allow build-up of as many wheels as necessary. Black or beige housings, snap-in or rear screw mounting, solder or PCB terminals. OMRON ELECTRONICS, INC., 233 South Wacker Drive, Chicago, Illinois 60606. Phone (312) 876-0800.

A7M MINI THUMBWHEELS **198**

quick ads

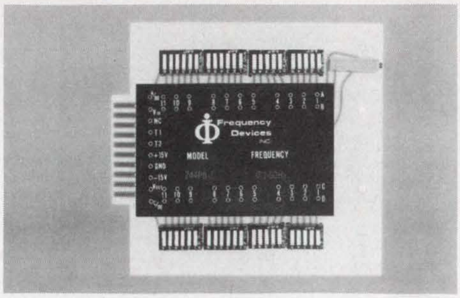
New and current products for the electronic designer presented by their manufacturers.

BASICS OF AC & DC LINEAR SOLENOIDS BROCHURE 16-Page "Dormeyer Coach's" treatise on fundamentals of applying AC and DC linear solenoids for commercial and consumer equipment. "Solenoids . . . What They Are, How To Use Them" covers essentials of construction, operation, standard types, typical usage, effect of duty cycles and ambient temperature, plus provides a handy trouble-shooting chart. FREE. Dormeyer Industries, 3418 N. Milwaukee Ave., Dept. ED, Chicago, IL. 60641. Phone: (312) 283-4000.

BASIC BROCHURE ON SOLENOIDS **199**

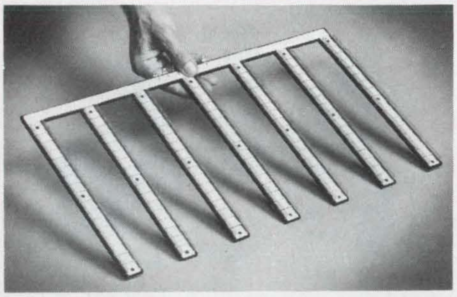
TV STUDIOS & VIDEO INDUSTRY New Allen Avionics Video & Pulse Delay Lines replace 75 ohm coaxial cable, provide a more suitable method of achieving precise short delays. The units reduce size, weight, installation cost, and save time and effort in making delay changes. Catalog also discusses Video Filters. See us at Wescon, Booth 1122. Allen Avionics, Inc., 224 E. 2nd St., Mineola, N.Y. 11501, 516-248-8080.

VIDEO RELAY LINES CATALOG **202**



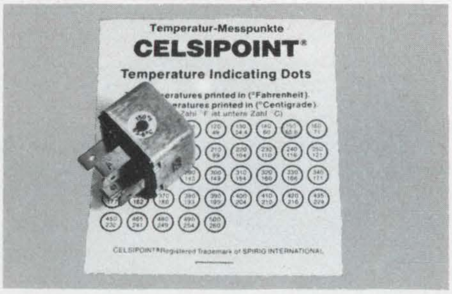
PROGRAMMABLE ACTIVE FILTERS provide a convenient breadboarding tool for designers. Series 744/FC102 are 4 pole lowpass filters with cutoff frequency (F_o) that can be varied over a 500:1 tuning range in 0.2% increments via self contained programming switches. Ten models cover the frequency range from 0.1 Hz to 50 kHz with Butterworth and Bessel transfer functions. Frequency Devices, Inc., 25 Locust Street, Haverhill, MA 01830. (617) 374-0761.

PROGRAMMABLE FILTERS **205**



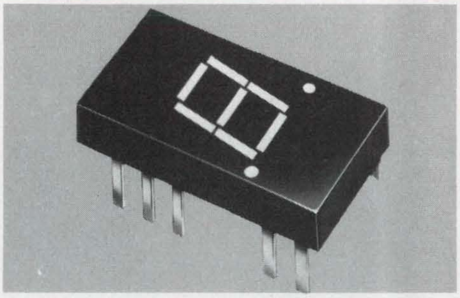
METHODE BUS BARS REPLACE MAZE OF COSTLY CABLE HARNESSES in computer, communications, industrial control systems. Ten years custom design experience, plus innovations like extra-strength staked and soldered .025" pins, puts METHODE first in bus bar designs for both military and commercial applications . . . FREE CATALOG. Methode Manufacturing Corp., 1700 Hicks Road, Rolling Meadows, IL. 60008. (312) 392-3500.

BUS BARS **200**



CELSIPOINT® temperature recording dots and strips do indicate by irreversible colour change (white→black) that a specific rated temperature was exceeded in the past of a component, equipment or any other item. Ideal for control of guarantee claims against overheating damages. Range from 100° F in 10° steps to 500°F. Accuracy ±1%. Distributors required. Spirig-Signalarm, PO Box 3128, Springfield, Mass. 01101, (413) 788-0224. Internat: Spirig PO Box 160, CH8640 Rapperswil, Switzerland Tx 75400

TEMPERATURE INDICATORS **203**



LOW COST .3" LED DISPLAYS. IEE is offering three models of .3" LEDs; Model 1737 is common anode with right and left hand decimal; Model 1738 is common cathode with right hand decimal, and Model 1739 is common anode with ± overflow indicator. All models display excellent red character appearance and uniform segments. These LEDs are interchangeable with currently popular models of TI, Monsanto and HP. $1.20 ea. in 500 quantity. IEE, 7740 Lemona Ave., Van Nuys, CA 91405 (213) 787-0311, x 268.

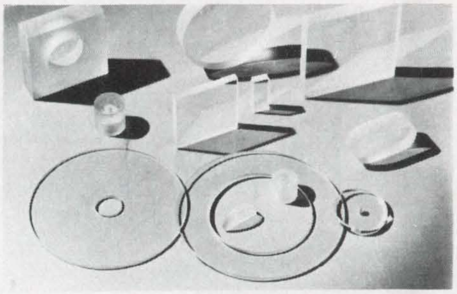
ECONOMICAL .3" LEDS **206**

CRAMOLIN CONTACT CLEANER & LUBRICANT dissolves oxide films caused by corrosive atmospheres i.e. sulphur dioxide. Effective on metals & alloys. Reduces contact resistance. Will not harm plastics. Free of acids. Wide operating temperature range. Tech data & test evaluation fluid sample available. Caig Laboratories, Inc., P.O. Box 64, Escondido, Ca., 92025. Tel: 714-743-7143

CRAMOLIN SAMPLE **201**

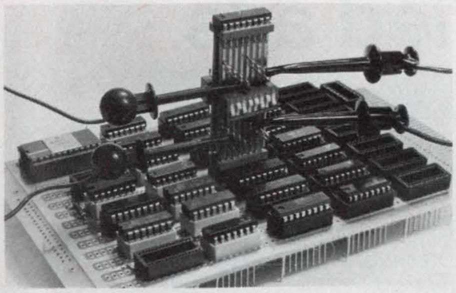
FREE TAKE HOME MICROCOMPUTER included in tuition. 3-day HANDS ON μP WORKSHOP $499. NEW 2-day HANDS ON μP INTERFACING WORKSHOP $299. Free micro has 6800 MPU, RAM, PIA, ACIA, ROM with FANTOM-II monitor/debug (single step, break points, etc.), expandable to 65k. Fall 77 Dallas, Houston, Washington, Melbourne, FL, Denver, Palo Alto, San Diego, Indianapolis, Boston, Detroit, Chicago, Puerto Rico. Call Jerilyn 317-742-6802 or write WINTEK Corp., 902 N. 9th St., Lafayette, IN 47904.

MICROPROCESSOR COURSE **204**



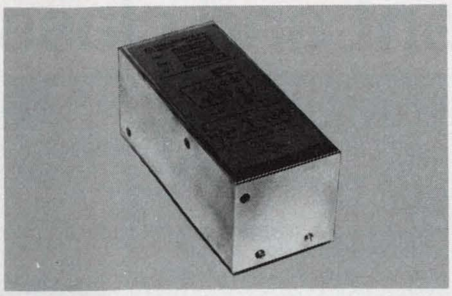
FREE 32 PAGE CATALOG. WINDOWS - PLATES - DISCS - OPTICS. Fused quartz, optical glasses, pyrex Ultra-low expansion materials, highly resistant to thermal shock. High UV and IR transmission. Chemically inert to most corrosive materials. Stocking center for lenses, prisms and laser accessories. Complete fabricating facilities. ESCO PRODUCTS, 181 Oak Ridge Rd., Oak Ridge, N.J. 07438. (201) 697-3700

LENSE, PRISM CATALOG **207**



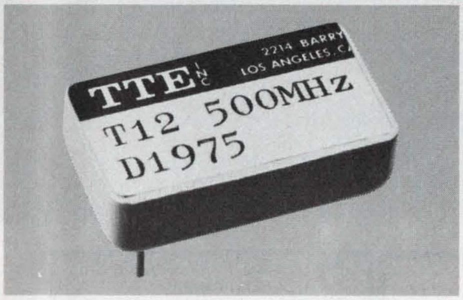
Dual-In-Line TEST/MODIFICATION Fixture Simplifies testing and provides a means for nondestructive circuit modification. DIP switches provide a means of isolating each circuit lead, test points are provided on both sides of the switches for testing or circuit modification. High rel components are used through out. 14 pin $21.95, 16 pin $22.95, 24 pin $28.95, 40 pin $40.95. Other sizes quoted on request. EMD Co., 7891 Camp Chaffee Rd., Ventura, CA 93001. 805-649-1513.

TEST AND MODIFICATION FIXTURE **208**



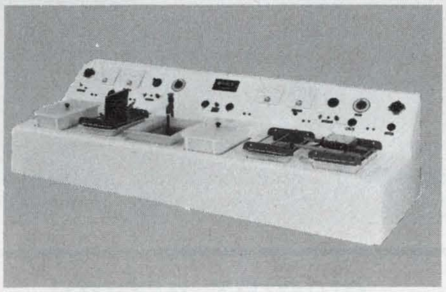
HIGH PERFORMANCE CRYSTAL OSCILLATOR This compact, highly stable, rugged oscillator operates over a wide range of temperatures and conditions and features excellent frequency stability (5x10-10/day), phase noise (90 db, 1 Hz from carrier), low power consumption, and low cost. The B 1325 oscillator meets performance requirements for modern instruments and systems. Frequency and Time Systems, Inc., 182 Conant Street, Danvers, MA 01923 (617) 777-1255 Telex: 94-0518

CRYSTAL OSCILLATOR **211**



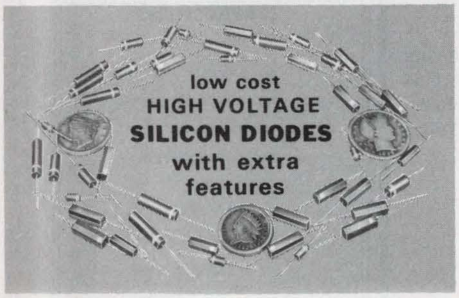
MINIATURE FILTERS for Highpass. Lowpass, Bandpass and Band Reject signal conditioning applications are described in the new catalog. Flat passbands and sharp cutoffs are featured. Specify any frequency from 3 Hertz to 500 Megahertz. T T Electronics, Inc., 2214 Barry Ave., Los Angeles 90064. (213) 478-8224.

MINIATURE FILTERS **209**



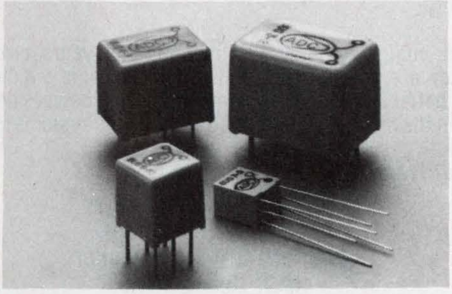
MINI-PLATING PLANT 5. Five 3-gallon plating tanks (10¼" x 6½" x 11" deep) plus one 3-gallon rinse tank. Two heater thermostats and two 10-amp rectifiers. 72" x 24" x 19½" overall. $1795. With three 10-amp rectifiers . . . $1950. Also MINI-PLATING PLANT III and all solutions and anodes. TECHNIC INC., P. O. Box 965, Providence, R.I. 02901 (401) 781-6100.

MINI-PLATING PLANT **212**



LOW COST HIGH VOLTAGE SILICON DIODES with extra features. A tremendous range of ratings, with special features, at very competitive prices. 143 different ratings from 400 V to 22,000 V., 3 mA to 1 Amp. Recovery times are as fast as 250-ns. EDI diodes offer many unique features. **Free samples.** Write outlining your application for free test samples. Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N.Y. 10710, (914) 965-4400, TWX (710) 560-0021

SILICON DIODES **210**



LADY BUG AUDIO TRANSFORMERS give you the reliability you'd expect from military transformers, at a commercial price. 46 different electrical configurations. Power ratings from 50mw to 2 watts. Operating frequencies from 100Hz to 100KHz. 4 case sizes (smallest: 1/3 cubic inch). ADC Products, 4900 W. 78th, Minneapolis, MN 55435. (612) 835-6800.

AUDIO TRANSFORMERS **213**

Electronic Design

Advertising Sales Staff
Susan G. Apolant
Sales Coordinator

Rochelle Park, NJ 07662
Robert W. Gascoigne
Thomas P. Barth
Stan Tessler
Constance McKinley
50 Essex St.
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)

Philadelphia
Thomas P. Barth
(201) 843-0550

Boston 02178
Gene Pritchard
P.O. Box 379
Belmont, MA 02178
(617) 489-2340

Chicago 60611
Thomas P. Kavooras
Berry Conner, Jr.
200 East Ontario
(312) 337-0588

Cleveland
Thomas P. Kavooras
(312) 337-0588

Los Angeles 90045
Stanley I. Ehrenclou
Burt Underwood
8939 Sepulveda Blvd.
(213) 641-6544

Texas
Burt Underwood
(213) 641-6544

San Francisco
Robert A. Lukas
465 S. Mathilda, Suite 302
Sunnyvale, CA 94086
(408) 736-6667

England
Constance McKinley
50 Essex St.
Rochelle Park, N.J. 07662
Phone: (201) 843-0550

Europe
Sanders, W. J. M.
Raadhuisstraat 24
Graft-De Ryp, Holland
Phone: 02997-1303
Telegrams: Euradteam-Amsterdam
Telex: 13039-SIPAS

G. Nebut
Promotion Presse Internationale
7 ter Cour des Petites Ecuries
75010 Paris, France
Telephone: 5231917, 1918, 1919

Dieter Wollenberg
Erikastrasse 8
D-8011 Baldham/Muenchen
Germany
Telephone: 0 8106/4541

Tokyo
Haruki Hirayama
EMS, Inc.
5th Floor, Lila Bldg.,
4-9-8 Roppongi
Minato-ku, Tokyo, Japan
Phone: 402-4556
Cable: EMSINCPERIOD, Tokyo

ABP BPA

Electronic Design

recruitment and classified ads

PLACE YOUR AD AT ONLY $45 PER COLUMN INCH IN Electronic Design

— GET A REPEAT AD FREE!

With our 2 for 1 plan, your net cost in *Electronic Design* is only $22.50 per column inch, lowest among all the national newspapers and electronics media. You get a total of 165,402 exposures to EOEM engineers and engineering managers (not counting 10,600 more among general or corporate managers) at only 27¢ per thousand! You can't beat the price. You can't beat the coverage *and* you can't beat the quality.

YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer • Project Engineer • Electronic Engineer • Engineer-Supervisor • Section Leader • Staff Engineer • Systems Engineer • Test Engineer • Standards Engineer • Master Engineer

Electronic Design RECRUITMENT ADVERTISING RATES

15% commission to recognized agencies supplying offset film negatives. 2% 10 days, net 30 days. Four column makeup. Column width 1-3/4" x 10".

SPACE	DIMENSIONS Wide	Deep	COST
One column inch	1-3/4"	x 1"	$45.
2 col. in.	1-3/4"	x 2"	$90.
1/16 page (1/4 col.)	1-3/4"	x 2-1/2"	$112.
1/8 page (1/2 col.)	1-3/4"	x 5"	$225.
1/4 page (1 col.)	1-3/4"	x 10" Vert.	$450.
	3-1/2"	x 5" Hor.	
1/2 page (2 cols.)	3-1/2"	x 10" Vert.	$900.
	7"	x 5" Hor.	
3/4 page (3 cols.)	5-1/4"	x 10"	$1350.
1 page	7"	x 10"	$1800.

NOTE: EACH RECRUITMENT AD YOU PLACE WILL BE REPEATED FREE OF CHARGE!

LATE CLOSING DATES

Electronic Design is mailed every two weeks. Because of its timeliness, personnel recruitment advertising closes only two weeks before each issue's mailing date.

1977 Mailing Date	Recruitment Closing Date	Issue Date on Cover
Sept. 9	**Aug. 26**	Sept. 27
Sept. 23	**Sept. 9**	Oct. 11
Oct. 7	**Sept. 23**	Oct. 25
Oct. 21	**Oct. 7**	Nov. 8
Nov. 4	**Oct. 21**	Nov. 22
Nov. 18	**Nov. 4**	Dec. 6
Dec. 2	**Nov. 18**	Dec. 20

HOW TO PLACE YOUR AD
CALL THE RECRUITMENT HOT LINE 201-843-0550

Camera-ready film (right reading negatives, emulsion side down) or camera-ready mechanicals must be received by deadline. Or, if you wish us to set your ad (typesetting is free) simply pick up the phone and call our RECRUITMENT HOT LINE — (201) 843-0550. Ask for:

Constance McKinley
RECRUITMENT ADVERTISING MANAGER
ELECTRONIC DESIGN
50 Essex Street, Rochelle Park, New Jersey 07662

NEW ENGLAND RECRUITERS

ELECT-TECH, a division of New England Recruiters, specializing in Electrical and Electronic Engineers has over 150 positions thru-out N.E. and the North East. The following are just a sample of the positions that are available.

DATA-TELE COMMUNICATIONS

PRODUCT MGRS (3) to 30K
Degree Comm Syst., modems or tele. networks
PRINCIPLE-PROJ. ENGS. (2) to 27K
Degree Data-Comm. Syst. modems. microprocessors
SYSTEMS ENGS. (3) to 25K
Degree Telephone, switching syst. Telex, micro
PRODUCT DESIGN (2) to 24K
Degree Design Data-Comm. Systs. micro hard/soft
SR. ENGS. (3) to 20K
Degree Data-Comm. test equip. or modems or TDM's.

SEMI-CONDUCTORS

LAB DIRECTOR to 40K
Degree Advance develop. Pilot research MOS semi-cond.
PROCESS ENGS. (2) to 25K
Degree Process develop. semi-cond.

POWER SUPPLIES

MANAGER (2) to 30K
Degree Superv. exp. power supplies, series & switching.
DESIGNERS to 25K
Degree converters, inverters, switching regulators.

COMPUTERS

ANALOG DESIGN (3) to 25K
Degree Heavy Analog circuits, amplifiers power supplies.
CPU DESIGNER OR PROGRAM to 25K
Degree-Design and interface mini or micro hard/soft.
COMPUTER-ARCHITECT (3) to 25K
Degree Logic design, processor, mini or micro hardware
PACKAGING to 25K
Thermo-Anal., cooling, enclosures, PC boards.

ELECTRONICS

SR. PROJECT (2) to 28K
Degree Mini-Comp microprocessor hard/soft.
SR. CONTROLS (3) to 26K
Degree mini-comp. micro hard/soft controllers
SYSTEMS ENGS. (2) to 25K
Degree Design optical, mechanical systs.
DIGITAL DESIGN to 30K
Degree Design ECL, Hi-speed digital logic.
QC MGR. (MEDICAL) to 25K
Degree QC exp. medical Co. FDA regulations.

ELECTRICAL

PROJECT ENG. to 25K
Degree Instrum. & controls heavy equip.
ENG. MGR. to 31K
Degree exp. in micro, sub-fract. or fract. HP motors.
DESIGN TRANSMISSION Open
Degree Design of power transmission systems.
PROJECT ENG. Open
Degree Design elect/Mech. Controls & speed drive systems. Integral motors.

ALL FEE PAID
NEW ENGLAND RECRUITERS
900 Chapel Street
New Haven, CT 06510
(203) 624-0161

Senior Design Engineer

SIGNAL CONDITIONING

Senior Design Engineer -- become involved with a new, but well-established second generation state-of-the-art product. And work for a growing company with plenty of resources to ensure success: Analog Devices.

Our performance in the area of signal conditioning and analog to digital interface has us growing at the annual rate of 25%. This is an opportunity to join a growing team in an environment offering challenge and personal recognition.

This second generation -- microprocessor based measurement and control system has created an opportunity for an exceptional individual in the design of low level signal conditioning circuits for data acquisition and control systems. This position requires a strong background in conditioning low level signals in a digital systems environment. Direct experience with thermocouple amplification and compensation circuits a must. Experience with circuit techniques for galvanic isolation of signals desired.

Qualified applicants should forward a resume, with salary history, to Mr. Ed D. O'Brien, Analog Devices, Inc., Route 1 Industrial Park, Norwood, MA 02062, or call him collect at (617) 329-4700. All inquiries will be acknowledged.

ANALOG DEVICES

An Equal Opportunity/Affirmative Action Employer M/F.

SENIOR ENGINEER MICROWAVES

Here is a real opportunity to grow! We need a solid electronic engineer with management ambitions and leadership qualities on our team. Experience in amplifiers and communication systems using microwave tubes is very desirable. You need to be a graduate engineer with a minimum of five years of design experience. The right man will either assume now or be capable of growing into a position of chief engineer.

You will find that working at Cober is stimulating and rewarding. We offer a full fringe benefit package including profit sharing.

Please send resume to: Don Scofield
Cober Electronics Inc.
7 Gleason Avenue
Stamford, Connecticut 06902

Recruitment Ads Pull

DIGITAL PRODUCT DEVELOPMENT

Exciting organization involved with advanced automotive electronic products and state of the art technology. Energetic professional atmosphere. Team management style.
Work encompasses electronic product design and development involving digital and microprocessor technology.
Credentials: BSEE + 2-5 years of digital product development experience for several DEVELOPMENT ENGINEERING positions and a BSEE + 6-10 years of the above experience for an ENGINEERING GROUP LEADER position.
Please call or write Gene Trusky CEC

DUNHILL PENN CENTER
Pgh. Pa. 15235 (412) 241-8383

UNADVERTISED $16-35K OPENINGS

- Hd/Software Des
- Pwr Supply Des
- Test Engring
- Mfg Engr & QC
- Radar
- Electro Optics
- Microwave Comm
- Marketing

Let our engineers assist you in advancing your career, or improving your choice of location. Due to our success, many NATIONWIDE companies have retained us to fill their confidential, unadvertised openings. Discretion assured. Contact Tech. Dir.

Corporate Advisors®
12955 Biscayne Blvd., Miami, 33181
Professional Placement
(305) 891-4801

SPECIAL

2

RECRUITMENT ADS

FOR THE PRICE OF

1

Double the coverage . . . double the effectiveness of every ad you place!

Engineers

Technological Leadership for 3 Decades!

Ampex, headquartered on the San Francisco Peninsula, is the company that "invented" the magnetic recording industry.

The technology pioneered by Ampex over three decades has affected many aspects of our modern lifestyles, and has established Ampex as a leader in magnetic recording. Our continued effort in developing new technology has always been the key to our leadership. Right now our Advanced Technology, Data Products and Audio-Video Systems Divisions are embarking on several new programs. To insure the success of these programs we are seeking innovative graduate engineers with experience in the fields listed below.

Opportunities like this don't happen very often. But they're happening at Ampex now.

Advanced Technology Division

- electron beam and optical recording
- magnetic recording
- tape or film handling
- servos
- high-bit rate digital circuit design
- optics
- signal analysis
- pattern recognition
- high frequency circuit
- communications theory

Data Products Division

- circuit/systems design of very high-bit rate systems
- disk read/write systems and equalizing systems for tape recorders
- codes for magnetic recording
- precision servo systems for both linear positioners and rotating systems
- mechanical design of high precision systems in disk recorders and in longitudinal, helical and transverse scan tape recorders

Audio-Video Systems Division

- analog videotape signal systems
- digital video signal processing
- servo systems
- videotape editing
- professional audio recorders
- head technology
- TV cameras

If you think you have something valuable to offer in any of these or closely related areas, and if you would like to join some of America's most talented engineers, please send your resume or a letter outlining your qualifications to: Ampex Corporation, ATTN: Corporate Staffing Manager, Building 2, 2655 Bay Road, Redwood City, CA 94063. Or you can send us this coupon and we'll get back to you. We are an equal opportunity employer m/f.

Manager Corporate Staffing
AMPEX Corporation
Building 2, 2655 Bay Road
Redwood City, CA 94063
Dept. 9

Name ______________________
Address ______________________
City, State, Zip ______________________
Phone ______________________

Occupation ______________________
Years of Experience ______________________
Employer ______________________

AMPEX

Advertiser's index

**Advertisers in non-U.S. edition*

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 Reader Service numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

new literature